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# The Effects of the Plan-Do-Check-Act Cycle on the Performance of the Small Size Construction Firms in the Kingdom of Saudi Arabia

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**Abstract:** In current competitive environment of the construction industry, continuous quality improvement is becoming a need of the day. One important tool for continuous quality improvement is PDCA cycle (plan, do, check, and act) which can be effectively used for quality improvement and subsequently improvement in the performance by the construction firms. The objectives of the study were to identify the extent to which the firms are utilizing the PDCA cycle, and its effects on the firm performance in the context of small scale construction firms in the Kingdom of Saudi Arabia. Measure were adapted from previous sources to develop a survey questionnaire and through convenience sampling, responses were generated from staff from 20 selected small scale construction firms (n=157). Descriptive statistics indicate that the level of utilization of PDCA cycle among the sample firm is moderate level. Further, the three stages of PDCA cycle including plan, do, and act is having positive and significant effects on the firm performance. Based on the findings, it is recommended that small scale construction firms should focus on greater utilization of the PDCA cycle.

**Keywords:** PDCA cycle, Deming, Firm performance, Construction industry, Small firms, Saudi Arabia

## INTRODUCTION

Construction industry plays crucial role in development of any country since it provide support to as many as up to the 40 related industries, provide society with the key infrastructure, employ people, generate taxes for the government, and stimulate the economic growth [1]. In the Kingdom of Saudi Arabia, construction industry is a leading industry as the construction industry of the country consumes more than 14% of its energy and encompasses about 15% of its workforce [2]. The value of its current projects is about US$1.1 trillion making it a leading country in the gulf region in terms of the value of construction projects [3]. The increase in construction project is unprecedented during the last two decades [4]. Currently, the industry is facing both prospects as well as some challenges. The prospects is due to the stable oil prices, and vision 2030 which is about making Saudi economy less dependent on oil and diversification in education, health, and tourism industries. The challenges are due to the increased regulations from the government and decline in economic growth. The result of this situation is that there is very heavy competition within the construction industry from both the local and the foreign firms. The performance of Saudi construction industry is also not up to the mark as it often fails to meet the time and cost targets, have health and safety issues, and constructions also fail to reach to its expected lifespan [5]. In such a competitive environment, there is greater pressure on the small scale construction firms to radically improve its competitiveness and performance. One way the small scale construction firms can improve their performance is to give greater focus on its quality management programs and emphasis on continuous improvement. Quality management gurus such as Deming, Juran, and Ishikawa provided different tools and concepts which helps in improving the quality of the products and process within an organization. One quality tool which can be used for continuous quality improvement is the PDCA cycle [6]. It is introduced by the Edward Deming after the Second World War The focus of the PDCA cycle is to integrate continuous improvement in the organizational routines in order to improve the quality of the products, services, processes and thus making organization more competitive. The central theme of this paper is use of PDCA cycle as a supporting tool for the continuous improvement among the construction firms in the Kingdom of Saudi Arabia.

The PDCA cycle consist of four stages. Plan is the first stage and is about planning for identification of potential improvement areas in the organization and developing plans for improvement [7]. The potential improvement which is planned can be related to the products, processes, and so on. In other words, the plan stage is about diagnosing the organization for any

weaknesses or areas which can be further improved. Example of plan stage in the construction industry can be that management thoroughly inspect all the processes and may identify that certain aspects such as material purchase or construction design need to be changed in order to be speedup. Do is the second stage and refers to the practical administration of the plan for test purpose [6]. In other words, it is a mini implementation of the quality improvement plan. Potential barriers or issues which can hinder the large scale implementation should be identified at this stage [7]. Example of do stage in the construction industry can be that management implement the new material purchase process for small section of the construction project or adopt new design procedure for some particular project. Check is the third stage which is used for controlling purpose [8]. The plans which are implemented on small scale basis as discussed in previous stage are evaluated for their practicality at this stage [7]. Desired objectives or outcomes, problems, completeness, timeliness, etc. are evaluated at this stage. The example of the check stage in the construction industry can be that management evaluates the results of implementing some new procedure on the basis of its efficiency, effectiveness, timeliness, and some other performance criteria. Act is the last stage of PDCA cycle. It is about implementation of improvement plan which are planned and tested on small scale as discussed in previous stages [8]. The example of act stage in the construction industry is that if management finds that a new procedure which is implemented at small scale as part of the PDCA cycle is producing better outcome than the regular procedure, so the new procedure (do stage) should be implemented at large scale. Here important thing is that management must critically evaluate the procedure before large scale implementation. In sum, the PDCA cycle can be used by the construction firms for identifying products or processes which need improvement, implementing improvement at small level, evaluating the implementation, and if found suitable then applying it at the larger level. The famous seven quality tools (Flow Chart, Cause and Effect diagram, Check sheet, Pareto diagram, Histogram, Scatter plot, and Control charts) can be used in different stages of the PDCA cycle as show in the figure 1 below [9, 10].

