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Managing Time Elements of Risk

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Certificate of Originality

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____________Peng Zhou________(Name of Student)

Abstract

Although current risk management has well defined process life cycle, already considers the need to continuously monitor the risk indicators and periodically identify new risks and re-estimate identified risks, most practitioners and researchers seldom explicitly model and use many time elements of risk. The modeling and management of time elements is essential for risk management since each risk has an associated time period of mitigation and occurrence. However, there are very few studies explicitly model these time elements. Also, there is a lack of theories for performing risk management with due consideration of them. To address the limitation of current risk management practices, this thesis aims to enhance the performance of risk management.

We explicitly model the time elements of risk by (1) identifying them during the whole life cycle of a risk, (2) establishing the relationships between them, (3) creating different risk mitigation cases and presenting possible transition between these cases based on the established relationships, and (4) developing the status change diagram of risk and analyzing the possible status change paths. We also identify and summarize the management of time elements in the risk management life cycle. Additionally, to facilitate the formal analysis, we build a stochastic simulation model, SMRMP, and validate and verify it based on the paradigm proposed by Sargent. We formally analyze how time elements affect risk mitigation at both risk-level and project-level. The results show that the traditionally used strategy for scheduling risk mitigation is not a good choice. From the results of formal analysis, we propose new practices for risk mitigation to enhance the effectiveness of risks management. At last, we extend our results by excluding two assumptions made in our study.

List of Publications

P. Zhou, and H. K. N. Leung, “Scheduling Strategies for Risk Mitigation,” in 8th International Conference on Software Engineering and Applications (ICSOFT-EA 2013), Reykjav ík, Iceland, 2013.

P. Zhou, and H. K. N. Leung, “An integrated risk analysis method using spatial interpolation,” in 19th Asia-Pacific Software Engineering Conference (APSEC 2012), Hong Kong, 2012, pp. 452-461.

P. Zhou, and H. K. N. Leung, “A stochastic simulation model for risk management process,” in 19th Asia-Pacific Software Engineering Conference (APSEC 2012), Hong Kong, 2012, pp. 737-742.

P. Zhou and H.K.N. Leung, “Improving Risk Management with Modeling Time Element”, 15th IASTED International Conference on Software Engineering and Applications, Dallas, USA, Dec. 2011, pp341-349.

P. Zhou and H.K.N. Leung, "A New Method and Metric for Quantitative Risk Analysis", 13th International Conference on Enterprise Information Systems, June 2011, Beijing, China, Vol.3, pp.25-33.

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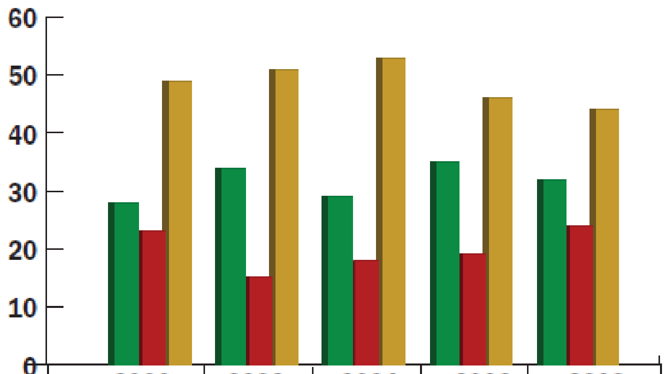
Chapter 1 Introduction

1.1 Background

Nowadays, Information Technology (IT) projects become increasingly more complicated and face many challenges and uncertain factors because of the advancements of technology and dynamic changes of business environment. According to a study from Standish group [1], the project success rates were low. Figure 1-1 shows the rate of succeeded project, failed project and challenged project from year 2000 to year 2008. Taking year 2008 as an example, the results are: only 32% of all projects were successfully delivered on time, on budget, with required features and functions, 24% projects were cancelled prior to completion or delivered and never used, and 44% were challenged in late, over budget, and/or with less than the required features and functions.



	2000	2002	2004	2006	2008
Succeeded	28%	34%	29%	35%	32%
Failed	23%	15%	18%	19%	24%
Challenged	49%	51%	53%	46%	44%

Figure 1-1 Project resolution from 2000 to 2008 from Standish Group (2009)

Studies show that the failure of IT projects was caused by the inconsistent use of estimation metrics, complexity of design and implementation of software, lack of experienced staff, and poor project management [2-4]. Other factors, such as poor moral, lack of employee commitment, lack of functional management commitment, poor productivity and poor stakeholder relations, play increasingly important role in project failure.

Another key contributor to the high failure rates in projects is the project managers are not taking prudent measures to manage the risks involved in these projects [5]. The positive correlation between effective risk management and project success was emphasized in [6, 7]. Sherer also pointed out that most of the failed projects are caused by poor risk management [8].

