Literature Review of Advantages and Disadvantages of Pre-planned Construction Projects 2013 PhD Conference

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Published in:
Proceedings of 13th PhD Conference on Research in Business Economics and Management (PREBEM)

Publication date:
2013

Document Version
Early version, also known as pre-print

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2013 PhD Conference

Word count (excl. tables/figures/reference list): 3752

ABSTRACT

The construction industry's focus on pre-planning, with its advantages and disadvantages, has not been investigated in a literature review which gives a state of art understanding of the topic.

The aim of the paper is to review related papers, to fulfill gaps in the literature which could be researched further in a Ph.D. project.

The review model is conducted on papers, which all support an input, processing and output stage. 561 journal papers were found, and by the processing stages 95 A-papers were categorized in six correlated themes.

The main finding of the review was that pre-planning has a linear positive impact on the construction projects´ chances to meet budget and quality, and to reduce duration and risk in the project process.

Gaps associated with pre-planning and construction projects were found by the review, and the problem should be further studied by a trend analysis to validate the gaps.

Keywords: Construction Project Management, Pre-planning, Process Optimization, Risk Management.

INTRODUCTION AND BACKGROUND

Despite several quantitative and qualitative studies in the last decade (2002-2012) the topic has been researched in different perspectives and themes, little effort has been made with significant findings to a systematic literature review, which gives a state of art understanding of the scientific environment of the topic.
The aim of this review is therefore to review gaps in the literature which need to be studied, and thereby increase our understanding of the relationship between pre-planning and industrialized construction systems.
The following subjects are pursued to be studied in the review, first the review seeks to understand existing experience with pre-planning and its influence on the construction processes. Secondly, it aims to study the relation between pre-planning and its use of industrialized construction systems, together with its relation on the construction process. Thirdly, obtain an understanding of finding´ impact on pre-planning, by exploring previous studies related to pre-planning. Finally, conduct a state of art review of pre-planning, to find further perspectives and gaps in literature to be studied.

Research Methodology

The review strategy used was divided into three main stages to secure an efficient review of the journal papers; “input stage”, “processing stage” and “output stage”, according to Levy and Ellis (2006), and adjusted in each stages according to Pittaway et al. (2004) and Kumar et al. (2007) to improve the review process.
The author identified five simple keywords from brainstorming and Ph.D. mentors’ know-how. A search was made with the keywords at the research platform Web of Knowledge, and based on the search and a second brainstorm six keywords were identified and converted into nine basic search strings.
An initial search was made at Web of Knowledge, using the nine search strings to identify further keywords. Five keywords more were found. Based on the identified eleven keywords, four keywords more were added based on the authors’ assessment.
The fifteen keywords in total were combined into advanced search strings by “and”, “or” and “same” for example [(project management OR construction management) AND (construction industry OR construction)]. The advanced search strings were used in the main search on acknowledged scientific platforms such as Web of Knowledge, SpringerLink, Elsevier Scopus and SciVerse.
To reduce the number of papers, exclusion and inclusion criteria in two stages were conducted where also each reference was reviewed to validate the standard, and cross check missing papers in the study. Using the exclusion and inclusion criteria the papers were primarily sorted into the following groups; A - papers whit particular relevance, B – papers, some relevance and C – papers, minor relevance.
A - paper abstracts were hereafter reviewed where papers with less than 10 points were removed, and papers with more than 14 points were analyzed, by forward and backward author and reference check. The Ph.D. mentors were hereafter invited to evaluate the A – papers, where no further adjustment was made. Using the inclusion, exclusion criteria the final grouping of A - papers was made, see Table 1 for the paper review selection.
The final A - paper list was hereafter reviewed and categorized by topic related to subject to construct arguments and theme. The different sections were hereafter written as the theme

was found relevant to the subject.

