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Data mining model for identifying project profitability variables

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Abstract

Many engineering design companies collect data such as profits to manage projects. But the relationships between operational variables and performance are usually not thoroughly analyzed and interpreted. This paper proposes a data mining model and procedure to relate influence variables to project profitability. Data categories and variables are defined at the project input, process and output stages. The model proposed herein was tested by analyzing 548 projects of an engineering consulting company. The relationships between profitability and various input and process variables were identified and interpreted. For example, the effect of QA/QC on profitability is positive. Based on documented data and derived information, this model can help companies gain operational knowledge and thus further improve performance.
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Keywords: Data mining; Systems approach; Managing projects; Profitability; Knowledge management

1. Introduction

Engineering companies usually collect data such as project profit and man-hours to manage design work but then do not analyze these data rigorously. Therefore, information is not derived to interpret cause–effect relationships, improve performance, plan future work, and create knowledge. Such inadequate engineering management is common and causes one-third of A/E projects to miss cost and schedule targets [1–3].

Many studies propose frameworks to create or acquire knowledge, but they usually do not provide details of how this can be accomplished [4]. Knowledge management demands better information in terms of data needs, collection, analysis, and interpretation. When data needs and collection are well planned, analysis and interpretation will generate knowledge and better project management. For example, if project man-hour is seen as related to profitability, project man-hour and profit data are needed, collected, and analyzed to interpret their relationship to verify the tacit knowledge.

For engineering companies, explicit knowledge is more technical in nature and can be more easily expressed and transmitted than tacit knowledge [5]. Tacit knowledge is difficult to articulate and mostly embedded in less-understood non-technical issues such as project management methods [6]. Bloodgood and Salisbury [7] argue that making such tacit knowledge available throughout the company will improve the company's performance and profitability.

Knowledge can be generated by data mining tools [8]. Data mining refers to the application of acquisition methods to the generation of potentially useful knowledge from the organization and analysis of raw data [9]. The research described in this paper establishes a system model and procedure to guide the data mining process. The model was tested by analyzing 548 projects of an engineering consulting company to search for the relationships and knowledge among the input variables, process variables, and profitability.

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2. The data mining model

The system model of input–process–output (I–P–O) has often been used to manage organization operation and project performance [10,11]. Our research develops a similar model, shown in Fig. 1, to analyze engineering company profitability. Because knowledge is potentially infinite, measuring organizational knowledge has to rely on general categories to capture the rich variety of knowledge [12]. Therefore, general categories and variables are established at the project stages in Fig. 1. The project data (I_1) and project nature (I_2) and their variables are listed at the input stage; work division (P_1) and management (P_2) at the process stage; and profitability and other performance measures (O) at the output stage.

Organizations (except non-profit ones) pursue profits and collect relevant information. Profitability is influenced by the input and process variables. To identify the relationships between these variables and profitability, a company has to establish categories and collect data of the selected variables. Two explicit categories are established at the input and process stages, respectively. The project data category (I_1) includes variables that have been given at the beginning of a project such as project type, duration, contract amount, etc. Work-division (P_1) includes variables that can be deployed by a company such as budget and QA/QC. These variables contain basic data for performance analysis and can be collected by companies. But few variables are tracked in engineering design projects except those mostly of quantitative nature such as duration and actual hours [13].

There are also implicit variables that influence profitability. They are qualitative in nature and cannot be easily recorded in a database, such as I_2 and P_2 expressed in the shade portions of Fig. 1. Project nature (I_2) includes variables such as project characteristics, interdependence of tasks, and project possessed information. The five variables listed under project nature in Fig. 1 are the sources of project uncertainty and equivocality (U&E) that describe work characteristics to a great extent [14]. They are used as proxies to measure project nature. The management category (P_2) includes coordination, stakeholder needs, schedule effectiveness, etc. These process variables have been proven to improve project performance [15,6]. They are adopted here to remind management of their importance.

3. Implementation procedure

A concept has to be implemented and tested in order to verify its value. The procedure developed to implement the proposed model is shown in Fig. 2. It involves three steps to prepare the data and five steps to analyze and interpret it, which is similar to a data mining process [16].

1. Define data needs. Define profitability or other pertinent performance measures (O) such as productivity. The measurable I_1 variables usually include project type, contract amount, the owner, etc. Other variables can be included such as the design impacting variables [17]. Since the qualitative I_2 variables are not usually readily available, a task nature questionnaire was designed to collect them. Similarly, define the process variables P_1 (and P_2).
2. Establish database and collect data. A sufficient amount of data must be collected to conduct the subsequent analyses.
3. Pre-process the company's database. Extract data from the database and categorize them according to I, P, and O variables. Clean and wash them as necessary.
4. Analyze I–O relationships. The purpose is to know whether profitability can be predicted upon receiving a project.
5. Analyze P–O relationships. Determine which process variables affect profitability. The relationships identified in steps 4 and 5 will help management understand profitability problems and act appropriately.

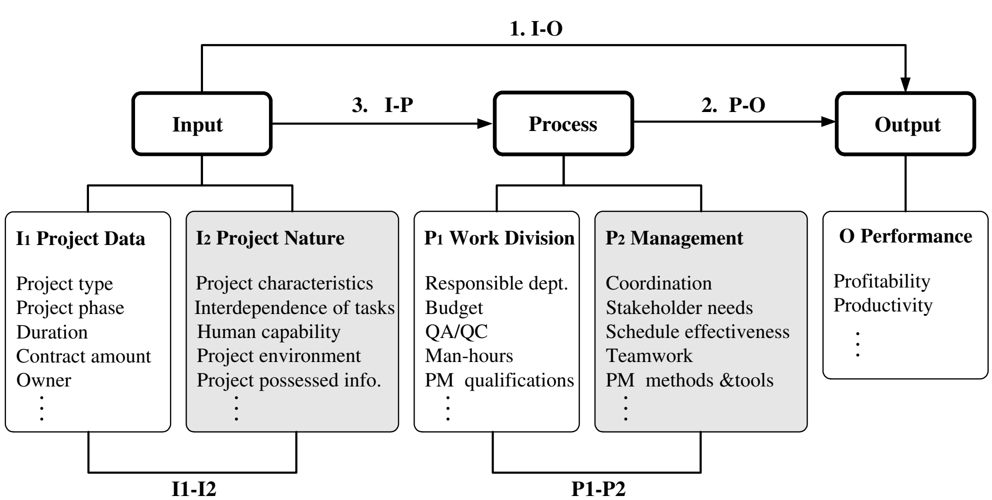

Fig. 1. The system data mining model.

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