

# Linking Project Health to Project Performance Indicators: Multiple Case Studies of Construction Projects in Saudi Arabia

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## ABSTRACT:

This research presents an empirical study of the relationship between project health and project performance in the project delivery context. Based on an existing Project Health Check (PHC) framework, the relationship has been tested in terms of a set of predefined indicators through the use of case study approach. The Swiss Cheese model was employed as a guiding principle to represent the links between PHC indicators and project Key Performance Indicators (KPIs). Three cases of construction projects in Saudi Arabia were investigated through a comprehensive review of the project performance history, using current performance indicators to establish the first slice of the Swiss Cheese model. PHC assessments were then conducted to shape the second slice of the model, which represent the maturity level of the project management. The relationships between the two slices were obtained from semi-structured interviews with the project managers. These relationships were analysed qualitatively by tracking patterns across the three cases. The result was used to develop the Swiss Cheese Performance Management Framework, which can potentially serve to help project managers identify the root causes of any shortcomings at the early stage in the project delivery process. This in turn can assist project managers in managing the overall project performance more effectively.

**KEYWORDS:** Case study, construction, project health, performance measurement, KPI, Saudi Arabia

## 1 Introduction

Performance measurement is a vital knowledge area. Indeed, it is considered as the force that drives project management improvement. Unfortunately, the majority of performance studies are concerned with Key Performance Indicators (KPIs) that measure project performance outcomes. These traditional measurements fail to provide insight into the means for improving performance, thus having limited use in internal management decision making (Bassioni et al, 2004). For this reason, the industry continues to suffer from projects that never achieve the outcomes expected by the key stakeholders (Humphreys et al. 2004). Importantly, Bassioni and others (2004) postulate that, “research needs to identify the reasons for failure to translate measurement information into action and suggest necessary remedies”. Moreover, Sarshar and others (2000) state that “the industry is unable to systematically assess construction process, prioritize process improvements, and direct resources appropriately”. Therefore, the performance management approach that focuses only on project KPIs can no longer be sustained in today’s competitive complex environment. Project managers need to manage a project’s performance in a proactive manner rather than reactive.

In response to these challenges, many researchers have begun to take a proactive approach in relation to performance management. Such approach involves forward measurement which aims at measuring the state of the process that leads to better results. Some examples of the research framework grounded on this approach include: SPICE, introduced by Sarshar and Haigh (2000, 2004); a model for assessing and correcting construction project health, introduced by Mian and Humphers (2009); and the Project Health Check (PHC) introduced by Jaafari (2007). The present paper focuses on the last framework, the PHC. Essentially, the PHC has been developed as a tool to diagnose management maturity, aiming to shift the management focus from measuring the performance effect to assessing the enabling factors (Jaafari 2007). This proactive approach provides the opportunity to enhance the project performance and avoid shortcomings. The enabling factors within the PHC emphasise project management roles and practices as the key to the success of any project. For example, the way the teamwork conducts, communicates and performs their tasks determines, to a large degree, the overall success of a project. Indeed, it could be argued that such enabling factors are most important. However, measuring these factors without incorporating performance outcomes might provide misleading data. Therefore, it is argued in this research that the PHC tool needs to be linked to project performance indicators (results) so that the managers understand the whole picture of the project performance. Jaafari (2007) noted that “the information obtained from the PH-Check and progress reports should be combined and used to judge which of the enabling factors need to be attended to and in what way to address any performance shortcoming”. When the project is not progressing as required and gives faulty outcomes, the project manager needs to be able to identify from where such undesirable result emerges and how it develops. In other words, the mechanism of failure has to be understood in order to avoid future failures and to develop an appropriate corrective action. Remedial actions cannot be taken if the root cause is not acknowledged or foreseen (Kangari 1988).

More importantly, to ensure that the project succeeds, it is also important to know which process enablers (management practices) lead to desirable outcomes. Thus, defining the success and failure processes within the project will help to ensure that the success is repeated and failure avoided. Linking process enablers and outcomes is therefore essential for effective performance management. With this in mind, the research presented herein was developed with the primary aim to identify and establish, through a systematic framework, the relationships between PHC core functions (i.e. process enablers) and project outcomes.

