Project control system (PCS) implementation in engineering and construction projects: an empirical study in Saudi's petroleum and chemical industry

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Abstract

Purpose – There is growing recognition that effective project control systems (PCS) are critical to the success of projects. The relationship between the individual elements of PCS and successfully achieving project objectives has yet to be explored. This research investigates the enablers and barriers that influence the elements of PCS success and drive project objectives.

Design/methodology/approach – This study adopts a mixed approach of descriptive analysis and regression models to explore the impact of six PCS elements on project outcomes. Petroleum and chemical projects in Saudi Arabia were selected as a case study to validate the research model.

Findings – Data from a survey of 400 project managers in Saudi's petroleum and chemical industry reveal that successful PCS are the key to achieving all project outcomes, but they are particularly critical for meeting project cost objectives. Project Governance was identified as the most important of the six PCS elements for meeting project objectives. A lack of standard processes emerged as the most significant barrier to achieving effective project governance, while having skilled and experienced project team members was the most significant enabler for implementing earned value.

Practical implications – The study offers a direction for implementing and developing PCS as a strategic tool and focuses on the PCS elements that can improve project outcomes.

Originality/value – This research contributes to project management knowledge and differs from previous attempts in two ways. Firstly, it investigates the elements of PCS that are critical to achieving project scope, schedule and cost objectives; secondly, enablers and barriers of PCS success are examined to see how they influence each element independently.

Keywords Project control systems, Project success, Maturity, Engineering, Construction, Enablers, Barriers

Paper type Research paper

1. Introduction

The COVID 19 pandemic has and continues to have a dramatic impact on the global economy and industrial sectors. Business has been severely interrupted by the pandemic and the ensuing economic challenges (Gamil and Alhagar, 2020; Shibani *et al.*, 2020). All sectors, other than essential services such as public health and utilities, have been impacted. Organizations

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around the world have responded by shifting to a work-from-home concept to mitigate government-imposed restrictions and social distancing regulations. Globally, Gross Domestic Product (GDP) is likely to be impacted by 3–6% but might fall to 15% in some countries (Prasad and Prasad, 2020; Maliszewska *et al.*, 2020).

Recent studies have highlighted the extent to which different industries have been negatively affected by the COVID-19 pandemic, with the engineering and construction industry being one of the hardest hit (Gamil and Alhagar, 2020). This pandemic has impacted on the engineering and construction industry in many ways such as the suspension of projects, schedule extension, cost overrun, resource unavailability and financial shortfalls. Given the fact that projects in this sector typically have a high level of uncertainty due to large scope, design difficulty, complex interfaces and involvement of multiple stakeholders, challenges to complete projects once the pandemic subsides are more prevalent (Assaf and Al-Hejji, 2006; Shibani *et al.*, 2020). There is growing recognition that effective project control systems (PCS) are critical to the success of projects and more importantly to address challenges in the engineering and construction industry (Al-Jibouri, 2003; Ford *et al.*, 2007; Jayaraman, 2016). Therefore, an effective PCS becomes more crucial for the industry as it recovers and comes out of the pandemic.

Although some studies developed different maturity models to assess and improve the effectiveness of PCS (Backlund *et al.*, 2013; Brookes *et al.*, 2014; PMI, 2013; Crawford, 2014), the question of how the PCS relates to, and influences, overall project objectives still needs to be investigated. Previous research (Jawad and Ledwith, 2021) has identified six elements of PCS: 1) change management, 2) earned value, 3) baselined plan, 4) resource allocation, 5) progress method and 6) project governance. However, the impact of each of these PCS elements on project scope, schedule and cost is not well understood. Additionally, the relationship between the enablers and barriers of PCS success (Jawad and Ledwith, 2020) and these PCS elements is also unknown. This research addresses these gaps by providing a comprehensive model linking critical enablers and barriers with PCS elements and project success this is illustrated in Figure 1. This can be summarized in the following research questions;

(1) What are the critical enablers and barriers of PCS success and how do they impact the PCS elements?

(2) Which PCS elements are critical to achieving project objectives: scope, schedule and cost?

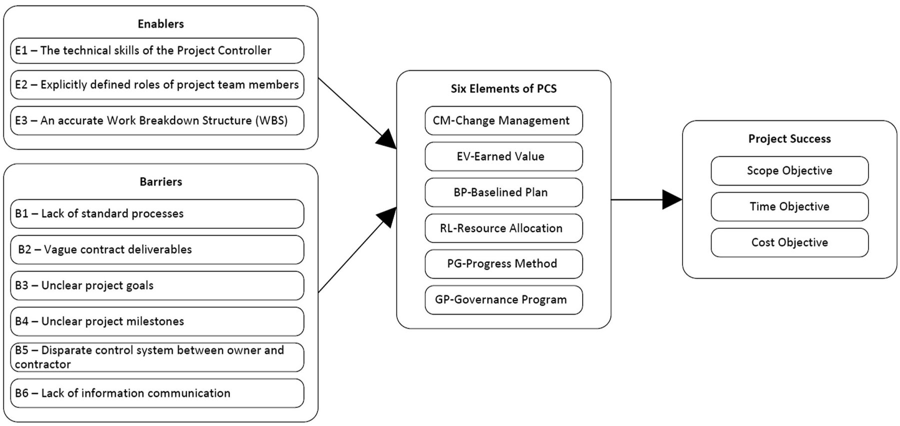

Figure 1.
Research model

To achieve this, three enablers, six barriers and six elements of PCS success were selected from previous research (Jawad *et al.*, 2018; Jawad and Ledwith, 2020, 2021) to develop a model for this study. The significance of this research is to provide organizations in the engineering and construction industry with a direction for implementing and developing PCS as a strategic tool that can improve project outcomes.

This paper is structured as follows. Section 2 presents a review of the literature on enablers and barriers of PCS, main elements of PCS success and project success objectives in the engineering and construction industry. The research methodology is described in Section 3 and the results of the study are reported in Section 4. Section 5 presents the discussion and final research model. Finally, Section 6 highlights the conclusions and implications of the study.

2. Literature review

Engineering and construction projects are naturally high risk due to scope complexity, contracting strategies, overly optimistic schedule, difficulties managing project change and resources capabilities (Assaf and Al-Hejji, 2006; Braimah, 2014). Therefore, achieving project objectives in this sector is one of the key subjects in project management (Olawale and Sun, 2014; Sakka *et al.*, 2016). Although the definition of project success is different amongst industries, it is based on the basic notion of overall achievement of project goals and expectations. Typically, the iron triangle of scope, time and cost has been the dominating performance indicator of project success (Al-Hajj, 2018; Tsiga *et al.*, 2017). Particularly in engineering and construction projects, a lack of definition of project scope at the beginning of the project is a major contribution to unsuccessful projects. An accurately defined and managed scope supports the delivery of a quality project outcome within stakeholders agreement for cost and schedule targets (Mišić and Radujkovic, 2015; Winch, 2012). While ineffective project performance remains a major area of concern for project management practitioners (Setia and Patel, 2013), previous research attributes the underperformance in a majority of construction projects to poor project control practices (Yean Yng Ling and Theng Ang, 2013; Liu, 2015a; Maqsoom *et al.*, 2020).

