

Outsourcing Engineering Tasks by Construction Firms: State-of-the-Art

Samar Abdel-Rahman^{1*}, Shady Dokhan¹, Karim El-Dash¹

¹ Department of Civil Engineering, Faculty of Engineering at Shoubra Benha University, Egypt.

* Corresponding Author

E-mail: karim.aldosh@feng.bu.edu.eg, shady.ahmed@feng.bu.edu.eg, samarabdelrhman94@gmail.com

Abstract: Engineering tasks performed by construction firms, including design review, preparation of shop drawings, planning and follow-up, cost control, value engineering, and as-built drawings, are essential for completing construction projects. Contractors usually perform these tasks using their resources. However, some contractors outsource engineering activities to specialized engineering or consultant firms. The main objective of this article is to review and summarize outsourcing studies published in different databases. In addition, studies related to engineering tasks by construction firms are reviewed to relate to the most comprehensive research on outsourcing these tasks. The overview process includes a basic definition of outsourcing and the different engineering tasks performed by construction firms. Additionally, this study presents the drivers of outsourcing, risks, and outsourcing decisions. The study highlighted a shortage of existing research on the outsourcing of engineering tasks performed by construction firms. It may serve as a starting point for researchers interested in outsourcing engineering tasks.

Keywords: Outsourcing, Contractors, Risks, Drivers, and Outsourcing Decision Making.

1. INTRODUCTION

By outsourcing, a firm transfers some of the work usually performed by its resources to an external supplier or service provider to perform this work [1]. As outsourcing becomes more and more popular, [2] refers to it as a business strategy that enables a firm to acquire a product or service rather than create itself.

Outsourcing is used in different industries [3], where it is used in IT and banking [4]; maintenance services [5]; purchasing [6]; facility management [7]; human resource management [8], and manufacturing [9].

In addition, outsourcing is a standard procedure in construction projects where the contractor is not able to perform all tasks. For construction firms, outsourcing is an efficient and cost-effective means of utilizing the necessary resources with the increasing size and complexity of construction projects. Construction firms conduct many engineering activities in addition to construction activities on traditional construction projects. These engineering activities may include, but are not limited to design review, preparation of shop drawings, planning and follow-up, cost

control, value engineering, and as-built drawings. Many construction firms prefer to perform these tasks in-house; therefore, they have more control over the process. However, other construction firms outsource engineering tasks to specialist engineering companies.

Moreover, the outsourcing of engineering tasks as a practice may vary among construction firms because each company has its own identity and frequently focuses on a few services or areas of expertise. In addition, a company's scale, location, and cash flow can impact its capacity to perform engineering tasks. In addition, some firms may outsource every engineering task, while others may outsource certain tasks while performing others in-house, or may perform all engineering tasks in-house.

Because of limited research on outsourcing engineering, the strategies used by construction firms to make outsourcing decisions and their reasons are unknown. However, the outsourcing of engineering tasks has been noticed on many outsourcing websites offering and requesting outsourcing, such as Upwork.com, Freelancer.com, Fiverr.com, and

Guru.com. Because of its novelty and challenges, outsourcing engineering tasks should be explored in depth [10]. Hence, the objective of this study is to use a review of previous studies to identify the state of existing knowledge on outsourcing published in various sources. A review of prior studies covers engineering tasks performed by construction firms and the outsourcing of these tasks. The overview process includes the basic definition of outsourcing, the drivers of outsourcing, risks, and outsourcing decisions.

2.METHODOLOGY

A comprehensive survey of previous studies was carried out using books, journals, articles, conference proceedings, dissertations, and the Internet to obtain an essential and clear idea of outsourcing in construction projects, specifically engineering tasks by construction firms. The review covers the definitions, previous research, drivers for outsourcing, and pros and cons of outsourcing.

Accordingly, the data gathering process was conducted through different search engines and databases such as Scopus, Google Scholar, the American Society of Civil Engineers (ASCE), Web of Science (WoS), ELSEVIER, Emerald Insight, Taylor and Francis, Springer, Research Gate, and Academia to provide thorough coverage of scientific journals, many of them are high impact journals. The survey process used the following keywords: outsourcing, construction, engineering tasks, outsourcing benefits, outsourcing risks, outsourcing drivers, and outsourcing decision-making. Since outsourcing is somehow a modern work strategy, the literature covers the years 1990-2023.

3.OUTSOURCING DEFINITION

Outsourcing comes from the American monetary system and represents a combination of words outside and resource (s). Kakabadse and Kakabadse [11] argue that one of the first outsourcing models can be noticed in Antic Rome as the tax collection process was outsourced.

Alexander and Young [12] define outsourcing as an “act of moving some of a firm’s internal activities and decision responsibilities to outside providers.” Outsourcing can also be defined as the acquisition of products or services from external sources outside the organization [13].

Outsourcing refers to the acquisition of services from external service providers to perform tasks [14].

Outsourcing is commonly used in many industries, such as mining, manufacturing, construction, logistics, and IT [15]. In the construction industry, outsourcing occurs in different project phases, where different stakeholders may make outsourcing decisions. For example, employers can

outsource design tasks and construction work to expert designers and construction firms. Construction projects are too complicated and fragmented to be executed by individual contractors, and these contractors may outsource some of their tasks to different types of subcontractors, which is known as subcontracting [16].

Outsourcing differs from subcontracting and is intended to increase profit by focusing on the execution of key tasks for which the construction company possesses the highest level of expertise. This significantly distinguishes subcontract activities and enables the construction company to develop its long-term competitive advantages [17]. Outsourcing refers to executing activities and processes previously executed by in-house resources by an external party [18].

Outsourcing is a management technique in which a company outsources non-core activities to professionals and service providers. Construction companies usually utilize special contractors to execute different types of work or to fit the up-and-down workload. Outsourcing, in general, can be defined from the perspective of medium or long-term relationships, while subcontracting is only for a limited time and certain tasks of the project [19].

