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Trends of Outsourcing Engineering Tasks by Construction Firms in Egypt

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Abstract: The primary tasks of construction firms are construction, engineering, administration, legal, human resources, business development, and public relations tasks. Engineering tasks may include design review, preparation of shop drawings, planning and follow-up, cost control, value engineering, and as-built drawings. However, engineering tasks are essential for construction projects; they are challenging because they are time-consuming and require high knowledge and skills. Because of these challenges, some construction firms outsource engineering tasks to specialized engineering firms. Since limited literature currently exists for engineering tasks outsourcing, this study aims to identify engineering tasks outsourcing among construction firms in Egypt in terms of which tasks, reasons for the outsourcing, and related risks. The research conducted a questionnaire survey among construction firms to achieve the study objectives. The results conclude that 77% of the responding firms have outsourced one or more engineering tasks, which shows that outsourcing has become an important strategy for conducting engineering tasks. Data on firm demographics, types of engineering tasks outsourced, reasons for outsourcing, and other aspects related to outsourcing engineering tasks were also collected. The results show that construction firms perceive engineering outsourcing as more efficient than in-house engineering task implementation, especially in terms of high quality and timely implementation. However, outsourcing has a negative impact in terms of cost. In addition, the results show that shop drawings are the most outsourced engineering task with about 75%, while cost management is the least outsourced engineering task with only 8%.

Keywords: Outsourcing, Risks, Reasons, Construction Firms in Egypt.

1. Introduction

The construction industry is a complicated, risky industry that constantly changes from the commencement of a project to its completion, where several parties are engaged in an enormous range of processes with several inputs and multiple phases [1]. Construction firms are essential stakeholders and are responsible for constructing the project and achieving its requirements. To achieve such requirements, perform different tasks including construction, engineering, administration, legal, human resources, business development, and public relations tasks. The engineering tasks may include design review, preparation of shop drawings, planning and follow-up, cost control, value engineering, and as-built drawings. Construction projects are complicated projects to be executed by individual contractors, so many construction firms prefer to execute some of their tasks by specialized subcontractors, which is known as subcontracting [2]. For the engineering tasks performed during the project, construction firms may outsource engineering tasks to external parties, for example, BIM modeling [3].

Outsourcing refers to transferring some of the work usually executed by a firm's resources to external parties or firms to execute this work [4]. [5] refer to outsourcing as a business strategy that enables a firm to acquire a service from others instead of performing it.

Outsourcing is a business strategy used in different industries, whereas it is used in human resource management [6], IT and banking [7], purchasing [8], facility management [9], manufacturing [10], and maintenance services [11].

Outsourcing is a common practice in construction projects because of the contractor's inability to perform the specialist activities in a project. Due to the increasing size and complexity of construction projects, outsourcing by construction firms may be an effective method for using the necessary resources owned by the external party.

Outsourcing of engineering tasks is observed in the practical fields and on many websites offering and requesting outsourcing, such as Upwork.com, Freelancer.com, Fiverr.com, and Guru.com. However, the strategies used by construction firms to decide on outsourcing and their purposes are not identified. However, the trends of outsourcing engineering tasks by construction firms are not defined, and the reasons, risks, and ways in which the decision to outsource is made are also not defined.

Because of the gaps in the available literature on outsourcing engineering tasks, the objective of this research was to determine outsourcing trends among construction firms in Egypt and understand the significant role that outsourcing plays in construction projects. This study also identified the reasons for outsourcing, the perceived value

generated by outsourcing, and which engineering tasks were outsourced. Data on company demographics, outsourcing practices, and engineering tasks commonly implemented by construction firms and the tasks often outsourced were analyzed to examine possible relationships.

2. LITERATURE REVIEW

2.1 Engineering Tasks Performed by Construction Firms

The main tasks of construction firms are construction, engineering, and administration tasks in addition to legal, human resources, business development, and public relations. Construction activities include actual construction work being executed on the site. Engineering tasks include preparing the cost estimate, design review, design of temporary structures, preparation of shop drawings, scheduling, and cost control [12]. Recently, building information modeling BIM with different functions has become an engineering task performed by construction firms [3]. The below section explores the engineering tasks performed by construction firms.

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 [13].

Quantity takeoff is an essential task during the life cycle of a construction project because many other tasks in the project depend on surveying the project components and using those quantities subsequently to produce cost estimates and determine related resources. Project drawings can be used to compute quantity takeoff or on-site work can be used to measure it [14].

Planning and scheduling are different terms that may be used as synonymous. The process of deciding the technique and sequence of work to be employed in completing a project while taking into account all possible ways and sequences of tasks is known as project planning [15].

Construction cost management can be defined as a set of techniques and methods for controlling and improving a company's activities and processes, products, and services to achieve cost efficiencies (cost reduction, value creation, and substitution) through the collection, analysis, evaluation, and reporting of costs information on budgeting, estimating, forecasting and monitoring costs to support decision making [16]

Design reviews are essential engineering tasks in construction projects, they avoid the costs of rework and minimize clashes [17]. The design review by contractors is an essential engineering task that is very important in some cases and mandatory in others.

