THEME 4: PROCUREMENT AND RISK SHARING

Full Paper

THE DEVELOPMENT AND USE OF SECONDARY PERFORMANCE INDICATORS FOR MEASURING PROJECT HEALTH

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ABSTRACT

Maintaining the health of a construction project can help to achieve the desired outcomes of the project. As part of an ongoing research project of the Cooperative Research Centre for Construction Innovation (CRC-CI), a multi-stage toolkit is being developed to monitor and correct the condition of construction projects. The first stage of the toolkit is designed to assess the state of the construction project through the use of critical success factors (CSFs). CSFs that are found to be underperforming are identified and used as the basis of a more detailed investigation in the second stage of the toolkit to identify factors contributing to the problems. Secondary performance indicators (SPIs) are used to assess the condition of the contributing factors so that root causes can be identified and remedial actions suggested. The final stage of the toolkit monitors the project for changes to ensure continuous improvement. This paper will discuss the way that SPIs were obtained for this toolkit and how they are used to guide the identification of root causes.

Keywords: Construction project condition, critical success factors, key performance indicators, secondary performance indicators.

1. INTRODUCTION

There is a constant stream of public reports and commentary about projects that fail to meet pre-determined objectives. Adverse impacts include cost and time overruns, inadequate build quality, poor project relationships, loss of reputation, public clamour and legal disputation. In some instances poorly performing projects can attract unwanted publicity, particularly those which are publicly funded and enjoy a high profile.

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

2. BACKGROUND

Rubin and Seeling (1967) were the first to introduce success and failure measures. The findings from their study concluded that the wrong choice of project manager, unplanned project termination and unsupportive senior management were the main reasons for project failure. Russell & Jaselskis (1992) and Abidali & Harris (1995) measured project success by using financial ratios derived by statistical search through a number of plausible financial indicators. 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. 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'.

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.

Mian et al (2004) found that the most common cost overrun measures found in the literature over the last decade 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.

They also found out that over this 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.

Like CSFs, the contributing factors will 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. The Construction Best Practice Program (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 KPIs. However, the SPIs will also be used as the basis for prescription of remedies and will therefore need to be easily benchmarked.

3. THE USE OF PROJECT HEALTH MODEL TO DIAGNOSE CONSTRUCTION HEALTH PROBLEMS

Humphreys et al (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. Some of the parallels between construction project health and human physical health identified in the work of Humphreys et al (2004) include:

- 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

In this approach project health infers the degree to which the project is meeting expected outcomes. It is synonymous with project performance in that a project or any particular aspect of a project which is not performing as expected by the stakeholders would be perceived as unhealthy or failing. Conversely, a healthy project would be one which is fulfilling the expectation of the stakeholders.

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. Figure 1 shows the basic form of the model. The SPIs discussed in this paper are used in stage 2 of the model "Identification of root cause". The root causes are then used in the third stage of the model to help develop a set of remedies. Note that the model has been designed to include a Deeming (1986) type feedback loop for continuous improvement. This provides a means to assess the effectiveness of the proposed remedies to return the project to good health and is also analogous to the human health model.

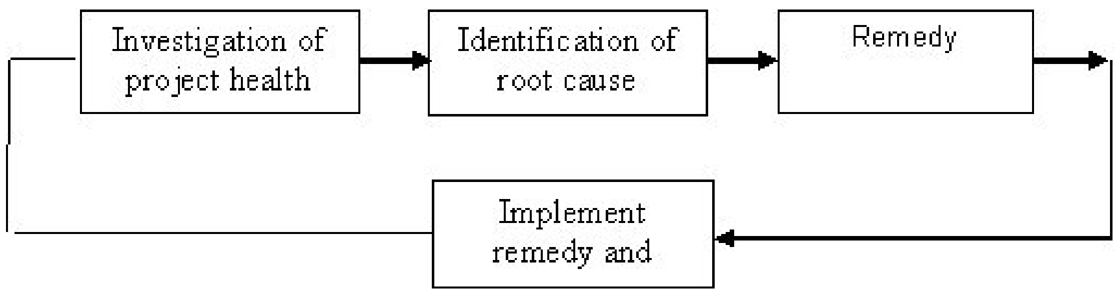

Figure 1 – Project Diagnostics Model

The use of KPIs to assess the performance of CSFs in stage 1 this model has been described in work by Mian et al (2004). In summary, the proposed model uses CSFs as the basis for a broadly inclusive fundamental health check to gauge project health in terms of specific success factors agreed to by interested parties. In order to use these CSF's as an indication of health, they need to be assessed. This was achieved by developing an associated list of Key Performance Indicators (KPIs) for each CSF.