Based on the definitions discussed above for outsourcing in construction, there are three definitions:

- Subcontracting is a common form of outsourcing in construction projects [20].
- Outsourcing and subcontracting are synonyms and can be used interchangeably to refer to the activities and tasks conducted by external party [21], [22].
- Outsourcing is used to perform non-core business or activities by external parties; tasks that are outsourced generally are tasks that can be performed by a firm's in-house team. By outsourcing tasks, the company can reserve company time for their core tasks. Accordingly, for construction firms, outsourcing places greater emphasis on the strategic level. In contrast, subcontracting usually refers to the practice of bringing in an outside firm or individual to perform specific parts of a contract or project. Therefore, subcontracting is a tactical option (i.e., using many contractors’ resources to benefit their capabilities) [20],[17].

4.PREVIOUS RESEARCH FOR OUTSOURCING IN CONSTRUCTION

The research was conducted as explained in the methodology section. This section provides a brief overview of the previous research on outsourcing techniques and then identifies key traditional project outsourcing strategies from previous studies.

The research process shows that, in the construction industry, outsourcing exists at different stages of the project life cycle, and different stakeholders can make outsourcing decisions [23]. Project owners can outsource design and construction tasks to expert designers and construction firms. The designers and consultants may outsource some of their tasks [24]. Whereas construction projects are too complicated to be performed by single contractors, they also prefer to outsource some of their tasks to specialized subcontractors, which is called subcontracting [25]. In addition, the contractors may outsource some engineering tasks, for example, BIM modeling [15].

In addition, the research process shows that the limited literature covers the outsourcing of engineering tasks by construction firms. However, there is some research on the

outsourcing of BIM by contractors, for example [15], [26], which is a task from the engineering tasks that will be useful for the research topic and can be generalized somehow due to its similar nature with other engineering tasks.

Due to the limitations of the literature mentioned above, the research extends to cover the research areas identified in the methodology of outsourcing in different fields of construction to enrich the topic and highlight the similarities or differences of outsourcing by construction stakeholders.

TABLE 1 summarizes the reviewed previous outsourcing studies. The table shows the project stakeholder who outsources some of his tasks, the research area: drivers of outsourcing, risks of outsourcing, benefits of outsourcing, etc. In addition, TABLE 1 shows the outsourced tasks.

TABLE 1. Summarizes the outsourcing research by past researchers

	Reference	Stakeholder Outsource	Research Area				Outsourced Task									
			Drivers of outsourcing	Impact of outsourcing	Reasons not to outsource	Outsource decision	Quantity Surveying	Project management	Architect	Structural consultant	MEP consultant	Construction Packages	Shop drawings	BIM modeling	Facility Management	
1	[20]	Client	✓				✓									
2	[27]	Client		✓			✓	✓	✓	✓	✓					
3	[18]	Contractor	✓									✓				
4	[28]	Contractor	✓									✓				
5	[15]	Contractor	✓	✓	✓								✓	✓		
6	[24]	Designer	✓	✓	✓								✓	✓		
7	[29]	Contractor				✓						✓				
8	[17]	Client		✓				✓								
9	[30]	Client				✓										✓
10	[31]	Contractor	✓			✓										
12	[22]	Contractor				✓						✓				
13	[32]	Client		✓			✓	✓	✓	✓						
14	[33]	Consutant			✓				✓							
15	[34]	Client				✓		✓								
16	[35]	Contractor	✓		✓							✓				
17	[26]	Contractor				✓									✓	
18	[36]	Contractor														
19	[37]	Contractor				✓										
20	[38]	Contractor			✓											
21	[39]	Client	✓		✓	✓										✓

5.MOTIVATION FOR OUTSOURCING

By outsourcing, the owner, consultant, or contractor performs the core business activities and outsources their non-core business activities to an external organization to deliver them efficiently [5]. Construction is not the only industry in which activities are outsourced; this trend has been observed in other industries since the 1960s [40]. There are numerous arguments in favor of businesses' decisions to outsource specific jobs and tactics for their success. Traditional outsourcing reasoning is based on economies of scale and scope for immediate financial benefits to the company outsourcing tasks. Small and medium-sized businesses may discover that some jobs can be completed more cheaply and proficiently by outside specialized companies than they can internally [41]. However, even larger businesses prefer to outsource tasks

for strategic reasons when the benefits of economies of scale are less obvious [15].

Nowadays, an increasing number of businesses are attempting to use resources overseas to provide a sufficient workforce for domestic projects due to the growing number of projects and technician shortages in some nations [42]. As a result, outsourcing is becoming a new fashion; it is the future because it achieves sustainable development as a shared model to redistribute resources globally in a more equitable way, in addition to being effective and economical [24].

Through a literature survey, 12 factors were identified as the drivers or motivations for outsourcing decisions. TABLE 2 shows some of the different previous studies and the outsourcing drivers for each study. These factors serve as success criteria and aid in making the best choice of whether to retain the services inside or outsource them.

TABLE 2. Summary of literature review for outsourcing drivers

	References	Convert fixed costs to variable Costs	Lack of experienced employees	Provide high-quality	Cost Reduction	Lack of professionals seeking employment	Increase the speed of implementation	Risk sharing with contractors	Focus on Core business	Technological drivers	The complexity of a task	Environmental drivers	Political drivers
1	[15]	✓	✓	✓	✓	✓							
2	[5]	✓		✓	✓		✓	✓	✓	✓			
3	[43]		✓	✓	✓				✓				
4	[44]	✓											
5	[45]				✓								
6	[46]		✓										
7	[47]	✓		✓	✓			✓			✓	✓	✓
8	[26]	✓	✓	✓	✓	✓			✓				
9	[48]		✓	✓	✓			✓	✓	✓			
10	[41]			✓	✓		✓						
11	[24]	✓	✓		✓								
12	[18]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
13	[20]	✓			✓				✓	✓		✓	✓
14	[49]				✓								
15	[39]				✓				✓				✓
16	[50]	✓		✓	✓				✓				
17	[51]	✓	✓	✓	✓			✓					
18	[52]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
19	[53]	✓	✓	✓	✓		✓		✓	✓			
20	[54]		✓	✓	✓		✓						

