

A Framework to Anticipate Indirect Impacts of the Events in Project External Environment

Nguyen Dinh Chau Minh ^{*}, Yoshiko Ohno ^{*}, Kohei Tanaka ^{*}
Mikiko Nakada ^{*}, Fumihito Oura ^{*}, Seiko Shirasaka ^{*}

Abstract

Events in the project external environment may cause positive or negative impacts to project outcomes. The number of those external events is enormous and their impacts are uncertain. There could be direct or indirect impacts or no impact on the project. However, it is necessary to anticipate those potential impacts and their sources. Previously, the work was done by expert judgment methods, which rely on the backgrounds of the experts. This paper proposes a framework that can address the need regardless of user background. The framework is called Extended N2 Chart. It was evaluated through a workshop on a hypothetical project. The results suggest that the proposed method helps participants to consider more indirect impacts and reduce the number of irrelevant anticipations.

Keywords: Anticipate, external environment, N2 chart, risk management, uncertainty

1 Introduction

We are living in a world full of events that may or may not impact our projects while they exist and operate within their external environment. Some of those external events are predictable while there are other unforeseen ones that occur constantly in project management practices [1]. Recently, the influence of external factors was also addressed in the seventh edition of PMBOK. “They can enhance, constrain, or have neutral influence on project outcomes” [2]. Having multiple aspects or factors to be considered, the project external environment becomes uncertain with an uncountable number of events, it should be a challenge to define which ones will affect our projects. This situation is called effect uncertainty, which relates to the capability of an individual to anticipate the impact of changes or events in the external environment [3]. In spite of this, Stephen Ward and Chris Chapman [4] argued that it is necessary to consider any uncertain things at first instead of focusing only on some events that may potentially impact the project as traditional risk management practices did. The impacts on the projects may be uncertainties, still their sources should be addressed [5]. Project managers were emphasized for their responsibility to identify the external events that may not directly impact their projects but instead causing a sequence of events that eventually lead to project failure [6]. These effects are unlikely to be considered by project teams since they occur through indirect pathways. The negative result on important stakeholders may not be taken into account [7]. This will have significant effects on the project’s performance and outcomes. Hence, although the indirect impacts are not easy to be realized, it is necessary to give more efforts to address them.

This paper introduced a framework to anticipate potential direct or indirect impacts on a project

^{*} Graduate School of System Design and Management, Keio University, Yokohama, Japan

that were caused by the events in its external environment. The anticipation of those potential impacts on the project in order to define their sources is valuable even if their likelihood is not considered since it will raise the interest in the events and more scanning in the area can be expected [8].

2 Previous Studies

The approaches to address the need can be added into two groups, ‘exploratory’ and ‘normative’ [9]. The ‘exploratory’ group focuses on prediction of what is likely to happen while the latter are more goal-oriented. Nevertheless, there are expert judgment methods that could be both exploratory and normative. Delphi technique is an example of this approach. The method relies on the experience, knowledge and skills of experts to define potential change scenarios. This is a qualitative method implemented by a group of chosen experts to interact with each other and exchange opinions in a systematic way [10]. Identities of the experts are hidden with each other, and the opinions are not shared directly but through decision makers and distributors. Indirect and anonymous interaction among experts are two important characteristics of the Delphi method to avoid unwanted influence from one to another while giving opinions. Since there are many factors to be considered in the external environment such as political, economic, social, technological, legal, environmental and so on, it is normally difficult to gather as many experts with corresponding backgrounds. Nakatsu and Iacovou [11] in 2009 expressed a limitation of Delphi technique is that the backgrounds of the experts influenced their concern and their judgment. The proposed methodology should be able to anticipate indirect effects of external events with less dependencies on individual background.

3 The Proposed Framework

In order to address the need, we designed our framework with the functions:

- To predict direct and indirect impacts of the external events on projects
- To avoid irrelevant matters by following the change sequences those were initiated by external events
- To support non-expert people to anticipate the impacts

Visualization tools were often used with the focus on positive aspects but they should be valuable to address the negative ones, too [12]. We would like to propose a framework that can anticipate potential impacts caused by the event in the project external environment regardless of what the event is and what kind the impacts are, positive (opportunity) or negative (risk). This framework is expected to help define the impacts on the project without totally relying on individual background. The Extended N2 Chart was expected to effectively predict the indirect impact caused by the change sequences.

