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Can it be Possible to Control Both Planning and Performance in Construction?

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Abstract

The objective is to investigate how index of last planner system (LPS) is co-related to earned value management system (EVMS) index using both quantitative and qualitative ways. The research will develop an implementation strategy to effectively match earned value management system (EVMS) and LPS based on case study. The analysis was done separately during 10 consecutive stages: (1) 0–10% of construction duration; (2) 10–20% to (10) 90-100% of the project schedule. The reason why the researcher divided 10 consecutive stages is project duration was too long for analyzing. If the duration is not divided, not only detailed information but also meaningful results are not abstracted. The results of analysis were followed; In success group, negative results between EVMS and LPS were calculated in Period 3-6.In failure group, any meaningful results were not existed. So, if general contractor and subcontractors are able to use EVMS and LPS simultaneously, the last planner system may enhance schedule and cost performances. Then, general contractor and subcontractors understand LPS and EVMS clearly, it is possible to coexist reliability and project performance. Otherwise, the reason why negative results in success project were calculated was many subcontractors participated in period 3-6, so, data in period 3-6 could not be filtered between big and small companies. Then, general contractor and big-sized subcontractors' will can integrate LPS and EVMS, and it is possible to coexist reliability and performance. Otherwise, it is hard to apply LPS and EVMS to small-sized subcontractors because of its insufficiency of understanding. This paper adopted statistical analysis for comparing EVMS and LPS in same time in all subcontractors. So, univariate tests should be separately done considering of company's size and time difference effect.

Key Words: Productivity, reliability, performance, correlation analysis, indices.

1. Introduction

It is important to diagnose current status for leading project success, many managers try to measure project performance periodically. There are many way to measure project performance, construction industry traditionally uses schedule performance index (SPI) and cost performance index (CPI) to track its project performance. Based on SPI and CPI, project manager and corporate executive can diagnose project performance, and can predict final results in both schedule and cost. Otherwise, project reliability deeply relates to workers' production, therefore, production planning and control tool are more important than project performance. Kim and Ballard[1] divided construction sites into two levels that the management level and the operational level. The management level focused on project results such as ahead of schedule and under budget. However, the operational level's concern is different to the management level. The operational level, for example field engineer or production unit focuses on today's assignment. Last planner system (LPS) is a representative technique for maximizing of productivity in work flow[2].

However, there are two contradictory claims exist. First, some studies asserted that the last planner system also improves schedule and cost performances. And second, Kim and Ballard[1,3] claimed that the earned value method incentivizes manipulating work sequence by performing easy but high-budgeted works as priority to maximize its earned value (EV); thereby impacting on work flow reliability negatively. Recently, Kim et al.[4] found that indexes of the LPS and earned value measurement system (EVMS) do not have direct relation in statistical way.

Hence, the question arises that high percent plan complete (PPC) guarantee schedule performance improved or PPC has direct co-relation with project performance. However, to date, few studies have investigated the relationship between LPS and EVMS. Thus, the objective of this paper is to investigate how index of LPS is co-related to EVMS index (SPI and CPI) using both quantitative and qualitative ways. The research will develop an implementation strategy to effectively match EVM and LPS based on case study. The paper is divided into six sections. The next section supports a review of the EVMS and LPS indices. Then, the following section contain the statistical analysis and a discussion of the major findings. Finally, we present the conclusions of the study.

2. Literature Review

2.1. Earned Value Management System (EVMS)

Earned Value (EV) came from the US Department of Defense(DoD) established to check the efficiency of their major projects in 1963[5]. From late 1960s, many

research has been done in EVMS. The research theme contains the integration of Work Breakdown Structure (WBS) and Cost Breakdown Structure (CBS), and the real time of EVMS to construction areas. Then, research interests of existed studies can be divided into two subjects: (1) the various concepts of integration and (2) EV's application. To use EV, it is ideal to combine schedule and cost data. Accordingly, previous research studied four concepts of the integration. Teicholz[6], Hendrickson and Au[7], and Kim[8] suggested typical integration models utilizing EV. Also, Abudayyeh and Rasdorf[9] suggested work-packaging model that is summing cost data to the WBS. And there are 2 major indices for calculating project performance. The 2 indices are SPI and CPI.