TABLE 3. Summary of literature review for outsourcing risks

	References	Loss of managerial control	Availability	Hidden costs	Increased engagement of top management	Dependence on external part reliability	Concerns with flexibility	Changing in needs	Confidentiality	Poor quality	Many Hidden costs	Lack of customer focus	Cultural issues	Loss of loyal employees	Increased Time
1	[15]	✓								✓					
2	[43]	✓	✓	✓					✓						
3	[39]		✓						✓		✓				
4	[35]	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5	[56]	✓	✓		✓	✓	✓	✓	✓	✓			✓	✓	✓
6	[57]	✓	✓			✓	✓	✓	✓	✓			✓		
7	[58]	✓	✓			✓			✓	✓					
8	[5]						✓		✓	✓				✓	
9	[46]		✓			✓			✓						
10	[52]	✓			✓		✓								
11	[20]	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
12	[41]	✓						✓		✓	✓				
13	[47]				✓		✓			✓					

6.RISKS OF OUTSOURCING

Although firms decide to outsource some of their non-core tasks to achieve the advantages of outsourcing, the decision to outsource may have potential risks associated with outsourcing [55]. Despite its numerous benefits, problems are imminent in the outsourcing process. Outsourcing may increase an organization's exposure to legal liability and reduce its control over how outsourced work is completed. Outsourcing may lead to a loss in the performance of the entire business. by outsourcing, related risks such as quality risks, loss of control, and confidentiality should be considered. TABLE 3 summarizes the risks related to outsourcing discussed by previous researchers.

7.OUTSOURCING DECISION MAKING

According to [59], [60] the outsourcing decision, which is also called the make-buy decision, is considered a strategic decision of the company; however, for many decades, the decision was made based on cost factors. Previous studies on outsourcing decisions can be generally divided into two

categories: first, they are based on cost and benefits factors [61], [62], and second, non-financial factors [63]. Different approaches have been developed in previous studies to address outsourcing decision-making problems. Tjader [64] presented an ANP-based outsourcing framework to select the best method for outsourcing tasks. To choose the best legislative options for outsourcing, the framework considers long-term and short-term perspectives and combines factors related to outsourcing decision-making (benefits, opportunities, costs, and risks), alternatives, and stakeholders (decision-makers and influencers).

By introducing a theoretical framework based on transaction cost economics and a resource-based perspective, a study by [65] evaluated the trade-offs involved in outsourcing decisions. This research makes the case that studies are frequently constrained in their ability to explain the justifications for outsourcing, but that these justifications might occasionally be contradictory. Because an organization's competitive priorities are linked to its outsourcing motivations and consequent capabilities, the researcher examines trade-offs in outsourcing manufacturing.

According to a study by [66], a taxonomy of outsourcing decision models can help researchers and practitioners make better judgments by providing an organized evaluation of the outsourcing decision model literature. To ascertain whether they apply to outsourcing decisions, this study also reviews and assesses the current models. A decision model integrating ANP and BSC was proposed by [67] to decide on an organization-level IT outsourcing strategy. Through the proper application of the ANP technique, the interaction effect of the indicators inside and between the BSC perspectives of the BSC-ANP strategic decision framework was thoroughly examined. Gunasekaran [68] conducted an analysis of the literature on performance indicators and outsourcing decisions. The study's main contribution is its taxonomy of pertinent performance metrics and measurements for the manufacturing and service sectors, which considers decisions made before, during, and after outsourcing in scenarios involving offshore, nearshore, and onshore outsourcing. Hahn [69] suggested a multidimensional approach to the outsourcing decision dilemma that integrates strategic and tactile perspectives. This study develops a scenario-based non-parametric ranking approach to address the problem of selecting the most advantageous outsourcing solutions while taking into account numerous financial and non-financial metrics at the strategic level.

In a study similar to this research topic, [26] developed a conceptual model that helps contractors' BIM outsourcing decisions. Through interviews and a questionnaire survey, 15 criteria for BIM outsourcing decisions were compiled based on the Balanced Scorecard (BSC) concept. The Analytic network process (ANP) then deals with how various criteria interact with one another and calculates the relative relevance of each condition. Based on the criteria and associated weights, a conceptual model for BIM decision-making was created and validated by ten contractors. The results showed that the two most crucial views for choosing BIM outsourcing were the customer's perspective and the internal operations perspective. Five factors, including "Customer satisfaction," "Core focus," "Timely BIM delivery," "Availability of BIM service," and "Flexibility to the needs of the market," were more important from both the standpoints of the customer and internal operations.

8. OUTSOURCING OF ENGINEERING TASKS BY CONSTRUCTION FIRMS

8.1 Engineering tasks

The main typical activities of construction firms are operations, engineering, and administration activities besides the activities of legal, human resources, business development, and others. The operations activities include

the actual construction work being performed on the site. The engineering activities include preparing the cost estimate, design review, design of temporary structures, preparing shop drawings, scheduling, and cost control [70]. Recently building information modeling BIM with different functions is included in the engineering activities performed by construction firms [15].

8.1.1 Shop Drawings

Shop drawings are drawings developed by contractors that contain the required details based on the design drawings, and are then reviewed and approved by the engineer for the execution of the work on site. They are prepared based on the design drawings and specifications submitted by the project designer [71]. Varma [72] highlighted the technical importance of Shop Drawings in the construction process, in addition, Shop drawings can make design concepts of the architect/engineer's project drawings more detailed, to be suitable for actual construction, and any errors in these drawings may lead to many risks during and after construction.

8.1.2 Quantity Takeoff

Quantity takeoff is an important engineering task in the construction industry because many other tasks are based on, where the project components are surveyed, and these quantities are used later to develop cost estimations and related resources. Quantity takeoff can be calculated from project drawings or measured from on-site work. Quantity takeoff data are listed in a document called a Bill of Quantities [73]. Quantity takeoff can be conducted several times during the different phases of the project. In the planning stage, the quantity takeoff is used as a base for the conceptual cost estimate; in the tendering stages, it is used to develop detailed cost estimation by the contractors, and the detailed schedule; and during the construction stages, it is used to calculate actual quantities for invoicing and cost control purposes [74].

8.1.3 Planning and Follow-up

Planning and scheduling are phrases that are occasionally synonymous. However, they're different. Scheduling is part of the planning process. Project planning can be defined as the process of determining the method and sequence of work to be used in the execution of a project considering all the alternative ways and sequences that could be used [16]. Scheduling is the determination of the timing and logic of activities in the project and their aggregate to define the project completion time. Contractors need project scheduling to: determine the project's total duration, determine early and late dates for each activity, coordinate between different trades and subcontractors, resolve conflicts, expect and analyze the cash flow, enhance work

efficiency, work as project control, valuation the impact of variation, and analysis of the extension of time claims. The contractor may develop different types of schedules in different stages of the project, like master schedules, detailed schedules, and others.