To guarantee the success of IT project, applying systematic approaches to deal with the risk is necessary. Many paradigms, frameworks and standards have been developed to facilitate the implementation of risk management. The risk management paradigm developed by Software Engineering Institute (SEI) [9] and the Project Management Institute (PMI) risk management framework [10] are widely used in the industry. Besides them, there are some well accepted risk management standards, such as IEEE Std 1540, AS NZS 4360 and ISO 31000 [11-13].

In many organizations, senior management includes risk management as a routine requirement in any project management effort. The adoption of risk management practices can help to increase the success rate of project and then enhance the competitiveness of organizations.

1.2 Motivation and Objective

A project may fail completely due to inadequate project risk management [8]. Consequently, managing risk is a key success factor in managing a software project [11]. An effective risk management methodology can help to identify different project risks so that specific treatment can be developed to reduce or eliminate them. Many studies have focused on risk identification and proposed different approaches to identify risks. Some guidelines have been proposed for quantitatively estimate the probability and impact of risk. Recently, Kwan and Leung expended risk analysis with the consideration of risk dependency [14]. Based on risk analysis, different risk mitigation options can be applied to treat the identified risks. Although many studies have been conducted in the area of risk management and also several models and standards have been developed, risk management is the least mature among all project management knowledge areas [15].

The current risk management practices basically follow the SEI paradigm or the PMI framework. The practices generally follow the Plan-Do-Check-Act (PDCA) cycle and perform a set of cyclic steps to manage risks throughout the project [9, 10, 16]. Currently, after identifying risks, practitioners estimate the probability and impact of these risks and prioritize them with the consideration of probability and impact only. They often mitigate the top N (i.e. N=10) risks due to limited resources [17].

Although current risk management follows a well-defined process life cycle, already considers the need to continuously monitor the risk indicators and periodically identify new risks and re-estimate identified risks, most practitioners and researchers seldom explicitly model and use many time elements of risk [18]. In current practices, practitioners mainly focus on probability and impact of the risk when managing individual risk. The failure to consider many time elements of risk may lead to ineffective risk management practices. For example, current practices seldom consider the emergency of risk (i.e. one risk would occur much earlier than others) and the needed effort to mitigate it. Consequently, practitioners may not schedule the risk mitigation activities properly, leading to an ineffective risk management.

The management of time elements is essential for risk management since each risk has an associated time period of mitigation and occurrence. Both [10] and [11] point out the necessity of managing them when performing risk management. Explicitly modeling these time elements can help users fully understand their risk management activities and better perform risk management [18]. However, there are very few studies explicitly model them. Also, there is a lack of related theories for performing risk management with due consideration of these time elements. Therefore, explicitly modeling and managing time elements of risk is an improvement area of project risk management.

To address the above limitation of current risk management practices, this thesis aims to enhance the performance of risk management with due consideration of time elements of risk.

1.3 Methodology

Figure 1-2 shows the steps that we follow to conduct the research. To effectively perform risk management with due consideration of time elements of risk, we first explicitly model the key time elements of risk, then we build a stochastic simulation model to facilitate the analysis of introduced time elements on current practices, conduct formal analysis on introduced time elements both at the risk-level and project-level, and propose improved risk management practices at last.

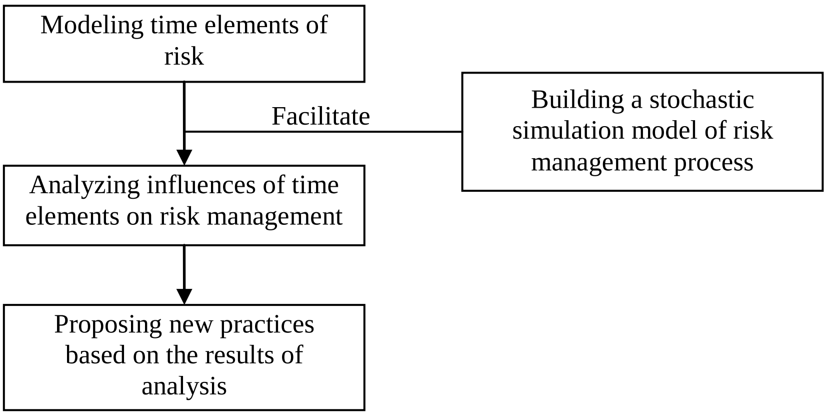


Figure 1-2 Path of Conducting Research

To formally analyze introduced time elements, we build a stochastic simulation model of risk management process. Then, we analyze the results of applying different risk management practices statistically and obtain meaningful results that are difficult to obtain from applying other methodologies.