$$\text{SPI} = \frac{Budgetd\ \ cost\ Workperforme\ \ d\ (EV)}{Budgetd\ \ cost\ Work\ \ accomplis\ hed\ (PV)} \quad (1)$$

If the SPI is over 1.0, the project is ahead of schedule, but if the SPI is below1.0, the project is behind schedule. Then, the CPI measures the cost efficiency.

$$\text{CPI} = \frac{Budgetd\ \ cost\ Workperformed\ \ \ (EV)}{Theactualcostsforaccomplis\ \ \ hingt\ heearnedvalue\ \ \ (AC)} \quad (2)$$

If the CPI is over 1.0, the project is under budget, but if the CPI is below1.0, the project is over budget.

2.2. Last Planner System (LPS)

Koskela et al.[10] suggested that Lean Construction is a "way to design production systems to minimize waste of materials, time, and efforts in order to make the maximum amount of values". LPS was from Lean Construction and it is a production planning and control tool to enhance work flow reliability[11,12]. A lot of reports and papers suggested that LPS enhance reliability, consequently reducing project time and expenditure[13]. In particular, Kim and Ballard[1] provided practical research indicating that LPS can enhance reliability but also enhance CPI and SPI in EVM. LPS provided a metric for calculating planning reliability which is PPC. Originally, PPC means Week PPC, however, this paper followed the previous study[4], and used each 3 PPC for calculating reliability.

$$\text{Day PPC}(\%) = \frac{No.ofcompletedonDayd}{No.ofassignedonDayd} * 100 \quad (3)$$

$$\text{Week PPC}(\%) = \frac{\sum_{d=1}^{7} DayPPConDayd}{Np.ofdaysworkedduringWeekw} * 100 \quad (4)$$

$$\text{Week E-PPC}(\%) = \frac{No.ofcompleted}{No.ofassingedonWeekW} * 100 \quad (5)$$

3. Analysis of Data

3.1. Description of Data

To increase accuracy, the analysis is focused on the residential building. The standard of success and failure depends on the SPI and CPI. Therefore, when

both the CPI and SPI are over than 1.0, it is success. But when either one of the two indices is below1.0, it is failure. To analyze the relationship among indices (the Day PPC, Week PPC, Week E-PPC, SPI, and CPI) covering different time basis, researcher matched the time span at monthly basis as shown in table 1. The researcher conducted a statistical analysis among the indices. The statistical analysis was carried out separately during ten consecutive stages of each residential building. The reason why the researcher broke out 10 consecutive stages is project time was too long for analyzing.

Table 1: Univariate Tests

Succuss projects					
Group	**Variables**	**Period 3**	**Period 4**	**Period 5**	**Period 6**
LPS vs EVMS	1. *Day_PPC*(monthly) & *SPI*	0	-0.6586***	0	0
	2. *Week_PPC*(monthly) & *SPI*	-0.61413***	-0.38258***	-0.34191**	0
	3. *Week_E-PPC*(monthly) & *SPI*	0	-0.51419***	-0.38523***	-0.39175***
	4. *Day_PPC*(monthly) & *CPI*	0	0	0	0
	5. *Week_PPC*(monthly) & *CPI*	0	0	0	0
	6. *Week_E-PPC*(monthly) & *CPI*	0	0	0	0
*** (**) correlation is significant at 0.01 (0.05) level.					
Failure projects					
Group	**Variables**	**Period 3**	**Period 4**	**Period 5**	**Period 6**
LPS vs EVMS	7. *Day_PPC*(monthly) & *SPI*	0	0	0	0
	8. *Week_PPC*(monthly) & *SPI*	0	0	0	0
	9. *Week_E-PPC*(monthly) & *SPI*	0	0	0	0
	10. *Day_PPC*(monthly) & *CPI*	0	0	0	0
	11. *Week_PPC*(monthly) & *CPI*	0	0	0	0
	12. *Week_E-PPC*(monthly) & *CPI*	0	0	0	0
*** (**) correlation is significant at 0.01 (0.05) level.					