The Follow-up process started after the commencement of the project and included monitoring the activities and schedule updating. Schedule updating is adding actual project information including the actual start date for activities, the actual finish date for activities, the percentage of work completed for activities, and any changes to the remaining work [17]. Popescu and Charoenngam [18] defined an updated schedule as a version of the schedule that shows the project status at a certain date for completed activities, in-progress activities, and changes in the sequence. Construction schedules may be updated monthly, or weekly, the update period depends on the duration of the project and the required span of control.

8.1.4 Cost Management

Cost management is the procedure where the costs and expenses that are consumed on the project are estimated, budgeted, and invoiced [19]. Hanid [20] defines cost management as a set of tools and functions used for controlling and enhancing a firm's activities and operations, products, and services to realize cost efficiencies (reduce cost and value creation) through the collection, analysis, evaluation, and reporting of costs information on budgeting, estimating, forecasting, and monitoring costs to aid in decision making. According to [21], the practice/system of cost management consists of a set of principles, methods, and tools whose primary goal is to calculate costs and generate information to support various management decisions at different stages of a project.

The cost management processes include three processes namely; (1) Estimate cost: a rough description of the financial resources required to complete the project activities. (2) Define the budget: The process of calculating costs for individual activities and the aggregate of these costs. (3) Control cost: The process of monitoring the project, including organizing, executing, and analyzing project budgets [16].

The cost estimate is the process of collecting and analyzing historical data and applying quantitative models, methods, tools, and databases to predict future cost estimates for a project, product, program, or task. A cost estimate is an application of art and technology to estimate the possible value (or cost), size, or nature of something based on the information available at the time [22].

Postula [23] refers to cost monitoring as cost accounting and is defined as the historical reporting of expenditures, costs, and disbursements for a project. Along with the latest

work estimates, cost monitoring and accounting help accurately reflect the project's status. Cost control points to the direction of changes in preplanned values compared to actual performance to avoid unacceptable deviations. Cost control includes monitoring costs and recording data, then analyzing it to take reasonable actions at a suitable time. Once the project starts, management will be the main task of the contractor as the profits of the contractor depend heavily on the effectiveness of the cost monitoring and control system.

8.1.5 Design Review

Design reviews are essential to the successful execution of a construction project. They eliminate the costs of rework and clashes [24]. In Construction projects, the contractor's obligations are to design (if requested), construct, and finalize the works in the contractual time or any approved extension of time. However, if the design is prepared by the client many contract forms and laws do not exempt the contractor from mistakes in designs and the contractor would be responsible for any errors in the design even if it was prepared by the others. English law obligates the contractor to alert the client about the design errors which the contractor discovers. FIDIC conditions obligate the contractor to warn the engineer and the employer of any fault, errors, missing, or other deficiency in the design or specifications for the project that he may notice during the reviewing of the project's document in the construction phase.

In Egypt and different Arab countries, the contractor is subject to extra-legal responsibility referred to as decennial liability. The application decennial liability is a public strategy obligation, this obligation would be binding for parties even if it was not written in the contract.

According to civil law the contractor's duty to based on the ideology of the good-faith to warn the employer about any defects in the design. Accordingly, the contractor would be responsible for such an obligation even if it is not stated in the conditions of the contract. The contractor's duties are not only to warn the employer but also to review the design. Accordingly, as discussed above the design review by construction firms is one of the engineering tasks which is very important in some cases and mandatory in others.

8.1.6 As-Built Drawings

Contractors may develop "as-built drawings" that illustrate the project as it has been executed and as it is commonly submitted by contractors at the handing-over stage, the as-built could be part of the project's contract documents [25]. As-built drawings also may be called "record drawings" and "red-line drawings", As-built drawings are drawings that compare project design against the final constructed project and provide a detailed blueprint of the project as

constructed at the end of the project. Business Dictionary defined as-builts drawings as a revised set of drawings submitted by a contractor at the end of a construction project. They consist of all variations made to the construction's requirements and design drawings. [26]. Complete and accurate as-built drawings are more than documents developed when a construction project is completed. They are key tools that provide essential information needed in the operation and maintenance stages [27].

8.1.7 Building Information Modeling (BIM)

BIM is utilized by construction stakeholders that model a construction project in a multi-dimensional digital model and provides several benefits from project inception to its operation [15]. The benefits generated by BIM execution can be associated with the numerous functions provided to help designers, contractors, owners, and other project stakeholders. Accordingly, many project clients public and private are requiring BIM implementation on their projects. BIM can be implemented in many ways, but it is essentially

a software process used by designers, and contractors in construction projects. BIM modeling is an integrated process from which designers and contractors can benefit in various ways. Ku [78] identified seventeen different functions that contractors could use, such as visualization, constructability, and others.

In the context of construction firms, BIM functions may integrate construction elements into building objects in a virtual structure for the compilation of all project information, including three-dimensional modeling, scheduling, resource allocation, estimating, code analysis, clash detection, and lifecycle management [79].

8.2 Time Frame for Engineering Tasks

TABLE 4 shows the time frame for engineering tasks performed by the construction firms, these tasks started in the tendering phase where the relation of the construction firms started with the project and ended in the closeout phase.