The organisation of this paper is as follow. In the next section, details of the PHC framework are presented. This is followed by the sections addressing research objective (Section 3) and research methodology (Section 4). The details of case study method employed for data collection and analysis are then explained in Section 5, followed by the associated results (Sections 6 and 7). Discussion and conclusion are provided in the last section (Section 8).

## **2 Project Health Check**

The PHC framework was developed by Jaafari (2007) with the intention to shift management focus from measuring performance effects to learning about project behaviour as a complex system, and to focus on the state of managerial approaches, also known as enabling factors (Jaafari 2007). The aim of the PHC tool is to systematically define how the project variables are being managed in order to determine whether a project is managed systemically (in case of a healthy project) or haphazardly (in case of an ill project). The system approach reflects the critical success factors and proven project management principles (Jaafari 2007).

### **2.1 Project Health Check framework and components**

The tool contains 18 criteria that represent project management core functions and 67 indicators representing the enabling factors for managing each core function. These core functions are grouped into two main sections: Business and Strategic Assessment, and Project Implementation Assessment. Each management area of a project can be assessed against these criteria that correspond to it. The systematic approach means that the project should have secured the tools and process for each criterion. Targets and goals and how they are monitored and measured through project phases should have been set.

For the purpose of this research, the Implementation Assessment was conducted for all the cases. Therefore, the performance of the project's implementation has to provide a confidence systematic approach regarding the following criteria in Table 1.

<Insert Table 1: PHC Core Functions and Indicators>

The assessment assesses the management process that is being handled by the project team in the delivery stage. Therefore, the way the project team implements the project and manages the PHC core functions is the concern of this assessment. PHC intends to draw project team's attention from focusing on process results to focusing on

process enabling factors. Thus, it enables the project team to watch and control stakeholders' influences. Therefore, the assessment does not assess the extended stakeholders; although they may influence the project, their influences highly depend on the maturity of project team's management process. Governance and leadership, communication management and the other core functions are responsible for managing stakeholders' influences. The assessment also assumes that the project team is the key function and should manage the stakeholder's influences because the project team has the responsibility to deliver the project as agreed upon. For example if the project underperformed because of one of the stakeholders, the project team should take responsibility in ensuring that this issue will not affect the KPIs. This is addressed by responding to the specific issue and its impact as well as maintaining the project scope.

## 2.2 Conducting Project Health Check assessment

The project health check (PHC) assessment is an interactive tool that allows the assessor to select the assessment either at the criteria level or the indicator level. The assessor then chooses the most applicable criteria/ indicators and sets the target levels for each chosen criteria. The tool then further asks the assessor to rate the management excellence by selecting the descriptions that correspond to the actual management performance, capabilities and practices undertaken by the project being assessed. Once the assessment is done, the tool then calculates how well the project performs and placing it in one of the five levels (tiers) of management excellent (Top 5%, 15%, 30%, 50% or 65%). These five tiers of management excellence form the basis for the measurement of project health maturity (Jaafari 2007).

## 3 Research Objective

It has been established earlier in this paper that project health should be linked with project outcomes in order to understand which specific project management core functions contribute to the success/failure of achieving certain project outcome. The main objective of the current research is therefore to develop a rational framework for investigating the link between certain project outcomes and project health during the construction phase. With this relationship understood, it is possible to investigate the factors that lead to project success as well as to identify the root causes of poor project performance. In addition, this framework will help managers to understand the mechanism of failure and to supervise the performance using a holistic and proactive approach. To achieve this outcome, the following research hypothesis has to be tested:

**Hypothesis:** Project outcomes improve when PHC core functions managed systematically.

## 4 Research concept: the Swiss Cheese Model

To develop a framework for assessing the relationship between project health and project outcomes, the Swiss Cheese model was adopted in this research. Reason (1990, 2000) introduced Swiss cheese model to link latent failures to active failures which highlighted the precondition of failures. Therefore, the Swiss Cheese model has been employed in safety management to investigate root causes of accidents. It is particularly useful as accidents investigation tool because it forces the investigators to tackle latent failures within causal sequences

(Shappell and Wiegmann 2000). Indeed this research argues that the Swiss Cheese model can be used in performance management to investigate ill projects and to pinpoint the root causes of the poor performance, as well as to facilitate understanding the mechanism of failure. Understanding the causality sequences of project performance enables proactively controlling the performance. Figure 1 shows the conceptual framework of the Swiss Cheese model.

