# Discussion of “Risk Propagation in Multilayer Heterogeneous Network of Coupled System of Large Engineering Project”

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# Discussion of "Risk Propagation in Multilayer Heterogeneous Network of Coupled System of Large Engineering Project"

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This paper presents a discussion of "Risk Propagation in Multilayer Heterogeneous Network of Coupled System of Large Engineering Project" by Yun Chen, Liping Zhu, Zhigen Hu, Shu Chen, and Xiazhong Zheng. https://doi.org/10.1061/(ASCE)ME.1943-5479.0001022.

The authors established in their paper a multilayer heterogeneous network comprising a stakeholder network and a project schedule network, and proposed a risk propagation model for large engineering projects (LEPs) based on this double-layered network structure, taking into account multiple uncertainties and the coupling relationship between these two layers. The authors utilized in their model a schedule risk analysis model previously developed by Ökmen and Öztaş (2008) called the correlated schedule risk analysis model (CSRAM). The proposed model was applied to determine the risk propagation in terms of a single specific risk called delayed payment risk in an actual LEP to verify the feasibility of the model. This application provided valuable results and the research as a whole made new contributions in this area with respect to previous research through the abstraction of the LEP structure into a multilayer heterogeneous network, and the model proposed to characterize the coupling relationship between these different networks. This research can be considered as important progress regarding risk propagation control in LEPs.

The issues that are considered worthy of discussion related to the form of the paper and that, if clarified, are thought to contribute to the achievements of this research are first presented in the following. Other comprehensive points are then discussed.

The full name of CSRAM has been used in the paper as the "related schedule risk analysis model," possibly due to a typo.

Eqs. (1)–(4), which are mentioned as having been adopted from Zhong et al. (2015) in the paper, actually belong to CSRAM, i.e., the study of Ökmen and Öztaş (2008).

The usage of the terms "traditional CSRAM," "original CSRAM," and "improved CSRAM" in different parts of the paper without pointing out the differences among them may create confusion.

Fig. 5, which illustrates the simulation flowchart of the proposed model, contains a portion from the "improved CSRAM" of Zhong et al. (2015) but the emphasis of this point and also indication of the parts actually adopted from the CSRAM of Ökmen and Öztaş (2008) in this figure have been skipped in the paper.

A key feature of CSRAM is its ability to qualitatively model possible correlations between risk factors while capturing correlations between activities in terms of their durations in a critical path method (CPM) schedule activity network. Based on this two-dimensional correlation modeling feature (i.e., between activities and between risk factors separately), CSRAM has the capability of predicting the variation on the key components of CPM schedules of construction projects (such as the project completion time, critical/noncritical activities, and critical/noncritical paths) more realistically through Monte Carlo simulation. However, the risk propagation model proposed by the authors does not take the correlation effect between the risk factors into account, although the model was established based on CSRAM. In other words, the correlation capturing feature of CSRAM between the risk factors was not utilized in their model. Obviously, it would not be realistic to assume that all of the risks influencing a CPM schedule occur through a risk propagation mechanism operating from upstream to downstream, i.e., from the stakeholder network layer to the schedule network layer, as it is visualized in Figs. 2 and 3 in the paper. On the contrary, there might also exist risk factors that occur independently from the stakeholder network, and moreover, correlations might generate between these risk factors. In other words, while some risks may propagate from upstream to downstream, others may affect the schedule directly free of the propagation mechanism. Thus, ignoring this fact and avoiding full processing of CSRAM in such a risk propagation model may produce incomplete and misleading results regarding the uncertainty impact on various CPM schedule components, some of which are mentioned previously. As a solution to this issue, other possible risk progation mechanisms besides the mechanism operating from the stakeholder network layer to the schedule network layer and also possible correlations generating between risk factors are recommended to be taken into account in a study that could possibly be done as a continuation of the authors' work.