TABLE 4: Time Frame for Engineering Tasks Performed by the Construction Firms

	Engineering Task	Construction Phase		
		Tendering Phase	Construction Phase	Closeout Phase
1	Quantity takeoff	✓	✓	✓
2	Cost Management			
2-1	Cost Estimation	✓		
2-2	Cost Control		✓	
2-3	Cost Claims		✓	✓
3	Scheduling			
3-1	Master Schedule	✓		
3-2	Detailed Baseline Schedule		✓	
3-3	Follow up and update the time schedule.		✓	✓
3-4	Extension of time claims		✓	✓
4	Design review		✓	
5	Shop drawings		✓	
6	BIM Modeling		✓	
7	As-Built Drawings			✓

8.3 Reasons for Outsourcing Engineering Tasks

The reasons for outsourcing engineering tasks may vary from one company to another and the company size may affect the decision to outsource. Small and medium size companies with limited technical resources, may prefer to outsource engineering tasks. However, large companies also due to workload may utilize the outsourcing of engineering tasks. The reasons for outsourcing the engineering tasks may vary due to the task itself, for example, the design review task is a specialized task that requires a professional designer which rarely exists in construction firms. Hence the reason for outsourcing is the complexity of the task. However, the shop drawings may be outsourced due to the huge number of drawings required in

a limited time as the construction activities waited till the submission and approval of the shop drawings, hence the reason for the outsourcing is to speed the process of the shop drawings. Figure 1 shows the different reasons for outsourcing engineering tasks.

8.4 Risks of Outsourcing Engineering Tasks

Outsourcing engineering tasks by construction firms can be associated with several risks such as losing control over part of the business or becoming reliant on an external supplier [35]. The risk of outsourcing engineering tasks may have some changes due to the nature of the task. Outsourcing cost management by construction firms can offer several benefits, but there are also potential risks that

should be considered [75], Figure 2 shows the different risks related to outsourcing engineering tasks.

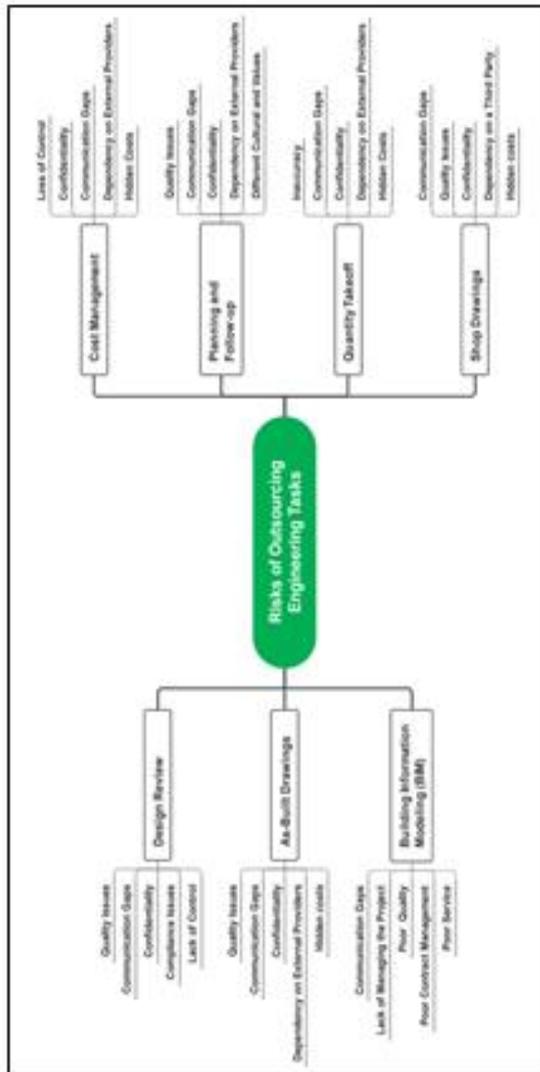


Fig 1. Reasons for outsourcing engineering tasks

8.4 Risks of Outsourcing Engineering Tasks

Outsourcing engineering tasks by construction firms can be associated with several risks such as losing control over part of the business or becoming reliant on an external supplier [35]. The risk of outsourcing engineering tasks may have some changes due to the nature of the task. Outsourcing cost management by construction firms can offer several benefits, but there are also potential risks that should be considered [75], Figure 2 shows the different risks related to outsourcing engineering tasks.

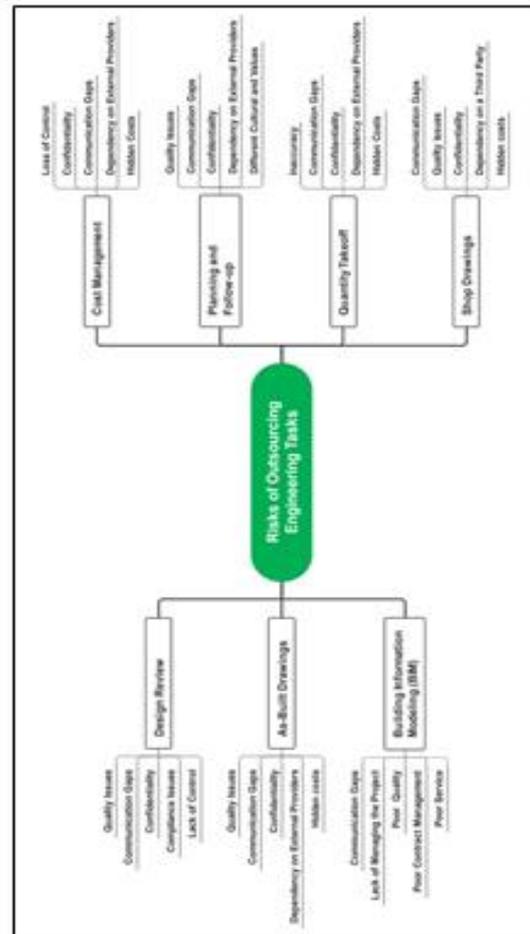


Fig 2. Reasons for outsourcing engineering tasks

9. CONCLUSION

Based on a systematic literature review, this study presents an overview of engineering tasks performed by construction firms. Further, this study explores the definitions of outsourcing drivers, risks, and decision-making. The reasons for outsourcing engineering tasks include access to advanced technology, improved quality, reduced costs, time savings, and expertise. The risks of outsourcing engineering tasks were identified as confidentiality, hidden costs, quality issues, loss of control, and dependence on external parties. The study highlighted that there are a very limited number of studies that cover this topic and how to make outsourcing decisions. However, there are some surveys about the general concept and the impact of applying it within construction firms. Despite the observation of engineering tasks being outsourced, limited attention has been paid to this area. Therefore, future studies are needed to identify engineering task outsourcing patterns among construction firms. In addition, identifying the drivers for outsourcing, the impact of outsourcing, outsourcing practices, engineering tasks commonly implemented by construction firms, and the tasks often outsourced would be analyzed to examine possible relationships and the

obstacles of the process of outsourcing that can provide outsourcing practitioners with additional knowledge. Additionally, developing a decision-making tool to assist contractors' outsourcing decisions is potential research on this topic.