3.2. Quantitative Analysis

Success Group

- Period 3: negative result between the Day PPC and SPI (row 1) was calculated.
- Period 4 and 5: negative results between the Day PPC, Week PPC, and Week E-PPC and SPI (row 1) were calculated.
- Period 6: negative result between the Week E-PPC and SPI was calculated.
- Any meaningful result was not in period 1, 2, 7,8, 9, and 10.

Failure Group

- Any meaningful result was not in failure group.

4. Discussion

There is no meaningful result between operational level(the Day PPC, Week PPC, and Week E-PPC) and management level(SPI, CPI) in period 1 and 2, because period 1 and 2 are early stage in residential building. In this time, all participants such as site manager, field engineer, subcontractors, and production unit try to set up their own environment. Then, there are meaningful results from period 3-6, however the direction is negative. Small sized-subcontractors

participate from period 3, they do not have enough ability to build the planning reliability. They should focus only project performance, it means they try to seek schedule completion and lucrative profit. That is to say, EVM cannot be integrated with LPS from the operational level.

Otherwise, there is no meaningful result between LPS and EVMS in failure projects. Therefore, if there is no result during residential building, site manager, field engineer, subcontractors, and production unit will have to pay attention to their planning reliability and project performance. They will accomplish the obvious consequence, project failure in some day. Then, Proposition 1 and 2arecome out:

- Proposition 1: Does LPS indices obstruct project success?
- Proposition 2: Is it possible to coexist Planning reliability and Project Performance?

The answer of proposition 1 is depend on general contractor and subcontractors' ability. If general contractor and subcontractors are able to use EVMS and LPS, the last planner system can improve schedule and cost performances as like previous research. But if general contractor and subcontractors are not able to understand system level and operational level, LPS indices will make the opposite consequence toward project success.

In addition to Proposition 1, Proposition 3 can be addressed as followed. Using LPS and EVMS separately can lead project to be success. And general contractor and subcontractors understand LPS and EVMS clearly, it is possible to coexist planning reliability and project performance. To understand negative correlation in success project, researcher interviewed general contractor and big-sized subcontractors that participated in reinforced concrete work and door and window. Those big-sized subcontractors understand EVMS and LPS, and their results were quite meaningful. However negative correlation in period 3-6 was abstracted, many subcontractors participated in period 3-6, so, the data in period 3-6 could not be filtered between big and small companies. Then, general contractor and big-sized subcontractors' will can integrate LPS and EVMS, and it is possible to coexist Planning reliability and Project Performance. Otherwise, it is hard to apply LPS and EVMS to small-sized subcontractors because of its insufficiency of production planning.

5. Conclusion

EVMS and LPS are one of the powerful management technique that has different view. EVMS is useful in management level, also LPS is good in operational level. However, it is hard to integrate EVMS and LPS in same construction project, it is similar to previous study[4]. In order to direct result between EVMS and LPS, the researcher divided 10 consecutive stages. The results were followed.

- In success group, negative results between EVMS and LPS were

identified in Period 3-6.

- In failure group, any meaningful figure was not existed.

A lot of paper showed planning reliability could lead project performance's result[13], it is theoretically reasonable. However, it cannot be applied to all construction projects such as this and previous study[4]. Best practice in integrating EVMS and LPS is understanding and will of general contractor and subcontractors. If a company seeks to one of EVMS and LPS, the results between EVMS and LPS will be negative or not meaningful. Therefore, general contractor and subcontractors understand and apply LPS and EVMS actively, it is possible to coexist planning reliability and project performance.

5.1. Future Works

This paper adopted univariate tests for comparing EVMS and LPS in same time in all subcontractors. So, statistical analysis should be separately done considering of company's size and it may exist correlation between former planning reliability and later project performance such as lagging effect.

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