Naylor et al. [19] defined simulation as:

> a numerical technique for conducting experiments on a digital computer, which involves certain types of mathematical and logical models that describe the behavior of business or economic system over extended periods of real time.

It is a technique of performing sampling experiments based on a model of the system. A stochastic simulation experiments with the model over time and includes sampling stochastic varieties from probability distribution [20, 21]. Since sampling from a specified distribution involves the use of random numbers, stochastic simulation is also called Monte Carlo simulation, which uses random or pseudorandom numbers for solution of a model [21]. Random numbers are often uniformly distributed in [*0, 1*].

We use stochastic simulation in our study for the following reasons:

1. We can obtain enough data for analysis at the project level. First, there is no public data available for use. Since current risk management practices do not consider many time elements of risk, we cannot get the relevant data from past projects. Further, it is difficult and very time consuming if we collect data from real projects. We cannot collect enough data (i.e. data from at least 5 real projects) in a short time because it is not easy to find companies that are willing to use new management practice when there is no significant evidence to show that it is effective. However, we can generate data from a simulation model easily.

2. We can do comparison study easily. Even if we have enough time and resource to collect data from real projects, it would be hard to do comparison study. To compare two different approaches, we should apply them in the same context. However, we cannot apply two incompatible risk management practices in the same project as each real project is a onetime process that cannot be repeated. For example, we cannot perform current risk management practice without considering time elements of risk and then the

same practice with the consideration of time elements in the same project. Also, it is difficult to find two similar projects with similar risk sets and are managed by risk management teams with similar experiences. So, it is difficult to perform comparison study and analyze the performance of different risk management practices using real projects. However, we can easily run any number of simulations on the same project, and compare the results of applying different risk management practices.

3. We can get more meaningful results. Since projects are unrepeatable and risks involve uncertainties, we cannot draw a conclusion that one practice is better than another based on a small number of cases. For example, the result of performing Practice-A is better than Practice-B when we apply them to two similar projects. However, it does not mean that Practice-A is better than Practice-B since we may be "lucky" (risks did not occur even if they have a high chance to occur) when we perform Practice-A, while we are "unlucky" (risks occurred even if they have a low chance to occur) when we perform Practice-B. We cannot eliminate this uncertainty-factor when we cannot repeat a project many times. On the contrary, we can run many simulations of a project and use the average result for the comparison of different practices, giving a more meaningful result.

Given above advantages of simulation, we will use a stochastic simulation model to analyze the influences of introduced time elements on risk management practices.

Note that it is inevitable that some assumptions will be made when using a stochastic simulation model. Inappropriate assumptions may lead to invalid results. Therefore, we should make realistic and appropriate assumptions to ensure that we can produce meaningful results.

1.4 Contributions

This study contributes in following aspects:

1. We explicitly model the time elements of risk that have been ignored by traditional risk management practices.

2. We build a stochastic simulation model of risk management process (SMRMP) which not only facilitates the formal analysis of introduced time elements, but also helps in risk management in many aspects, including understanding of risk management process, predicting risk management outcome, and making informed risk management decision.

3. We formally define the scheduling strategy for risk mitigation, identify a set of scheduling strategies and establish their relative performance.

4. We identify and summarize the new management activities for the introduced time elements. We formally analyze the introduced time elements both at the risk-level and project-level and find that
   - For a risk R_i, any transition between a mitigation case and its successor mitigation cases in the Positive Transition Sub-graph, except for the Null Transition, decrease the expected occurrence rate and expected impact of R_i, and any transition between a mitigation case and its successor mitigation cases in the Negative Transition Sub-graph, except for the Null Transition, increase the expected occurrence rate and expected impact of R_i.
   - The traditionally used mitigation strategy, risk value first strategy (V strategy), is not a good choice for scheduling risk mitigation.
   - There is no strategy that can be the best strategy for scheduling risk mitigation of most projects. This indicates that we should not always apply the same strategy to all projects.

- On average, always applying the best scheduling strategy can increase the performance of always applying the traditional V strategy by 10%, the worst strategy by 31%, and other strategies by at least 8% for all sample projects.

5. Based on the results of formal analysis at risk-level and project-level, we propose new practices for more effective risks management with due consideration of the time elements of risk.

1.5 Thesis Organization

The remainder of the thesis is organized as follows. Chapter 2 reviews concept of project risk and the most common risk management process and practices, related works on modeling time elements of risk and the methodology for validation and verification of a simulation model. In chapter 3, we explicitly model the time elements of risk and their relationships. Chapter 4 proposes a stochastic simulation model and validates it under the paradigm proposed by Sargent. Chapter 5 summarizes the management of identified time elements in the risk management life cycle, propose new scheduling strategies for risk mitigations, conducts formal analysis of introduced time elements at both risk-level and project-level, and proposes new practices for more effective risk management with due consideration of time elements based on the results of analysis.

