A Model for Assessing the Process Complexity in Engineering Projects

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Abstract: Engineering projects manage different processes to achieve the project goal. The more complex the engineering projects are, the more workloads the projects have to deal with. However, the evidences show that complexity not only brings costs and wastes, the complexity can make profits and increase competitive forces. The engineering projects should focus on how to manage the complexity, not avoid them. The paper proposes the complexity -value matrix which includes two indicators, complexity and value of the engineering projects, to manage the whole processes of the projects

1. Introduction

Engineering projects face problems of processes managements. the more processes the engineering project has, the more complexity it will face. The complexity may lead to high costs and time spending. In many views, complexity as the bottleneck should be decreased or avoided. However, Complexity is a double-edged sword which has value-added and nonvalue-added parts. The value-added complexity increases the projects' values and improve the ability to gain market shares. The advantages of high complexity are that it is difficult to be copied by competitors and help the project to improve effectiveness. On the other hand, the non-value-added complexity will increase the non-value-added cost of the project. When the engineering projects' performance decline, they will not be able to effectively cover the cost or the period of the project is overtime, which may bring more trouble to the whole projects. Therefore, the process complexity should be managed, not eliminated.

2. Lean Management and Process Complexity

The first step of managing complexity is to measure complexity. According to Marco Peron and G Miragliotta (2004), the way projects operate systematic complexity has a profound impact on performance, and the ability to control complexity becomes a core competency. Due to the nonlinearity and emergence of complexity, it is difficult to manage and measure complexity. The complexity has many components, and each of components have different relationships. Clarifying the relationships among each component are the aspect to measure process complexity. In addition, the level of complexity of different projects are different, thus the key of managing complexity is to find the method which can process different projects.

Afshin Jalali Sohi, Marcel Hertogh, Marian Bosch-Rekveldt and Rianne Blom (2016) thought that the overspend and overtime in projects in the construction industry is not due to assigning the complexity of projects. The author suggests applying lean management in managing projects as a possible solution of managing complexity. The paper approved that the lean production has an effective correlation with the complexity management which based on the factor analysis through collected data from structured questionnaires. Piotr Nowotarski, J PasIawski and J Matyja (2016) based on study of the construction of center office buildings in the Poland, presented how lean management affects the total cost of managing storage selection process in the construction site. The

author subjectively scored different processes, then applied lean management and scored again. The results showed that lean management can be assessed risk issues and effectively analyzed the risks and complexities of different processes. Lean management can effectively reduce the waste of time and cost. Therefore, the evidences show that lean management can be effective as a tool to manage process complexity in engineering projects.

3. Methodology: Complexity-Value Matrix

This paper innovatively proposed using complexity-value matrix to analyze process complexity of engineering project. The method includes four steps: 1. building project flow chart 2. calculating process complexity, 3. calculating value streams indicators 4. building complexity - value matrix. The method attempts to establish a two-dimensional matrix by separately calculating the process complexity and value streams for seeking an effective way to manage process complexity in engineering.

3.1. Establish Process Flow Chart

The first step is to build a flow chart of the whole engineering project. The process flow chart should base on the sequence of each processes. The subsequent process cannot be completed without finishing the previous process. The sequence must be consistent with the project procedures and sequences. Each key process and bottlenecks should be marked in the chart.

3.2. Calculation Process Complexity

Based on the process flow chart, the complexity of each single key process will be calculated. The complexity calculation mainly includes two parts, objective complexity and subjective complexity.

3.2.1. Objective Complexity

According to H EIMaraghy, T Algeddawy, SN Samy and V Espinoza (2014), the objective complexity can be measured by the layout complexity (LCI) method. LCI is weighted calculated by multiple indicators, such as the number of production processes, product types, raw material types and process interleaved nodes. Engineering projects can select the six key indicators based from the actual situations and importance. The formula of objective complexity is shown as the following:

$$\mathrm{LCI} = (\sum_{t-1}^{n} \mathrm{C_i})^2 - \sum_{t-1}^{n} \mathrm{C_i^2}$$

$$\mathrm{C_i} = complexity\ for\ each\ indicator \quad (1)$$

3.2.2. Subjective Complexity

According to Mattsson, Sandra, P. Gullander, and A. Davidsson (2015), subjective complexity has ten important indicators which included product categories, models, diversity, manual binding, methods of operation, layout, production equipment, tools, organizational processes and leadership. Projects leader needs to design questionnaires based on these ten indicators, and issue questionnaires to three people who are related to each process scoring each process. The investigated people should include designers, production workers and product managers which can avoid errors. People from different positions or playing different roles may rate disparate scores for the same questions. Therefore, the questionnaire should be added rating grades during designing process (5 (unsteady factor), 0 (completely robust), 1 (micro-stable), 3 (medium-stable) and 9 (especially not robust)). Then, the scores of investigated people are calculated. The calculated scores will be weighted by the ratio of 5 (Production Department) :3 (Design Department) :2 (Management Department) as the subjective complexity. The engineering project weights an overall process complexity based on the objective complexity and the subjective complexity index.