<Insert Figure 1: Conceptual Framework based on Swiss Cheese Model>

According to Figure 1, the Swiss\_Cheese model adopted in this research consists of three slices. The first slice of the performance Swiss Cheese embodies the project performance indicators (such as SPI, CPI, defect rate, accident rate and others) shown in progress reports, and used to monitor project performance. The attributes of this slice is that it shows the process outcomes which are the active failures and does not show the latent failures or the causes of the problems. In addition, the big holes or problems in this slice are easy to be seen and recognised. Indeed, the size of the holes represents the severity of the symptoms which are the values of the key performance indicators. These values highlight the level of project health but cannot provide information about the causes so more investigation is needed.

The second slice of the Swiss Cheese model embodies the PHC core functions, representing nine management practice areas, as explained in Table 1. These are considered as the enabling process that really influences project health. For this reason, the PHC tool diagnoses these factors and gives a snapshot of the project process enablers. The holes in this slice stimulate the holes in the first slice. If, however, the project is managed well and in a systematic manner, the holes in this slice will not be developed which, in turn, will not create holes in the first (KPI) slice.

In the third and last slice of the Swiss Cheese model, most root causes can be found. According to Shappell and Wiegman (2000), the holes in this slice represent latent failures. These failures are ambiguously a result of the environment factors, such as the organization's culture towards commitment, quality, image, etc. These factors impact on the maturity of the management practices. Consequently, this maturity will be reflected in the project's key performance indicators; the end result is that the projects will indicate any shortcomings in the organization or in the management on the project's performance. Unfortunately, this causality of failures in the project's performance will only be indicated by the symptoms, which need to be diagnosed to determine the root causes.

It is important to note that, in the present research, the focus was on the linkage between the first slice and the second slice. The role of the last slice will be examined in future research.

## **5 Research Methodology: Case Study Research**

In order to achieve the research objectives, this research was designed and based on the examination of case studies conducted within the Saudi Arabian construction industry. The case study methodology used is an

empirical approach that tries to develop and improve our understanding of “real world” events. Usually, a case study’s objectives relate to an in-depth examination of a contemporary phenomenon where the investigator has little control over the events (Yin 2009). Consequently, the purpose of the case study is not just to describe a situation but rather to understand how or why events occur (Yin 2009). Based on that contention, the researchers assessed the conditions surrounding the phenomenon to build a reasonable explanation for the problems, or in the context of this research - holes in the slice, and to discover a causal relationship that links project management excellence to the project outcomes (KPIs).

### 5.1 Case study selection

Limited cases can be studied in any research project so randomly chosen cases are neither necessary, nor preferable (Eisenhardt 1989). However, to ensure that investigated links emerge, it is recommended that the researcher chooses extreme situation cases or polar types. Therefore, for the purpose of this research, the cases were selected to represent two polar types: successful and unsuccessful projects.

In the current study, the researchers initially conducted and assessed five cases. This allowed them to have the opportunity to choose the best cases that served the purpose for an in-depth investigation. The five initial cases were:

1. Designing and building a tower;
2. A power plant project for a university;
3. A power plant project for a medical city;
4. An extension of a hospital; and
5. A service centre for a medical city.

Each case was investigated using following processes:

- Reviewing and investigating project documents;
- Having general discussions with the project manager about the project status and condition;
- Undertaking a Project Health Check assessment; and
- Conducting a semi-structured interview with a project manager to investigate the link between the process enablers and the project KPIs.

In the end, the last three cases (3, 4 and 5) were chosen and renamed as Projects A, B and C, respectively. The details related to the three chosen cases are presented in the table below.

<Insert Table 2: Summary of the Three Cases>

### 5.2 Data collection

In order to obtain robust results, a case study should have multiple data sources, which can be triangulated to ensure the internal validity of the results (Eisenhardt, 1989, Yin, 2009). In the current study, the data were collected from three sources: archival material, structured interviews, and semi-structured interviews. Each of these data collection techniques are described in the following sections.

### 5.2.1 *Archive*

Progress reports are a type of archival material that provides two sorts of information: the state of the KPIs; and observations of the managerial practice. The main sort of information used throughout the current analysis is the key performance indicators, which are:

- **Time** – concerned with the extent to which the project is behind or ahead of schedule;
- **Cost** – concerned with the extent to which the project is over or under budget;
- **Scope** – concerned change in the amount or the value of variation orders;
- **Quality** – concerned with the level of the quality of the work accomplished, or the amount and the value of the defects;
- **Safety** – concerned with the level of safety in the project or the number of accidents; and
- **Satisfaction** – concerned with the level of customer satisfaction.