REFERENCES

- [1] X. Rao and M. Dai, "In-Sourcing or Outsourcing: An Economic Analysis on Internal and External Alternatives for Enterprise R&D," *American Journal of Industrial and Business Management*, vol. 06, no. 06, pp. 794–804, 2016, doi: 10.4236/ajibm.2016.66073.
- [2] S. Jimmy Gandhi, A. Gorod, and B. Sauser, "Prioritization of outsourcing risks from a systemic perspective," *Strategic Outsourcing: An International Journal*, vol. 5, no. 1, pp. 39–71, 2012.
- [3] M. A. Sandhu, A. Shamsuzzoha, and P. Helo, "Does outsourcing always work? A critical evaluation for project business success," *Benchmarking: An International Journal*, vol. 25, no. 7, pp. 2198–2215, 2018.
- [4] R. K. Jain and R. Natarajan, "Factors influencing the outsourcing decisions: a study of the banking sector in India," *Strategic Outsourcing: An International Journal*, vol. 4, no. 3, pp. 294–322, 2011.
- [5] S. Assaf, M. A. Hassanain, A. Al-Hammad, and A. Al-Nehmi, "Factors affecting outsourcing decisions of maintenance services in Saudi Arabian universities," *Property management*, vol. 29, no. 2, pp. 195–212, 2011.
- [6] K. Ruamsook, D. M. Russell, and E. A. Thomchick, "Sourcing from low-cost countries: Identifying sourcing issues and prioritizing impacts on logistics performance," *The International Journal of Logistics Management*, vol. 20, no. 1, pp. 79–96, 2009.
- [7] B. Perera, M. H. S. Ahamed, R. Rameezdeen, N. Chileshe, and M. R. Hosseini, "Provision of facilities management services in Sri Lankan commercial organisations: is in-house involvement necessary?," *Facilities*, vol. 34, no. 7/8, pp. 394–412, 2016.
- [8] H. Abdul-Halim and N. Che-Ha, "HR outsourcing among Malaysian manufacturing companies," *Business Strategy Series*, vol. 11, no. 6, pp. 363–370, 2010.
- [9] H. Schiele, P. Horn, and B. Vos, "Estimating cost-saving potential from international sourcing and other sourcing levers: Relative importance and trade-offs," *International Journal of Physical Distribution & Logistics Management*, vol. 41, no. 3, pp. 315–336, 2011.
- [10] E. Badu and P. Amoah, "Quantity surveying education in Ghana," *The Ghana Engineer*, pp. 1–12, 2004.
- [11] A. Kakabadse and N. Kakabadse, "Trends in Outsourcing: Contrasting USA and Europe," 2002.
- [12] M. Alexander and D. Young, "Strategic Outsourcing," 1996.
- [13] W. M. Lankford and F. Parsa, "Outsourcing: a primer."
- [14] V. Grover, M. J. Cheon, and J. T. C. Teng, "A descriptive study on the outsourcing of information systems functions," *Information & Management*, vol. 27, no. 1, pp. 33–44, Jul. 1994, doi: 10.1016/0378-7206(94)90100-7.
- [15] J. Fountain and S. Langar, "Building Information Modeling (BIM) outsourcing among general contractors," *Autom Constr*, vol. 95, pp. 107–117, Nov. 2018, doi: 10.1016/j.autcon.2018.06.009.
- [16] J. Tarzijań and F. Brahm, "Subcontracting in project-based firms: Do you follow the same pattern across your different projects?," *International Journal of Project Management*, vol. 32, no. 6, pp. 995–1006, Aug. 2014, doi: 10.1016/J.IJPROMAN.2013.12.001.
- [17] I. Chernysh, A. Glebova, and O. Maksymenko, "Business Processes Outsourcing in Building Enterprises," 2018. [Online]. Available: www.sciencepubco.com/index.php/IJET
- [18] D. Ma, Y. Chen, Y. Fu, and C. Meng, "Influencing factors of outsourcing in construction projects: a holistic perspective," *International Journal of Managing Projects in Business*, vol. 15, no. 2, 2022, doi: 10.1108/IJMPB-04-2021-0107.
- [19] J. J. Venter, "The relevance of outsourcing in construction project management companies: A literature study," *A Study Project Presented to the Graduate School of Business of the University of Stellenbosch in Partial Fulfillment of the Requirements for the Degree of Master of Business Administration*, 2000.
- [20] N. Ranasinghe, B. A. K. S. Perera, and R. Dilakshan, "Drivers of decisions behind outsourcing of quantity surveying services in construction projects," *International Journal of Construction Management*, vol. 22, no. 2, pp. 292–304, 2022, doi: 10.1080/15623599.2019.1622199.
- [21] A. Elazouini, Y. Gajpal, and A. Fares, "Negotiating win-win payment terms between construction contractors and subcontractors," *Autom Constr*, vol. 146, p. 104676, Feb. 2023, doi: 10.1016/J.AUTCON.2022.104676.
- [22] H. A. El-khalek, R. F. Aziz, and E. S. Morgan, "Identification of construction subcontractor prequalification evaluation criteria and their impact on project success," *Alexandria Engineering Journal*, vol. 58, no. 1, pp. 217–223, Mar. 2019, doi: 10.1016/j.aej.2018.11.010.
- [23] A. Mahmoudi and S. A. Javed, "Performance Evaluation of Construction Sub-contractors using Ordinal Priority Approach," *Eval Program Plann*, vol. 91, p. 102022, 2022.
- [24] Y. Jwe, "BIM Outsourcing: Opportunities and Challenges for Construction Design and Management in Cross Country Collaboration," 2020.
- [25] H. A. El-khalek, R. F. Aziz, and E. S. Morgan, "Identification of construction subcontractor prequalification evaluation criteria and their impact on project success," *Alexandria Engineering Journal*, vol. 58, no. 1, pp. 217–223, 2019.
- [26] G. Chen, Z. Yan, J. Chen, and Q. Li, "Building information modeling (BIM) outsourcing decisions of contractors in the construction industry: Constructing and validating a conceptual model," *Developments in the Built Environment*, vol. 12, Dec. 2022, doi: 10.1016/j.dibe.2022.100090.
- [27] G. I. Idoro, "Influence of in-sourcing and outsourcing of consultants on construction project performance in Nigeria," *Australasian Journal of Construction Economics and Building*, vol. 11, no. 4, 2011, doi: 10.5130/ajceb.v11i4.2271.
- [28] J. Lai, Y. Fu, Y. Chen, and B. Du, "Interactions among antecedents of project outsourcing strategies: evidence from Chinese construction firms," *Engineering, Construction and Architectural Management*, 2022, doi: 10.1108/ECAM-01-2022-0047.
- [29] S. S. Ortiz, "Guidelines for construction companies to decide between outsourcing and self-performing for prefabricated components," *Purdue University*, 2014.
- [30] M. H. S. Ahamed, B. Perera, and I. Illankoon, "In-house versus outsourcing Facilities management: A framework for value-added selection in Sri Lankan commercial buildings," 2013.
- [31] M. Akbari, S. J. Clarke, and S. Maleki Far, "Outsourcing Best Practice - The Case of Large Construction Firms in Iran," in *Proceedings of the 2017 InSITE Conference*, 2017, doi: 10.28945/3737.