Chapter 2 Literature Review

This chapter reviews concept of project risk, the risk management process and practices, related works on modeling time elements of risk and the methodology for validation and verification of a simulation model.

In section 2.1, we review the definition of project risk and its basic attributes. In section 2.2 and section 2.3, we review the definition of project risk management and summarize risk management process by reviewing well accepted risk management paradigms, models and standards. Section 2.4 reviews related works on modeling time elements of risk. At last, we discuss the tools for building a stochastic simulation model and the method for the verification and validation of a simulation model in section 2.5.

2.1 Project Risk

Merriam-Webster online dictionary defines risk as the "possibility of loss or injury" and the "chance that an investment will lose value" [22]. ISO/IEC Guide 73 defines risk as "effect of uncertainty on objectives" and is often expressed as "a combination of the consequences of an event and the associated likelihood of occurrence" [23]. Another definition of risk given in AS/NZS 4360 is: "the chance of something happening that will have an impact on objectives" [12]. Hillson and Murray-Webster pointed out that there is no uniform definition of the term risk, and concluded that risk is related to uncertainty and it has consequence [24]. The uncertainty can be expressed as the probability that an event would occur and the consequence is the impact of an event affecting objectives. Thus, a risk has two basic attributes, risk probability (P) and risk impact (I).

In the context of software project, the event can be personnel shortfall, develop wrong functions, or longer development time than planned. The impact of risk can be missing required functions, delay of deadline, or overrun budget, etc. To fully understand a risk, it must be expressed clearly. A statement of the risk must include a description of the current conditions that may lead to the loss and a description of the loss.

Recent risk management literatures have broadened the definition of risk to include *opportunity* [10, 25]. According to PMI, a project risk is an event that can have either positive or negative effect on project objectives [10]. An event offers *risk* if $I > 0$, and it offers *opportunity* if $I < 0$.

According to probability theory, the risk probability, P, theoretically ranges in [0, 1]. The range of risk impact, I, does not have theoretical boundaries. However, we can estimate it on a relative scale which range from $-i$ to $+i$ (i is a positive number) or normalize the scale to [-1, 1]. We adopt [-1, 1] in the thesis since the normalized scale is more convenient to use. Where 1/-1 means a complete loss/gain and 0 means no loss.

Not all events can be considered as risks. White argues that three kinds of events are not risk [26]. An event is not a risk if it never happens ($P = 0$), happens without any impact ($I = 0$), or surely happens ($P = 1$).

In summary, a risk R can be represented by $R(P, I)$, where P is a real number in the range (0, 1), and I is a real number which ranges in [-1, 1] and does not equal to 0 ($I \in [-1, 0) \cup (0, 1]$). In this thesis, we focus on risk rather than opportunity since practitioners are more interested in managing risk. Thus, the impact ranges in (0, 1].

Accordingly, risk is a function of P and I. We use Risk Value (RV) to represent the measurement of risk. So

$$RV = f(P, I) \qquad (2.1)$$

To facilitate discussion, we give some definitions that will be used later in the thesis.

Definition 1. Given a project *Z*, it includes a set of identified *n* risks at time t, $RS(Z, t) = \{R_1, R_2, \ldots, R_n\}$.

The size of *RS(Z, t)*, | *RS(Z, t)*| may change as time elapses since new risks may be identified and added into *RS(Z, t)* and expired risks will be eliminated from *RS(Z, t)*. Note that we can only manage the identified risks, and cannot manage unidentified risks.

Definition 2. For any $R_i \in RS(Z, t)$, and $1 \leq i \leq |RS(Z, t)|$, $R_i(P_i, I_i)$ represents risk R_i with probability P_i and impact I_i .

2.2 Project Risk Management

Risk management is "coordinated activities to direct and control an organization with regard to risk" [23]. It aims to identify risks and take actions to reduce or eliminate their probability and/or impact so that the project is kept from being damaged by risks. Performing risk management is not a onetime effort performed at the beginning of the project. It is a continuous process that risks should be repetitively identified, analyzed, treated and communicated with all related stakeholders of the project.

To guide the practice of risk management, many paradigms, models and standards have been developed. The risk management paradigm developed by SEI [9] and the PMI risk management framework [10] are widely used in the industry.

The SEI paradigm is an elaboration of the classic plan-do-check-act cycle [16]. The cyclic steps of this paradigm include "Identify", "Analyze", "Plan", "Track" and "Control". Besides the five-step of managing risks, this paradigm also contains a "Communicate" component which facilitates the interaction among all the steps of risk management and ensures information is shared effectively between the appropriate organizational levels and across developers, customers and users.