Construction firms may develop “as-built drawings” that show the project as it has been executed, these types of drawings are usually prepared by contractors at the handing-over stage, and the as-built drawings may be a contractual obligation [18].

BIM modeling is an integrated process from which designers and contractors can benefit in various ways. Ku [19] identified seventeen different functions contractors could use, such as visualization, constructability, and others. 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 [3].

2.2 Outsourcing

In construction projects, outsourcing exists in different project stages, and different stakeholders can make outsourcing decisions. Clients can outsource design to expert design firms, construction work to contractors, and facility management to specialized firms. Construction projects are complex and fragmented to be performed by single contractors, so general contractors usually outsource construction work to subcontractors [20].

There are many reasons for the decision to outsource specific tasks for their success. Traditional outsourcing reasoning is to reduce the costs based on economies of scale and financial benefits to the firm outsourcing tasks. Small and medium-sized firms may conduct some tasks with less cost and high quality by external specialized companies than conduct these tasks with in-house resources [21]. However, large firms may outsource some tasks for different reasons when the benefits of economies of scale are not the main reason [3].

Fountain and Langar [3] identified the reasons for outsourcing BIM modeling as the ability to use BIM services when needed, lack of in-house employees with BIM experience, outsourcing providing high-quality models, reduced costs, and lack of BIM professionals.

Through the literature survey, 12 factors were identified as the reasons for outsourcing decisions. TABLE 1 shows the most cited reasons for outsourcing in the previous studies.

Although firms choose to outsource some of their non-core work to achieve the benefits of outsourcing, outsourcing may have significant risks [39]. Outsourcing may increase an organization's risks of legal liability and loss of control over how outsourced work is performed. Outsourcing may lead to a loss in the performance of the entire business. When using outsourcing, risks such as quality risks, loss of control, and confidentiality should be considered. Fountain and Langar [3] identified risks related to outsourcing BIM modeling as communication gaps, lack of management of the project, poor quality, poor service, and poor contract management. TABLE 2 summarizes the risks related to outsourcing discussed by previous researchers.

TABLE 1. Reasons for outsourcing tasks by construction firms

#	**Outsourcing Reasons**	**References**
1	Cost reduction	[3], [11], [22], [23], [24], [25], [26], [21], [27], [28], [29], [30], [31], [32], [33], [34], [35], [36]
2	Enriched cash flows for more projects	[3], [11], [37], [24], [25], [27], [28], [29], [32], [33], [34], [35]
3	Increased revenue and profitability	[3], [11], [37], [24], [25], [27], [28], [29], [32], [33], [34], [35]
4	Timely services delivery	[11], [21], [28], [34], [35]
5	High-quality services	[3], [11], [22], [24], [25], [26], [21], [28], [32]
6	Technological (Software & Hardware)	[11], [26], [28], [29],[34], [35]
7	Focus on Core business	[11], [22], [25], [26], [28], [29], [31],[34], [35]
8	Flexibility to market needs	[3], [11], [37], [24], [25]
9	Lack of in-house employees with experience	[3], [22], [38], [25], [26], [27], [28], [33], [34], [35], [36]
10	The complexity of a task	[24], [28], [34],
11	Risk sharing with the vendor	[11], [24], [26], [28], [33], [34]
12	Lack of professionals seeking employment	[3], [25], [34]

TABLE 2. Risks associated with outsourcing tasks by construction firms

#	**Outsourcing risks**	**References**
1	Lack of ability to manage project	[3], [22], [40], [41], [42], [43], [34], [29], [21]
2	Communication gap	[11], [58], [59], [60], [5], [55]
3	Poor quality	[3], [40], [41], [42], [43], [11], [29], [21], [24]
4	Confidentiality	[22], [31], [40], [41], [42], [43], [11], [38], [29]
5	Costs of outsourcing	[22], [31], [40], [41], [42], [29], [21]
6	Lack of firms specializing in engineering tasks	[22], [31], [40], [41], [42], [43], [38]
7	Excessive dependence on vendor reliability	[40], [41], [42], [43], [38], [29]
8	Poor service	[11], [58], [59], [60], [5], [55]
9	Concerns with flexibility	[40], [41], [42], [11]
10	Cultural issues	[40], [41], [42], [29]
11	Increase the time of tasks	[40], [41]
12	Increased engagement of top management	[41], [34]

3. RESEARCH METHOD

The study aims to determine outsourcing trends among construction firms in Egypt to understand the significant role that outsourcing plays in construction projects, identify the reasons for outsourcing, assess the impact of outsourcing, and examine relationships between outsourcing and firm demographics.

A survey method was used to achieve the research goal. Owing to the method's ability to gather information from a sample number of respondents, trends could be identified and correlations could be established at a certain time [44]. There are several methods available for conducting the survey; hence, the online survey was selected for many reasons, including the targeted population having access to emails, increasing the probability of response, and the ability to know undelivered invitations.