3.1 N2 Chart

N2 chart is a tool that uses a (n x n) matrix to record the interconnections between elements of a system. It is a systematic approach to analyze interfaces. However, in this case N2 chart is utilized to anticipate the impacts of change events in external environment to our project. Figure 1 shows an example of N2 Chart. The matrix has four entities on the leading diagonal. System elements have inputs and outputs. Outputs are contained in rows; inputs are contained in columns. The messages from Entity 1 to PM for example must go through interface IF 1, IF 2... and the messages from PM to Entity 1 must go through interfaces IF3, IF4 and so on.

| | | | |
|-------------------------------------|-------------------------------------|---------------------------------------|--------------------------------------|
| Entity 1 (E1) | E1→PM - IF 1 - IF 2 - | | |
| PM→E1 - IF 3 - IF 4 - | PM | PM→E2 - IF 5 - IF 6 - | PM→E3 - IF 7 - IF 8 - |
| | E2→PM - IF 1 - IF 2 - | Entity 2 (E2) | E2→E3 - IF 9 - IF 10 - |
| | | E3→E2 - IF 13 - IF 14 - | Entity 3 (E3) |

Figure 1: N2 Chart

3.2 The Extended N2 Chart

It should be aware that there are entities in the project external environment that do not have any direct interface with the project team and sometimes have no interface with any of the entities that have direct interfaces with the System of Interest, too. If some events happened in those entities, it would be difficult to anticipate if they will impact the project or not. In case they did impact a project, then the impact should be caused by going through other entities and interfaces as sequences of changes. If the changes in those entities were not reflected by changes in their interfaces with other entities, then it should be internal matters, which would be irrelevant to the project. We use Extended N2 chart, a tool for interface analysis to anticipate and describe those change sequences. The original N2 chart was made by putting all of the entities in the context diagram on the leading diagonal. Interfaces between the entities are filled in the off-diagonal cells. After that, define the external entity where the change event happened. Call it as 'External Entity A' and put it on the extended leading diagonal. Users are supposed to anticipate the change sequences that are initiated from the External Entity A through other external entities and interfaces and potentially impact on the project. A change sequence is anticipated by following these steps (Figure 2).

