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Construction Projects Immediate Health Check: A CSF & KPI Approach

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Abstract
Many factors have the potential to influence human health. These factors need to be monitored to maintain health. As is the case with human health, construction projects have a number of critical factors that can facilitate a broad evaluation of project health. In order to use these factors as an indication of health, they need to be assessed. This assessment can help to achieve desired outcomes for the project. This paper discusses the approach of assessing Critical Success Factors (CSFs) using Key Performance Indicators (KPIs) to ascertain the immediate health of a construction project. This approach is applicable to all phases of construction projects and many construction procurement methods. KPIs have been benchmarked on the basis of industry standards and historical data. The robustness of the KPIs to assess the immediate health of a project has been validated using Australian and international case studies.

Keywords: key performance indicators, project health, case studies, questionnaire, critical success factors, construction project

1 Introduction

There is a constant stream of public reports, and commentary, about projects which fail to meet pre-determined objectives. Many of these are high profile publicly funded projects which attract much adverse publicity. In some cases adverse impacts include cost and time overruns, inadequate build quality, poor project relationships, loss of reputation, public clamour and legal disputation. Despite the availability of a large number of published reports, reviews and research treatises providing guidance to successful project execution, this situation continues. The industry continues to suffer from projects not achieving intended outcomes.

In order to improve the potential for a project to achieve the outcomes expected, a construction project health check model was developed that allowed the immediate assessment of current project health, identify the root causes of the reasons why the project is not performing as expected and suggest a means of returning the project to better health. (Humphreys, Mian, Sidwell, 2004). The model evolved from a human health care model using symptoms to evaluate project health, detailed investigation of key symptoms to diagnose cause of problem and proposition of a remedy to return the project to good health.

This paper discusses the first stage of the model that involves immediate assessment of current project health. The research on project success and /or failure in the last decade will be discussed first, followed by reviewing the concept of project health to measure project success / failure. The CSF and KPI approach to measure project health is discussed in detail next. To validate these KPIs case studies are investigated. Finally the limitations with the case studies and the direction for future research are presented.

2 Changing measures of project success or failures over the last decade

Project success or failure means different things to different people. Each stakeholder considers a different definition of success or failure which is consistent with his or her perception and interests in relation to the project outcome. In order to develop common measures that broadly represent the interests of all stakeholders, the subject of project success or failure has been one of the main areas of focus for a number of researchers over the last decade.

The success and failure measures were first introduced by (Rubin and Seeling 1967). Their research was based on investigating the impact of a project manager's experience on project's success or failure. Technical performance was used as a measure of success. It was concluded that project manager's previous experience had minimal impact on the project's success or failure. This research was followed by a theoretical study conducted by (Avots 1967). The findings from the study concluded that the wrong choice of project manger, unplanned project termination and unsupportive senior management were the main reasons for project failure.

At the start of the last decade Russell & Jaselskis (1992), Abidali & Harris (1995) and Kanagari (1992) developed prediction models that were focussed on explaining failure factors at the project level. These models used financial ratios derived by statistical search through a number of plausible financial indicators. More recently Arditi (2000) reasoned that the use of financial ratio's to measure project failures may not be very reliable as they can only highlight symptoms and that these indicators might be measured using data that has been 'created' by the management to hide the poor financial condition of the organization. Concurrent research carried out by (Belassi et al 1996) proposed that Time, Cost and Quality were the basic criteria of project success. They are also discussed in articles on project success such as that of Skitmore (1997) and Shenhar & Levy (1997). Atkinson (1999) called these measures as the 'iron triangle'. The most common cost overrun measures found in the literature in this period were poor estimating, inclement weather and insufficient and untimely cash flow. Less common issues included lack of contractor project type experience and contractor's lack of familiarity with local regulations. Issues such as complexity of project and inflation were found occasionally. Similarly time overrun measures most commonly encountered included communication gap between project parties, inaccurate prediction of production output, inclement weather, design changes, safety issues, industrial action and skill shortages. Issues reviewed less frequently included lack of supply of plant, equipment & materials and site storage problems. Issues that were occasionally covered included locational project restrictions (site access) and production of design drawings.