Table 1 – Sorting of papers during each stage of review

Name of analysis phase	Included	Excluded	Duplicates
Literature search.	561	-	-
Title analysis, exclusion criteria.	471	87	3
Abstract analysis, inclusion criteria.	391	79	1
Primary sorting C papers.	-	79	-
Primary sorting B papers.	-	93	-
Primary sorting A papers.	219	-	-
Abstract quality C ranked papers, abstract standard criteria.	-	2	-
Abstract quality B ranked papers, abstract standard criteria.	-	57	-
Abstract quality A ranked papers, abstract standard criteria.	160	-	-
Forward and backward literature search.	4	-	-
Final C paper grouping.	-	-	-
Final B paper grouping.	-	65	-
Final A paper grouping.	99	-	-
Narrative inclusion	95	4	-

Theme Categorization

To provide an overview of the relationships between the different theme and the study purpose as explained in introducing and background, the literature is sorted in themes according to subject. The theme categorization serves to give an overview of the following literature review, where different approached and perspectives are reviewed in the papers to construct and find gaps which the author´s find particularly relevant for future research, see Table 2 below for theme description.

The theme categorization of papers is not statically categorized, and papers can therefore influence several of the six themes in different perspectives and approaches.

Table 2 – Theme description according to paper categorisation

Cost and Scheduling Increase	Studies which focus on how, why and when cost and scheduling increases happen, and which factor that's stabilizing increases. 25 of the 95 papers were used to write the theme.
Planning & Scheduling	Research which explores advantages and complications by pre-planning in construction. 28 of the 95 papers were used to write the theme.
Pre-assembly Construction	Focusing on systems which are pre-assembled before construction. 8 of the 95 papers were used to write the theme.
Productivity	Studies which focus on how productivity affects construction projects and which factors reduce or improve productivity in construction. 21 of the 95 papers were used to write the theme.
Risk Planning	Focusing on risk factors which affect the construction processes and on how risk can be reduced in the processes. 7 of the 95 papers were used to write the theme.
Technology	Papers focusing on new technology in the construction industry, such as using parametric modeling. 6 of the 95 papers were used to write the theme.

LITTERATURE REVIEW

Cost and Scheduling Increase

Cost and schedule escalation is an important issue in construction projects, and appears to be a global challenge on five continents and for 20 nations, where cost escalation appears in 9 out of 10 transport infrastructure projects, with average cost increases of 45 % for rail, 34 % for tunnels and bridges, 20 % for roads, and with an average increase for all project types of 28 %. Further, a cost reduction has not been found in the last 70 years, where particularly developing nations seem to have a more pronounced increase than North American and European transport projects (Flyvbjerg et al. 2002; Flyvbjerg et al. 2003). To reduce increases Bhargava et al. (2010) and Son et al. (2011) find a relationship between cost and time overruns such that the two factors need to be simultaneously combined, further they find that contact size, project duration, weather conditions, bidding process and optimistic expectations to planning and cost, stimulate increases.

Focusing on which risk factors lead to cost overruns, project changes and scope changes are found to increase cost (Creedy et al. 2010; Fidan et al. 2011). These results are confirmed by Sun et al. (2009) and Ahadzie et al. (2008) who conclude that success of a project is determined by the ability to manage changes during a project, and the negative effect of changes can be loss of productivity, cost and time overruns. Top increase factors are found to be design changes, risk/uncertainties, inaccurate evaluation of project time/duration, complexities and non-performance of subcontractors (Olawale et al. 2010), where design changes and rework are estimated to mean directly 6.4 to 6.85 % and indirectly 5.5 to 7.36 % of contract value (Lopez et al. 2012; Love 2002).

The procurement method by design-bid-build and in-house construction is compared in all phases, and found total cost is nearly the same, but the design-bid-build method used 10 % more on change orders, need more construction management, but has advantages in larger construction project compared to in-house construction (Kuprenas et al. 2007).

The dynamic nature of projects, methods and its consequences by increasing work overtime, resource adding, and aggressive scheduling can be due to loss of productivity and quality (Park et al. 2010), where particularly quick decision-making by cost cutting and change of scope, along critical path influence not only single tasks, but the hole project (Chester et al. 2005; Chang 2002).