Within the context of this research, the above listed KPIs represent the holes in the first slice of the Swiss Cheese model, with the values of the KPIs determine the size of the holes. It is important to note that not all cases utilized the same method for measuring KPIs. When collecting the performance data, any measured indicators deemed to satisfactorily indicate the performance outcomes similar to the above indicators were considered suitable. As a further note, the purpose of obtaining the KPIs in the current study is to facilitate the investigation of relationships between project performance outcomes and project management practice, not to ascertain the validity of measurement techniques used to obtain such KPIs.

### 5.2.2 *Structured interview*

Interviews are one of the most important sources of information in case study research (Yin 2009). In this current research, structured interviews were mainly conducted based on the PHC assessment tool in order to determine the level of managerial practice for each case. The assessment was conducted face-to-face with project managers and at the project sites. Face-to-face assessment was chosen because it provides the opportunity for the researchers to clarify any ambiguities that may exist in the assessment tool; this helped to improve the precision of the assessment. Moreover, evidence to validate the answers in the PHC assessment was collected where possible. The outcome of this assessment was in the form of a set of scores for each management core function, which determined the size of the holes of the second slice of the Swiss Cheese model. The assumption is that the bigger and more holes in the second slice will cause many more and bigger holes in the first slice.

### 5.2.3 *Semi structured interview*

The purpose of the semi structured interview was to link the PHC core functions with the project outcomes, whether positively or negatively, and to measure the strength of the links. The approach was to ask the project managers about the root causes of the poor KPIs, then investigate further as to which PHC core functions caused

which outcomes. For each PHC core function, the list of indicators and associated descriptions (shown in Table 1) were used to help deduce qualitative responses from the project managers to establish the relationship between project outcomes and the PHC core functions. The project managers' opinion about the root causes of the poor performance were also assessed against project history and progress reports. The strength of the relationship was then further classified into the following categories:

- Strong and direct link: when there is a strong and direct impact from the core function on project outcome, and when this core function is the root cause of the outcome;
- Direct link: when there is a direct link, but the link does not have a strong impact that substantially affects the outcome; and
- No clear direct link: when there is clearly no evidence/indication that the core function has an impact on project outcome.

### 5.3 Analysis

The results from the project health assessments, and the data from the interviews and the archive, were analyzed using a qualitative approach. Specifically, cross case analysis was conducted to identify patterns and themes (Miles and Huberman 1994). When a pattern from one case is corroborated by the evidence of the same pattern from another case, the findings are stronger and more grounded (Eisenhardt 1989). This technique is usually used to enhance the generalizability of the results, deepen our understanding and improve the explanation.

Data collected from the semi structured interview that shows the nature of the link between the KPIs and the project managerial practices were used to track the patterns throughout the cases. The tactic used was to choose a dimension of the KPIs, for example cost, which was then used to identify the nature of the link between it and the PHC core functions. Next, the pattern was tracked throughout the cases to obtain the average strength of the link. It is important to note that the strength of the link was classified into three main categories: strong and direct relation, direct relation and no clear direct relation. While such subjective categorisation may appear to be crude, it is considered appropriate given the nature of case study research. According to Yin (2009), cross case analysis generally involves no precise comparisons; there may not be quantitative or statistical criteria involved on which to judge the pattern, thus allowing for some interpretive discretion on the part of the researcher.

In addition, although the links between KPI and the PHC core functions were determined primarily through qualitative interview data, additional quantitative information were also obtained and used to help triangulate the strength of the link. However, due to paper size constraint, details of this supplementary quantitative analysis are not included in the present paper. Readers are referred to Almahmoud (2010) for the complete description of such analysis.

Results of the case studies are presented in two parts: within-case and cross-case results. Within-case results are focused on the findings derived from each case whereas the cross-case results aggregate these findings and tabulated them in such a way that it enables clear identification of possible relationship patterns. The following sections present both parts of the case study results.