The survey was developed using Google Forms, an online tool that comprises three main sections: firm demographics, engineering tasks outsourcing, and figures on engineering tasks outsourcing. The developed survey covered the key questions and, not lengthy, as lengthy surveys affect the number of respondents [45]. In addition, the survey was pilot-tested by three construction firms, and the respondents had some recommendations regarding the clarity of language and understanding of questions.

The target population of the study was building work (integrated) contractors from different categories of construction firms in Egypt. For 2023, preliminary data from the Egyptian Federation of Construction and Building

Contractors (EFCBC) showed that there were approximately 35,045 firms registered as building works (integrated) contractors in Egypt, distributed over seven categories [46]. The categorization of the construction firms is determined according to multiple criteria, including the capital of the firm, experience, technical capabilities, and previous completed projects.

With a 10% margin of error and a confidence level of 90%, it was determined that forty-three construction firms were the recommended sample size. As the targeted population is the building works contractors in Egypt comprising seven categories, this research used the stratified sampling technique to determine the number of samples in each category, where the population of each category affects the sample size for each category. TABLE 3 shows the population of each category and the sample size for each category, as per the stratified sampling method. TABLE 3 shows that the number of the 7th category is 29,567 about 85% of the total population. If the population is handled as one package, the sample size for the categories with a relatively small number, for example, the 1st, 2nd,3^{rd,} and 6th categories, will be representative of less than one firm, which will be irrelevant. The study population was divided into two main groups and subgroups. The first group will be from the 1st category to the 4th category as subgroups with highly technical staff members, and the rest will be in the second group. The sample size was calculated for each main group individually and then distributed over the subgroups based on the population of each group. Table 3 shows the adjusted sample size for each category.

After collecting all effective responses, a descriptive statistical analysis was conducted to identify the application patterns of conducting engineering tasks and outsourcing trends through construction firms in Egypt. A Chi-square test was performed to test the probable relationship between company demographics, conducting engineering tasks, and outsourcing. The research used STATA /MP 14.2 software to conduct the statistical analysis.

TABLE 3. Population categorization and sample size

Category	No of Contractors As per EFCBC	Technical Staff	Sample Size	Adjusted sample size
1St Category	518	20	0.64	9.54
2nd Category	305	15	0.37	5.62
3rd Category	596	6	0.73	10.98
4th Category	916	4	1.12	16.87
5th Category	2063	3	2.53	2.71
6th Category	1080	1	1.33	1.42
7th Category	29,567	1	36.28	38.87
Total	35,045		43	86.00

4. RESULTS AND DISCUSSION

As the survey period ended, approximately 98 responses were collected from construction firms, indicating a response rate of approximately 32.7%. The responses were closely examined, incomplete, and missing key data were excluded, reducing the collected responses to 94 responses. As the objective of this study was to identify the relationship between engineering tasks outsourcing and construction firms in the Egyptian construction industry, only one response from each firm was required. Accordingly, the effective number of responses was reduced to 90 construction firms after removing the duplicated responses.

4.1 Survey Demographics

Figures 1 to 3 show the survey respondents' demographic information by firm experience (years), firm categories, and executed project types. Figure 1 shows the experience of the construction firm respondents to the survey based on the established year. The Figure indicates that most respondents' firms (33%) were established from 6-10 years ago.

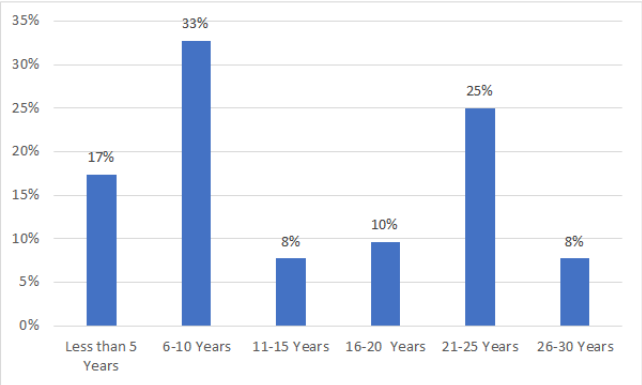

FIGURE 1. Construction firms experience

Figure 2 shows the categories of the respondents' firms to the survey. The data in the figures indicates that the 7th category, with 43%, is the most represented in the study, which is compatible with the sampling approach discussed above.

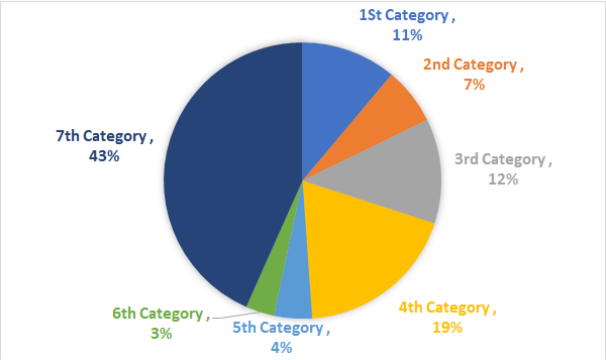

FIGURE 2. Construction firm categorization

Figure 3 shows the type of project the respondent firms in the survey were involved in. There are a variety of project types, however, the residential projects with 69.2% were the most projects for the respondents' firms.