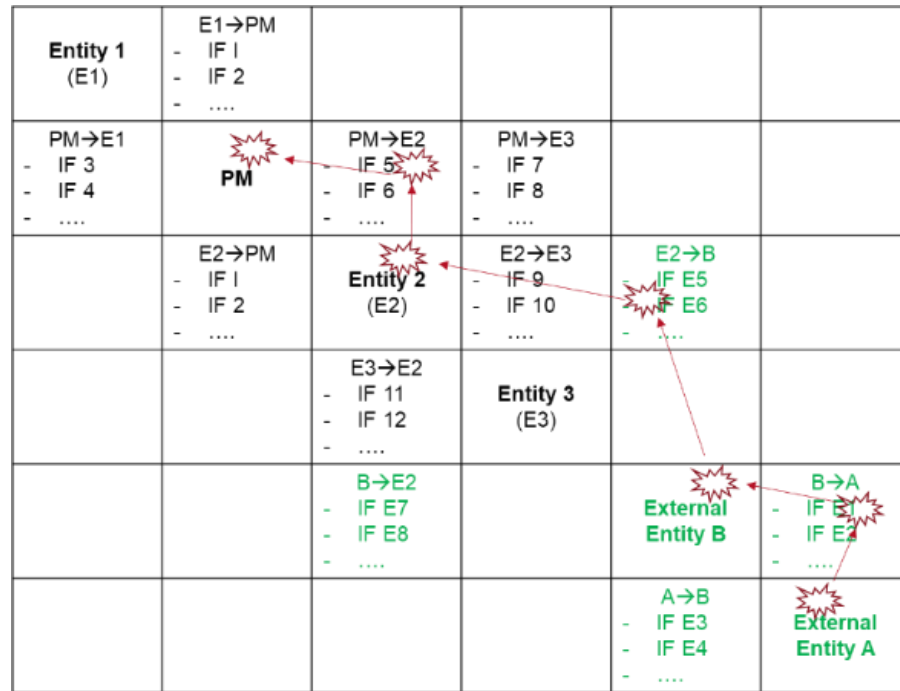


Figure 2: The Extended N2 Chart for anticipating change sequences

- Check interfaces between the “External Entity A” and other entities and identify the interfaces that were affected by the external events.
- From the affected interfaces, determine the “External Entity B” ($\sim N$) that is derived from and affected by the interfaces.
- Anticipate changes that may happen in the “External Entity B” because of this effect.
- Check the interfaces of the “External Entity B” and other entities, and identify the interfaces that are affected.
- Repeat the process until the affected interfaces between external interfaces and internal interfaces are found.
- Continue to draw the change sequences among internal entities and the system of interest
- Check to see if the project scope or plan is affected by the change sequences or not.

If any possible effect is detected, it should be considered as a potential risk or opportunity for the project. The change sequence anticipations can be continuously implemented even after the effects on the project team have been analyzed since their responses may extend the change sequences and cause more effects on the project.

This framework depends on the knowledge of the interfaces between entities and the capability of the users to anticipate responses of the entities against impacts.

4 Framework Evaluation

We evaluate the framework by organizing a workshop with 18 participants divided into three groups A, B and C. The participants are researchers and company employees of Graduate School of System Design and Management, Keio University. Their project management experience is varied from seven or eight years to less than a year. Each of the individuals have a different type of the project they use to deal with such as R&D, solar energy construction, extension of fuel tax and so on. The participants are randomly assigned to the three groups with six participants for each group. By an experiment on the groups, we would like to check if the tools are functional as expected or not. Capabilities of the participants to anticipate potential impacts and change sequences caused by external events will be analyzed and evaluated while managing a hypothetical project.

4.1 Workshop Planning

The workshop was conducted online. The participants were all provided information of a hypothetical project, its scope statement and work breakdown structure (WBS). Group A and Group B would have a context diagram with the description of internal entities involved in the project and their relationships with the project team in a project's execution stage while group C would be provided the same information but in text, not a visualization diagram. Finally, participants of group A would be explained about how to utilize the Extended N2 Chart to anticipate the change sequences started by an external event. With this tool, members of group A were expected to define more indirect impacts compared to the ones from the other groups.

When the workshop started participants would get information of a virtual project. We used a simple project so the knowledge of the participants would not have a high influence on their outcomes. After several minutes, a list of changes in the project external environment would be provided to participants. The events were assumed to be taken from a newspaper. The participants of the three groups were expected to think of as many potential impacts caused by those events on the project as possible.

Group A would have to show the impacts, their target entities and order of the impact while group B and group C would have to indicate the reasons behind each of the anticipations. The framework was meant to be tested without interactions and influences between participants. Therefore, all of them were asked to do the work individually with no discussion.

4.2 Workshop Implementation

Information of the virtual project:

Project goal: A customer ordered a laptop from your website. You need to deliver it to the customer.

User needs:

- 100% new product
- Receive at home within 5 days
- Pay by Cash on Delivery (COD)

Project scope statement: The project will start once the order of the customer is made. It will be implemented by one staff member (PM). First, he/she will check the order validity and then process it. After that he/ she needs to take the laptop from the warehouse and order an outside delivery service to deliver the laptop to the customer. The customer will pay for the laptop by Cash on Delivery, this payment will be transferred back to our company's bank account.

Work Breakdown Structure of the hypothetical project shows the tasks that the PM needs to do besides project management work in more detail and schedule plan. This Work Breakdown Structure can only be modified if the change is a response of an impact that was caused by an external event. The participants were not allowed to modify it by their own project management skill.