PCS is an integrated framework of processes, tools and people that businesses use to track and monitor project performance (Rozenes *et al.*, 2006; Jayaraman, 2016; Jünge *et al.*, 2019). The main purpose of a PCS is to provide a means to measure project performance parameters and present them in a way that allows effective feedback against defined expectations. On large complex projects PCS generally have many facets and demands consideration of time, costs, quality, safety and environmental issues (Wang *et al.*, 2017). In engineering and construction industry with multiple stakeholders, PCS require project information from different parties such as owner, contractor and vendor which makes the implementation of PCS more complicated (Bower and Finegan, 2009; He *et al.*, 2019; Jünge *et al.*, 2019).

An effective PCS has been shown to have a direct link to achieving project objectives and to reducing the reasons for project failure (Benjaoran, 2009; Ford *et al.*, 2007; Maqsoom *et al.*, 2020; Parnell *et al.*, 2020). Although many studies emphasis that implementing effective PCS is significant to project success (Al-Hajj, 2018; Durdyev, 2020; Sudhakar, 2016; Taherdoost, 2016), very few identify the elements of PCS that are most critical to improve project outcomes (Jawad and Ledwith, 2021).

Maturity models are recognized as systematic approaches to measure the relative performance of different aspects of project management (Backlund *et al.*, 2013; Brookes *et al.*, 2014). PCS maturity in the context of project management has been addressed in previous studies (Crawford, 2014). The majority of these studies have focused on specific elements of PCS such as change management and earned value. For instance, change management maturity model (CM3) was developed by (Sun *et al.*, 2009) which consists of six key processes evaluated against five maturity levels. Stratton (2006) also proposed a five-level maturity model as a tool to assess an organization's capability in earned value management. These studies show that established, high capability maturity levels lead to better and more consistent performance, particularly in the construction industry. Project management standards also identify PCS as one of the project management knowledge areas and have addressed PCS maturity as part of organizational maturity (PMI, 2013, 2017). A study conducted by Jawad and Ledwith (2021) has attempted to consider more PCS elements by proposing a new PCS maturity model that measures project control capabilities and the quality of applying project control tools. This model defines six critical elements of a PCS: 1) change management, 2) earned value, 3) baselined plan, 4) resource allocation, 5) progress method and 6) project governance. The approach of this model is to provide a comprehensive framework for PCS by including project governance that allows the project team to review project performance and add corrective verification processes (White and Fortune, 2002).

These models provide a practical framework to help organizations assess their performance in the main elements of PCS and improve their maturity in each element however, the impact of enablers and barriers on these PCS elements has not been investigated. A study of the construction industry in Oman identified a number of factors effecting PCS success. These are: 1) schedule with documented milestones and deliverables, 2) ability of project team to manage scheduled activities, 3) effectiveness in reworking schedules, 4) reliability of schedules, 5) lack of leadership, 6) lack of support from project stakeholders, 7) lack of skills in planning and scheduling, 8) ineffective control and reporting system between management levels and 9) lack of use of new technology for project control (Al-Nasseri and Aulin, 2016). Another study in the same year conducted in Kenya identified project team experience diversity as a critical factor for PCS success and found that it had a significant positive impact on the performance of construction projects (Obare *et al.*, 2016). In 2018, Jawad *et al.* identified the critical enablers and barriers linked with successful PCS in the petroleum and chemical industry using a fuzzy multi-criteria model and expert's judgment. Their study identified a total of nine enablers and 15 barriers that related to PCS success (Jawad *et al.*, 2018). A follow-on study was then conducted using interpretive structural modeling (ISM) to examine the relationship between these enablers and barriers and to identify the most dominant ones (Jawad and Ledwith, 2020). This study identified (3) dominant enablers that drive successful PCS: 1) "Skilled and experienced project team members", 2) "Explicitly defined roles of project team members" and 3) "An accurate Work Breakdown Structure (WBS)". Also identified were six dominant barriers: 1) "Lack of standard processes", 2) "Vague contract deliverables", 3) "Unclear project goals", 4) "Unclear project milestones", 5) "Disparate control system between owner and contractor" and 6) "Lack of information communication".

Although previous studies present practical frameworks for 1) the main elements of PCS success and 2) the enablers and barriers of successful PCS implementation (Jawad and Ledwith, 2020, 2021), the relationship between these two frameworks needs to be investigated in the context of project success. Two questions remain unanswered; 1) which PCS elements are critical to achieve project objectives of scope, schedule and cost? and 2) what are the critical enablers and barriers that impact these PCS elements.

This study builds on the research about PCS implementation and maturity models described above by identifying; 1) the specific elements of PCS that impact project success, and 2) the individual enablers and barriers that influence each of the six PCS elements. Hence, three enablers, six barriers and six elements of PCS have been selected to develop the research model for this study shown in Figure 1. A new modeling approach aims to provide a wider understanding of PCS as an integrated framework for project success. The proposed model contributes to project management knowledge and differs from previous attempts in two ways. Firstly, it investigates the elements of PCS that are critical to achieving project scope, schedule and cost objective; secondly, enablers and barriers of PCS success are examined to see how they influence each PCS element independently. The methodology to validate the proposed model presented is explained in the next section.

3. Research methodology

The objectives of this study are twofold: 1) to examine which of the PCS elements are more important for achieving project scope, schedule, and cost and 2) to identify which enablers and barriers of PCS implementation impact these elements and drives project success. Following the literature review presented in the previous section, six elements are identified as critical components of PCS. These elements are: 1) change management, 2) earned value, 3) baselined plan, 4) resource allocation, 5) progress method and 6) project governance. The performance of these elements can be measured using the PCS maturity model developed by Jawad and Ledwith (2021). This model presents a framework for the measurement of PCS success and improvement of PCS capability as shown in Table 1.

The assessment of maturity in this model involves improving project control capabilities of the six PCS elements against five maturity levels (Crawford, 2014; Kwak and Ibbs, 2002; Lianying *et al.*, 2012) as described in Table 2.

The level of maturity is expressed on a 1 to 5 Likert scale, where 1 is the lowest level of process maturity and 5 the highest (Backlund *et al.*, 2013; Crawford, 2014; Lianying *et al.*, 2012). This scale is well established in the literature and one of the most widely used in assessing process maturity in project management (Backlund *et al.*, 2013; Brookes *et al.*, 2014; Duffy, 2001; PMI, 2013).

To achieve the second objectives, the dominant enablers and barriers of PCS implementation have been selected from the literature review (Jawad and Ledwith, 2020). The description of these enablers and barriers are shown in Table 3.

The approach undertaken to achieve the research objectives is a questionnaire survey. To investigate the relationship between PCS elements and project success, the respondents were asked to rate the impact of each of the six PCS elements on project objectives: scope, schedule and cost. The survey also asked respondents to assess the performance of their PCS in each of the six elements and to report the impact that each of the enablers and barriers had on these elements. The steps of the applied methodology are outlined in Figure 2. The development of the survey instrument used to collect data, and the data collection process is described in the following sections.