The specific reasons and factors to cost and scheduling increase are studied by several researches between different geographic locations and construction methods, and finds comparable factors such as scope changes in construction process, inadequate contractors experienced, missing labor productivity, improper planning, whether conditions, rework, slow decision making, poor construction management, financing and payment for contractor and owner, insufficient resources, missing focus on environment factors, conflicts whit external partners and unforeseen geotechnical conditions (Odeh et al. 2002; Assaf et al. 2006; Arain et al. 2006; Lo et al. 2006; Abd El-Razek et al. 2008; Sweis et al. 2008; Han et al. 2009; Shane et al. 2009; Wambeke et al. 2011 and Kazaz et al. 2012).

Technology

Construction is an industry which fails to innovate and perform compared to other sectors. Winch (2003) has studied this phenomenon by comparing construction and auto industry as this sector typically is a good example on industrialization and performance. The study finds no evidence that construction is worse or better in performance then the auto industry, but points out that construction has challenges with customer dissatisfaction. Further, no reliable indication is found that construction has a lower, or a higher innovation rate than other industries.

Learning points from manufacturing industries are increasingly studied, for example Li et al. (2008; 2009) study how virtual prototyping (VP) and the lean product process can optimize process and simplify management. They find improved efficiency and productivity by using the two technologies together. VP are therefore studied further to planning and operations management where it are found that focus on VP has a positive impact (AbouRizk et al. 2011; Li et al. 2012 and Allen et al. 2008).

Pre-assembly Construction

The advantages and considerations in connection with using off-site production (OSP) is both a technical and softer issue. Where it are found that OSP is considered by taking particularly technical issues into account, when different production options is compared, which often disregard cost related benefits such as site facilities, crane, rectification, health and safety, effects on management and improved processes (Blismas et al. 2006). The softer issues are further studied by Thuesen et al. (2011) where a house platform is designed carefully to market and cost reduce by 30 % compared to traditional methods, but found that off-site construction are not the most optimal methods, rather than commitment and loyalty from the organization, and that target costing is more important than radical innovation.

The competitive strategy in construction is driven by profit from development by customer requirements, where the Japanese house industry has adopted a build-to-order technique by standardization, prefabrication and supply-chain management to deliver customized houses (Barlow et al. 2003). But even though the Japanese are leading in large scale industrialization are it found that after sale service and customer involvement also are in focus (Linner et al. 2012).

Naturally prefabricated construction systems need extra focus at the design stage, where a combination of pre-assembled components and computer-aided design, is found to reduce time and cost in the design and construction stage, and further improve safety (Li et al. 2011; Benros et al. 2009). These results are further reflected on Johnsson et al. (2009) which find that offsite construction has more stable processes that reduce “fire-fighting management” and improve quality rate. To support the stable processes it is further found by Alvanchi et al. (2012) that offsite construction can be accomplished whiteout conflicts between project partners, if they are early involved in the design stage.

Planning & Scheduling

The impact of pre-planning on project success has long been recognized, but varies in use by construction industries´ organizations. Gibson Jr. et al. (2004) define pre-planning as the process encompassing all tasks between project initiation and the beginning of detailed

design. Further Gibson Jr. et al. (2004) find a positive impact between efforts spend on pre-planning and capital project performance, but at the same time point out that pre-planning is a critical process which must be performed on each project, where project manager must find the right approach between design and build-ability, which similarities also are found by Ford et al. (2004). The gap between first plan and the construction plan, is that the first plan often not is fully designed and used for strategic and tactical planning, where uncertainties and risk in the construction process is overlooked and "pushed" between different project stages and partners whit different views of planning (Johansen et al. 2006; Song et al. 2009). Thomas et al. (2007) demonstrate that many small and medium sized contractors have poor focus on pre-planning, yet by simple planning principals they can streamline the construction process by approximately 30 %.

Benefits by pre-planning is studied by Hanna et al. (2010) and Hwang et al. (2012) where proactive project planning has an average profit margin of 23 % compared to reactive project planning with an average profit margin of -3 % and find further reduced risk and budgets between 10 to 15 %, improved quality on 5 to 10 %, which similarities is found by Barker et al. (2004) and Gonzalez et al. (2008). Puddicombe (2006) states that planning has limitations and suggests two levels of plans where the first is a milestone plan, and the second is an on-going plan which follows the construction process, based on the ability to change an on-going process rather than planning appearing to stimulate the project success.