To make it easier for the participants to imagine the project environment, we also provided to two of the three groups a context diagram. Context diagram (Figure 3) defining the highest-level view of a system in its environment [13]. In the framework evaluation, the project team is the system of interest (SoI) of the context diagram. The team has a project manager (PM) who is considered as their representative. This SoI is surrounded by entities that may have direct or indirect interfaces with it [13]. In project management we normally think of relationships between the project team and their project stakeholders. However, entities are not limited to people but could be products, business, regions or even nations. The function of the context diagram in the proposed framework is to describe the relationships between the project team and the entities with direct interfaces only.

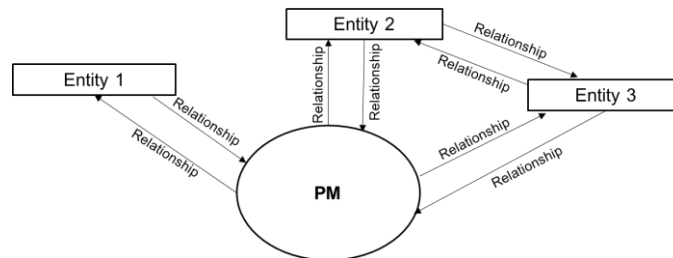


Figure 3: Context Diagram

The context diagram provided to group A and group B is shown in Figure 4. A project normally has several stages in its life cycle. Each of the stages may have a different context diagram. In this scenario, the external events would happen in the execution stage so only the context diagram of this stage is provided.

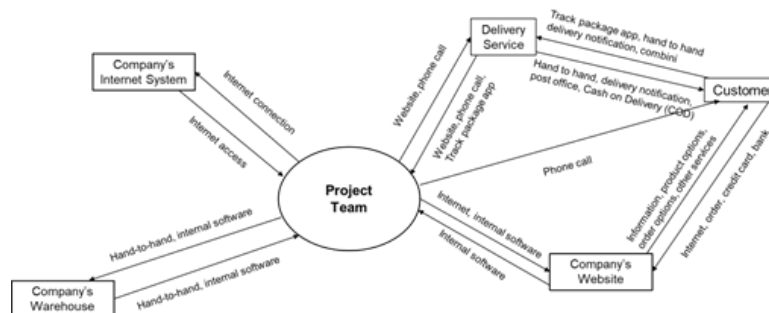


Figure 4: The context diagram provided to Group A and Group B

After 10 minutes, a list of three events in the external environment taken from a newspaper was shown to the participants:

- (i) Because of Covid-19 pandemic, the production of electronic devices will decrease deeply.
- (ii) Due to Covid-19 pandemic the government may have to prohibit all of the face-to-face activities.
- (iii) Facebook is accused for selling user data.

In 50 minutes, participants had to anticipate as many potential impacts that might be caused by the events to their project as possible. This did not include the time for group A to create the original N2 chart with no external entities. More explanation of the Extended N2 Chart was not allowed when the group was doing their work since the difficulty of using this tool was also an item to be evaluated.

Questionnaires were given to the participants before wrapping up. The purpose of the questions was to find out if the participants really understood their work or not and how much their background is related to the work. The questions were asked about the participants' comprehension of the work they need to do including purpose and process of the workshop. Another concern was the methodologies that they used. With this information, the utilization of individual capabilities could be revealed for each of the participants. Experience of the participants were also taken into account since it was a critical factor of their competence. On the other hand, an inquiry about their difficulties when imagining the potential impacts were also given. The answers for this question will show how the framework addressed the difficulties.

For participants of group A who needed to utilize the Extended N2 chart, we added a few more questions regarding the usability of the tool. The value of the tool was surveyed among the participants, especially its effectiveness in anticipating potential impacts. The last but not least was the concern about struggling of the participants when utilizing the tool.

4.3 Evaluation Result and Analysis

Evaluation criteria: We labeled the anticipated impacts into three categories 'Direct', 'Indirect' and 'Irrelevant'. Here, direct impact is the impact that affects directly to the project scope or any task in the WBS. Indirect impact is the impact to some target that is out of the project scope and WBS but if it belongs to a chain effect and the end of the chain is a direct impact then it is labeled as indirect impact. For instance, an external change cause impact 'n', then impact 'n' → impact 'n+1' → impact 'n+2' and the impact 'n+2' is a direct impact then 'n+1' and 'n' are both labeled as 'Indirect'. Another case is that, if impact 'n' is a direct impact and impact 'n+1' also has a direct impact to the project scope or WBS then impact 'n+1' will be labeled as 'Indirect'. The items that do not have any direct or indirect impact to the project or the ones that have a different source than the provided three events are put in the 'Irrelevant' column. One more important rule was that we did not rate the probability of the predictions because it would be biased. With the same reason, we avoided making any assumption on the predictions even in the case that the assumption was very likely to be true.