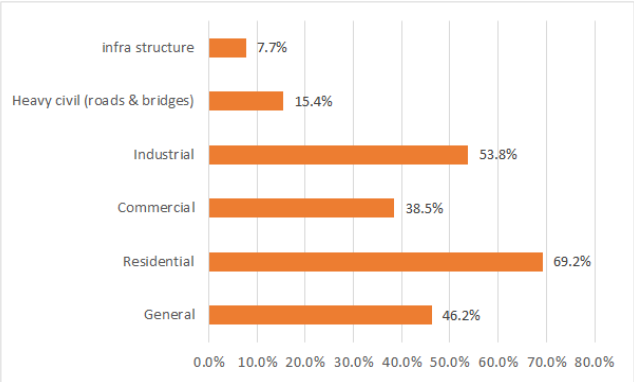

FIGURE 3. Construction firm project types

4.2 Engineering Tasks and Outsourcing Trends

The results show that one hundred percent of responding firms reported performing at least one of the engineering tasks within the past ten years. Figure 4 shows the percentage of each engineering task conducted by construction firms, where shop drawings were reported as the most conducted task with a percentage of 92.3%, while BIM modeling was the least conducted task with a percentage of 23.1%, which agrees with [47]. The high percentage of respondents conducting shop drawings shows the importance of shop drawings in construction projects for different types of projects and firm categories. Results also indicated the currently spreading and developing application of BIM modeling in the Egyptian construction industry with 23.1%, compared with 17.2% by [48], and agree with the findings of [49].

Seventy-seven percent of all responding construction firms reported having outsourced one or more engineering tasks to specialized engineering consultant firms, as shown in Figure 5. Firms that reported outsourcing engineering tasks were asked which specific tasks were outsourced. The most outsourced task was the shop drawings, with 75% of respondents reporting outsourcing this task. The next most outsourced task was design review with 50%, and the third was BIM modeling with 42%, as indicated in Figure 6. Cost management was the least outsourced task, with 8%.

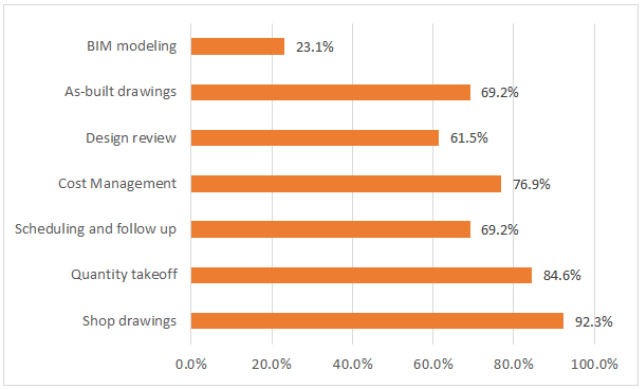

FIGURE 4. Engineering tasks conducted by construction firms

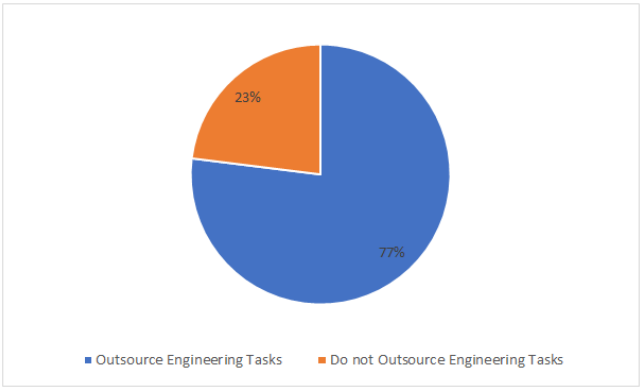

FIGURE 5. Outsourcing of engineering tasks by construction firms

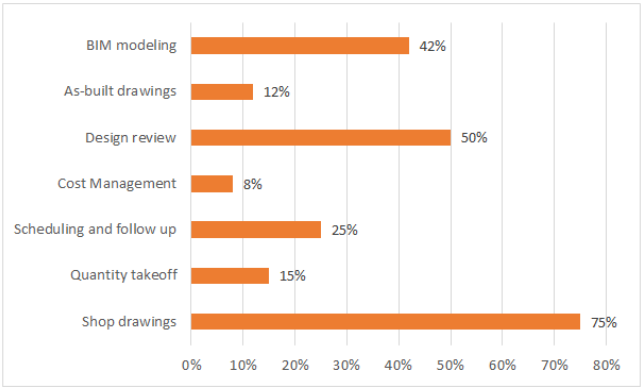

FIGURE 6. Outsourced engineering tasks by construction firms

Another important aspect of engineering tasks outsourcing is the duration for which an outsourcing firm's services are engaged per project. When firms that reported outsourcing engineering tasks were asked, the majority (46%) indicated that the outsourcing period varied considerably by the project. The different responses as per Figure 7 show that the time spent on outsourced tasks for each project varies by firm outsourcing strategy, project duration and complexity, scope outsourced, and current workload for firms.

