

## **A system-of-systems approach to ex-ante analysis of profit potential of a project portfolio**

Construction is a major industry worldwide and its contribution to a country's gross domestic product (GDP) is so extensive that it is commonly regarded as an economic indicator. However, the general characteristics and financial aspects of the construction industry are different compared to other sectors of the economy. The construction business process is quite complicated due to the mutual reliance of multiple stakeholders on their individual financial stability and operational performance, which exposes contractors to the effects of external changes out of their control and increases their operational risks. These characteristics contribute in many ways to a high business failure rate in the construction industry as well as a relatively high proportion of insolvencies compared to the rest of the economy.

It is evident from past studies that a contractor's ability to analyze the probable execution scenarios of its project portfolio and, subsequently, the effect of these scenarios on the realization of profit potential is essential for sustaining a viable business. However, current financial analysis methods do not consider the effect of interconnected influential stakeholders on the profit realization process of their mutual project or project portfolio. In other words, the realized profit of a contractor's project portfolio is an emergent outcome of a section of the construction market system rather than the performance of the construction contractor alone. Therefore, a model for the ex-ante analysis of profit potential of a project portfolio should be capable of modeling this complex system-of-systems (SoS) by capturing the dynamic interactions between the key constituents of the system and their subsequent influence on the contractor's profit potential.

To accomplish this objective, a new framework is proposed for translating the components of the construction industry into a SoS that can be analyzed quantitatively with an agent-based modeling (ABM) approach. An agent-based model subsequently was developed based on the proposed SoS framework that uses a project execution

scenario method based on earned value management (EVM) concepts. The proposed scenario definition method incorporates the longitudinal effects of all the stakeholders that could affect the financial outcome of a project/project portfolio. Finally, the agent-based simulation model was incorporated into a decision support system (DSS) that simulates the flow of money between the key players that are connected through mutual projects and reports the analysis outputs. The capability of the agent-based model in simulating the financial outcome of alternative scenarios enables the DSS to calculate the longitudinal financial performance (revenues, expenses, cash flow, realized profit, and NPV) of each project and the project portfolio of all the stakeholders. Outputs of the DSS can assist managers in decisions that are related to financial performance of a project portfolio under different scenarios like calculating the maximum overdraft as the basis of financing requirements, quantitative assessment of identified risks, choosing between alternative new projects, and income based valuation approaches that might get affected due to the system of systems interactions between the various players including owners, contractors, and subcontractors.