To find if the on-going plan is on the right track Chan et al. (2004) found it possible to benchmark best practice by a Construction Time Performance (CTP) index between different projects, which also Marco et al. (2009) have succeed. The focus on best practice and performance index is further studied by Hastak et al. (2008) who find schedule reducing's of 25 % by using best practice project management, owner commitment, high performance project teams and pre-planning.

Another aspect of pre-planning is the use of buffering to secure the completion time of an activity or project, where Park et al. (2004) and Lee et al. (2006) found positive results by using a dynamic buffer approach, which fits specific project demands and stabilizes the process. Rogalska et al. (2007) found the reverse by concluding that feeding buffers have no influence on the total project time if each activity is continuity assumed.

Several approaches exist to conducting pre-planning where 67 % of the contractors use CPM (Galloway 2006), and particular systems which focus on resources and information between partners before the Critical Path Method (CPM) is found to make a stable process (Chua et al. 2003). The CPM missing focus on resources is studied by Lu et al. (2003) who by Resource Activity Critical Path Method (RACPM) are able to plan with resources, which also can be found by (Yang 2007; Hammad et al. 2010 and Hegazy et al. 2010).

Most optimal planning, like Hoffman et al. 2007; Bruni et al. 2011 and particularly Chen et al. 2012 found an Intelligent Scheduling System (ISS) which is capable of analyzing factors such as schedule, cost, space, manpower, equipment and material to the process, and reduce project time by 7.6 %, which are validated by Hegazy et al. (2011) focus on rework factor in the planning process.

Another approach to CPM is the Monte Carlo simulation and Program Evaluation Review Technique (PERT) where Chou et al. (2009) and Battaza et al. (2011) find that Monte Carlo together with PERT can be used early in pre-planning to secure a stable process and a precise control and risk management in the later construction phase.

Productivity

Macroeconomic studies indicate a decline in labor productivity during 1979 to 1998 in the construction industry, where microeconomic studies indicate the contrary according to Rojas et al. (2003), who find data and methods used for construction productivity calculations at macro level so problematic that the results are unreliable, and cannot indicate increase, decline or a constant productivity development in the period. The finding is further studied by Abdel-Wahab et al. (2011) with a trend productivity analysis which conclude, that productivity has a slowdown in all OECD countries from 1971 to 2005 but at the same time they find the model for calculating construction productivity misleading, by not seeing the construction process in a larger perspective.

To solve the method for calculating construction productivity by direct and indirect factors, Park et al. (2005) develop a Construction Productivity Metrics System (CPMS) which measures at 56 elements in the process, and which is tested with positive comparably results. Crawford et al. (2006) and Bröchner et al. (2012) further improve CPMS by suggesting a review at all project phases with focus on quality, labor, capital and management in calculation of construction productivity. The development of CPMS is further tested by Kim et al. (2011) which by a Productivity Achievement Ratio (PAR) found the productivity model more stable to the construction process.

Looking at which factors affect craft workers' productivity negatively Dai et al. (2007; 2009; 2009) find that construction equipment, materials, tools and consumables, engineering drawing management, direction and coordination, project management, training, craft worker qualification, superintendent competency and foreman competency as most impact by analyzing underlying structure. This is also supported by Enshassi et al. (2007).

The opposite at which factors improving the productivity, indicate Park (2006), Choy et al. (2006) and Mawdesley et al. (2010) that focus on planning, control, risk, whether and safety impact the productivity and reduce disruptions, but too much press on planning by extended overtime and scope project changes reduce the labor productivity, quality, and cutting corners (Hanna et al. 2005; Nepal *et al* 2006 Moselhi et al. 2005; Ibbs et al. 2007).

To improve the construction productivity Rojas et al. (2003) study which opportunities the industry indicate as most important for improvement, where improved methods and training programs, enhance worker motivation, strategic management and procurement management was find as most important to the productivity.