Construction firms that previously outsourced engineering tasks were asked how they currently implement these tasks. Figure 8 shows that 69.2% of firms choose to outsource tasks they cannot perform in-house. Furthermore, 23.1% of construction firms reported that they equipped themselves with the required capabilities and were not

outsourcing engineering tasks anymore. In addition, the construction firms that outsourced one or more engineering tasks were asked about the owner of the outsourcing decision. Figure 9 shows that 53.8% of respondents reported that the decision was taken by the technical office manager, while 38.5 % of respondents reported that the decision was taken by the top management of the firm.

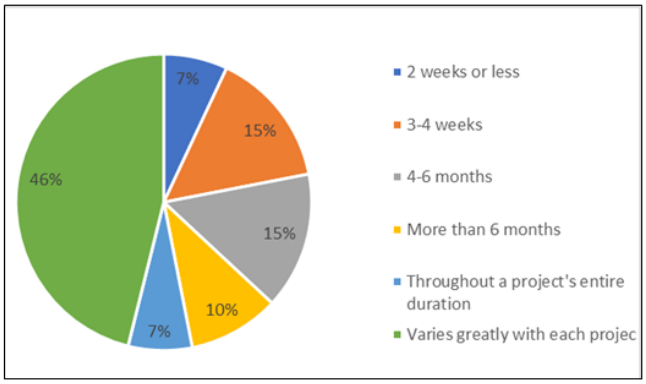

FIGURE 7. The engagement duration for the outsourced service provider

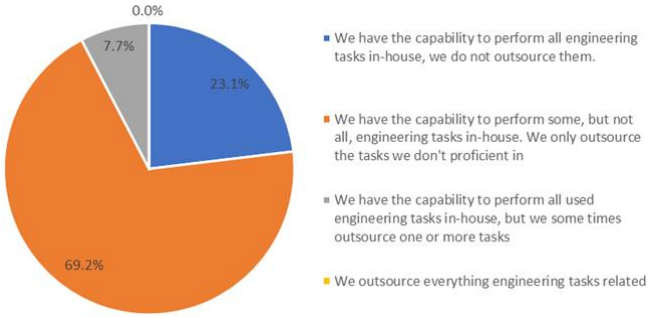

FIGURE 8. Engineering tasks implementation for firms that have outsourced previously.

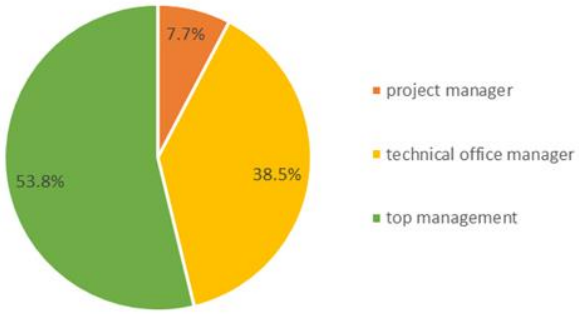

FIGURE 9. The owner of outsourcing engineering tasks decision

The construction firms that perform engineering tasks in-house were asked about the probability of outsourcing one or more engineering tasks in the future. Most of the respondents reported that they were either "likely" or "very likely" to outsource shop drawings (approximately 85%), design reviews, and BIM modeling (approximately 70%). In contrast, approximately 45% of respondents were either "unlikely" or "very unlikely" to outsource cost management, quantity takeoff, or planning and scheduling tasks. Commonly outsourced engineering tasks like shop drawings, design reviews, and BIM modeling have the same characteristics, such as a clear scope and low creative impact. The low values for the probability of outsourcing cost management, quantity takeoff, or planning and scheduling tasks are based on the nature of these tasks. The confidentiality of the data related to these tasks may represent the know-how of each firm, and outsourcing such tasks may cause exposure to high risks.

4.3 Reasons for Outsourcing Engineering Tasks

Respondents rank the reasons to outsource engineering tasks in general. Table 4 indicates that the top five ranked reasons for outsourcing engineering tasks are timely service delivery, high-quality services, flexibility to market needs, task complexity, and lack of professionals seeking employment. Timely service delivery ranked as the first motive for outsourcing engineering tasks as the engineering services are usually characterized by tight time for performing during the construction, using outsourcing can reduce time by utilizing many resources owned by the outsourcing firms.