Songer and Molenaar (1997) considered a project successful if it was completed on budget, on schedule, conformed to user expectations, met specifications, attained quality of workmanship and minimised construction aggravation. In this time period the most commonly found quality measures were reluctance to adopt quality systems, inadequate quality assurance and control systems, lack of product identification and traceability, lack of internal and external audits, infrequent inspections and insufficient training. Less commonly found factors included lack of control of inspection/measuring/testing equipment, lack of control of non-conforming product and poor data control. Quality measures least commonly found in the literature included lack of employee conscientiousness and lack of encouraging specialization in construction work. This indicated that the majority of clients and stakeholders now took the issue of quality conformance more seriously and believed that the issue of resuscitating failing projects due to poor quality of documentation or workmanship is vitally important to a vibrant, healthy industry. The old adversarial attitudes which were ingrained as part of poor project outcomes for at least some of the key participants were seen as being passé.

Pinto and Pinto (1991) based their findings on soft measures such as satisfaction levels and suggested that success measures should also include psychosocial outcomes such as safety, litigation and others that relate to interpersonal relationship within the project team. Pinto and Slevin (1987) and Morris and Hough (1987) found out that communication, environment events, community involvement, team member conflict, lack of negotiation and arbitration, legal disputes, management inability to understand site people, and stakeholders value were likely candidates for measuring project success or failures and warranted the need of including them along Cost, Time, Quality and Safety.

In some cases the researchers tried to link project success to different project stages i.e. delivery and post delivery stages. Similarly project success was also linked to individual perspectives of the involved stakeholders. In the quest to identify a robust set of success and failure measures previous researchers employed various methodologies ranging from unstructured interviews that asked the respondents to list a number of measures that are important to project success or contribute to project failure, to structured interviews that required the respondent to rank a list of measures that affect project performance.

3 Evolution of the concept of project health to measure project success or failures

(Humphreys, Mian, Sidwell, 2004) proposed that human physical health can broadly be thought of as the condition of the body. When physical health is poor, performance or quality of life can be compromised. Poor physical health often has associated symptoms that can be used to help pinpoint the cause of ill health quickly and accurately. Once the cause has been identified, a remedy can be implemented to return the body to good health. If symptoms are left unchecked, they can develop into critical situations and become much worse.

In many ways the "health" of a construction project is analogous to human physical health. Humphreys, Mian, Sidwell, (2004) identified some parallels between construction project health and human physical health:

- State of health influences performance
- Health often has associated symptoms
- Symptoms can be used as a starting point to quickly assess health
- Symptoms of poor health are not always present or obvious
- State of health can be assessed by measuring key areas and comparing these values to established norms
- Health changes temporally
- Remedies can often be prescribed to return good health
- Correct, accurate and timely diagnosis of poor health can avoid small problems becoming large

Here project health is synonymous with project performance, if a project or any particular aspect of a project is not performing as expected by the stakeholders it would be perceived as unhealthy or failing on the other hand if it is fulfilling the expectation of the stakeholders it would be perceived as healthy or successful.

The requirement for rapid, accurate diagnosis lead to the concept of an initial broad health checking mechanism which could guide a further more detailed investigation designed to identify the factors contributing to poor health. The use of performance indicators to assess the state of the contributing factors allows remedies to be prescribed, based on the condition of the contributing factors investigated.

A model presented in Figure 1 is derived from (Deming's 1986) continuous improvement management cycle. This was developed to adapt the medical health model to a construction project scenario. Although the model is based on a four stage process beginning with broad and rapid assessment of current health, followed by a more thorough analysis of the areas identified as unhealthy, which allows prescription of a remedy and finally continued monitoring of condition, the first stage will only be discussed in the following text.