3.1 Survey instrument

The survey questionnaire used for data collection in this study consists of four sections. The first section contained open questions collecting background information about the respondents and their projects such as position, total years of experience and the number of projects being managed. In the second section of the survey, respondents were asked to assess the performance of their PCS in terms of the maturity level of the six elements: 1) change management, 2) earned value, 3) baselined plan, 4) resource allocation, 5) progress method and 6) project governance. The respondents in this section had to rate each element on a five-level Likert scale, as follows: 1 = Level 1 (Ad-hoc), 2 = Level 2 (Repeatable), 3 = Level 3 (Defined), 4 = Level 4 (Managed) and 5 = Level 5 (Optimized). This scale is typically used to assess the maturity level in project management studies (Backlund *et al.*, 2013; Brookes *et al.*, 2014; Sun *et al.*, 2009). The third section of the survey was designed to allow the respondents to determine the impact that the three enablers and six barriers have on the six PCS elements. The impact level was measured on a five-point Likert scale: 1 = Not significant, 2-Low significance, 3-Significant, 4-High significance and 5-Very high

Elements of PCS success	Maturity level	Key capabilities of PCS success
1. Change Management A documented management of change process that clearly sets out the method of project change required to correct deviations against project objectives	Level 1	No change management processes in place. Few processes are defined on a regular basis
	Level 2	Basic change management processes are established, but it is not enforced consistently. The project team is reactive to changes
	Level 3	Change Management processes are followed in a consistent basis and documented. The project team begins proactive in anticipating changes. Audit trail is recorded
	Level 4	The change management processes are integrated throughout the team and with other functions. There is a dedicated measurement system for change management. The project team is supportive to managing changes
	Level 5	Change management Performance evaluation metrics are developed and implemented. Processes are monitored and analyzed for potential improvement. The project team takes full advantage of technology support
2. Earned Value The value of work performed; Earned Value (EV) can be provided from the PCS based upon the basis of the project schedule	Level 1	No or limited EVM implementation in place, any use of Earned Value is limited to individuals
	Level 2	Basic EVM at the lowest level of WBS is established and basic reviews of SPI and CPI are carried out
	Level 3	EVM system is defined and documented based on an international standard
	Level 4	There is a dedicated measurement system for EVM use. Advanced applications of Earned Value
	Level 5	Plans are put in place to improve the quality of the EV data and it use. Metrics are used to track EVMS improvements
3. Baselined Plan An appropriately presented base lined schedule within an agreed definition of project scope using a defined WBS	Level 1	No formal methods for capturing the major Project deliverables (WBS), activities are randomly placed in the schedule, and some schedule constraints, calendars and major deliverables are identified
	Level 2	Scope, constraints, and major deliverables are defined, not all activities are assigned to a WBS element
	Level 3	The project durations and deliverables are clearly defined and documented and related to the projects WBS including third parties, subcontractors, and field activities. Project has an established a clearly identifiable critical path
	Level 4	The schedule is comprehensively structured by the WBS and milestones. Cross-WBS linkages are defined in the schedule logic. Schedule is integrated with other functions such progress method and reporting. Schedule risks are identified
	Level 5	Changes to baseline are properly managed through a documented, integrated change control process. Schedule modeling techniques are used e.g. networking. All schedule optimization techniques are documented along with a rationale and risk assessment and are approved by management
4. Resource Loaded A schedule that defines activities and resources required to complete the project-considering the Construction, Commissioning and Handover to Operations stages	Level 1	No formal methods to define the resource requirements, resource categorization not defined
	Level 2	Basic Methods of presenting resource allocations and categorization are established
	Level 3	Methods of presenting resource allocations and categorization are defined and documented; resource requirements are based upon demonstrated historical performance
	Level 4	Risk mitigation of resource constraints can be identified, and timely corrective action proposed. Changes to schedule comprehend the resources constraints and is adjusted considering those constraints
	Level 5	Resource changes and update to PCS is defined in an integrated change control process. All schedule optimization techniques are documented along with a rationale and risk assessment and are approved by management

(*continued*)

Table 1.
Six elements of PCS success with maturity level criteria

Elements of PCS success	Maturity level	Key capabilities of PCS success
5. Progress Method Clear and documented method to progress deliverables, activities, and materials/sub-contractor throughout all stages of project "life cycle"	Level 1	No formal progress method defined or in place, progressing deliverables depend on the capabilities of individuals
	Level 2	Basic methods of progressing deliverables and activities are established
	Level 3	Methods of progressing deliverables and activities, forecasting, and performance measurements are defined and documented. Methods of progressing other project activities such as third-party services, construction, and commissioning are defined, documented and part of the PCS
	Level 4	Method in place to report deviation from the project baseline to allow corrective action to be undertaken. PCS is integrated and there is only one entry of raw data on regular basis
	Level 5	Processes are continuously monitored and analyzed for potential improvement
6. Project Governance The project has a governance program with all stakeholders where project performance is reviewed	Level 1	No governance program in place
	Level 2	Basic Process of project performance review with all stockholders is established
	Level 3	Governance program is defined and documented. Project management team roles and authorization level are defined and documented
	Level 4	PCS produces information and data that drives decision making. Information sharing process that streamlines and empowers decision making
	Level 5	Goals are set for improving the governance program. Project team shares holistic view of what value PCS is to the overall project success

Table 1.

Level	Title	Description
Level 1	Ad-hoc	Processes are not established
Level 2	Repeatable	Basic processes have been established
Level 3	Defined	The processes necessary to achieve the organizational purpose are documented, standardized and integrated with other processes in the business
Level 4	Managed	Evidence of quantitative objectives for quality and process performance, to be used as criteria in decision making
Level 5	Optimized	The organization is focused on optimization of its quantitatively managed processes for making organizational management decisions for the future

Table 2.
PCS maturity levels description

significance (Artur, 2019; Kriksciuniene *et al.*, 2019). The same scale was used in the last section of the survey, Section 4, to collect data on the impact of each PCS element on project objectives: scope, schedule, and cost. To increase the response rate, an online survey using the QuestionPro platform was developed. Finally, a pilot study was conducted to validate and pre-test the survey and subsequently modified before a final version was submitted to the respondents.