The areas which form the focus of stage 2 are determined by the outcome of the stage 1 investigation. CSFs that are found in poor health in stage 1 are studied in more detail in stage 2. This is an important feature of the model as it allows rapid initial identification of problem areas followed by efficient and accurate identification of the root causes. In order to facilitate a more detailed investigation of underperforming CSFs the main factors contributing to each underperforming CSF needs to be identified. Once a broadly inclusive set of CFs is identified, they are used to pinpoint the areas most likely to be causing poor project health. One of the main features of the CF approach is that is allows the uncoupling of single issues which may span several CSFs.

Like CSFs, the CFs will need to be assessed to pinpoint the areas most likely to be causing poor project health. The method used to assess the CFs was designed with the requirements of stage 3 in mind. Stage three of the model requires specific problem areas to be identified and described so that appropriate remedies could be prescribed. This lead to the development of a series of secondary performance indicators (SPIs) associated with each CF. These could then be used to assess the performance of each CF and, if found underperforming, would become the basis of a suggested remedial strategy.

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4. IDENTIFICATION OF CONTRIBUTING FACTORS AND SECONDARY PERFORMANCE INDICATORS

Pilot interviews were conducted on seven projects identified by the industry partners. These interviews were conducted using a structured questionnaire. The respondents included clients, consultants, contractors and sub contractors. A total of 28 interviews were conducted. The questionnaire was designed to allow identification of contributing factors and to allow them to be ranked in terms of relative importance using a numeric scale. The projects were varied and included a variety of contracts types such as Design and Build, Lump Sum and Schedule of Rates. Most of the projects were more than A$10M in value. The questionnaire was undertaken by personal interview with each respondent to ensure each question was understood and addressed adequately. This was particularly important in this case as terminology used to describe CFs was derived from an initial literature and did not necessarily reflect the terminology of the respondent. For this reason also, the raw data form all interviews needed to be collated as the name for a single CF can vary from person to person.

The data analysis started with examination of questionnaire to identify of CFs for each of the seven unhealthy CSF themes. The collation of CFs based on common terminology reduced the total number of CFs by identifying common CFs between the seven CSF themes. The respondents were required to limit the number of contributing factors that they proposed to four. In most cases respondents provided four different contributing factors of varying relative importance, however occasionally the answers consisted of one contributing factor for each CSF. The respondents were required to rank the CFs using a scale of 1-4.

To determine the overall ranking of the identified CFs for each unhealthy CSF using the importance scale nominated by the respondents (clients, consultants, contractors & sub contractors) the importance index was computed using the following modified equation by Mezher (1998):

$$II = \left(\sum_{i=1}^{4} \frac{x_i y_i}{3} \right) \qquad \text{(Eq. 1)}$$

Where II denotes importance index and $x_í$ is a constant that represents the weight of the íth response where $x_í$ = 1,2,3,4 and $y_í$ represents the frequency of the íth response where í = 1,2,3,4. Hence;
y_1 = frequency of the least important contributing factor.
y_2 = frequency of the less important contributing factor.
y_3 = frequency of the important contributing factor.
y_4 = frequency of the most important contributing factor.
Table 1 provides an example of the CFs identified in the study for the CSF "Cost Overrun" as well as the rank and importance index of the CF.

Table 1: Rank and index of contributing factors

CSFs	**Contributing Factors (CFs)**	**Index**	**Rank**
Cost Overrun			
	Variations	14.7	1
	Inaccurate cost estimate	6.0	2
	Rework	3.3	3
	Lack of client decision making	2.7	4
	Competitive nature of market	2.3	5
	Poor quality of design & documentation	2.3	5
	Approvals	2.0	7
	Contractor / Sub contractor work efficiency	2.0	7
	To manage project simultaneously a large component of work was done in another city branch office	2.0	7
	Poor workmanship	1.3	10
	Work sequencing with other trades	1.3	10
	Audit testing	1.0	12
	Change of management	1.0	12
	Emissions and under measures in documentation	1.0	12
	Lack of completeness of contract documents	1.0	12
	Limited resources	1.0	12
	Lack of architect higher management interest	0.7	17
	Productivity of workforce due to traveling involved due to remote location of project	0.7	17
	Relationship workshop	0.7	17
	High quality product required	0.3	20
	Higher management direct involvement	0.3	20
	Programming issues causing pressure on contractors	0.3	20

A similar listing was generated for each of the seven CSFs. A total of 127 contributing factors were identified. Table 2 ranks the seven CSF themes based on the findings of the investigation (note3 that quality has been divided into two groups for Table 2 – quality of construction and quality of documentation).