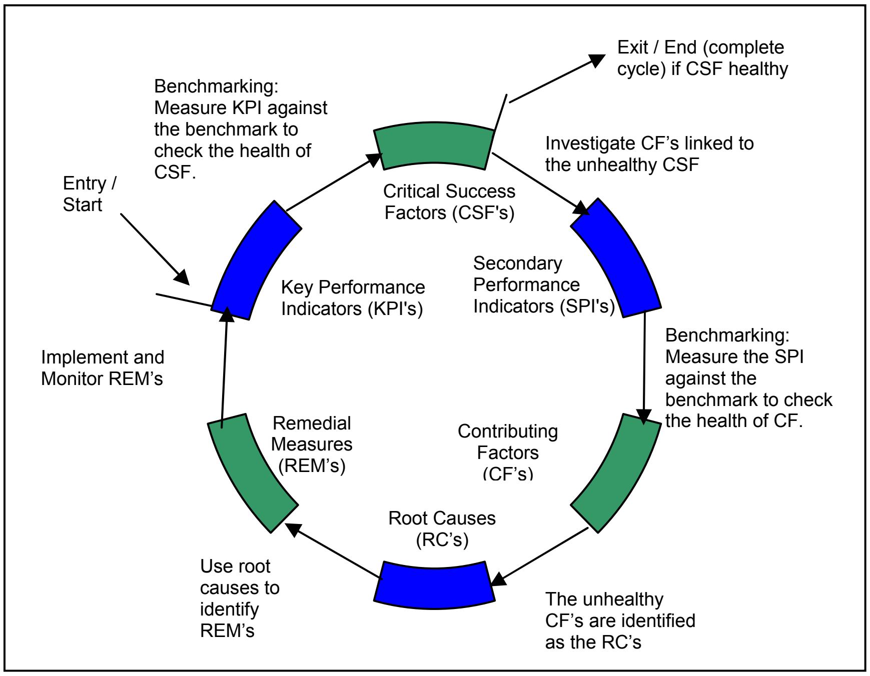


Figure 1 – Construction Project Model (Mian 2003)

4 Immediate assessment of current health of projects- using CSFs and KPIs

Research carried out in the last decade provides several lists of success and failure factors totalling more than 120 different success and / or failure measures. In order to make these cumbersome lists more manageable to work with and to help analyse the interactions, they were represented by seven main themes of success factors namely Cost, Time, Quality, Relationships, Safety, Environment and Stakeholders value for the immediate assessment of current health of a construction project. As is the case with human physical health, these themes are critical areas that can facilitate a broad evaluation of project health. These are thus called Critical Success Factors (CSFs) and used as the basis for a broadly inclusive fundamental health check to gauge project health in terms of specific success factors that are critical to the interested stakeholders. This differs somewhat from the traditional use of CSFs by (Rockart 1979) who introduced them as those aspects of a project which, if successfully executed, can significantly influence the success of a project. In short Rockart suggest that CSFs are the ingredients that give the greatest chance of a successful outcome. In the health model these are areas that are critical to all the stakeholders and need to be investigated in order to ascertain project health.

In many cases projects fail because project teams are self selected. These teams include members who have enthusiastically volunteered to be a part of this team. However enthusiasm tends to result in lenient review procedures and the warning signs that do appear may be ignored. This is especially true as Royer (2003) suggests, ‘that the value of someone who is able to pull the plug on a project before it becomes a money sink hasn’t generally been appreciated’. From the start no matter how exciting a project is, it should have an evaluation system that tells the members of the team how the project is progressing at each stage of the development. Royer (2003) suggests that the chances of bringing a failing project back on track are better if the problem is identified at an early stage. If a project does not have an efficient early warning system or if the warning signs are not seen with scepticism, a point might come when it would be impossible to recover from the damage caused by the persisting problem. This might have costed the involved parties much more than they had expected and tied up the resources for much longer they had anticipated. In comparison the cost associated with identifying and remedying a problem at an early stage is much lesser. This is analogous to human health, where the chances of remedying a disease are better if it is diagnosed at an earlier stage rather than neglected and permitted to spread.

The seven CSF themes of Cost, Time, Safety, Relationships, Quality, Stakeholders Value and Environment represent critical areas of construction project health and used to form the basis of the project health check-up. In order to use these CSFs as an indication of health, they need to be assessed. This was achieved by developing an associated series of Key Performance Indicators (KPIs) for each CSF.

KPI Working Group (2000) proposes that the purpose of KPIs is to enable measurement of project performance throughout the construction industry). Munir (2002) defines a KPI as a number or value which can be compared against an internal target or an external target benchmark to give an indication of performance. Furthermore the use of KPI's to assess the performance of the main CSF themes allows the model to be applicable to all the project stages and majority of the procurement methods. To facilitate the KPIs application to assess the performance of the CSF's, these were calibrated using benchmarks from Australia (Coles 2003), UK (cbpp 2003) & USA (CII 2003). This allowed the model to be applicable to a project regardless of whether a performance target was set by an interested party, legislation or by other projects.