PMI model divides the project life cycle into many project management processes appropriate to all industries. The model provides a basic foundation of nine project management knowledge areas and organizes project activities by their respective project management processes. In PMI model, risk management includes six processes of conducting "Plan risk management", "Identify risks", "Perform qualitative risk analysis", "Perform quantitative risk analysis", "Plan risk responses", and "Monitor and control risks".

There are also other well accepted standards, such as IEEE 1540, AS NZS 4360 and ISO 31000 [11-13], for risk management.

Although these models and standards address the risk management processes in different manners, they can be mapped to each other. Table 2-1 shows the mapping between these paradigms, frameworks and standards.

Table 2-1 Risk Management Models and Standards

SEI Paradigm	**PMI 2008**	**IEEE 1540**	**AS NZS 4360**	**ISO 31000**	**Basic risk management practices**
	Plan risk Management	Plan and implement risk management	Establish the context	Establishing the context	define how to conduct risk management activities for a project
Identify	Identify risks	Perform risk analysis	Identify risks	Risk identification	apply various techniques to identify risks may affect the project and document their characteristics
Analyze	Perform qualitative risk analysis		Analyse risks and Evaluate risks	Risk analysis and Risk evaluation	classify and prioritize identified risks by estimating and combining their probability of occurrence and impact
	Perform quantitative risk analysis				numerically analyze the effect of identified risks on overall project objectives

<table>
<tr><td rowspan="2">Plan</td><td>Plan risk responses</td><td rowspan="2">Perform risk treatment</td><td rowspan="2">Treat risks</td><td rowspan="2">Risk treatment</td><td>translate risk information into decisions and develop options and actions to mitigate risks</td></tr>
<tr><td rowspan="3">Monitor and control risks</td><td>implement risk response plans</td></tr>
<tr><td>Track</td><td rowspan="2">Perform risk monitoring</td><td rowspan="2">Monitor and review</td><td rowspan="2">Monitoring and review</td><td rowspan="2">identify risk indictors and monitor the status of risks and correct variations from plans; identify new risks and evaluate risk process effectiveness throughout the project</td></tr>
<tr><td>Control</td></tr>
</table>

Generally, all these paradigms, models and standards follow the cyclic process shown in Figure 2-1. This process of risk management will be presented in section 2.3.

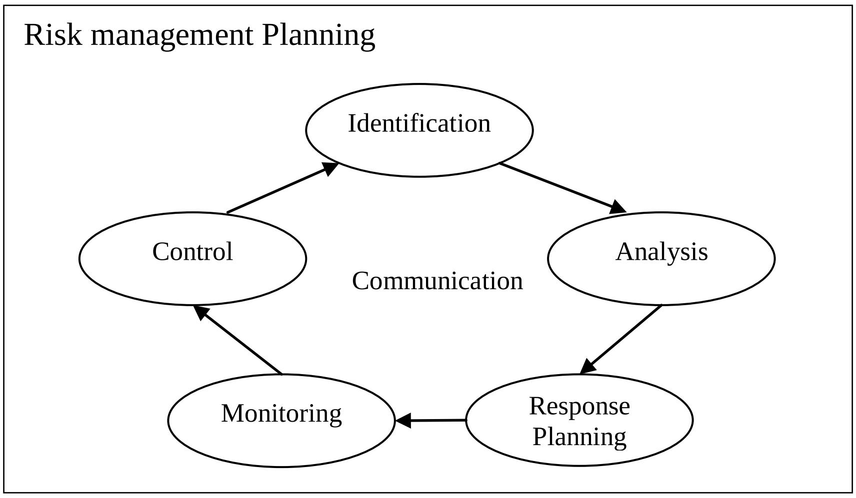


Figure 2-1 Cyclic Process of Risk Management

2.3 Risk Management Process

According to [23], risk management process involves systematically applying management policies, procedures and practices to perform activities of communicating, establishing the risk management context, and identifying, analyzing, evaluating, mitigating, monitoring and reviewing risk.

Since all well accepted models and standards can be mapped to each other to a large extent, we use PMI model to present the risk management process.

2.3.1 Risk Management Planning

Risk Management Planning defines how to conduct risk management practices throughout the project. A careful risk management planning can increase the probability of success of risk management. It is important to provide adequate resources and time for risk management activities and establish the context of risk management which includes internal and external context. Establishing external context defines the relationship between the organization and its external environment. Establishing internal context defines the internal environment in which practitioners conduct the risk management. Table 2-2 shows the environments of risk management [23].