Table 2: Rank and index of CSFs

CSFs	Index	Rank
Cost	6.68	1
Quality of construction- increase in rework	4.65	2
Relationships	4.15	3
Time	3.86	4
Safety	3.60	5
Stakeholders value	3.43	6
Environment	3.40	7
Quality of documentation -Increase in RFI's	3.20	8

In addition to the CF identified in the study, other important findings included:

- All projects were considered successful by the respondents; however, some projects possessed unhealthy CSFs.
- Contributing factors for the healthy CSFs may be useful for identifying remedies in Stage 3.
- A variety of perspectives were obtained from the broad range of respondents interviewed in each project.
- Verbal clarification was required for some questions, particularly those requiring percentage estimates and relationships.
- All respondents were extremely co-operative although reluctant to focus on negative issues.
- The investigation of only projects which were considered successful may have implications on the completeness of the set of CFs.

Due to the investigation of only successful projects in this pilot study the list of CFs was not considered comprehensive and was augmented with CFs identified from a literature survey.

The CFs were further validated using a Delphi type approach using industry partner as specialists and asking them to add CFs to the list obtained from pilot study so as to have a comprehensive list. This was repeated by have a second round of feedback on CF and finally they were discussed in a workshop attended by the same specialists to get a final list bases on the consensus of these specialists.

5. SPI'S

Although a large number of SPIs were identified in the literature review, these often lacked certain characteristics that would make them applicable, useful, independent and practical. To increase the robustness and usefulness of the model certain characteristics were chosen which need to be possessed by SPIs used in this model. The SPI characteristics along with description are shown in Table 3.

Table 3: Required SPI Characteristics

Characteristic	Description
Easily measurable	Must able to be measured quickly, directly and accurately with as little effort as possible.
Sensitive	The indicator must be tuned to project health to allow accurate health assessment.
Assessable	Once measured, the indicator must be able to be compared to a known value to allow judgement of health to made.
Reflect reality	The measured variable must encourage a description of reality rather than 'ideal' or perceived situations.

The focussed assessment of SPIs should allow underperforming CFs to be rapidly identified. A number of SPIs fulfilling the above criteria were identified from the literature survey for each of the CFs. However due to the nature of some of the characteristics described above it was necessary to validate the robustness of these SPIs by testing them on actual projects. The validation stage was also important as the outcome of this stage was to be a robust set of SPIs that would facilitate in pinpointing root causes of poor construction health. 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.

To enhance the chances of checking the robustness of SPIs, the case studies were chosen to be *unsuccessful*: An unsuccessful project was preferred to maximise repetitive evaluation of the SPIs, *live*: This was useful for SPIs 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 SPIs. The projects were carefully chosen to ensure that they encompass different project stages and different procurement methods.

SPIs consisted of objective metrics and subjective questions. In order to increase the objectivity the questions consisted of a series of conditional statements that facilitated assessment whilst minimising subjectivity.

The data was collected through face to face interviews and the interview questions were structured around the information required to measure SPIs. At the beginning of the case study a list of project documentation required for measuring the SPIs was circulated among the case study participants. It is envisaged that this would help in cross checking the subjective answers of the respondents with the hard data from the project documentation e.g. RFI register, Claims register, EOTs and many other. The third important factor as shown in Table 3 that contributes to a cost overrun is rework and the associated SPI to investigated rework is shown in Table 4.

Table 4 – Example of CF / SPI

CF	**Contributing Factor**	**SPI**
Cost Overrun		
	Rework	**Definition**

		RR = RC / TACV Where: RC = rework cost TACV = total adjusted contract value contract

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 contributing factors to pin point the root causes 'well' for a SPI 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 sensitively tuned to health of a project. The validation process for the health check model helped to identify the most efficient, robust and effective SPIs.