- [32] B. O. Awuzie, Z. P. Mcwari, P. S. Chigangacha, C. O. Aigbavboa, T. C. Haupt, and L. Obi, "Analysing outsourced and insourced public infrastructure projects' performance in a provincial department of public works: a grounded theory approach," *Journal of Engineering, Design and Technology*, 2022, doi: 10.1108/JEDT-11-2021-0640.
- [33] M. I. Mulder and J. L. Heintz, "Offshore outsourcing—Now available for architects," in *Proceedings of the 2nd International Conference World of Construction Project Management*, 2007.
- [34] T. Holopainen, "Feasibility of In-house vs. Outsourced Project Management in Public Facility Implementation," 2022.
- [35] I. C. Osuizugbo, A. Lahanmi, O. Oyeyipo, and A. Morakinyo, "Construction Firms' Satisfaction on Outsourced Services at Construction Phase of Building," *Journal of Economics, Management and Trade*, 2020, doi: 10.9734/jemt/2019/v25i630212.
- [36] C. K. Tembo, F. Muleya, and A. Kanyemba, "An appraisal of cost management techniques used in the construction industry," *International Journal of Construction Management*, 2022, doi: 10.1080/15623599.2022.2132355.
- [37] S. Perera, X. Jin, M. Samaratunga, and K. G. Thalagala Achchi Maddumage, "Construct NSW: Digitalisation of Construction Industry: Industry Report on Digitalisation of Design and Construction of Class 2 Buildings in New South Wales," 2021.
- [38] E. J. Pater, "Outsourcing Design Verifications Tasks to Subcontractors in the Dutch Civil Engineering Industry MSc Thesis Project-Scientific Paper Outsourcing Design Verifications Tasks to Subcontractors in the Dutch Civil Engineering Industry Outsourcing Design Verification Tasks to Subcontractors in the Dutch Civil Engineering Industry," 2018.
- [39] M. K. Kurdi, A. H. Abdul-Tharim, N. Jaffar, M. S. Azli, M. N. Shuib, and A. M. Ab-Wahid, "Outsourcing in facilities management - A literature review," in *Procedia Engineering*, 2011, pp. 445–457. doi: 10.1016/j.proeng.2011.11.187.
- [40] K. McLellan and B. Marcolin, "Information technology outsourcing," *Business quarterly*, vol. 59, no. 1, pp. 95–99, 1994.
- [41] F. H. Rohde, "IS/IT outsourcing practices of small-and medium-sized manufacturers," *International Journal of Accounting Information Systems*, vol. 5, no. 4, pp. 429–451, 2004.
- [42] Y. Li, S. Al-Haddad, T. R. B. Taylor, P. M. Goodrum, and R. E. Sturgill, "Impact of utilizing construction engineering and inspection consultants on highway construction project cost and schedule performance," *Transp Res Rec*, vol. 2673, no. 11, pp. 716–725, 2019.
- [43] T. R. Stacey Steffen OKH & Barrett AJ, "Outsourcing of professional services," *J South Afr Inst Min Metall*, vol. 99, no. 4, pp. 181–184, 1999.
- [44] Y. Liu and R. K. Tyagi, "Outsourcing to convert fixed costs into variable costs: A competitive analysis," *International Journal of Research in Marketing*, vol. 34, no. 1, pp. 252–264, 2017.
- [45] S. Cohen and J. Roussel, *Strategic supply chain management: the five disciplines for top performance*. McGraw-Hill Education, 2013.
- [46] M. W. Hansen, H. Schaumburg-Müller, and E. Pottenger, "Towards a developing country firm perspective on outsourcing," *Strategic Outsourcing: An International Journal*, vol. 1, no. 3, pp. 210–229, 2008.
- [47] T. Kremic, O. Icmeli Tukel, and W. O. Rom, "Outsourcing decision support: a survey of benefits, risks, and decision factors," *Supply Chain Management: an international journal*, vol. 11, no. 6, pp. 467–482, 2006.
- [48] J. B. Quinn, "Strategic outsourcing: leveraging knowledge capabilities," *MIT Sloan Manag Rev*, vol. 40, no. 4, p. 9, 1999.
- [49] J. I. Messner, "Offshoring of engineering services in the construction industry," *The Offshoring of Engineering: Facts, Unknowns, and Potential Implications*, pp. 137–148, 2008.
- [50] C. Fill and E. Visser, "The outsourcing dilemma: a composite approach to the make or buy decision." [Online]. Available: <http://www.emerald-library.com>
- [51] S. A. Adelese and F. O. Abulude, "Perception of some professionals in Ondo State, Nigeria on the impact of outsourcing in construction projects," *Continental J. Applied Sciences Adelese and Abulude (2020)*, vol. 15, no. 2, pp. 25–44, 2020.
- [52] J. J. Venter, "The relevance of outsourcing in construction project management companies: A literature study," *A Study Project Presented to the Graduate School of Business of the University of Stellenbosch in Partial Fulfillment of the Requirements for the Degree of Master of Business Administration*, 2000.
- [53] B. Ghodeswar and J. Vaidyanathan, "Business process outsourcing: an approach to gain access to world-class capabilities," *Business process management journal*, vol. 14, no. 1, pp. 23–38, 2008.
- [54] M. I. Mulder and J. L. Heintz, "Offshore outsourcing—Now available for architects," in *Proceedings of the 2nd International Conference World of Construction Project Management*, 2007.
- [55] D. F. Blumberg, "Strategic assessment of outsourcing and downsizing in the service market," *Managing Service Quality: An International Journal*, vol. 8, no. 1, 1998, doi: 10.1108/09604529810199340.
- [56] L. M. Abdullah and J. M. Verner, "Analysis and application of an outsourcing risk framework," *Journal of Systems and Software*, vol. 85, no. 8, pp. 1930–1952, 2012, doi: 10.1016/j.jss.2012.02.040.
- [57] A. Mahmoudi, M. Abbasi, X. Deng, M. Ikram, and S. Yeganeh, "A novel model for risk management of outsourced construction projects using decision-making methods: a case study," *Grey Systems*, vol. 10, no. 2, pp. 97–123, May 2020, doi: 10.1108/GS-09-2019-0038.
- [58] R. Aron, E. K. Clemons, and S. Reddi, "Just right outsourcing: Understanding and managing risk," *Journal of management information systems*, vol. 22, no. 2, pp. 37–55, 2005.
- [59] L. E. Cáneez, K. W. Platts, and D. R. Probert, "Developing a framework for make-or-buy decisions," *International Journal of Operations & Production Management*, vol. 20, no. 11, pp. 1313–1330, 2000.
- [60] R. T. McIvor, P. K. Humphreys, and W. E. McAleer, "A strategic model for the formulation of an effective make or buy decision," *Management Decision*, vol. 35, no. 2, pp. 169–178, 1997.
- [61] R. H. Coase, "The Nature of the Firm," *Economica*, vol. 4, no. 16, 1937, doi: 10.2307/2626876.
- [62] H. A. Juris, "The economics of collective action.," *National Forum on Hospital and Health Affairs*, 1976, doi: 10.4324/9780203007907-10.
- [63] W. Ford and H. Porter, "Deciding whether to make or buy," *Library of factory management and suppliers*, vol. 3, pp. 45–52, 1915.
- [64] Y. C. Tjader, J. S. Shang, and L. G. Vargas, "Offshore outsourcing decision making: A policy-maker's perspective," *Eur J Oper Res*, vol. 207, no. 1, 2010, doi: 10.1016/j.ejor.2010.03.042.
- [65] M. Dabhilkar, "Trade-offs in make-buy decisions," *Journal of Purchasing and Supply Management*, vol. 17, no. 3, pp. 158–166, Sep. 2011, doi: 10.1016/j.pursup.2011.04.002.
- [66] P. Westphal and A. S. Sohal, "Taxonomy of outsourcing decision models," *Production Planning & Control*, vol. 24, no. 4–5, pp. 347–358, Apr. 2013, doi: 10.1080/09537287.2011.648486.
- [67] Y. Tjader, J. H. May, J. Shang, L. G. Vargas, and N. Gao, "Firm-level outsourcing decision making: A balanced scorecard-based analytic network process model," *Int J Prod Econ*, vol. 147, no. PART C, pp. 614–623, Jan. 2014, doi: 10.1016/J.IJPE.2013.04.017.
- [68] A. Gunasekaran, Z. Irani, K. L. Choy, L. Filippi, and T. Papadopoulos, "Performance measures and metrics in outsourcing decisions: A review for research and applications," *International Journal of Production Economics*, vol. 161, 2015. doi: 10.1016/j.ijpe.2014.12.021.
- [69] G. J. Hahn, T. Sens, C. Decouttere, and N. Vandaele, "A multi-criteria approach to robust outsourcing decision-making in stochastic manufacturing systems," 2014.