3.2 Case study and data collection

Petroleum and chemical projects are a major part of the engineering and construction industry that includes chemical plant, oil and gas field engineering, manufacturing, construction, operation and maintenance services. In Saudi Arabia, although the Saudi government presented Vision 2030, an ambitious plan for moving the kingdom beyond oil dependence, the petroleum and chemical sector is still critical to the country and a major

Enablers	Definition
E1 – Skilled and experienced project team members	A variety of skills and competencies required for a project team to be effective in project control. These capabilities can be gleaned from experience and often take years to master
E2 – Explicitly define roles of project team members	Job description that indicate responsibilities and corresponding expectations, clearly define level of authority in order to make decisions defined by project organization chart, working methods defined by standard processes, procedures and tools
E3 – Accurate and detailed WBS	The work breakdown structure (WBS) identifies the project elements that will need resources and thus is the primary input to resource planning. Any relevant outputs from other planning processes should be provided through the WBS to ensure proper control

Barriers	Definition
B1 – Lack of standard processes	Poor standardized project management that is composed of standardized practices standardization means the degree of absence of variation in implementing such practices
B2 – Vague contract deliverables	Vague and inconsistent information regarding contract, Scope of Work and contract deliverables
B3 – Unclear project goals and objectives	A lack of direction and define desired benefits and outcomes of project
B4 – Un-clear project milestones	Poor planning for schedule activities that shows an important achievement in a project.
B5 – Disparate control system between owner and contractor	Different control system between owner and contractor in term of defining Scope of Work, deliverables, scheduled, payment methods and indistinct criterion used to define project completion
B6 – Lack of information communication	Poor communication planning that includes the processes required to ensure timely and appropriate generation, collection, distribution, storage, retrieval and ultimate disposition of project information

Table 3.
Description of PCS enablers and barriers

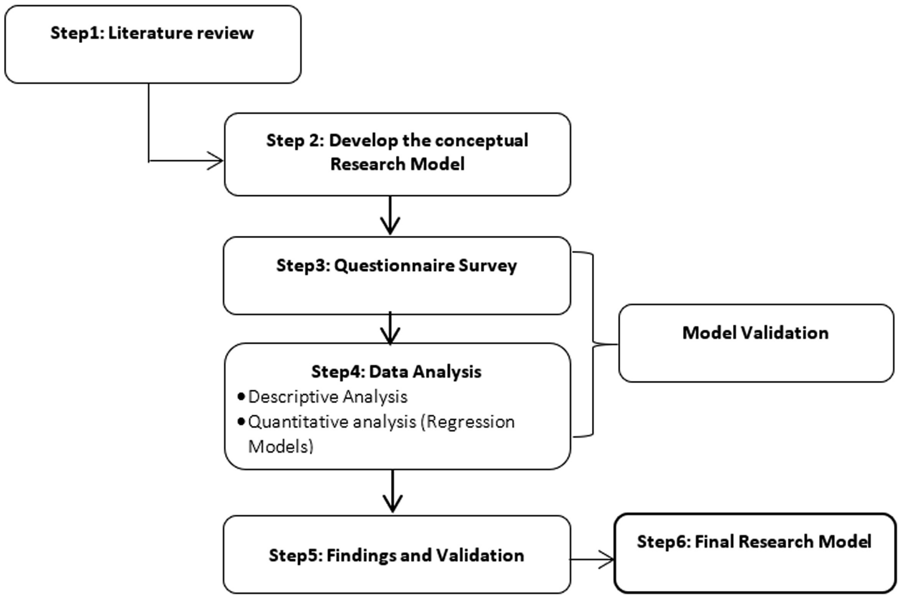

Figure 2.
Research methodology

contributor to the kingdom's economic growth (Alkahtani *et al.*, 2018; Erdogan *et al.*, 2010; Moshashai *et al.*, 2020). Schedule delays, budget overruns and scope changes that prevail in those projects, particularly with the COVID 19 pandemic, pose serious challenges in this sector (Gamil and Alhagar, 2020; Shibani *et al.*, 2020). An effective PCS will have a significant influence on the way which these challenges can be addressed. Therefore, petroleum and chemical projects in Saudi Arabia were selected to validate the research model.

The survey targeted organizations involved in the petroleum and chemical industry in Saudi Arabia. The initial list came from a company register (gulftalent.com) this list was shortened to include those companies that operated in the petroleum and chemical sector which comprise 72 companies. The sampling technique used for data collection was random sampling of respondents sourced from professional platforms. The survey was sent to 1,400 participants in October/September 2020. According to Adam (2020), the number of respondents required to provide a 95% confidence level in the survey was 302. The total completed responses received back was 400 which represent 29% response rate and well above the required 95% confidence level. The completed respondents came from nine owner/operator, 13 engineering and 21 engineering, procurement and construction (EPC) companies. Table 4 shows the complete analysis of the survey, the high non-disclosure percentage for completed surveys was expected due to the high level of confidentiality that exist within the petroleum and chemical industry. The valid data set was then organized and analyzed using SPSS software.

4. Data analysis and results

4.1 Data profile and reliability tests

Initial analysis of the main attributes of respondent's profiles including; position, years of experience and number of projects managed, is shown in Table 5.

The survey questionnaire in this study consists of 13 constructs, shown in Table 1. The first construct assesses the performance of the six elements of PCS using PCS maturity levels, the next nine constructs map enablers and barriers individually against PCS elements and the last three constructs evaluate each element of PCS against project objectives scope, schedule, and cost. The reliability of the research instrument was examined in terms of the stability and consistency of the results for each construct (Mohamad *et al.*, 2015; Taherdoost, 2016). To assess the consistency of the results, Cronbach's coefficient alpha is applied. According (Streiner, 2003; Gliem and Gliem, 2003) Cronbach's coefficient alpha is considered the most preferred method for assessing the reliability of measures. The coefficients of 0.7 or above are

Description	Number of items	%
Total surveys distributed	1,400	100.0%
Surveys completed	400	29%
Surveys terminated	39	3%
Surveys not responded	961	68%
Company representation from survey		
Respondents from owner/operator	*127*	*32%*
Number of organizations in survey	19	
Number of organizations represented in respondents	9	
Respondents from engineering consultant	*79*	*20%*
Number of organizations in survey	28	
Number of organizations represented in respondents	13	
Respondents from EPC contractors	*101*	*25%*
Number of organizations in survey	25	
Number of organizations represented in respondents	21	
Respondents from undisclosed	*93*	*23%*

Table 4.
Survey summary

generally considered to be an excellent value for reliability (Cho and Kim, 2015; Streiner, 2003). In this study the value of Cronbach's Alpha for each construct was greater than 0.7 as presented in Table 6.

4.2 Descriptive analysis: PCS elements that drive project objectives

The next stage of the analysis is to measure the performance of the companies surveyed in the six elements of PCS. The respondents were asked to assess the maturity level of each of the PCS elements: 1) change management, 2) earned value, 3) baselined plan, 4) resource allocation, 5) progress method and 6) project governance against the capabilities defined for each level

Respondent's years of experience	<10 years	42%
	Between 11 years and <20 years	42%
	>20 years	12%
Respondent's position	Project management	51%
	Technical management	11%
	Construction/Field management	6%
	Project controls	28%
Average projects being managed by respondents	<10 projects	77%
	Between 11 projects and 20 projects	7%
	>20 projects	16%