3.3. Calculated Value Stream Indicators

As mentioned before, lean management can effectively measure and manage complexity. Value stream is one of the most important parts in lean management. Value stream aims to continuously improve processes efficiency and effectiveness. Meral Gunduz (2015) proposes five indicators to measure the value of the value stream from "the Value Stream Performance Assessment in the Lean Manufacturing Business". The first step is to calculate three indicators in the process, as shown in the following table:

Table1. Three Indicators

Value Stream Measurement	How to measure it
Values per process	Values created by each process
On time delivery	The percentage by delivery on time
Average cost per process	Total cost divided by total processes

3.3.1. Values Per Process

Values per process measures values added by each process. For calculating values per process, the project leader needs to estimate total values the project will have. Then using total values divided by total process.

3.3.2. On Time Delivery

On time delivery is used to measure the percentage of completing each process on time. In order to getting on time delivery, the number of processes finishing on time divided by total processes.

3.3.3. Average Cost Per Process

Average cost per process measures the input for each process. Average cost per process is calculated through total cost divided by number of processes.

3.3.4. Value Steam Indicator

Value stream indicator is basis on values per process, on time delivery and average cost per process.

Value stream indicator = (value per process-average cost per process) * on time delivery

3.4. Establish Complexity - Value Matrix

Based on the indicators calculated in the second and third steps, the complexity-value matrix is established. Complexity-value matrix consists of high complexity, low complexity, high value and low value, and it is divided into four parts: high value-high complexity, low value-high complexity, low value-low complexity and high value-low complexity.

3.4.1. High Value - High Complexity

This process can create value for the project's profits. It should increase the investment to simplify the process as much as possible, reduce the cost caused by complexity while maintaining competitiveness, and convert high complexity into Low complexity. However, it is not possible to reduce product innovation in order to reduce complexity. The purpose of the matrix is to manage complexity rather than reduce complexity.

3.4.2. Low Value - High Complexity

Project leader needs to pay close attention to this part and look for the reasons what cause the project is low value - high complexity. If the process is necessary but non-value added, the project leader needs to simplify processes and reduce complexity. If it is a non-essential process, it can be combined with other process to reduce costs. For value added processes, the project leader should look for ways to improve processes and add value to move to high-value.

3.4.3. Low Value - Low Complexity

For this process, project leader can continue to increase its value and shift to high value - low complexity.

3.4.4. High Value - Low Complexity

This process as the profit center is generally the core process of the project, and the corporate needs to pay close attention on it. On the one hand, the value of this process should be continuously maintained or improved. On the other hand, the project must plan a good complexity management, innovate and improve the processes according to project demand, increase the complexity at the right time, and avoid being eliminated in the cost competition.

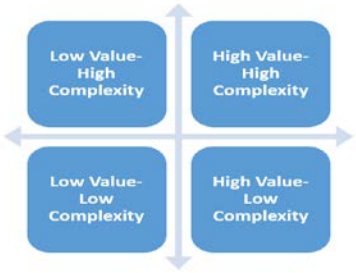

Figure 1. Complexity- Value Matrix

3.4.5. The Meaning of the Complexity - Value Matrix

Complexity has two sides. On the one hand, increasing the complexity of the processes can improve the value at a certain extent, innovation, and satisfy the increasingly complexity needs from the society. On the other hand, the increasing of complexity will bring additional costs to projects. Some of these costs are value-added, but some are non-value-added costs as wastes for the project. Therefore, projects cannot simply reduce complexity, but should choose the right way to manage complexity.

After objectively analyzing various data of complexity-value matrix, different management methods are provided by different situations. This matrix can effectively shorten the time of the whole process, increase the time-to-value ratio, reduce the inefficient inventory, increase the liquidity, and strengthen the liquidity of the project. In terms of cost, the matrix effectively manages process complexity, simplifies information flow, eliminates waste and unnecessary labor time.

4. Conclusion

Projects need to increase complexity to survive in the fierce cost competition. Complexity cannot be simply eliminated or reduced, and the value-added complexity can bring profits to the projects, so projects need effective ways to manage complexity. The complexity of the process can be quantified through the model, and the value stream can assess the value-added and non-value-added parts of the process complexity. Projects can connect values and complexity by establishing a complexity-value matrix and manage them based on different situations. However, how projects can balance between cost saving from the method and the additional costs from implementing the method is the next question to be solved.

References

[1] Marco Peron and G Miragliotta. “Complexity Management and Supply Chain Performance Assessment. A field Study and a Conceptual Framework”. *International Journal of Production Economics.* 2004, 90 (1):103-115.

[2] Afshin Jalali Sohi, Marcel Hertogh, Marian Bosch-Rekveldt and Rianne Blom. “Does Lean & Agile Project Management Help Coping with Project Complexity?”. *Social and Behavioral*

Sciences. 2016, 226:252-259.

[3] Piotr Nowotarski, J PasIawski and J Matyja. “Improving Construction Processes Using Lean Management Methodologies – Cost Case Study”. *Procedia Engineering.* 2016, 161:1037-1042.

[4] H EIMaraghy, T Algeddawy, SN Samy and V Espinoza. “A Model for Assessing the Layout Structural Complexity of Manufacturing Systems”. *Journal of Manufacturing Systems.* 2014, 33 (1): 51-64.

[5] Mattsson, Sandra, P. Gullander, and A. Davidsson. "Method for Measuring Production Complexity." *International Manufacturing Conference IMC 28 - Manufacturing* SustainabilityInternational *Manufacturing Conference IMC 28 - Manufacturing Sustainability* 2011.

[6] Meral Gunduz. “Value Stream Performance Measurement in Lean Manufacturing Business”. International *Business and Management.* Vol. 10, NO.3, 2015, pp. 40-47.