Table 2-2 External and Internal Risk Management Environments

External Risk Management Environments	Internal Risk Management Environments
• the cultural, social, political, legal, regulatory, financial, technological, economic, natural and competitive environment; • key drivers and trends having impact on the objectives of the organization; • relationships with, and perceptions and values of external stakeholders.	• governance, organizational structure, roles and accountabilities; • policies, objectives, and the strategies that are in place to achieve them; • the capabilities that in terms of resource and knowledge (i.e. capital, time, people, processes, systems and technologies); • information systems, information flows and decision making processes; • relationships with, and perceptions and values of internal stakeholders; • the organization's culture; • standards, guidelines and models adopted by the organization; • form and extent of contractual relationships.

The output of risk management planning includes: (1) The definition of approaches, tools, and data sources to be used to perform risk management. (2) The definition of risk management team members and their responsibilities. (3) Required resources for implementing the risk management and when the risk management activities will be performed throughout the project. (4) The definition of risk probability and impact scales that will be used in qualitative risk analysis (see Figure 2-2 for an example of impact scales). (5) The adopted risk matrix to be used for ranking risks (see section 2.3.3 for examples). (6) The definition of how to document the outcomes of risk management and record them for further use.

The risk management planning process should be performed when a project is conceived and be completed at the early stage of project planning.

Project Objective	Relative or numerical scales are shown				
	Very low /.05	Low /.10	Moderate /.20	High /.40	Very high /.80
Cost	Insignificant cost increase	<10% cost increase	10-20% cost increase	20-40% cost increase	>40% cost increase
Time	Insignificant time increase	<5% time increase	5-10% time increase	10-20% time increase	>20% time increase
Scope	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Scope reduction unacceptable to sponsor	Project end item is effectively useless
Quality	Quality degradation barely noticeable	Only very demanding applications are affected	Quality reduction requires sponsor approval	Quality reduction unacceptable to sponsor	Project end item is effectively useless

Figure 2-2 Definition of Impact Scales for Four Project Objectives [10]

2.3.2 Risk Identification

Risk identification aims to identify risks that would affect the project objectives and document their characteristics. A risk cannot be managed and mitigated if it has not been identified. Current risk identification methods include examining the major areas of the project, collecting information from personnel, learning from past experiences and applying analytical tools [10, 27, 28]. A well-structured and systematic process is critical for comprehensive risk identification. Many studies have been conducted to identify risks systematically.

Chittister and Haimes proposed a framework for the assessment and management of risk associated with software development process [29]. This framework analyzes three perspectives of risk associated with software development based on hierarchical holographic modeling. The first perspective is functional decomposition which includes 7 basic attributes (requirement, product, process, people, management, environment, and system development) associated with software development. The second perspective is source-based decomposition which relates to four sources (hardware, software, organizational and human) of system failure introduced during the development process. The third perspective is temporal decomposition which relates to the stages of software development process.

Carr *et al.* developed a taxonomy of software development risks [30]. This taxonomy provides a framework for extensively studying the issues of software development and hence offers a systematic structure for identifying software development risks. The taxonomy consists of three major Classes which represent different aspects of software project development. Each class is further divided into Elements and each element is characterized by its Attributes. The first class, Product Engineering, is the technical aspects of the work to be accomplished. The second class, Development Environment, includes methods, procedures, and tools used to produce the product. The third class, Program Constraints, consists of contractual, organizational, and operational factors which are related to software development, usually beyond the control of the local management.

Sherer presented a three dimensional framework to identify risks [31]. The technical dimension of software risk relates to the uncertainty in the tasks and procedures. The organizational dimension relates to poor communication and organization structure. The environmental dimension relates to the change of environment and problems in relationships with external stakeholders.

Conrow and Shishido summarized the project risk source for software intensive project from previous studies, and classify them into 6 groups: project level, project attributes, management, engineering, work environment and others [32].

Longstaff *et al.* presented a framework for identifying software risk in system integration [33]. It consists of 7 primary visions from the engineer, manager, or analyst perspective. These visions are: software development, temporal, leadership, environment, acquisition, quality and technology. Each of these visions addresses multiple categories of risk sources.

Ropponen and Lyytinen conducted a survey and identified six software risk categories: scheduling and timing risks, functionality risks, subcontracting risks, requirements management, resource usage and performance risks, and personnel management risks [34]. Each risk category is associated with several risk sources.

Murthi found that most risk classifications cannot fully cover the external risks, and proposed several risk categories for projects: requirements, technology, business, political, resources, skills, deployment and support, integration, schedule, maintenance and enhancement, and design [35].

Hoodat and Rashidi specified a classification for software risks [36]. They group software risks into 5 classes: software requirement risks, software cost risks, software scheduling risks, software quality risks and software business risks. Each of these classes consists of a specific set of risks.