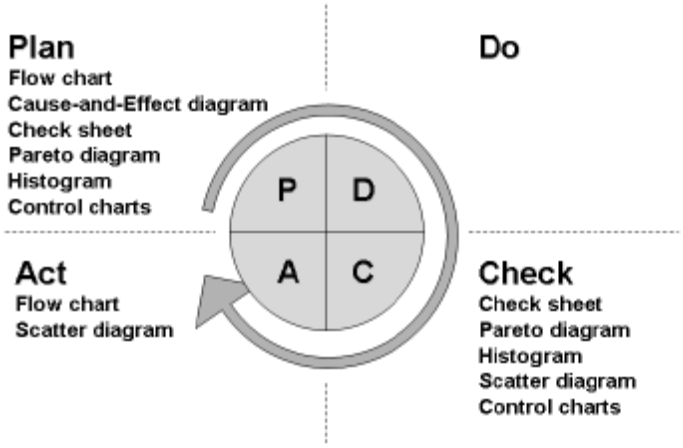


**Fig-1: Use of Seven Quality Tools in PDCA Cycle**

The plan stage is about identification of problems and areas of improvement. In this stage, all seven tools can be utilized. For example, cause and effect diagram can be used for brain storming purpose and identifying the causes of poor quality or quality failure. The Scatter diagram or check sheet can be used for monitoring the performance and quality related information at the check stage. In act stage, flowchart can be used for visualizing the entire process, its sub-components, and monitoring.

**PDCA Cycle and Performance**

The PDCA cycle is being investigated in different context and is found to be producing favorable outcomes. For example, it is investigated in plastic manufacturing industry in a study [11]. The findings of the study are that good implementation of PDCA requires engagement from employees, and if implemented properly, then it produces favorable outcomes. Similarly, in another study, PDCA cycle and its implementation is investigated in the various activities of Red Cross emergency relief services [8]. The findings of the study are that it can be applied at different activities such as disaster preparedness, recovery, helping people during a disaster, and so on. Another study investigated the use of PDCA in the software development industry and found that it leads to the improvement of the software quality [12]. Based on the findings of previous studies, it can be argued that if organization implements PDCA cycle, then it can lead to the improvement of its performance. The objective of the study is to see the effects of the PDCA cycle on the firm performance of the small scale construction firms in the Kingdom of Saudi Arabia.

The significance of the study is that it enhances our understanding about the PDCA cycle and its effects especially in the context of small scale construction firms in the Kingdom of Saudi Arabia. It is first such study conducted in the Saudi Arabian construction industry context. The practical significance of the study is that it will provide empirical evidence about the extent of implementation of the PDCA cycle and its effects which can be beneficial for the management of the construction firms for better utilizing the PDCA and similar tools. Consultants can also use the findings of the study for designing better interventions for the clients. The study can also be used by the academics and students for developing better understanding about the concept. Government and its subsidiary organizations can use it for designing training programs for the construction firms.

## MATERIAL AND METHODS

Details about different aspects of research methodology for the current study in terms of research design, research method, population and sampling, research tools, reliability and validity are discussed below.

### Research Design

The design of the study is cross-sectional and non-experimental. Its cross sectional since data is only collected at one point in time and non-experimental as there is no experiment involved and data is collected in natural setting from the participants.

### Research Method

The research method used in this study is quantitative. Quantitative method is based on the statistical tools and analysis and is suitable for explanatory and descriptive type of studies [13].

### Population and Sampling

The focus of the study is the small scale construction firms in the Kingdom of Saudi Arabia. Through convenience sampling, data is collected from different categories of staff from selected small scale manufacturing firms. A total of 323 survey questionnaire were distributed out of which, a total of 157 survey were returned.

### Research Tools

Data is collected based on a structured survey. PDCA survey measure is adapted from previous source [14] and consist of three items each for measuring plan, do, check, and act. Performance of the construction firms is measured by using 5 items which were based on the key performance indicator related to the construction industry and adapted from the previous work based on the key performance indicator for the construction industry [15, 16]. These performance indicators included predictability in terms of cost, predictability in terms of time, profitability, customer satisfaction, and the reduced defects.