Table 5.
Respondents' profile

Construct no.	Description	Number of items	Cronbach's alpha
Construct 1	Maturity level of the six elements of PCS, Change Management, Earned Value, Baselined Plan, Resource Loaded, Progress Method and Governance Program	6	0.951
Construct 2	Significance of the impact of "E1 – Skilled and experienced project team members" on the six elements of PCS	6	0.951
Construct 3	Significance of the impact of "E2 – Explicitly define roles of project team members" on the six elements of PCS	6	0.968
Construct 4	Significance of the impact of "E3 – Accurate and detailed WBS" on the six elements of PCS	6	0.929
Construct 5	Significance of the impact of "B1 – Lack of standard processes" on the six elements of PCS	6	0.929
Construct 6	Significance of the impact of "B2 - Vague contract deliverables" on the six elements of PCS	6	0.910
Construct 7	Significance of the impact of "B3 – Unclear project goals and objectives" on the six elements of PCS	6	0.912
Construct 8	Significance of the impact of "B4 - Un-clear project milestones" on the six elements of PCS	6	0.948
Construct 9	Significance of the impact of "B5 – Disparate control system between owner and contractor" on the six elements of PCS	6	0.937
Construct 10	Significance of the impact of "B6 – Lack of information communication" on the six elements of PCS	6	0.958
Construct 11	Significance of the impact of the six elements of PCS on project Scope objective	6	0.932
Construct 12	Significance of the impact of the six elements of PCS on project Schedule objective	6	0.876
Construct 13	Significance of the impact of the six elements of PCS on project Cost objective	6	0.783

Table 6.
Reliability statistics

(Table 1). The purpose of this step was to operationalize the six elements of the PCS which represent the dependent variables in the research model. The variables were operationalized by averaging the items scores across each variable. Table 7 presents the distribution of survey respondents. For example, for change management 0.8% of the respondents indicated that they were at Level 1 (Ad-Hoc) and 50.8% indicated that were at Level 5 (Optimized). Generally, the results show that a minimum of 90% of the respondents indicated that their organizations operated at level 4 (Managed) or Level 5 (Optimized) for all six PCS elements.

The first objective in this study is to examine the relationship between PCS elements and project success objectives. To achieve this, the respondents were asked to map how each of the six PCS elements impacted the three project objectives scope, schedule and cost. The average values for each construct between the six elements of PCS and three project objectives were calculated. Table 8 presents the results showing which PCS element was considered by respondents to have the greatest impact on each project objective.

The results show that project governance and baselined plan were judged to have the highest impact on achieving project scope objectives with scores of 4.26 and 4.11, respectively. Project governance (4.26), earned value (4.13) and resource allocation (4.13) were ranked as most important for meeting schedule objective. Finally, for project cost objectives, project governance and earned value were deemed as the most important with scores of 4.45 and 4.38. Based on these results, the top two elements within each of project objectives were selected for regression analysis. These elements are: project governance, earned value, baselined plan and resource allocation. From Table 8, it can be observed that all six elements have a high score for project cost objective. This would indicate that the respondents consider the PCS elements more important in controlling project cost and executing projects within the planned budget.

4.3 Quantitative analysis: regression models

The second objective of this study was to identify which enablers and barriers of PCS implementation impact PCS elements and drive project success. To achieve this objective, the respondents were asked to assess the impact of each enabler and barrier individually on the each of the six PCS elements. The results of the previous analysis of PCS elements identify the

Maturity level	Change management	Earned value	Baselined plan	Resource allocation	Progress method	Governance program
Level 1 Ad-Hoc	0.8%	0.5%	0.5%	0.8%	0.8%	0.5%
Level 2 Repeatable	2.0%	2.0%	2.0%	2.0%	2.0%	2.5%
Level 3 Defined	5.5%	6.8%	5.8%	6.5%	6.5%	4.8%
Level 4 Managed	41.0%	39.8%	38.8%	39.8%	39.3%	39.3%
Level 5 Optimized	50.8%	51.0%	53.0%	50.8%	51.5%	53.0%

Table 7. Respondents feedback on maturity level for each PCS element

Scope objective		Schedule objective		Cost objective	
Governance program	4.26	Governance program	4.26	Governance program	4.45
Baselined plan	4.11	Earned value	4.13	Earned value	4.38
Progress method	4.08	Resource allocation	4.13	Resource allocation	4.29
Earned value	4.04	Progress method	4.05	Progress method	4.29
Resource allocation	4.04	Baselined plan	3.86	Baselined plan	4.24
Change Management	4.00	Change Management	3.83	Change Management	4.21

Table 8. PCS elements ranking for project objectives

four (4) elements are the most important in accomplishing the three project objectives scope, schedule and cost. These elements are: project governance, earned value, baselined plan and resource allocation. Therefore, these elements were used for further quantitative analysis to examine the significant enablers and barriers that impact their performance.

Linear regression analysis provided an estimate of the linear equation coefficients, concerning one or more independent variables that resulted in the best prediction of the dependent variable value (Seber and Lee, 2012). Prior to running any of the regression's models, multicollinearity was checked with bivariate correlation analysis (Pallant, 2010). None of the independent variables (enablers and barriers) have a correlation with each other of greater than 0.7 (Appendix 1). This result indicates that the multicollinearity assumption has not been violated. A regression analysis was thus conducted for a total of 400 responses. The following tables present the four regression models run between the independent variables (three enablers and six barriers) of PCS implementation and the dependent variables of project governance, earned value, baselined plan and resource allocation. All models are significant explaining between 28% and 35% of the variation of the dependent variables (Appendix 2).

4.3.1 Regression model 1 – project governance. The dependent variable for regression model 1 is project governance. The independent variables are the three enablers and six barriers of PCS implementation that are listed in Table 3. The model was significant and had an R^2 of 0.339, ($p < 0.01$). One enabler and three barriers made a unique contribution to the performance of project governance;

(1) E1- Skilled and experienced project team members (beta = 0.177, $p < 0.01$).

(2) B1-Lack of standard processes (beta = 0.246, $p < 0.01$).

(3) B3-Unclear project goals (beta = 0.176, $p < 0.01$).

(4) B5-Disparate control system between owner and contractor (beta = 0.141, $p < 0.01$).

The beta value indicates that "Lack of standard processes" has the most significant impact on project governance.

4.3.2 Regression model 2 – earned value. The dependent variable for regression model 2 is earned value. The independent variables are the three enablers and six barriers of PCS implementation that listed in Table 3. The model was significant and had an R^2 of 0.281, ($p < 0.01$). One enabler and three barriers made a unique contribution to the performance of earned value;

(1) E1- Skilled and experienced project team members (beta = 0.218, $p < 0.01$).

(2) B1-Lack of standard processes (beta = 0.151, $p < 0.01$).

(3) B3-Unclear project goals (beta = 0.183, $p < 0.01$).

(4) B5-Disparate control system between owner and contractor (beta = 0.157, $p < 0.01$).

The beta value indicates that "Skilled and experienced project team members" has the most significant impact of earned value.

4.3.3 Regression model 3 – baselined plan. The dependent variable for regression model 3 is baselined plan. The independent variables are the 3 enablers and 6 barriers of PCS implementation that listed in Table 3. The model was significant and had an R^2 of 0.302, ($p < 0.01$). One enabler and three barriers made a unique contribution to the performance of baselined plan;

(1) E1- Skilled and experienced project team members (beta = 0.157, $p < 0.01$).

(2) B1-Lack of standard processes (beta = 0.224, $p < 0.01$).

(3) B3-Unclear project goals (beta = 0.186, $p < 0.01$).

(4) B5-Disparate control system between owner and contractor (beta = 0.134, $p < 0.01$).

The beta value indicates that "Lack of standard processes" has the most significant impact of baselined plan.