Among these proposed approaches, the taxonomy developed by Carr *et al.* [30] is more popular than others. To facilitate the application of this method, a Taxonomy-Based Questionnaire (TBQ) has been designed. The TBQ consists of questions at the attribute level so that practitioners can follow it to identify project risks. Although it is a useful tool for risk identification, it does not cover all risks of today’s project. It was enhanced by identifying eleven new attributes and extending the scope of thirty original attributes [37].

The output of risk identification is a set of identified risks that will be managed and mitigated later in the risk management process. Usually, risk should be documented in a structured format which includes four elements: sources, events, causes and consequences [23]. Risk identification is an iterative process since new risks may appear or become known as the project progresses. Generally, project risks are firstly identified at very beginning of risk management and periodically reviewed in later risk management process.

2.3.3 Qualitative and Quantitative Risk Analysis

The risk analysis aims to understand the identified risks and provide data to assist in managing them. Generally, risk analysis includes: (1) estimate the probability, impact, and the expected timing of the risk [11]; (2) analyze risks and prioritize them. Risk analysis may be performed in different degrees of detail which relies on the need of practice and available resources. It can be conducted in both qualitative and quantitative way.

Qualitative risk analysis uses several categories to describe the magnitude of probability and impact of risk, whereas quantitative risk analysis uses real number for their estimation rather than categories. Further, qualitative risk analysis ranks risks with a risk matrix while quantitative risk analysis prioritizes risks with metrics. Generally, quantitative risk analysis provides deeper understanding of all identified risks. However it is complex and time consuming, and more expensive than qualitative risk analysis [12]. In practice, qualitative analysis is often used to obtain a general indication of the risk level and reveal major risks first. Later, quantitative risk analysis can be applied on major risks for further insight.

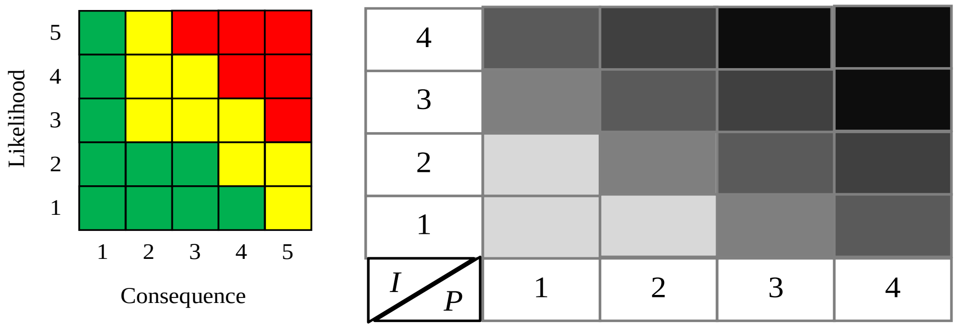
A basic issue of risk analysis is estimating probability and impact of identified risks. In practice, practitioners should estimate probability and impact based on the established probability and impact scales specified in risk management planning (see section 2.3.1 and Figure 2-2). Note that the probability and impact scales should be tailored for each project. Holton [38] points out that the estimation of probability is subjective and differs between individuals. It is hard to develop objective measures. However, some guidelines and principles have been developed for the estimation of probability and impact [39-41].

Another issue of risk analysis is how to measure risks and prioritize them. Next, we will explore the qualitative and quantitative risk prioritization methods respectively.

Risk matrix is a widely used qualitative method for measuring and ranking risks [9, 10, 42]. A risk matrix is a table that has several categories of probability for its rows (or columns) and several categories of risk impact for its columns (or rows) respectively. Cox [43] gave some examples of risk matrix used in different business areas. Some risk matrix examples that can be applied to software projects were given in [9, 10, 39, 41, 42]. Figure 2-3 shows three examples of risk matrix. The gray level/color indicates the priority of the risks. The scale of probability and impact could be descriptive, numeric, or range of values. Table 2-3 shows examples of commonly used scales of probability and impact for a 5X5 risk matrix.

After qualitatively estimating the probability and impact of a risk, it can be ranked according to the region it mapped in the adopted risk matrix.