### Reliability and Validity

Reliability is about degree to which the measures are free from error and produces the consistent results [17]. Reliability is evaluated using the internal consistency method through Cronbach alpha. All our measure had Cronbach alpha of above 0.60 which can be considered as reasonably good level of reliability for the measure involved [17]. Validity is about the extent to which an empirical measure adequately reflects the real meaning of the concept under consideration [18]. We used the content validity method for establishing the validity of the survey items. For this purpose, the instrument is presented to an expert university professor who evaluated the items for their suitability for the measurement of the concepts involved. Additionally, we used the pilot study method for establishing the reliability and validity based on a small sample (n=10) from the sample construction firms. We checked the reliability on the responses from the pilot study and also asked the survey participants about the survey items. Mostly the participants were able to easily understand the concept and found it adequate to measure the concept involved. Thus, the pilot study also helped us to improve the reliability and validity of the survey measure involved.

## RESULTS AND DISCUSSION

Results of the study are discussed below. It includes the demographic information of the survey participants, descriptive statistics, and the hypothesis testing. Details are as under.

### Demographic Information

Demographic information of the survey participants is as under.

**Table-1: Demographic Information**

| Variable | Frequency and Percentage | | | |
|---|---|---|---|---|
| **Gender** | **Male** | **Female** | | |
| | 145(92.4%) | 12(7.6%) | | |
| **Age Group** | **18 to 25 Years** | **25 to 35 Years** | **35 to 45 Years** | **Above 45 Years** |
| | 9(5.7%) | 106(67.5%) | 34(21.7%) | 8(5.1%) |
| **Qualification** | **College Diploma** | **Bachelors** | **Masters** | **Above Masters** |
| | 2(1.3%) | 122(77.7%) | 30(19.1%) | 3(1.9%) |
| **Job Role** | **Engineer** | **Technical** | **Managerial** | **Others** |
| | 61(38.9%) | 37(23.6%) | 50(31.8%) | 9(5.6%) |
| **ISO9001 Certification** | **Yes** | **No** | | |
| | 124(79%) | 33(21%) | | |
| **Number of Employees in Firm** | **Less than 50 Employees** | **50 to 100 Employees** | **100 to 200 Employees** | **Above 200 Employees** |
| | 20(12.7%) | 46(29.3%) | 62(39.5%) | 29(18.4%) |
| **Firm Origin** | **Local** | **Foreign** | | |
| | 127(80.9%) | 30(19.1%) | | |

Table1 provide the demographic information of the survey participants. It shows that total of 157 participants participated in the survey. From total, 145 were male and 12 were female. In terms of age, 9 participants belonged to the age group of 18 to 25 years; 106 belonged to the 25 to 35 years; 34 belonged to the 35 to 45 years; and 8 belonged to the above 45 years of age group. In terms of qualification, 2 participants had college level diploma, 122 had bachelor level degree, 30 had master level degree, and 3 had above master qualification. In terms of job role, 61 were engineer, 37 were technical staff, 50 were managerial staff, and 9 belonged to the other category. The firms of 124 participants had ISO9001 certification while 33 participants belonged to the construction firms having no ISO9001 certification. In terms of number of employees, 20 participants belonged to the firm having less than 50 employees; 46 belonged to the firm having 50 to 100 employees; 62 belonged to the firm having 100 to 200 employees; and 29 belonged to the firm having above 200 employees. In terms of firm origin, 127 participants belonged to the firm having local (Saudi Arabian) origin, while 30 belonged to the firm having foreign origin.

**Descriptive Statistics**

The descriptive statistics for the measures involved is given below**.**

**Table 2: Descriptive Statistics**

| | Number of Items | Minimum | Maximum | Mean | Std. Deviation | Cronbach Alpha |
|---|---|---|---|---|---|---|
| Plan | 03 | 1.33 | 5.00 | 3.3694 | 1.04226 | .778 |
| Do | 03 | 1.00 | 5.00 | 3.3503 | .86545 | .605 |
| Check | 03 | 1.67 | 5.00 | 3.6582 | .81732 | .789 |
| Act | 03 | 1.00 | 5.00 | 3.6454 | .79590 | .733 |
| Outcome | 05 | 1.40 | 5.00 | 3.4854 | .83917 | .830 |

The descriptive statistics as given in table 2 above suggests that based on the participants perception, all four aspects of PDCA cycle were slightly above average in their respective small scale construction firms including plan (M=3.36, SD=1.04); do (M=3.35, SD=.86); check (M=3.65, SD=.81); and act (M=3.64, SD=.79). The perceived performance was also slightly above average in their respective firms (M=3.48, SD=.83). The Cronbach alpha for all five variables was also above 0.60 which indicate good reliability as Cronbach alpha above 0.60 can be considered good [18] (Field, 2005).