Final result is presented in Table 1, the portion of 'irrelevant' predictions of group A was much lower than group B's and group C's, 45.8% compared to 78.5% and 75.6%. Furthermore, the percentage of their indirect impacts were much higher than the others', 39.6% compared to 3.1% and 10%. It can be seen that the number of anticipations given by group C is the highest and they also had a higher number of total relevant anticipations than group B did (22 to 14). The of anticipation number of indirect impact from Group B was much lesser than group A (2 to 19) but they got more direct impact anticipations (12 to 7).

Table 1: Results of the participants

| ID | Direct | Indirect | Irrelevant | Total | % Direct | % Indirect | % Irrelevant |
|----------|-----------|-----------|------------|-----------|-------------|-------------|--------------|
| A | 7 | 19 | 22 | 48 | 14.6 | 39.6 | 45.8 |
| A1 | 1 | 9 | 0 | 10 | 10.0 | 90.0 | 0.0 |
| A2 | 1 | 1 | 4 | 6 | 16.6 | 16.7 | 66.7 |
| A3 | 3 | 7 | 4 | 14 | 21.4 | 50.0 | 28.6 |
| A4 | 0 | 0 | 5 | 5 | 0.0 | 0.0 | 100.0 |
| A5 | 1 | 0 | 6 | 7 | 14.3 | 0.0 | 85.7 |
| A6 | 1 | 2 | 3 | 6 | 16.7 | 33.3 | 50.0 |
| B | 12 | 2 | 51 | 65 | 18.4 | 3.1 | 78.5 |
| B1 | 2 | 1 | 9 | 12 | 16.7 | 8.3 | 75.0 |
| B2 | 2 | 1 | 5 | 8 | 25.0 | 12.5 | 62.5 |
| B3 | 1 | 0 | 9 | 10 | 10.0 | 0.0 | 90.0 |
| B4 | 2 | 0 | 7 | 9 | 22.2 | 0.0 | 77.8 |
| B5 | 2 | 0 | 13 | 15 | 13.3 | 0.0 | 86.7 |
| B6 | 3 | 0 | 8 | 11 | 27.3 | 0.0 | 72.7 |
| C | 13 | 9 | 68 | 90 | 14.4 | 10.0 | 75.6 |
| C1 | 1 | 2 | 8 | 11 | 9.1 | 18.2 | 72.7 |
| C2 | 1 | 0 | 13 | 14 | 7.1 | 0.0 | 92.9 |
| C3 | 4 | 2 | 11 | 17 | 23.5 | 11.8 | 64.7 |
| C4 | 3 | 3 | 9 | 15 | 20.0 | 20.0 | 60.0 |
| C5 | 1 | 1 | 8 | 10 | 10.0 | 10.0 | 80.0 |
| C6 | 3 | 1 | 19 | 23 | 13.0 | 4.4 | 82.6 |

Regarding distribution of the result, two members of group A (A1 and A3) got a total 16 out of 19 indirect impact anticipations while in the case of group B this number was similar for all of the members. Among members of group C, two of them (C3 and C4) got the top total direct and indirect predictions which was six predictions for each compared to two or three predictions of the latter.

Answers of the questionnaires: Regarding utilization of the Extended N2 chart, only half of the group A's participants could understand the tool why the other could not or limited. The participants have given some reasons behind this problem. Some of them needed a more concrete example so they would be able to understand the way to use the tool more while others struggled with filling interfaces in the Extended N2 Chart and did not consider much about external entities. On the contrary, all of the participants from this group had a good feeling of the effectiveness of this tool to anticipate impacts of the events in external environments regardless of the events' types.