## 6 Within-Case Results

### 6.1 PROJECT A: power plant for medical city

#### 6.1.1 Summary of the case

The project is the construction of a power plant that supplies electricity for a medical city. The medical city contains university and employee residential units located within the hospital compound. The project involved building an electricity plant to supply a power of 66 MVA for the medical city. The contractor of this project had ISO 9002 and United Kingdom Accreditation Services (UKAS) for the quality management accreditation (dated September 2009). Most of the project cost was based on the procurement delivered, in the main, from overseas companies. The project did not contain much civil or architectural work. Therefore, the procurement core function was the most important management task in the project.

Overall, the project was progressing well within budget. It was almost within the schedule at the time of data collection (see the section below for more details). It was determined that the contractor's level of management practice in the project health check exceeded the level that was targeted for the core functions (Table 3). One problem arose in relation to the placement of an old cable, which was found to interrupt the laying of the proposed cable. This problem fell under the client's responsibility because the cable was not shown in the original tender documents. However, the contractor's responses to this issue in relation to the client's initiated fault were evaluated in terms of governance, communication, risk management, and all other core functions.

#### 6.1.2 Project Key Performance Indicators

The following KPIs were obtained from the progress reports provided by the consultant Saudi Electric Company and through an interview with the contractor.

- Cost: highly confidential; the contractor could not specify a particular cost, but he mentioned that the project was within the budget.
- Time: the project is slightly behind schedule at the middle of the project duration, as indicated by the SPI (at 9 months) of 0.855.
- Scope: there has been no variation orders; the project is up-to-date. However, there is major additional work under examination, namely, the change in the cable direction as mentioned above. This change

has been requested by the client because an old cable, not originally shown on the status drawings, was found in the field.

- Quality: no defect and no rework required by the project.
- Safety: no safety issues exist; however, a request has been initiated to remove some items in the warehouse to a drier place.
- Satisfaction: In this project the consultant SEC also acts as the client because this new power plant has to be incorporated in his power network. The SEC is totally satisfied with the project's progress and the up-to-date outcomes.

### 6.1.3 *Project diagnostic (PHC)*

Table 3 shows PHC scores and justifications for Project A. For each core function (column 1), the actual and target scores are shown in columns 2 and 3 respectively. The last column depicts the findings that indicate the actual performance in the project. As mentioned in the preceding section, the interview results assisted measurement of the management practices across these indicators. As seen, the contractor's project manager was targeting the level of practice at 85 for most criteria, based on the project's sophistication. However, the result from the PHC shows that the management excellence exceeded this target in most criteria. Highly qualified contractor employed in this project might partly contribute to this.

<Insert Table 3: PHC Scores and Justification Project A>

## 6.2 Project B: Hospital extension

### 6.2.1 *Summary of the case*

This project involved a hospital extension consisting of a nine-storey building and a service building for the power generator and water storage. The project was almost 3 years behind schedule and had just achieved 14% of the work scope. All the project outcomes or the project symptoms showed that the project was severely unhealthy. The only positive indicator identified was the quality of concrete work. Diagnosing the project, it was found that the contractor's project manager was handling this aspect well because of his extensive experience in the concrete industry. Apparently, however, this project manager had good experience with concrete, but was unqualified in project management. The Project Management Office and the client asked the contractor many times to replace the project manager, but this was not carried out. To make matter worse, there were many design changes in the project, which contributed to the delay.

### 6.2.2 *Project Key Performance Indicators*

The following KPIs were obtained from the progress reports, provided by the Project Management Office (PMO), and through the interview with them.

- Cost: Highly confidential; the contractor could not specify the specific cost, but he mentioned that the project was over budget. Obviously, as the contractor was 30 months behind schedule, overhead costs were increasing.
- Time: The project did not have a planned expenditure cash flow (S curve), and the project was behind schedule. The proportion of time elapsed for the project was 97.26%, but the proportion of work performed is only 14.05 %.
- Scope: There were many changes in the project's architectural design. Some spaces and bedrooms needed to be redesigned to better use the space; and some spaces did not match with the medical code, such as elevators.
- Quality: There were neither defects nor rework found in the project. The quality of concrete was better than the requirement, with an exception for a few concrete foundations and columns that were not properly protected, which could result in rusting of the reinforcing.
- Safety: No safety issue was found that caused a problem to the project; however, it was found that the labourers did not follow basic safety regulations, such as wearing safety helmets and shoes.
- Satisfaction: The owner was dissatisfied with the project's progress.