TABLE 4. Ranking of outsourcing engineering tasks by construction firms

	Outsourcing Reasons (5: extremely important, 1: least important)	Rank
1	Cost reduction	11
2	Enriched cash flows for more projects	12
3	Increased revenue and profitability	10
4	Timely services delivery	1
5	High-quality services	2
6	Technological (Software & Hardware)	6
7	Focus on Core business	8
8	Flexibility to market needs	3
9	Lack of in-house employees with experience	7
10	Task complexity	4
11	Risk sharing with the Vendor	9
12	Lack of professionals seeking employment	5

In addition, the respondents ranked the reasons to outsource each engineering task. Table 5 shows that the top five ranked reasons for outsourcing engineering tasks are similar with some variance in the ranking order. However, the lack of professionals seeking employment is ranked in the top five reasons only in Design review and BIM modeling tasks as professional engineers in these tasks usually seek employment in consultant firms. Technological assets provided by outsourcing firms were ranked in the top five reasons for outsourcing in all engineering tasks, as the software and hardware used to perform engineering tasks are usually updated and may form a financial load for construction firms especially if it is not used in an economic scale.

TABLE 5. Ranking of outsourcing engineering tasks by construction firms (per task)

	Outsourcing Reasons	Rank						
		Rank for shop drawings	Rank for quantity takeoff	planning and follow-up	Cost Management	Design review	As-Built drawings	BIM Modeling
1	Cost reduction	10	8	10	7	6	9	11
2	Enriched cash flows for more projects	11	12	12	8	8	10	9
3	Increased revenue and profitability	12	11	8	9	12	11	7
4	Timely services delivery	3	2	5	6	9	3	12
5	High-quality services	4	3	1	10	2	4	2
6	Technological (Software & Hardware)	1	4	3	3	1	2	1
7	Focus on Core business	2	6	2	2	11	5	5
8	Flexibility to market needs	5	7	4	1	3	1	8
9	Lack of in-house employees with experience	7	1	6	4	10	12	4
10	Task complexity	6	5	9	5	4	6	6
11	Risk sharing with the vendor	8	10	11	11	7	833	10
12	Lack of professionals seeking employment	9	9	7	12	5	7	3

4.4 Risks Associated with Outsourcing Engineering Tasks

The top five risks identified by the respondents related to outsourcing engineering tasks, as shown in Table 6, are confidentiality, costs of outsourcing, lack of ability to manage projects, excessive dependence on vendor reliability, and a communication gap. Confidentiality was ranked as the highest risk for outsourcing engineering tasks, as the project's data are shared with the outsourcing firm, which may expose the construction firm to many hazards.

Table 7 shows the risk ranking of outsourcing for each engineering task. The lack of firms specializing in engineering tasks is reported in the top five risks only in the quantity takeoff task. Confidentiality and communication gas were ranked by respondents in the top five risks for all engineering tasks. While, the cost of outsourcing, poor quality, and lack of ability to manage projects are ranked in the top five risks related to outsourcing in most engineering tasks.

4.5 Impacts of engineering tasks outsourcing on projects

Construction firms were asked about their perceptions of "In-house" and "Outsourcing" for engineering tasks implementation. Figure 10 shows that approximately 5% of construction firms selected "Very Positive" and 15% of construction firms selected "Positive" in the category of cost, 31% "Very Positive" and 54% "Positive" for the category of time, and 23% "Very Positive" and 54% "Positive" for the category of quality, in favor of outsourcing perceived project impacts. Therefore, it seems to be the opinion of most construction firms that outsourcing engineering tasks is superior to in-house in terms of time and quality, while in terms of cost, in-house performing engineering tasks is superior to outsourcing.

TABLE 6. Ranking of risks related to outsourcing engineering tasks

	Outsourcing risks (5: extremely important, 1: least important)	Rank
1	Lack of ability to manage project	3
2	Communication gap	5
3	Poor quality	8
4	Confidentiality	1
5	Costs of outsourcing	2
6	Lack of firms specializing in engineering tasks	6
7	Excessive dependence on vendor reliability	4
8	Poor service	7
9	Concerns with flexibility	10
10	Cultural issues	12
11	Increase the time of tasks	9
12	Increased engagement of top management	11

TABLE 7. Ranking of outsourcing engineering tasks by construction firms (per task)

	Outsourcing Reasons	Rank						
		shop drawings	quantity takeoff	planning and follow-up	Cost Management	Design review	As-Built drawings	BIM Modeling
1	Lack of ability to manage project	5	7	3	4	5	3	1
2	Communication gap	1	2	2	2	2	1	2
3	Poor quality	4	3	4	6	3	4	8
4	Confidentiality	2	1	1	1	1	5	4
5	Costs of outsourcing	3	6	5	3	4	8	5
6	Lack of firms specializing in engineering tasks	6	4	7	8	8	7	6
7	Excessive dependence on vendor reliability	7	8	8	7	7	6	7
8	Poor service	8	5	6	5	6	2	3
9	Concerns with flexibility	9	12	10	11	11	12	10
10	Cultural issues	10	10	9	9	10	9	11
11	Increase the time of tasks	11	9	11	12	9	10	12
12	Increased engagement of top management	12	11	12	10	12	11	9