For the question about impact categories, the usefulness of the Extended N2 Chart is kind of vague. Only two participants thought it was while the latter couldn't give a certain answer. Lastly, the members of the group didn't give any concrete recommendation on how to improve the framework using both context diagram and Extended N2 Chart but expressed again that we should have given them more examples and practices in order to use the Extended N2 Chart better.

All of group B's members could understand the work well. Most of them thought that the

project was too simple and with a context diagram it was easy to relate the project with the events in its external environment. These participants thought the context diagram was a very useful visualization tool for their work and only one participant among them mentioned that he had taken a look at the WBS and no one mentioned about the project scope. It makes sense why there were many irrelevant anticipations in their result. A participant stated that he used force association during his work.

Different from group B, the participants of group C used the skills and methods they had been familiar with. In particular, a system engineer focused on life cycle and stakeholder while a sales management expert used an excel file to accumulate and manage information. The work outcomes depend on their personal skills and knowledge. The participants thought they had many factors and influences to consider about the impacts of the provided events.

5 Discussion

The participants of group A utilized the Extended N2 Chart to describe the change sequences from the provided events to the project and could find out the most indirect impacts. Number of irrelevant predictions from group B and group C were similar and very high. We found out that the participants tended to use the provided context diagram (group B) and relationships description in text (group C) to consider the impact. However, when they were considering potential impacts, they sometimes didn't think of linking the impacts to the project scope or WBS. For instance, the participants predicted an impact to the delivery service is that face-to-face activities are prohibited then cash-on-delivery payment method using the old way is not possible anymore. They stopped there as if it was already an impact to the project although at this state it was still a problem of the delivery service. It would become an indirect impact only if they could think of a follow-up direct impact to the project, for example the delivery service notified the PM that they would like to return the laptop for they could not deliver the product to the customer face-to-face. With the capability to have a systematic view at the relationships between all of the internal stakeholders with the project team, the participants of group B and group C tend to stand at the viewpoint of other stakeholders to consider their problems caused by the impacts. This behavior might lead to an increasing number of unexpected events [14]. Therefore, the framework was also useful to keep project managers away from the anticipations that are irrelevant to the project so time will not be wasted on those impacts and corresponding events.

The two members of group A who have the best results in the group are the ones who were able to use the Extended N2 Chart the most. It could be stated that the tool was supportive as expected. This can be proved by the result of group B since by utilizing the context diagram they came up with more anticipations of direct impacts but very few anticipations of the indirect ones. Lastly, the two participants of group C who had the best outcomes were senior system engineers and sales managers. They could use their knowledge and skills to get a better result compared to the others'. It can be concluded that the framework is effective for defining the external events that may indirectly impact the project.

There was an issue that the Extended N2 Chart was difficult for the members of group A. They spent most of their time filling more interfaces in the Extended N2 Chart instead of trying to anticipate change impacts. This was the main reason why the number of direct impacts that were anticipated was fewer than the other groups. Besides, the tool requires users to think of interfaces and external entities by themselves, this depends on the knowledge of the users about the external and internal entities as well as their interfaces with each other.

The evaluation result suggested that the framework was valuable in predicting indirect impacts from the external events and helped to avoid irrelevant matters. On the other hand, the outcomes

of group A members were influenced by their capabilities of using the Extended N2 Chart along with their knowledge about the interfaces. Grouping of the participants in this study was done randomly. Although the effectiveness of the proposed method is suggested within the scope of this validation, it will be necessary to increase the number of participants and to validate the method in different projects in order to analyze the relationship between the participants' knowledge and the deliverables in more detail.

6 Conclusion

Project external environment is full of uncertainty because of many events. It is a challenge to anticipate whether an event is a source of impacts on a project or not. Under the circumstance where experts cannot be relied upon, this study proposed the method to address this issue. The framework uses the context diagram and the Extended N2 Chart to predict the potential impacts of those external events. It was evaluated by an online workshop. The workshop result showed that the framework did support participants to get more indirect impact anticipations and reduce the number of irrelevant predictions. The participants who were not experts could use the framework to achieve a remarkable result.