### 6.2.3 Project diagnostic (PHC)

The PHC scores and justifications for Project B are shown below in Table 4. The level of practice required for this project was 90, based on the complexity of the hospital projects. Unfortunately, the level of practice was found to be far below this target. None of the process enablers were carried out as required. The PHC assessment revealed that the project was managed haphazardly. The significantly large gap between the actual and the target PHC scores could be associated with the poor project KPIs.

<Insert Table 4: PHC Scores and Justification Project B>

## 6.3 Project C: Service centre for a medical city

### 6.3.1 Summary of the project

This project was concerned with constructing a 8-storey main service building, which was aimed to provide necessary services required for a medical city. The project was almost three years behind schedule. At the time of handing over the project, just 18.83% of the work scope had been achieved. All the project outcomes were poor; the project was severely unhealthy. As a result of the process enablers not performing well, two major issues emerged and caused most of the deficiencies in the outcomes. These deficiencies were: a shortage of labour and professionals; and a lack of integration between the shop drawings and between the shop drawings and the procurement process.

### 6.3.2 Project Key Performance Indicators

The KPIs were obtained from the progress reports provided from the PMO, and through the interview with the contractor's project manager.

- Cost: Highly confidential; the contractor could not specify the precise cost. However it was mentioned that the project was over budget. Obviously, as the contractor was 28 months behind schedule, the overhead costs for the contractor kept increasing.
- Time: The project did not have a planned expenditure cash flow (S curve); the project was behind schedule. The proportion of the time elapsed for this project is 90.37%, but the proportion of work performed was only 18.83 %.
- Scope: Scope variation was found, which involved changing the main water feeding pipes to match the main source diameter.
- Quality: There were some defects in the concrete slabs. The contractor did not have a method to measure the defects rate.
- Safety: Safety and security plans were not submitted. Several occasions of lost time due to injuries were found. Otherwise, there were no major safety issue.
- Satisfaction: The owner was dissatisfied with the project's progress.

### 6.3.3 Project diagnostic (PHC)

Table 5 shows PHC scores and justifications for Project C. The project manager set a target PHC score of 80 for each criterion, based on the complexity of the project. However, the PHC assessment shows a lack of systematic project management processes employed; the project was conducted in haphazard manners. For example, the PM stated that there was no formal schedule for regular meetings, rather the meeting was called for only when needed. Risk management was also interpreted by the PM as safety management.

<Insert Table 5: PHC Scores and Justification Project C>

## 7 Cross-Case Results

The nature of relationships between the KPIs and PHC variables defined through semi structured interviews for the three cases were combined and compared. This combination helped to track cross-case patterns to determine the strength of each relationship. The strength level gives an idea about how each process enabler (PHC core functions) could affect and contribute to the project outcomes. Table 6 was developed using mode functions to provide a consistent framework for measuring levels of relationship strengths, as it best suits qualitative measurement.

<Insert Table 6: Measurement of the Relationships>

### 7.1 Cost

The relationships between the *Cost*, as a key performance indicator, and the PHC core functions throughout the cases are shown in the Table 7.

<Insert Table 7: Cost Relationships with PHC Core Functions>

From Table 7 above, it can be seen that the relationships between *Cost* and all PHC core functions, except *Offsite Management* (PH8), are consistently direct and strong across the three cases. This finding seems reasonable as *Cost* is one of the most sensitive dimensions in a project, and every process in the project most likely affects it. *Offsite Management* is the only core function where the relationship with *Cost* is not clear; this is constant across the three cases.

## 7.2 Time

The relationships between *Time* as a key performance indicator and the project health core function for all the cases are shown in Table 8.

<Insert Table 8: Time Relationships with PHC Core Functions>

From Table 8 above, it can be seen that the relationships between *Time* and all the PHC core functions are both direct and strong consistently throughout the three case studies. This finding is self evident because *Time* is one of the most sensitive dimensions in the project and every process in the project affects it. *Offsite management* (PH8) is the only core function in which the relationship with *Time* is not strong in two projects, but it is direct. In these two projects, the level of practice for PH8 was at level 3 in PHC excellence scale mentioned earlier, which is not too bad. However, it did not have enough influence to resolve the delay in the projects. In the first project, the relationship was strong because the project was progressing well in terms of time, as well as in this core function. Therefore, the relationship between the *Offsite Management* and *Time* was considered direct.