The authors have assumed that the duration extension of a construction activity is solely caused by the behavioral risk of stakeholders, which is not intentionally generated by stakeholders but rather propagated by other high-level risks occurring within the stakeholder network. However, the extensions in activity durations may also occur from risk factors that could not be related either to the stakeholders or to the behavioral risk of stakeholders. For instance, adverse weather conditions may be the cause of duration extensions for many activities, especially those performed outdoors, and this risk factor will have no relation with the stakeholders or their behavioral reactions. Furthermore, the authors have assumed that the loss-making stakeholders, who will be taken into account during the implementation of their model as the risk propagators, exhibit randomness and therefore they proposed to determine the final loss-making stakeholders out of the stakeholders constituting the stakeholder network through the usage of probability of risk occurrence and risk propagation. Depending on this approach, the proposed model requires the risk propagation in the stakeholder network be characterized by different probability density functions that would change based on the varying risk propagation conditions and stakeholder network structure. However, the assumption in question may not be appropriate because considering the impact of loss-making stakeholders on risk propagation and, in turn, on CPM schedule activities as a phenomenon of randomness would be controversial. Furthermore, such an approach would not be practical enough to be compatible with the practicality provided by CSRAM. Thus, instead of following such a methodology, the uncertainty associated with loss-making stakeholders and the influence of this uncertainty on the activity durations can be modeled



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alternatively through a cause-effect search based on the risk-influence diagramming method, and this would be a more tangible approach. Besides, the need for customizing probability density functions in each project or due to variations in high-level risk configuration and stakeholder structure would contradict the practicality of CSRAM. Moreover, the authors have not clearly reflected this requirement in Fig. 5 in the paper and have not clearly stated in the paper how those probability density functions will be developed and processed during the implementation of their model. Considering these points in a future study that may be complementary to the current work of the authors will increase the contributions of this research to the relevant body of knowledge.

The case study the authors conducted to verify their model and show its applicability was built on a simplified CPM schedule network containing a single activity path and five construction activities constituting this path. In a way, the schedule examined in this case study cannot be considered as an activity network and therefore it does not reflect many attributes of a CPM schedule such as the critical/noncritical paths and critical/noncritical activities. Because the example project examined was constituted on a single activity path, all five activities on that path would inevitably be critical in any case from the perspective of CPM scheduling. However, it is also important to observe the effect of risk propagation on the noncritical activities and noncritical paths of a CPM schedule network and how the proposed model reacts when applied on a full multipath CPM network. However, while conducting such full-scale case studies, it is important to fully operate CSRAM without neglecting its ability to model correlations between risk factors. In addition, it should be essential that risk propagation is not tied solely to stakeholders or their behaviors. In this regard, it is recommended to conduct more comprehensive case studies in future research taking into account the aforementioned points.

LEPs possess distinctive features that the authors also mentioned in the paper such as long duration, multiplicity of technical disciplines, large number of project stakeholders, and high levels of complexity and uncertainty. Large number of stakeholders, which was focused on in the paper as the source of risk propagation, is only one aspect of the complexity in such projects. Thus, through a holistic view, numerious project complexities and their interactions with risk factors should be taken into account in modeling and analyzing the schedule risks and the influence of risk propagation on the schedules. A framework regarding the complexities surrounding the LEPs can be found in Bosch-Rekveldt et al. (2011), noting that there are also other studies conducted on this subject by different researchers. Various complexities apart from large number of stakeholders and their behavioral risk may create risk propagation and in turn affect the main project objectives aimed to be achieved in LEPs such as the schedule objective handled in the study of the authors. A complexity-based risk propagation modeling approach involving multidimensional correlation-capturing mechanisms is needed to fully evaluate the uncertainty effect on schedules of LEPs. Such an approach will also provide guidance in modeling the risks and risk propagation that influence other project objectives such as cost, quality, and safety. The application of such an approach in future studies that may be a continuation of the authors' work has the potential to expand the contributions made through this study by the authors to the body of knowledge in the field of engineering management.

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