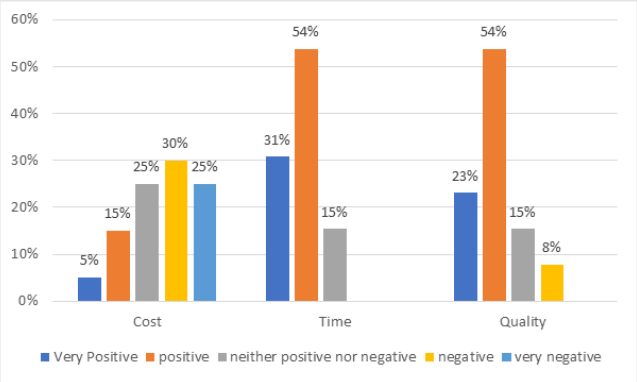

FIGURE 10. The impact of outsourcing engineering tasks on project performance.

4.6 Outsourcing and Firm Demographic Relationships

The research tested if a relationship existed between the firm's category and the use of engineering tasks by the firm in the last ten years during the life cycle of the construction project. The Chi-square test and Cramer's V conducted in SPSS and results shown in Figure 11 demonstrate a significant relationship between a firm's category and a firm's performed engineering tasks over the past ten years, $\chi 2$ (3) = 170, $p < 0.001$, Cramer's V = 0.561. The study also found that a high category of the company reflects an increase in utilizing engineering tasks. Thus, the likelihood of a firm implementing most engineering tasks was greater for firms in the first category than those in the seventh category, as these firms work on smaller-scale projects and, sometimes, as subcontractors where the general contractors perform the engineering tasks.

The researcher also assessed if a relationship exists between a firm's category and outsourcing using the chi-square test. The Chi-square test results in Figure 12 demonstrate no relationship between a firm's category and its tendency to outsource engineering tasks, $\chi 2$ (3) = 5.406, $p = 0.493$, and Cramer's V = 0.245. It was noticed that different categories may outsource one or more engineering tasks.

5. CONCLUSION

Construction firms occasionally use outsourcing strategies to perform engineering tasks. This study aims to investigate the trends in outsourcing engineering tasks by construction firms in Egypt. For this purpose, the relevant studies on outsourcing, its reasons, and its risks were reviewed. The questionnaire survey was designed based on data collected from the previous studies review and conducted among 90 Egyptian construction firms from different categories. The analysis of the collected data was carried out using descriptive statistical analysis to identify the application patterns of outsourcing trends. A Chi-square test was performed to test the probable relationship between company demographics, conducting engineering tasks, and outsourcing by using STATA /MP 14.2 software.

The results of the study showed that 100% of the construction firms responding to this survey reported using one or more engineering tasks during the lifecycle of projects. Seventy-seven percent of respondents reported having outsourced one or more tasks to specialized engineering firms, which indicates the importance of the research topic. The three most commonly outsourced engineering tasks by construction firms were shop drawings, design reviews, and BIM modeling. Commonly, outsourced engineering tasks have characteristics such as a clear scope and low creative impact. The least common outsourced engineering task is cost management; however, this task is one of the most common engineering tasks performed by firms. Cost management, including detailed cost estimation during the tender phase, is one of the core business functions of the construction firm and requires a high level of confidentiality.

The top five reasons for outsourcing engineering tasks were also identified: timely service delivery, high-quality services, flexibility to market needs, the complexity of a task, and a lack of professionals seeking employment. Firms that currently perform engineering tasks without outsourcing and those that outsource engineering tasks indicated that there are risks for outsourcing or reasons for not outsourcing (in order of importance): confidentiality, costs of outsourcing, lack of ability to manage projects, excessive dependence on vendor reliability, and communication gaps.

Additionally, the research highlighted that outsourcing engineering tasks is a significant feature of the modern construction industry. The outsourcing of engineering tasks is applied by the first category of firms that own the technical for reasons related to the various workload capabilities, and the outsourcing is also applied by the 6th and 7th categories for reasons related to the shortage of technical resources and technological assets.

The findings of this study can help outsourcing firms understand with reasons and risks of outsourcing from the construction firms' point of view, which, if considered, can increase the work outsourced to them and, in turn, realize more profits.

However, the importance shown for the research, limited research is available in examining of the outsourcing engineering tasks by construction firms. There are many unexplored areas of research for future investigation. Case studies may be conducted on projects where engineering tasks were outsourced, followed by a comparison of case studies on similar project types where engineering tasks were conducted in-house, which may expose differences and encourage further analysis.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.701E2[a]	36	.000
Likelihood Ratio	172.341	36	.000
Linear-by-Linear Association	77.976	1	.000
N of Valid Cases	90		

a. 47 cells (95.9%) have expected count less than 5. The minimum expected count is .13.

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Nominal by Nominal	Phi	1.375			.000
	Cramer's V	.561			.000
Interval by Interval	Pearson's R	-.936	.012	-24.949	.000[c]
Ordinal by Ordinal	Spearman Correlation	-.930	.013	-23.773	.000[c]
N of Valid Cases		90			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

FIGURE 11. Results for Chi-Square Test between firm's category and engineering tasks.