## 7.3 Scope

The relationships between the *Scope* as a key performance indicator and the PHC core functions throughout the cases are shown in the Table 9.

<Insert Table 9: Scope Relationships with PHC Core Functions >

As shown in Table 9 above, it can be seen that the relationships between *Scope* and the *Procurement, Transportation and Warehousing* (PH3), *Quality Management* (PH7) and *Offsite Management* (PH8) core functions are consistent, showing “no clear direct link”. On the other hand, the relationship between *Scope* and the *Engineering, Detailed Design and Specifications* (PH2) core function is constantly “strong and direct”. The *Scope* relationships with the *Governance and Leadership* (PH1), *Planning and Control* (PH4), and *Information and Communications Management* (PH6) are “strong and direct” in two projects, with “no clear direct” relationship in one project, so overall it can be determined as “strong and direct”.

## 7.4 Quality

The relationships between *Quality*, as a key performance indicator, and the PHC functions for all the three cases are shown in the Table 10.

<Insert Table 10: Quality Relationships with PHC Core Functions>

According to Table 10, the relationships between *Quality* and most of the PHC core functions are strong and direct. However, the relationships between *Quality* and the *Risk Management* (PH9) core function throughout all the cases are consistently found to be “no clear direct link”, while those between *Quality* and the *Planning and Control* (PH4) are “direct link”.

## 7.5 Safety

The relationship between *Safety*, as a key performance indicator, and the PHC core functions throughout all cases is shown in Table 11.

<Insert Table 11: Safety Relationships with PHC Core Functions >

Based on Table 11 above, the relations between *Safety* and all the PHC core functions are “strong and direct”. However, the relationship between *Safety* and *Engineering, Detailed Design and Specifications* (PH2) is determined as “no clear direct link” across all three cases. The relations between *Safety* and *Risk Management* (PH9) have also been determined as “no clear direct link”.

## 7.6 Satisfaction

The relationships between *Satisfaction*, as a key performance indicator, and the PHC core functions for all the three cases are shown in Table 12.

<Insert Table 12: Satisfaction Relationships with PHC Core Functions>

As shown in Table 12, the relationships between *Satisfaction* and the *Governance and Leadership* (PH1), *Engineering, Detailed Design and Specifications* (PH2) and *Information and Communications Management* (PH6) core functions are “strong and direct”. All other relations between *Satisfaction* and the PHC core functions are evaluated as “no clear direct link”.

# 8 Discussion and Conclusion

## 8.1 Research outcomes

The nature of the relationships between the project health core functions and the key performance indicators were investigated through multiple case studies. These relationships were compared across the cases to examine

any patterns that indicated the nature of the relationships. Table 13 presents a summary of all the relationships between KPIs and PHC core functions derived from the case studies.

<Insert Table 13: Relationships between KPIs and PHC Core Functions>

According to Table 13, the PHC core functions appear to impact on the project's performance indicators at different levels. Some core functions have more influence than others. Many of the core functions have strong and direct links with the KPIs, while some are not.

## 8.2 Results discussion

As stated earlier, the research objective was to build a rational framework that would help manage project performance from a holistic perspective. Based on the project management core functions, the resulting framework is expected to facilitate an in-depth analysis of the reasons/causes affecting the performance in projects. The first step towards achieving this primary objective was to investigate the link between the project management core functions of PHC and the key performance indicators. The research reveals that the Swiss Cheese Model can provide a viable framework for managing project performance through identifying the relationship between various PHC core functions and project KPIs. The findings highlight that the link between the process enablers and the project outcomes is valid.

It is found that *Governance and Leadership* and *Information and Communication Management* are the most influential management functions affecting all project performance indicators (signified by the strong and direct links across all KPIs). This implies that these two core functions provide a building block for enhanced project outcomes. Information and communication management is identified as one of the key core functions for ensuring smooth implementation of governance and leadership and achieving success in projects. *Engineering Detailed Design and Specifications* and *Planning and Control* are the second highest influencing function impacting the project outcomes. These core functions are needed for the appropriate configuration of the project mechanism to achieve the desired outcomes. *Procurement, Transportation and Warehousing Management* comes third, together with *Team Performance* and *Quality Management*. *Risk Management* and *Offsite Management* appear to have the least impact on the overall project performance. It can be implied that these core functions play a supportive role in achieving high performance project outcomes. This, however, does not mean that their roles are less important than those of the previous core functions. These supportive core functions can strongly contribute indirectly to the project performance. However, such indirect influence was not examined in this research.