4.3.4 Regression model 4 – resource allocation. The dependent variable for regression model 4 is resource allocation. The independent variables are the three enablers and six barriers of PCS implementation that listed in Table 3. The model was significant and had an R^2 of 0.306, ($p < 0.01$). One enabler and three barriers made a unique contribution to the performance of resource allocation;

(1) E1- Skilled and experienced project team members (beta = 0.207, $p < 0.01$).

(2) B1-Lack of standard processes (beta = 0.214, $p < 0.01$).

(3) B3-Unclear project goals (beta = 0.183, $p < 0.01$).

(4) B5-Disparate control system between owner and contractor (beta = 0.141, $p < 0.01$).

The beta value indicates that "Lack of standard processes" has the most significant impact of resource allocation.

The results of the four regression models are presented in Table 9. The results show that "Skilled and experienced project team members", "Lack of standard processes", "Unclear project goals and objectives" and "Disparate control system between owner and contractor" have significant impact in all four models ($p < 0.01$). The negative coefficients reported for "Unclear project milestones" and "Lack of information communication" in some of the regression models is surprising since the survey questions asked only for significance of the impact of independent variables against dependent variables not whether that impact was positive of negative. However, since the results showed these independent variables as

	Dependent variables							
	Model 1 Governance program		Model 2 Earned value		Model 3 Baselined plan		Model 4 Resource allocation	
Independent variables	Beta	Sig. (p)	Beta	Sig. (p)	Beta	Sig. (p)	Beta	Sig. (p)
E1 – Skilled and experienced project team members	0.177	0.001	0.218	0.000	0.157	0.003	0.207	0.000
E2 – Explicitly defined roles of project team members	0.087	0.108	0.132	0.019	0.054	0.330	0.076	0.171
E3 – An accurate work breakdown structure (WBS)	0.112	0.022	0.075	0.143	0.086	0.089	0.082	0.101
B1 – Lack of standard processes	0.246	0.000	0.151	0.006	0.224	0.000	0.214	0.000
B2 – Vague contract deliverables	0.013	0.760	0.035	0.430	0.042	0.343	0.016	0.718
B3 – Unclear project goals	0.176	0.000	0.183	0.000	0.186	0.000	0.183	0.000
B4 – Unclear project milestones	−0.031	0.536	−0.056	0.280	0.001	0.987	−0.067	0.190
B5 – Disparate control system between owner and contractor	0.141	0.001	0.157	0.001	0.134	0.003	0.141	0.002
B6 – Lack of information communication	−0.028	0.595	−0.078	0.153	−0.004	0.936	0.011	0.838
R^2	0.339		0.281		0.302		0.306	
Model significance	0.000		0.000		0.000		0.000	

Table 9. Results of the four regression models

insignificant with ($p > 0.1$), they were not considered as part of the research model and thus warrant no further investigation.

5. Discussion and final research model

A well implemented PCS contributes to the boarder strategic goals of the organization by supporting an integrated framework of processes and people that work together to execute projects successfully (Jayaraman, 2016; Jünge *et al.*, 2019). A clear understanding of the enablers and barriers that impact PCS implementation has a direct bearing on an organization's ability to deliver successful projects. In this context, it is crucial that the PCS elements linked with project success are defined and that the associated enablers and barriers are understood and managed. Therefore, the main objectives of this study were: (1) to investigate the PCS elements that are critical to achieve project success; and (2) to identify the significant enablers and barriers of PCS success by examining the impact of these enablers and barriers on each elements of PCS. Based on the results of a previous studies (Jawad and Ledwith, 2020, 2021), three enablers, six barriers and six elements of PCS success were selected to further study in this research.

Descriptive analysis was conducted to map the PCS elements against each project objectives scope, schedule and cost. Quantitative analysis was then preformed to identify which enablers and barriers impact the performance of the critical PCS elements that defined for each project objective. Figure 3 presents the final research model.

Some of the major findings of this model are:

(1) The result suggests that engineering and construction organizations should consider PCS as a key tool to achieve project cost objectives. Although there is a slight difference in weighting between the importance of PCS for each of the three project objectives, the high importance rating allocated to project cost indicates that respondents should considered PCS as the main project management tool for completing a project within the planned budget.

(2) The study has identified project governance, earned value, baselined plan and resource allocation as the most important PCS elements to accomplish the three project objectives scope, schedule and cost.

(3) Project governance was identified as the most critical PCS element for all three project objectives – scope, schedule and cost. Although project governance is not discussed frequently in project management studies as part of PCS (Too and Weaver, 2014; Too *et al.*, 2017), this study has highlighted that it is the main PCS element that directly links with project performance. Good project governance clearly articulates structured roles, responsibilities and accountabilities within a project, this facilitates an effective monitoring and decision-making process. Project governance is the key PCS element that provides different project stakeholders with a structure that aligns the project deliverables with their organizational goals (Joslin and Müller, 2015).

(4) The results also show that "Lack of standard processes" is a significant barrier that impacts the performance of the four PCS elements and is most significant for project governance. This result infers that from respondent's perspective project governance requires structure and repeatability to be effective. This barrier can only be addressed when the organization has formally documented the processes that are implemented in line with organizational standards for PCS. This requires strong organizational leadership and a concerted effort especially when the organization undertakes a wide variety of projects with different clients and different magnitudes of scope (Dinsmore and Cabanis-Brewin, 2014; PMI, 2017).

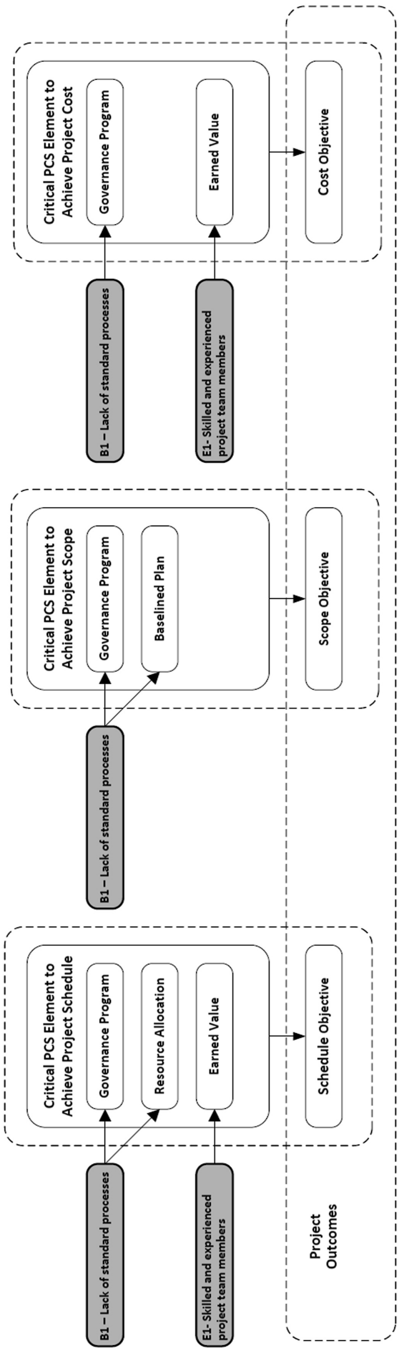

Figure 3.
Final research model

(5) The findings of this study show that "Skilled and experienced project team members" is a significant enabler that impacts the performance of the four PCS elements, most significantly impacting earned value. Organizations need to recognize that essential competencies are required in project team members across all elements of the PCS, particularly earned value. These competencies involve detailed knowledge of the systems and software being utilized on projects. Acquiring these competencies can involve years of experience as well as technical qualifications (Khoury, 2014; Wang and Yuan, 2011). In engineering and construction projects, the diversity and complexity of projects requires skills gained through experience in the industry using specific PCS systems and tools (Yosua *et al.*, 2006).