Looking at the labor intensity, Denmark has a significant lower labor input to produce one square meter compared to Germany who uses 7.8 % more, Scotland 20.2 % and England 49.6 %, where the difference between Denmark and compared counties is the extensive prefabrication and use of bathroom pods (Clarke et al. 2004). The improved productivity by use of prefabricated elements is further documented by Goodrum et al. (2009) and Jarkas et al. (2010) who find improved productivity by lower material weight and productivity, and focus on billability and exchange of experience affect labor productivity.

Risk Planning

Two methods have dominated the literature about risk in pre-planning perspective; matrix risk where the approach is orienteered to simple qualitative risk systems, and a quantitative approach where risk is treated by systems such as Critical Path Method (CPM), Program Evaluation Review Technique (PERT) and Monte Carlo simulation.

Which approach is most useful is not possible to tell according to Forbes et al. (2010), where

selection of risk tool is found independently of the project stage and risk appetite of owner, but problems with risk tools are a combination of political, economic, social, technological, legal and environmental factors with incompleteness and randomness.
Construction projects are therefore sensitive to specific project conditions (Han et al. 2004), and it is found that financial difficulties of owner and contractors, contractors´ inadequate experience, and shortages of materials are the main courses of delays in projects (Luu et al. 2009). This is further studied by Nasir et al. (2003) who find that environmental, geotechnical, labor, owner, design, area condition, political, contractor, contractor non-labor resources and material are identified as risk to construction scheduling by a literature review.
To reduce and to manage the risk in a construction project, a business culture within an industrial context, is typically used to manage quality, performance and risk environment (Almeida et al. 2010; Schatteman et al. 2008). Furthermore, it is found that the risk related to human impact and its motivation factors has a larger impact on projects success, with a quantitative approach (Lehtiranta 2011).

DISCUSSION

The findings of this review indicate that cost and schedule increase are found on five continents and have not been reduced in 70 years, where the most significant factor is project scope changes, and the ability to manage such changes is the key factor to project success. Further, it was by the theme innovation found that there are no indications that construction industry is less or more innovative than other industries, but it has a challenge with customer dissatisfaction. To reduce the "firefighting management" in the process, pre-assembly construction was found to reduce cost, and time on design and construction; but also commitment and loyalty from the project organization is found particular important to a stabile process.
Another approach to stabile processes was found to be pre-planning where focus on planning has a positive impact on capital, quality and reduced risk; but difference in planning purpose between partners was found to be a problem. To reduce project duration it was found that factors which reduce productivity are equipment, management and material, and improving factors are planning, control and risk management. Further, it was found that the model for construction productivity calculations is misleading by not seeing the overall process, which was found to be sensitive to specific projects conditions, where the large risk factor is financial difficulties between owner and contractors.

CONCLUSION

This paper found that pre-planning has a linear positive impact on the construction project's chances to meet budget, improve quality and reduce duration and risk in the processes, which have positive effects on stable processes. But at the same time factors such as change of project scope was found devastating for a process, where the project managers' ability to manage such changes affect the success of a project.
The relationship between pre-planning and use of pre-assembly construction has not been found, but advantages of pre-assembled construction were found which stimulate pre-planning, such as reduced cost, time to design, construction, and "firefighting management" linked to scope changes.
Further, it is stated that construction projects are sensitive to specific project conditions where risk is associated to political, economic, socio-cultural, technology, environment and law

aspects, where financial difficulties between owner and contractors is most common.
Another challenge to pre-planning is the gap between the first plan used for strategic and tactical planning and construction planning's focus on process where the different views of planning is "pushed" between project partners.

FURTHER RESEARCH

Findings of the literature review indicate that pre-planning does have a positive impact on the construction process, where several advantages have been identified by the existing literature. Yet, it was by all six themes in the review found that the construction process was extremely dynamic, and involve several stages and project specific conditions which also have impact on the success rate of a project.
Further research on pre-planning must therefore focus on a trend analysis of particular themes such as planning and scheduling, cost and scheduling increase and pre-assembly construction.

ACKNOWLEDGEMENT

The work in this paper has been carried out with scientific debate and process considerations with Ph.D. student Henrik Sørensen, Ph.D. student Søren Munch Lindhard and Ph.D. student Kristian Ditlev Bohnstedt who all have provided new perspectives and ideas to the review.

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