**Hypothesis Testing-Regression Analysis**

Hypotheses were tested using the regression framework. Results are given in the table below followed by interpretation

**Table 3: The Effects of PDCA on the Firm Performance**

| | Model 1 | Model 2 |
|---|---|---|
| (Constant) | 2.304** | .134 |
| NumberofEmployeesDummy1 | 1.033 | 1.198* |
| NumberofEmployeesDummy2 | .856 | .973 |
| NumberofEmployeesDummy3 | .953 | 1.029 |
| OriginDummy1 | .296 | .083 |
| Plan | | .169** |
| Do | | .198* |
| Check | | -.118 |
| Act | | .700*** |
| Rsquare | .036 | .487 |
| Change in Rsquare | | .451 |
| Fstat | 1.439 | 17.590*** |
| DWstat | | 2.005 |

**Control Variable:** Number of EmployeesDummy1=Less than 100, Number of Employees Dummy2= 100-200, Number of EmployeesDummy3=Above 200, OriginDummy1=Local
**Independent Variables:** Plan, Do, Check, Act
**Dependent Variable:** Performance
n=157, *=P<0.05, **=P<.01, ***=P<.001

For hypothesis testing, we used the regression framework. Results are given in table 3 as given above. In model 1, only control variables were entered, while, plan, do, check, and act were entered in the model 2. Results indicate that while controlling for the number of employees and firm origin, the plan had positive and significant effects on the firm performance (β=.169, P<.05); do had positive and significant effects (β=.198 P<.05); check had negative and insignificant effects (β=-.118, P<.05); and act had positive and significant effects on the firm performance (β=.700, P<.05). The Rsquare values shows that four aspects of PDCA cycle explained 48.7% change in the dependent variable of firm performance. The Fstatistics suggest that overall model was fit and significant (Fstat=17.59, P<.05). The DW statistics is about 2 which indicate that the no autocorrelation assumption is satisfied. Additionally, we used the collinearity statistics in which VIF values of all four independent variables were less than 2 which indicate that no multicollinearity assumption is satisfied in our data [18].

## DISCUSSION

The objective of the study was to measure the effects of the PDCA cycle on the performance of the small scale construction firms in the Kingdom of Saudi Arabia. For this purpose, we used the convenience sampling approach and collected data from 157 survey participants belonged to the 20 construction firms. Our results indicate that in sample firms, the four stages of PDCA are utilized at moderate level. Generally, the utilization of quality management related tools among the organizations in Saudi Arabia is moderate level as found in a previous study [19]. There can be different reasons for low level of understanding and application of PDCA cycle in the Saudi Arabia such as lack of resources, lack of understanding, lack of skilled staff, lack of interest by leadership, poor communication system, poor customer focus, and non-supporting organizational culture [20, 21]. A similar study investigating lean production which is also a type of quality improvement tool found that there is low level of lean construction followed by the construction industry in Saudi Arabia, however, the lean construction is rising gradually [22]. Further, the results indicate that the stages of PDCA cycle including plan, do, and act are having positive and significant effects on the performance of the construction firms. These results are consistent with the findings of previous studies conducted in different context including the Red Cross [8]; in plastic manufacturing industry [11]; and in software development industry [12]. Broadly speaking, the PDCA cycle leads to the continuous improvement in the firm which is necessary for survival, growth, and favorable outcomes in current competitive environment [23]. Thus, we can say that overall our results are consistent with the theory and support the use of PDCA cycle in the construction industry.

## CONCLUSION

Based on the findings of our study we can conclude that understanding and utilization of PDCA cycle is moderate level among the small scale construction firms in the Kingdom of Saudi Arabia. Additionally, it can be concluded that the PDCA cycle is beneficial for the small scale construction firms in the Kingdom of Saudi Arabia. Different quality tools can be used in conjunction with the PDCA cycle and it can assist the organizations in achieving the ISO9001 certification. Therefore, small scale construction firms should focus on utilizing the PDCA cycle. There can be some barriers or difficulties while utilizing the PDCA

cycle which need further investigation. The question that whether the PDCA will produce favorable outcome if one move from one context to another such as from construction to the services sector or other manufacturing also demands further research in the future. Based on our findings, we provide the following recommendations.

- Small scale construction firms should focus on PDCA cycle and incorporate it in to its operations.
- Staff should be properly trained to understand the PDCA cycle, its various stages, and its integration with the use of other quality tools.
- Leadership should take initiative and active part in implementing the PDCA cycle.
- The PDCA cycle related contents should be added in the relevant programs such as engineering management and quality management related courses.
- Government should provide support in the form of training and consulting to the small scale construction firms for implementing the PDCA cycle.

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