(6) In addition, this study identified "Unclear project goals and objectives", and "Disparate control system between owner and contractor" as significant barriers for the four PCS elements. This result can be explained by reflecting that engineering and construction projects typically include multiple parties with different interests and project goals. Differences in organizations' objectives, combined with the enormous variety of unexpected situations that emerge during project execution, makes disparate control system between owner and contractor unavoidable (Doloi, 2011; Kivilä *et al.*, 2017; Pinto *et al.*, 2009). Effective PCS then depends on the project team defining goals and objectives that all parties agree with and consider legitimate, this allows them to be built into the organization's PCS.

The research model has revealed some nuances specific to the three project objectives scope, schedule and cost. These are discussed below:

5.1 Project scope objective

The results indicate that project governance and a baselined plan are the most important PCS elements to achieve the project scope of work. A baselined plan is a clearly defined starting point for a project that allows the project management team to assess deviations against the agreed plan. This baseline represents the planned execution of the project scope with defined deliverables and associated resources (Dinsmore and Cabanis-Brewin, 2014; PMI, 2017). The results also show that "Lack of standard processes" is the most significant barrier to developing a baselined plan. This result confirms that having a standardized approach to creating a baseline plan is critical in order to deliver project scope objectives.

5.2 Project schedule objective

The results of this study suggest that project governance, resource allocation and earned value are the most important PCS elements to meet a project schedule. This result confirms that the project management team needs to understand the resources required to deliver each scheduled activity in order to complete a project on time (Dinsmore and Cabanis-Brewin, 2014; PMI, 2017). This also becomes important as any deviations observed through project governance can be effectively corrected if resources are identified and available. The results also show that "Lack of standard processes" is the most significant barrier to the resource allocation element of PCS. This result confirms that a standardized approach to resource loading the project baseline plan is critical to ensure that a project adheres to its schedule.

5.3 Project cost objective

Investigation into the most important PCS elements for project cost revealed that project governance and earned value are the critical elements to deliver a project within the planned budget. A clear earned value process through the project lifecycle is crucial to have an accurate understanding of the project progress and thus the actual and forecast cost.

The present study aimed to extend previous research in project control by providing an empirical investigation of the elements of PCS that are critical to achieving project scope, schedule and cost objectives. Moreover, enablers and barriers of PCS success are examined to see how they influence each element independently. The final research model was validated with data from a survey of 400 project management practitioners, thus the findings of this study can be generalized across similar industries.

6. Conclusion and implications

With the growing cost of overruns and delays in engineering and construction projects globally, particularly due to the impact of the Covid-19 pandemic, there is a need for governments and organizations to address the challenges of delivering projects within scope, cost and schedule objectives. Although many studies in project management have stressed PCS as a main component of project success and conversely failure, these studies have not offered empirical methods to address the factors that influence the level of PCS success.

This study contributes to our knowledge of project management by presenting a new model that explains the relationships between the six elements of PCS, and their enablers and barriers and the achievement of successful project outcomes, cost, schedule and scope. The results of this study revealed that project governance, earned value, baselined plan and resource allocation are the most important PCS elements to accomplish the three project objectives scope, schedule and cost. Moreover, this study identifies “Skilled and experienced project team members”, “Lack of standard processes”, “Unclear project goals and objectives” and “Disparate control system between owner and contractor” as the most significant factors for PCS success through the four identified elements. The study offers a direction for implementing and developing PCS as a strategic tool and focuses on the PCS elements that can best improve project outcomes. This paper provides project management teams in engineering and construction organizations with some practical implications:

(1) This study highlights the importance of effective project governance with clear responsibilities for decision making to achieve project objectives scope, schedule and cost. Every project should have demonstratively active project governance in place to ensure project objectives are reviewed by stakeholders and senior management.

(2) In order to achieve effective project governance, organizations need to ensure that standard processes are used by all project stakeholders. A lack of defined and documented processes inhibits the performance of all PCS elements.

(3) “Skilled and experienced project team members” is another area that organizations need to focus on when assembling project teams. This is a main enabler to assure the effective deployment and utilization of PCS in particulate earned value.

(4) Effective PCS is found to be particularly critical for achieving project cost objectives. Therefore, if a project is cost sensitive project managers need to ensure that all six elements of PCS are fully implemented.

One limitation of this research is that it is based on a case study of engineering and construction projects within the petroleum and chemical industry in Saudi Arabia. It is expected that the findings of this research will have applicability to other industries, but further studies in different sectors and regions should be undertaken to validate this assumption.

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Appendix 1

Table A1. Bivariate correlation test

	E1-skilled and experienced project team members	E2-explicity defined roles of project team members	E3-accurate work breakdown structure (WBS)	B1-lack of standard processes	B2-vague contract deliverables	B3-unclear project goals	B4-unclear project milestones	B5-disparate control system between owner and contractor	B6-lack of information communication
E1- Skilled and experienced team members	1	0.310**	0.308**	0.350**	0.016	0.351**	0.163**	0.277**	0.252**
E2-Explicity defined roles of project team members	0.310**	1	0.185**	0.483**	0.106*	0.273**	−0.052	0.411**	0.312**
E3-Accurate work breakdown structure (WBS)	0.308**	0.185**	1	0.158**	0.016	0.121*	−0.089	0.174**	0.268**
B1-Lack of standard processes	0.350**	0.483**	0.158**	1	0.122*	0.397**	0.018	0.624**	0.150**
B2-Vague contract deliverables	0.016	0.106*	0.016	0.122*	1	−0.076	0.029	0.151**	0.065
B3-Unclear project goals	0.351**	0.273**	0.121*	0.397**	−0.076	1	−0.032	0.247**	0.100*
B4-Unclear project milestones	0.163**	−0.052	−0.089	0.018	0.029	−0.032	1	−0.110*	−0.024
B5-Disparate control system between owner and contractor	0.277**	0.411**	0.174**	0.624**	0.151**	0.247**	−0.110*	1	0.215**
B6-Lack of information communication	0.252**	0.312**	0.268**	0.150**	0.065	0.100*	−0.024	0.215**	1

** Correlation is significant at the 0.01 level (2-tailed)

Appendix 2

1-Regression Model 1 – project governance

Dependent Variable: Project Governance
Independent Variables: three enablers and six barriers of PCS implementation

Model summary

					Change statistics				
Model	*R*	*R* square	Adjusted *R* square	Std. Error of the estimate	*R* square change	*F* change	*df*1	*df*2	Sig. *F* change
1	0.582[A]	0.339	0.324	0.52982	0.339	22.252	9	390	0.000