This research still has some limitations that should be addressed in future research. First, utilization of the Extended N2 Chart was not so simple, it may require more time to learn and practice. Second, using the Extended N2 Chart to predict the indirect impacts from the external environment requires knowledge of external entities and interfaces between external entities, internal entities and the project team. There should be a step of the framework to capture the external entities interfaces in advance for the users. As a future work, we will improve the process so that the proposed method can be used even by those who are not familiar with Extended N2 charts, and we will also ask non-experts in the field to use the proposed method to examine events that have a chain of effects on the project to see if they can come up with the same ideas as the experts. Finally, we shall gather more participants to join the research validation.

7 References

- [1] Söderholm, "Project management of unexpected events," *Int. J. Proj. Manag.*, vol. 26, no. 1, pp. 80–86, Jan. 2008, doi: 10.1016/j.ijproman.2007.08.016.
- [2] P. M. Institute, *A Guide to the Project Management Body of Knowledge*, Seventh edition. Newtown Square, Pennsylvania: Project Management Institute, 2021.
- [3] F. J. Milliken, "Three Types of Perceived Uncertainty About the Environment: State, Effect, and Response Uncertainty," p. 12.
- [4] S. Ward and C. Chapman, "Transforming project risk management into project uncertainty management," *Int. J. Proj. Manag.*, vol. 21, no. 2, pp. 97–105, Feb. 2003, doi: 10.1016/S0263-7863(01)00080-1.
- [5] R. Atkinson, L. Crawford, and S. Ward, "Fundamental uncertainties in projects and the scope of project management," *Int. J. Proj. Manag.*, vol. 24, no. 8, pp. 687–698, Nov. 2006, doi: 10.1016/j.ijproman.2006.09.011.
- [6] D. Berkeley, P. C. Humphreys, and R. D. Thomas, "Project risk action management," *Constr. Manag. Econ.*, vol. 9, no. 1, pp. 3–17, Feb. 1991, doi: 10.1080/01446199100000002.

- [7] R. C. Sperry and A. J. Jetter, "A Systems Approach to Project Stakeholder Management: Fuzzy Cognitive Map Modeling," *Proj. Manag. J.*, vol. 50, no. 6, pp. 699–715, Dec. 2019, doi: 10.1177/8756972819847870.
- [8] K. J. Sund, "Revisiting organizational interpretation and three types of uncertainty," *Int. J. Organ. Anal.*, vol. 23, no. 4, pp. 588–605, Oct. 2015, doi: 10.1108/IJOA-06-2013-0686.
- [9] F. Samsami, S. H. Khodadad Hosseini, A. Kordnaeij, and A. Azar, "Managing Environmental Uncertainty: From Conceptual Review to Strategic Management Point of View," *Int. J. Bus. Manag.*, vol. 10, no. 7, p. p215, Jun. 2015, doi: 10.5539/ijbm.v10n7p215.
- [10] J. Winkler, C. P. J.-W. Kuklinski, and R. Moser, "Decision making in emerging markets: The Delphi approach's contribution to coping with uncertainty and equivocality," *J. Bus. Res.*, vol. 68, no. 5, pp. 1118–1126, May 2015, doi: 10.1016/j.jbusres.2014.11.001.
- [11] R. T. Nakatsu and C. L. Iacovou, "A comparative study of important risk factors involved in offshore and domestic outsourcing of software development projects: A two-panel Delphi study," *Inf. Manage.*, vol. 46, no. 1, pp. 57–68, Jan. 2009, doi: 10.1016/j.im.2008.11.005.
- [12] M. Correll, "Ethical Dimensions of Visualization Research," in *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, Glasgow Scotland Uk, May 2019, pp. 1–13. doi: 10.1145/3290605.3300418.
- [13] R. L. Flood and E. Carson, "Dealing with Complexity: An Introduction to the Theory and Application of Systems Science," Springer Science & Business Media, 1993.
- [14] K. Aaltonen, J. Kujala, P. Lehtonen, and I. Ruuska, "A stakeholder network perspective on unexpected events and their management in international projects," *Int. J. Manag. Proj. Bus.*, vol. 3, no. 4, pp. 564–588, Sep. 2010, doi: 10.1108/17538371011076055.