From the perspective of project KPIs, it can be observed that "Time" shows strongest relationship with the overall project health (as indicated by the strong and direct links across the PHC core functions). This is followed by "Cost", "Quality", "Safety" and "Scope", respectively. "Satisfaction" seems to be the only KPI that has not much relationship with project health. This finding implies that the project performance indicators

are also different in terms of sensitivity, and this can provide insights into project performance management. Some indicators, such as *Time* and *Cost*, can be very much sensitive to the project health. In other words, any deficiency in project management process can potentially have a significant impact on the time and the cost of the project. As such, the PHC core functions must be carefully managed if time and cost of the project are critical. On the other hand, *Satisfaction*, for example, is not very sensitive to PHC core functions. It can only be directly affected by *Governance and Leadership*, *Engineering Detailed Design and Specification*, and *Information and Communication Management*. Therefore, management can focus on these core functions to ensure that the level of client satisfaction is maintained. In this way, information will help management to better focus their effort on critical project management process when targeting certain KPI. These findings clearly support the research hypothesis that successful project outcome is directly linked to the effective management of the core project management functions.

### 8.3 Implications for management

It has been evident that the Swiss Cheese framework for performance management can be implemented in project management for two purposes:

1. To manage project performance using a holistic approach.
  - By understanding the relationship between the project outcomes and the process enablers, the project manager will be able to decide in which management area the available resources should be spent.
  - Project performance usually fluctuates during the project life cycle. Therefore this framework can help project managers to prepare, in advance, the recourses required for each process enabler that is linked with the fluctuated outcomes predicted.
2. To pinpoint the poor performance root causes, and to develop remedy prescriptions.

When a project indicator identifies any deficiency in the performance (e.g. running out of time and money), the project manager should be able to address the root causes by:

- Determining the shortage in the outcomes;
- Diagnosing management practices by using the Project Health Check tool; and
- Use the data in Table 13 to determine which process enablers need to be attained.

The remedy can be developed by determining which process, shown in project health check matrix, should be accommodated to enhance the process enablers.

### 8.4 Limitation and future research

The current study has investigated the direct links between the management core functions and the project performance indicators. However, there are indirect links that may affect the project performance. As identified in the research, project managerial functions as well as the project outcomes are integrated and can affect each other. For example: client satisfaction is always influenced by project time and cost; and governance and

leadership may affect the way information and communication is managed. These indirect links have not been fully addressed in this research. It is recommended that future research focus on examining the indirect links that may exist among the project health check core functions as well as the project KPIs. Indirect links can be measured using techniques such as Cross Impact Analysis or Social Network Analysis. These techniques assist determining the influence of each variable on the other variables. Use of such techniques is part of the researchers' ongoing research which will be disseminated in due course.

The research can be improved, if experimental studies are implemented. This means that a project health check assessment can be conducted during the project life cycle. For example, an assessment can be undertaken every three months, to watch the trend in the PHC and to compare it with the trend in the performance indicators. Moreover, the findings will be more significant if one project implements remedy, while another project does not. The PHC score trends and project performance trends could then be compared.

Another limitation was the fuzzy measurement to determine the strength of the relationships between the KPIs and PHC core functions. This research utilised the qualitative approach based on semi structured interview with project managers to investigate the causes and its impacts. Interview is known to rely on personal opinion and susceptible to biasness. This however was mitigated by a triangulated data collection process, which utilised multiple data sources including observations, progress reports and the interview.

#### 8.5 PHC limitations and recommendations

The PHC tool was developed to diagnose management practice and provide a snapshot of the management's maturity. Therefore, the status of KPIs of a project will not have an impact on the maturity level. In other words, the assessment does not take into account actual KPIs. However, the tool can be developed and adjusted for performance investigation by adapting the results from this research study and representing the relationships in the assessment. For example, the status of KPIs of a project can be the starting point to decide which core function should be assessed. Also, the assessment questions can be developed to ask directly how the core function manages the related outcome.

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