Note(s): [A]Predictors (Constant), El, E2, E3, Bl, B2, B3, B4, B5, B6

Anova[A]

Model	Sum of squares	*df*	Mean square	*F*	Sig
1 Regression	56.219	9	6.247	22.252	0.000[B]
Residual	109.479	390	0.281		
Total	165.697	399			

Note(s): [A]Dependent Variable: Project Governance
[B]Predictors: (Constant), El, E2, E3, Bl, B2, B3, B4, B5, B6

Co-efficients[A]

	Unstandardized coefficients		Standardized coefficients		
Model	*B*	Std. error	Beta	*t*	Sig
1 (Constant)	0.101	0.366		0.276	0.783
E1-Skilled and experienced team members	0.191	0.055	0.177	3.450	0.001
E2-Explicity defined roles of project team members	0.077	0.048	0.087	1.609	0.108
E3-Accurate work breakdown structure (WBS)	0.131	0.057	0.112	2.293	0.022
B1-Lack of standard processes	0.269	0.057	0.246	4.731	0.000
B2-Vague contract deliverables	0.015	0.048	0.013	0.305	0.760
B3-Unclear project goals	0.231	0.058	0.176	3.982	0.000
B4-Unclear project milestones	−0.031	0.050	−0.031	−0.620	0.536
B5-Disparate control system between owner and contractor	0.132	0.041	0.141	3.207	0.001
B6-Lack of information communication	−0.022	0.041	−0.028	−0.532	0.595

Note(s): [A]Dependent Variable: Project Governance

2-Regression Model 2 – earned value
Dependent Variable: Earned Value
Independent Variables: three enablers and six barriers of PCS implementation

Model summary

Model	R	R square	Adjusted R square	Std. Error of the estimate	Change statistics R square change	F change	$df1$	$df2$	Sig. F change
1	0.531[A]	0.281	0.265	0.54496	0.281	16.974	9	390	0.000

Note(s): [A]Predictors (Constant), E1, E2, E3, B1, B2, B3, B4, B5, B6

Anova[A]

Model	Sum of squares	df	Mean square	F	Sig
1 Regression	45.369	9	5.041	16.974	0.000[B]
Residual	115.821	390	0.297		
Total	161.190	399			

Note(s): [A]Dependent Variable: Earned Value
[B]Predictors: (Constant), E1, E2, E3, B1, B2, B3, B4, B5, B6

Co-efficients[A]

Model	Unstandardized coefficients B	std. error	Standardized coefficients Beta	t	Sig
1 (Constant)	0.484	0.376		1.287	0.199
E1-Skilled and experienced team members	0.233	0.057	0.218	4.080	0.000
E2-Explicity defined roles of project team members	0.116	0.049	0.132	2.347	0.019
E3-Accurate work breakdown structure (WBS)	0.086	0.059	0.075	1.467	0.143
B1-Lack of standard processes	0.163	0.059	0.151	2.781	0.006
B2-Vague contract deliverables	0.039	0.050	0.035	0.789	0.430
B3-Unclear project goals	0.237	0.060	0.183	3.970	0.000
B4-Unclear project milestones	−0.056	0.051	−0.056	−1.082	0.280
B5-Disparate control system between owner and contractor	0.145	0.042	0.157	3.417	0.001
B6-Lack of information communication	−0.060	0.042	−0.078	1.432	0.153

Note(s): [A]Dependent Variable: Earned Value

3-Regression Model 3 – baselined plan
Dependent Variable: baselined plan
Independent Variables: three enablers and six barriers of PCS implementation

Model summary

Model	R	R square	Adjusted R square	Std. Error of the estimate	Change statistics: R square change	F change	$df1$	$df2$	Sig. F change
1	0.549[A]	0.302	0.285	0.54152	0.302	18.712	9	390	0.000

Note(s): [A]Predictors (Constant), E1, E2, E3, B1, B2, B3, B4, B5, B6

ANOVA[A]

Model	Sum of squares	df	Mean square	F	Sig
1 Regression	49.384	9	5.487	18.712	0.000[B]
Residual	114.366	390	0.293		
Total	163.750	399			

Note(s): [A]Dependent Variable: Baselined Plan
[B]Predictors: (Constant), E1, E2, E3, B1, B2, B3, B4, B5, B6

Co-efficients[A]

Model	Unstandardized coefficients: B	Std. error	Standardized coefficients: Beta	t	Sig
1 (Constant)	0.219	0.374		0.586	0.558
E1-Skilled and experienced team members	0.169	0.057	0.157	2.983	0.003
E2-Explicity defined roles of project team members	0.048	0.049	0.054	0.976	0.330
E3-Accurate work breakdown structure (WBS)	0.099	0.058	0.086	1.704	0.089
B1-Lack of standard processes	0.244	0.058	0.224	4.187	0.000
B2-Vague contract deliverables	0.047	0.049	0.042	0.950	0.242
B3-Unclear project goals	0.241	0.059	0.186	4.074	0.000
B4-Unclear project milestones	0.001	0.051	0.001	0.016	0.987
B5-Disparate control system between owner and contractor	0.125	0.042	0.134	2.965	0.003
B6-Lack of information communication	−0.003	0.042	−0.004	−0.080	0.936

Note(s): [A]Dependent Variable: Baselined Plan

4-Regression Model 4 – resource allocation
Dependent Variable: resource allocation
Independent Variables: three enablers and six barriers of PCS implementation

Model summary

Model	R	R square	Adjusted R square	Std. Error of the estimate	Change statistics: R square change	F change	$df1$	$df2$	Sig. F change
1	0.553[A]	0.306	0.290	0.56104	0.306	19.072	9	390	0.000

Note(s): [A]Predictors (Constant), E1, E2, E3, B1, B2, B3, B4, B5, B6

Anova[A]

Model	Sum of squares	df	Mean square	F	Sig
1 Regression	54.031	9	6.003	19.072	0.000[B]
Residual	122.759	390	0.315		
Total	176.790	399			

Note(s): [A]Dependent Variable: Resource Loaded
[B]Predictors: (Constant), E1, E2, E3, B1, B2, B3, B4, B5, B6

Co-efficients[A]

Model	Unstandardized co-efficients B	Std. error	Standardized co-efficients Beta	t	Sig
1 (Constant)	0.285	0.387		0.736	0.462
E1-Skilled and experienced team members	0.231	0.059	0.207	3.932	0.000
E2-Explicity defined roles of project team members	0.070	0.051	0.076	1.371	0.171
E3-Accurate work breakdown structure (WBS)	0.099	0.060	0.082	1.645	0.101
B1-Lack of standard processes	0.241	0.060	0.214	4.002	0.000
B2-Vague contract deliverables	−0.018	0.051	−0.016	−0.362	0.718
B3-Unclear project goals	0.247	0.061	0.183	4.029	0.000
B4-Unclear project milestones	−0.069	0.053	−0.067	−1.313	0.190
B5-Disparate control system between owner and contractor	0.136	0.044	0.141	3.124	0.002
B6-Lack of information communication	0.009	0.043	0.011	0.205	0.838

Note(s): [A]Dependent Variable: Resource Loaded

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