Benchmarking is a technique of evaluating performance in specific areas when compared to recognized leaders (Plemmons 1994). For the health check model the benchmarks were used for the same purpose but in most cases compared to industry averages instead of market leaders. This shift can be attributed to the nature of the health check model where it is more appropriate to classify a project as 'unhealthy' if it is not doing better than the industry average rather than compared it against the best practice.

Although a large number of KPIs were identified in the literature review, these often lacked certain characteristics that would make them applicable, useful, independent and practical for the immediate health assessment of ongoing or historical projects. In order to have a robust, accurate and immediate assessment of current health of a construction project in terms of the seven broad themes certain characteristics were chosen that need to be possessed by the KPIs. The six critical KPI characteristics were identified as:

- *Easily measurable*– must be able to be measured quickly, directly and accurately with as little effort as possible.
- *Broadly applicable* – must be able to be measured at any stage of a project or at least a combination of indicators across a CSF should be able to represent all stages of a project. The indicators should also be able to represent different procurement methods.
- *Assessable*– once measured, the indicator must be able to be compared to a known value to allow correct judgement of health to be made.
- *Independent (not duplicate)* – independence from other project variables is desirable to provide clarity in assessment of a specific CSF by avoiding interference which can give misleading results.

- *Reflect reality* – the measured variable must encourage a description of reality rather than 'ideal' or perceived situations
- *Sensitivity*–the indicator must be tuned to project health to allow accurate health assessment.

After careful scrutiny a total of thirty three KPIs were chosen according to the above criteria. However due to the nature of some of the characteristics described above it was necessary to validate the robustness of these KPIs by testing them on actual projects. Table 1 provides an example of one of the indicators used to investigate the Cost CSF and an explanation of how the indicator is used.

Table 1: Cost Performance Indicator (CPI)

CSF	Proposed indicator	Explanation of indicator
Cost	CPI (Cost performance indicator)	**Definition** CPI = BCWP / ACWP Where: BCWP= budgeted cost of work actually performed ACWP = actual cost of work actually performed **Benchmark** CPI $\geq$ 0.85 indicates a healthy project CPI< 0.85 indicates an unhealthy project **Why**: Snap shot of cost performance on the day of health check **Key sources of information**: progress claims, cost plan , progress reports etc **How**: Determine BCWP and ACWP on the day of the health using key documents, calculate the CPI ratio and compare it with the benchmark to ascertain project health. **Comments:** There may be factors contributing to the unhealthy cost that are to be identified and investigated in the second stage of the health check model.

5 Case studies - validation of KPIs

After the six characteristics were selected and the first stage of the construction project health model developed, the validity of the KPIs needed to be assessed. The validation stage was important as the outcome of this stage was to be a robust set of KPIs that could form a part of the tool and used as basis of carrying out deeper analysis to identify root causes. The validity was assessed with three projects within Australia and a fourth international project overseas that was especially helpful in validating measures associated with international joint ventures.

5.1 Profile of the Projects

To enhance the chances of checking the robustness of KPI's, the case studies were chosen to be *unsuccessful*: An unsuccessful project was preferred to maximise repetitive evaluation of the KPI's, *live*: This was useful for KPI's meant to give a snap shot at a point in time. This would facilitate the implementation and monitoring of remedial measure, which was the final objective of the health check model and of *different sizes***:** helped to evaluate the size dependent KPI's. The projects were carefully chosen to ensure that they encompass different project stages and different procurement methods.

5.2 Profile of the respondents

The respondents were public and private sector clients, consultant, contractors and sub-contractors. The approval was granted by the client and the contractor and consultants were then approached with a 'Case Study Scope Statement' listing the scope and methodology of data collection.

5.3 Questionnaire instrument

A semi-structured questionnaire was developed for this purpose. However in order to assist the respondents with the data collection, face to face interviews with the projects parties were carried out on-site.

Due to the sensitive nature of the subject of project failure and success the respondents were assured of the anonymity of the information disseminated by them. A comprehensive confidentiality statement was developed and issued with the questionnaire and scope statement to that highlighted that the issues with the project will be kept private and not made available to any third party.

