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Analysis of Workflow Variability's Impacts on Trade and Project Performance

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Abstract

Variability, defined as the deviation of production capacity from an expected average, has a negative impact on the productivity of downstream trades and the entire system. It increases project duration, lost capacities and inventory of the downstream trades. This paper, using Parade Game Simulation, aims to identify the key trade(s) of a single-line production system that contribute(s) the most in reducing/increasing the project duration, total lost capacity and total inventory buffer. The simulation model includes seven trades with two different variability levels. A cooperative game theory was utilized to investigate how the productivity of downstream trades and the entire system is affected by the location of variability. This research revealed the key trades and strategic assignments of trades to maximize the trade and system performance. The findings are beneficial to construction managers as it helps them to manage the workflow efficiently by focusing on the key trades.

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Keywords: Reliability; Variability; Discrete Event Simulation (DES), Game theory.

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1. Introduction

Construction operations usually include various on-site tasks performed sequentially by different specialty trades (or trades) with a complex interaction between materials, equipment and labour. During the construction operation, trades have a tendency to focus only on their own tasks and even sometimes work toward their own priorities without considering how the variability in their production capacity affects the rest of trades' tasks and the whole project outcome [1]. However, because of existing interdependencies, any variability in the trade's production capacity can be transferred from one task to the next and causes workflow variability [2]. Previous studies demonstrated that the unstable workflow affects the performance of the construction trades negatively and reduces their productivity [3-6].

A workflow can be managed effectively by promoting work-plan reliability through the better planning strategies [4,7,8]. [7] argued that planning is the primary method for organizing construction activities and that current planning strategies do not ensure the reliable movement of work between activities and between trades. The authors introduced last planner system (LPS) as a production planning and control system based on lean production principles, which allows overcoming previous issues in construction planning and improves workflow reliability. To increase the reliability of work-plan, [4] propose a reliable commitment model (RCM) which utilizes lean construction principals and statistical models and uses a common site information such as workers, buffers and planned/actual progresses statistical models to predict commitment planning.

Although considerable research has been made on managing the variability in workflow through improvement in work-plan reliability, there are limited research on managing the workflow by determining key trades and their strategic role in managing variability in production system. To bridge this gap, this research utilizes the cooperative game theory to determine the contribution of trades to reducing/increasing the total time, total lost capacities and total inventory buffer in single line production system. This study contributes to the body of knowledge as it uses simulation modeling and cooperative game theory to help construction managers to deeply understand how the location of variability in production system affects the performance of downstream trades and the whole entire system. The terms used in this research along with their definition are presented in following nomenclature.

Nomenclature

VARIABILITY: Deviation of the actual value of a parameter (ex. Production) from its mean [2].

RELIABILITY (of production capacity): Reliable production capacity means a production capacity with no variability [2].

RELIABILITY (of workflow): Reliability in workflow concerns with the state of consistency, dependability, and predictability of workflow [9].

RELIABILITY (of work-plan): A work-plan is reliable when trades can do what they have planned to do [10].

WORK-PLAN: A work-plan consists of scheduled tasks that the trade is going to perform in a short period [4].

WORKFLOW: Workflow refers to the movement of materials, information, and equipment through the system [9].

PRODUCTION CAPACITY: Number of trade-specific work units per unit of time a crew is technically able to finish provided their work is unconstrained [2].

INVENTORY BUFFER: Work units accumulated ahead of a crew, from which they can draw at will to perform work [2].

LOST CAPACITIES: The part of production capacity that couldn't be utilized due to lack of inventory buffer.