- [70] G. J. Carty, "Construction," *J Constr Eng Manag*, vol. 121, no. 3, pp. 319–328, 1995.
- [71] M. Kamal, S. Dokhan, and K. El-Dash, "Assessing the Impact of Delay of Shop Drawing Process in Construction Projects," 2022.
- [72] V. Varma, "Advances in the Production of Shop Drawings and Their Impact on Constructability," in *Annual Conference & Exposition*, 2008.
- [73] A. Monteiro and J. Poças Martins, "A survey on modeling guidelines for quantity takeoff-oriented BIM-based design," *Autom Constr*, vol. 35, pp. 238–253, 2013, doi: 10.1016/j.autcon.2013.05.005.
- [74] T. E. Farah, "Review of Current Estimating Capabilities of the 3d Building Information Model Software to Support Design for Production/Construction Repository Citation," 2005. [Online]. Available: <https://digitalcommons.wpi.edu/etd-theses>
- [75] F. Lu, T. Yan, H. Bi, M. Feng, S. Wang, and M. Huang, "A bilevel whale optimization algorithm for risk management scheduling of information technology projects considering outsourcing," *Knowl Based Syst*, vol. 235, p. 107600, 2022, doi: <https://doi.org/10.1016/j.knsys.2021.107600>.
- [76] P. T. Bryant, "Decline of the engineering class: Effects of global outsourcing of engineering services," *Leadership and Management in Engineering*, vol. 6, no. 2, pp. 59–71, 2006.
- [77] W. Song, Y. Zhu, S. Li, L. Wang, and H. Zhang, "Risk evaluation of information technology outsourcing project: An integrated approach considering risk interactions and hierarchies," *Eng Appl Artif Intell*, vol. 113, p. 104938, 2022, doi: <https://doi.org/10.1016/j.engappai.2022.104938>.
- [78] K. Ku and M. Taiebat, "BIM experiences and expectations: The constructors' perspective," *Int J Constr Educ Res*, vol. 7, no. 3, pp. 175–197, Jul. 2011, doi: 10.1080/15578771.2010.544155.
- [79] V. Bazjanac, "Virtual building environments (VBE) – applying information modeling to buildings," in *eWork and eBusiness in Architecture, Engineering and Construction*, 2004. doi: 10.1201/9780203023426.ch7.