5.4 Methodology

The aim of the validation process was to assess how 'well' an indicator measures what it is intended to measure. For the purpose of immediate assessment of current health of a construction project 'well' for a KPI refers to its ability; to be measured easily, to be comprehensively applicable i.e. applicable to all project stages and many procurement methods , to be assessed and make the correct assessment , to be independent and to be sensitively tuned to health of a project. The validation process for the health check model helped in weeding out the most efficient, robust and effective KPIs and reduced the KPI number from thirty three to eighteen.

Data for KPIs was collected through face to face interviews and after investigating the project documentation. The data was then compiled, each KPI was calculated using a spreadsheet program and the results were collated and used to address each characteristic identified above using a bar chart shown in Figure 2. A KPI was only retained if it satisfied these criteria on the majority of the projects otherwise it was changed or discarded. The details of the validation of all the KPIs is not provided here; however in order to give an overall idea the CPI validation process is discussed briefly next.

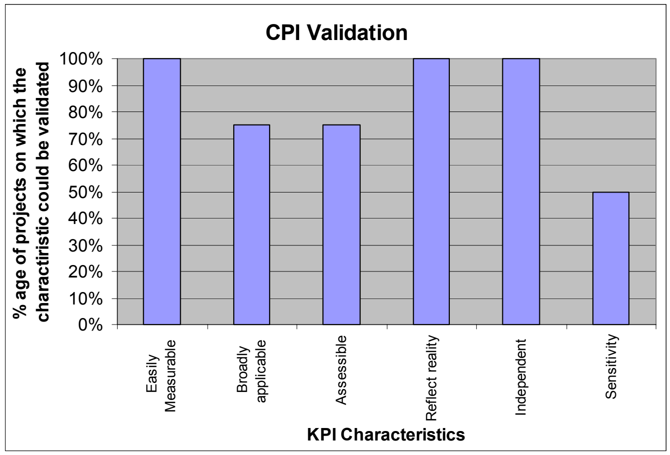
5.5 Results

The findings of the validation process for Cost Performance Indicator (CPI) are summarized below.

- Easily measurable: As shown in Figure 2, the data required to measure CPI was readily available for all (100%) the case studies. On projects where cost performance was not being monitored using earned value analysis / s-curves the consultant or contractor progress claim showing the approved amount until the day of health check was used to measure ACWP & the contractor / consultant cost plan showing the revised budged cost (including variations) until the day of the health check was used to measure BCWP. The availability of any of the above facilitated in measuring CPI quickly, directly and accurately with little effort. The information based on client's estimate and cash flow details could also be readily accessed to measure this KPI.
- Broadly applicable: The measure could only be measured with ease for the design stage for three (75%) case studies. The case studies consisted of project using many procurement methods such as construction management, traditional and design & construct and the CPI was accurately and easily measured on all of them.
- Assessable: Based on literature review and past experiences of industry specialists a benchmark of 0.85 was chosen to assess this KPI. It was also decided that any project having a CPI ratio lesser than this benchmark was unhealthy. Although CPI was easily measurable and thus easily assessable on all the case studies but it was more important to check if the results obtained from the assessment was the correct indication of actual cost performance of the project. The use of other psychosocial and subjective indicators that were based on the public, media and stakeholders comments reinforced the CPI results on three out of four (75%) case studies.
- Independent (not duplicate) – It became evident from the results obtained from all (100%) the case studies that CPI could be specifically used for the assessment of cost CSF and results obtained by measuring CPI were not duplicating the results obtained from other KPIs within the same Cost CSF e.g. CPI was used to get a snapshot of a project at a point in time (day of the health check) as compared to PJCI (project cost at completion) that represents cost at completion of a project.
- Reflect reality –This characteristic is linked to the availability of data for a KPI. CPI data was realistically available on all (100%) case studies mainly due to the presence of appropriate documentation.
- Sensitivity. Cost is directly tuned to project health as a cost overrun clearly indicates poor health. It was noted in the validation process that ACWP and BCWP kept on changing throughout the life cycle of the project and due to their influence on CPI and in turn on project health; the project health was sensitive to even minor changes in CPI. The sensitivity characteristic was only validated on two case studies (50%) because of the time associated with sourcing, collecting and analyzing data at different stages of the project. However it was noted that even though project health was tuned to CPI, if early warning signs were neglected and CPI not monitored and controlled during the early stages it was impossible to bring back the project on track in the final stages of the project.