Chi-Square Tests

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	5.406[a]	6	.493
Likelihood Ratio	5.967	6	.427
Linear-by-Linear Association	.225	1	.635
N of Valid Cases	90		

a. 8 cells (57.1%) have expected count less than 5. The minimum expected count is .67.

Symmetric Measures

		Value	Asymp. Std. Error[a]	Approx. T[b]	Approx. Sig.
Nominal by Nominal	Phi	.245			.493
	Cramer's V	.245			.493
Interval by Interval	Pearson's R	.050	.105	.473	.638[c]
Ordinal by Ordinal	Spearman Correlation	.043	.106	.403	.688[c]
N of Valid Cases		90			

a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

c. Based on normal approximation.

FIGURE 12. Results for Chi-Square Test between firm's category and outsourcing

6. References

[1] K. Prakash and N. Nandhini, "Evaluation of Factors Affecting Construction Project Performance Management," International Journal of Science and Engineering Research (IJ0SER), vol. 3, no. 4, pp. 1–5, 2015.

[2] 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.

[3] 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.

[4] 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.

[5] 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.

[6] H. Abdul-Halim and N. Che-Ha, "HR outsourcing among Malaysian manufacturing companies," Business Strategy Series, vol. 11, no. 6, pp. 363–370, 2010.

[7] 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.

[8] 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.

[9] 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.

[10] 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.

[11] 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.

[12] G. J. Carty, "Construction," J Constr Eng Manag, vol. 121, no. 3, pp. 319–328, 1995.

[13] M. Kamal, S. Dokhan, and K. El-Dash, "Assessing the Impact of Delay of Shop Drawing Process in Construction Projects," 2022.

[14] 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

[15] PMBOK® Guide, A guide to the Project Management Body of Knowledge (PMBOK guide), vol. 44, no. 6. 2017. doi: 10.1002/pmj.21345.

[16] M. Hanid, M. Siriwardena, and L. Koskela, "What are the big issues in cost management?," COBRA 2011 - Proceedings of RICS Construction and Property Conference, pp. 639–646, 2011.

[17] L. Soibelman, L. Y. Liu, J. G. Kirby, E. W. East, C. H. Caldas, and K.-Y. Lin, "Design review checking system with corporate lessons learned," J Constr Eng Manag, vol. 129, no. 5, pp. 475–484, 2003.

[18] M. J. Clayton, R. E. Johnson, Y. Song, and J. Al-Qawasmi, "A study of information content of as-built drawings for USAA," Retrieved January 14, 2007, from http://archone. tamu. edu/crs//documents/publications/asbuilt. pdf, 1998.

[19] 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.

[20] J. Tarziján 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.

[21] 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.

[22] 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.

[23] S. Cohen and J. Roussel, Strategic supply chain management: the five disciplines for top performance. McGraw-Hill Education, 2013.

[24] 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.

[25] 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.

[26] J. B. Quinn, "Strategic outsourcing: leveraging knowledge capabilities," MIT Sloan Manag Rev, vol. 40, no. 4, p. 9, 1999.

[27] Y. Jwe, "BIM Outsourcing: Opportunities and Challenges for Construction Design and Management in Cross Country Collaboration," 2020.

[28] 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.

[29] 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.

[30] J. I. Messner, "Offshoring of engineering services in the construction industry," The Offshoring of Engineering: Facts, Unknowns, and Potential Implications, pp. 137–148, 2008.

[31] [31] 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.

[32] C. Fill and E. Visser, "The outsourcing dilemma: a composite approach to the make or buy decision." [Online]. Available: http://www.emerald-library.com

[33] 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.

[34] 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.

[35] 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.

[36] 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.

[37] 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.

[38] 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.

[39] 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.

[40] 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.

[41] 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.

[42] 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.

[43] 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.

[44] G. G. Gable, "Integrating case study and survey research methods: an example in information systems," European journal of information systems, vol. 3, pp. 112–126, 1994.

[45] K. B. Sheehan, "E-mail survey response rates: A review," Journal of computer-mediated communication, vol. 6, no. 2, p. JCMC621, 2001.

[46] "https://tasheed.org/."

[47] H. M. Omayer and N. S. Badawy, "Building Information Modeling BIM as a development tool for the management of construction projects," Fayoum University Journal of Engineering, vol. 3, no. 2, pp. 9–26, 2020.

[48] A. H. Elyamany, "Current practices of building information modelling in Egypt," International Journal of Engineering Management and Economics, vol. 6, no. 1, pp. 59–71, 2016.

[49] L. M. Khodeir and A. A. Nessim, "BIM2BEM integrated approach: Examining status of the adoption of building information modelling and building energy models in Egyptian architectural firms," Ain Shams Engineering Journal, vol. 9, no. 4, pp. 1781–1790, 2018.