The main findings of the validation process for RR (Rework Ratio) are summarized as follows:

- Easily measurable: As shown in Figure 2, the data required to measure RR was readily available on three out of four all (75%) the case studies. On projects where rework cost was not being measures this cost was based on an approximation formula = 30 % of (total value claimed - total value approved) i.e. rework cost is approximately 30 % of the contractor claims that are not approved. The claims data was collected using contractor progress claim showing the claimed and approved. The availability of any of the above facilitated in measuring RR quickly, directly and accurately with little effort.

- Broadly applicable: Although the measure was only designed to measure contractor's rework cost , it was easily measurable for all the case studies using different procurement methods such as construction management, traditional and design & construct.

- Assessable: Based on literature review and past experiences of industry specialists a benchmark of 0.02 was chosen to assess this SPI. It was also decided that any project having a RR ratio greater than this benchmark was unhealthy. Although RR 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 RR results on all three out of four (75%) case studies.

- Reflect reality –This characteristic is linked to the availability of data for a SPI. SPI 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. Rework is one of the factors that contributed to cost overrun and poor project health. It was noted in the validation process that RC kept on changing throughout the life cycle of the project and due to their influence on RR and in turn on project health; the project health was sensitive to even minor changes in RC. The sensitivity characteristic was only validated on one case study (50%) because of the time associated with sourcing, collecting and analyzing data at different stages of the project.

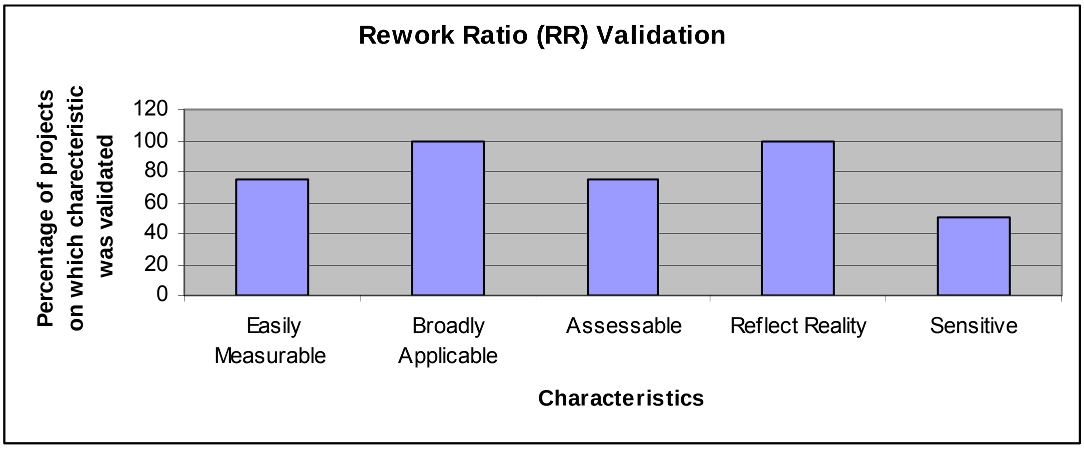

Figure 2: Rework Ratio (RR) Validation

The main overall conclusions drawn from the validation process are:

- 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 SPIs. 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 SPIs were objective and use mathematical formulas the evaluation process was rather straight, inexpensive and quick to implement. However the set also included some subjective SPIs that used opinions of clients, community and media. These were read together with the results obtained by using objective SPIs e.g. the safety incidents was measured using a direct question but the result was read together with Lost Time Injury Frequency (LTIF) and negative media coverage

6. SUMMARY

Project Diagnostics is developing a three stage toolkit to rapidly pinpoint underperforming areas of the project, identify factors which contribute to the underperformance and propose remedial measures to return the project to good health.

The second stage of Project Diagnostics identifies root causes of problem areas that have been identified by an initial investigation in stage 1 of the process. Factors which contribute to the root causes of the problems are evaluated using a system of secondary performance indicators.

A series of industry consultations and literature survey were used to identify a large number of contributing factors (CFs). Similar CFs were grouped to reduce the total number of CFs and workshops with industry partners were undertaken to refine the list. Each CF required a series of SPIs to measure its performance. The SPIs associated with each CF were determined as before through a consultative process with industry partners and detailed literature survey. The large primary list of SPIs was reduced by grouping like SPIs and a final list of SPIs was achieved through an industry partner workshop.

The CF / SPI system was tested on a series of case studies and found to possess the characteristics necessary for it to be an effective and efficient solution to stage 2 of the Project Diagnostics model.

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