The CPI was found to satisfy the criteria set for the indicators and thus retained without any modification for further use in identifying the root causes of poor health.

Figure 2: Cost Performance Indicator (CPI) Validation



Some of overall conclusions drawn from the validation process are listed below:

- The seven CSFs identified through the literature were the most significant for project success or failure as they receive the most attention from the on-site activities and the involved stakeholders.
- The robustness criteria defined above acted as a decision tool for retaining, discarding or changing KPIs. However it was necessary to retain only the most robust set of indicators that fully addressed the set criteria. This helped in minimizing the chances of in producing a tool that might end up being time and resource consuming and impractical to use.
- As the majority of KPIs were objective and use mathematical formulas the evaluation process was rather straight, inexpensive and quick to implement. However the set also included some subjective KPIs that uses opinions of clients, community and media that facilitated the counter checking of 'investigated results' supplied by objective KPIs with 'known results' supplied by subjective measures e.g. the time CSF was investigated and found to be unhealthy and this finding was supported by the negative media coverage.
- It was preferred to measure the Stakeholders KPI's before the other CSFs as many of the other KPIs are dependent on the results obtained from these KPIs.

5.6 Limitations

Generally speaking the collective belief which is based on the desire of project participants to be involved with only successful projects often blinds their ability to recognize and acknowledge the signs of failures. This often prevents them from disseminating any information for any sort of evaluation especially because of the fear of discovering the reality of the blind faith in their success. This problem was also encountered while validating the KPIs for the health model. This was obvious because of the conflicting nature of information received from different stakeholders. This was to some extent dealt with cross checking the collected data with the information obtained from other related KPIs.

Similarly KPIs were largely validated on completed projects. This problem was aggravated for KPIs that were solely meant to get a snap shot of a project on a particular day. In some cases this issue was sorted out by choosing a date in retrospect and measuring the KPI on this date. However the unavailability of past data limited the use of this technique.

6 Conclusions

A project health model derived from the human health model was developed to allow the immediate assessment of current project health, identify the reasons why the project may not be performing as expected and suggest a means of returning the project to better health.

The first stage involved the immediate assessment of current project health using KPI and CSF approach. The review of articles on performance measures reveal that Cost, Time, Quality, Safety, Environment and Stakeholders Value are most critical success measures. These are also important as they have been in most cases 'agreed to' and or 'are critical' to the interested parties. The literature review also indicates that these performance measures can be assessed using KPIs. It was shown that for a KPI to be useful in assessing the immediate assessment of the current health of a project it needs to possess six characteristics. To validate these KPI's, case studies are used in which each of the KPI is checked against the criteria consisting of the six characteristics. The KPIs that are retained can be used for detailed investigation and identification of factors that caused poor health in a similar way as the CSFs.

7 Discussion and future research direction

At the end of the immediate health assessment stage the CSFs that were found to be in poor health can used as the focus of a more detailed investigation. This will allow the cause of poor health to be diagnosed via Contributing Factors (CFs). These were largely identified using pilot projects within Australia. Like CSFs, the contributing factors need to be assessed to pinpoint the areas most likely to be causing poor project health. This will be accomplished with a series of Secondary Performance Indicators (SPIs) for each contributing factor. cbpp (2003) defines an SPI as '…an indicator showing the level of performance achieved against an operation that is of secondary importance to the successful completion of the services being provided. An SPI often provides a diagnosis the SPIs of the result of KPI'. To ensure the usefulness of the model to carry out detailed diagnose, the SPIs need to possess the same characteristics as the KPI's. However, the SPIs will also be used as the basis for prescription of remedies. The SPIs identification and validation process is underway and will pave the way for correct and timely identification of remedial measures. The list of remedies related to each contributing factor was to be developed through consultation industry experts and lessons learnt. It was proposed that remedies would be put in to action and their effect on the project monitored. As the cycle continues this should lead to a continuous improvement in project health.

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