Note that there is no standard risk matrix across different industries or across different projects. Different organizations may use different risk matrixes based on their risk management assets, such as risk documents of previous projects. Even in the same organization, different projects may use different risk matrixes according to the specific characteristics of the project. As shown in Figure 2-3, the risk matrix used in NASA, in an organization and in a real project are different. Practitioners should select an appropriate risk matrix for their own project at risk management planning (see section 2.3.1).



a. Risk matrix used in NASA b. Risk matrix used in an organization

			Impact				
			Insignificant	**Minor**	**Moderate**	**Major**	**Catastrophic**
			E	**D**	**C**	**B**	**A**
Probability			**0.0~0.2**	**0.2~0.4**	**0.4~0.6**	**0.6~0.8**	**0.8~1.0**
A	**Almost certain**	**0.9~1.0**	Medium	Medium	High	High	Extreme
B	**Likely**	**0.6~0.9**	Medium	Medium	Medium	High	Extreme
C	**Possible**	**0.4~0.6**	Low	Medium	Medium	High	High
D	**Unlikely**	**0.1~0.4**	Low	Low	Medium	Medium	High
E	**Rare**	**0.0~0.1**	Low	Low	Medium	Medium	Medium

c. Risk matrix used in a real project

Figure 2-3 Examples of Risk Matrix

Table 2-3 Examples of Scales for a 5X5 risk matrix

Probability			**Impact**		
Numeric	***Descriptive***	***Range***	***Numeric***	***Descriptive***	***Range***
5	Almost certain	90-100%	5	Catastrophic	0.8-1
4	Likely	60-90%	4	Major	0.6-0.8
3	Possible	40-60%	3	Moderate	0.4-0.6
2	Unlikely	10-40%	2	Minor	0.2-0.4
1	Seldom	0-10%	1	Insignificant	0-0.2

To quantitatively prioritize risks, different functions for measuring risk have been developed, such as Risk Exposure (RE) [42], Risk Factor (RF) [41], and Risk Intensity (RI) [44]. All these metrics can be viewed as different methods to compute the RV (Risk Value). No matter which metrics are used to measure risk, we pointed out that following rules should be satisfied [44].

- $\forall R_i(P_i, I_i), R_j(P_j, I_j) \in RS(Z, t)$, if $P_i = P_j$ and $I_i = I_j$ then $R_i = R_j$;
- $\forall R_i(P_i, I_i), R_j(P_j, I_j) \in RS(Z, t)$, if $P_i > P_j$ and $I_i > I_j$ then $R_i > R_j$;
- $\forall R_i(P_i, I_i), R_j(P_j, I_j) \in RS(Z, t)$, if $P_i > P_j$ and $I_i = I_j$ then $R_i > R_j$;
- $\forall R_i(P_i, I_i), R_j(P_j, I_j) \in RS(Z, t)$, if $P_i = P_j$ and $I_i > I_j$ then $R_i > R_j$;

Boehm [42] introduced Risk Exposure (RE) for measuring risk. It is widely used in practice. RE is defined as

$$RE = P \times I \qquad (2.2)$$

RE is intuitive. It measures the expected value of an undesirable outcome. RE ranges in (0, 1) when I is normalized to (0, 1].

Cooper *et al*. [41] proposed another metric, Risk Factor (RF), for risk prioritization. RF is defined as

$$RF = P + I - P \times I \qquad (2.3)$$

RF ranges from 0 to1 when both P and I range from 0 to 1. Note that RF is “merely a useful piece of arithmetic for setting priorities” [41].

We have proposed another indicator, Risk Intensity (RI) [44]. A risk can be mapped to a point in the PI (Probability, Impact) space. The basic idea behind RI is that a risk that is further away from the original point of the PI space should have a higher priority. Hence, RI is defined as the Euclidean distance between the original point and the risk point. Further, RI enables users to weight probability and risk impact differently with a parameter w.

$$RI = \sqrt{P^2 + (w \times I)^2} \qquad (2.4)$$

RI ranges in (0, $\sqrt{1+w^2}$) or (0, 1.41) when w equals 1, and both P and I range from 0 to 1.

Also, we have found that the result of qualitative and quantitative risk prioritization are often not align with each other when applying above mentioned qualitative and quantitative methods [45]. The reason behind the inconsistency is that RE, RF and

RI use arbitrary formula to prioritize risks without considering the risk matrix and practitioners' preference. The inconsistency may prevent practitioners from performing risk management effectively. To resolve the problem, we suggest a process to combine quantitative risk analysis with qualitative risk analysis, and propose a new method for quantitative risk prioritization to fit the process by applying spatial interpolation.

The results of risk analysis mainly include revised risk information and a prioritized risk list, and serve as input to the risk response planning process in developing a risk response plan.

2.3.4 Risk Response Planning

Risk response planning aims to identifying possible options to reduce or eliminate risks, assessing these options and making a plan to implement risk mitigation activities.

There are four different options that can be used to treat a risk. They are avoid, transfer, mitigate and accept [10, 12].

- Avoid. This option involves performing activities to eliminate the risk by reducing its probability and/or impact to zero. This option may be achieved through changing the objectives of the project, or acquiring expertise. For example, the project manager can avoid the risk that may not meet the deadline by extending the deadline after agreement with the stakeholders.
- Transfer. This option shifts some or all of the negative impact of a risk to a third party. This option transfers the ownership of risk to another party rather than eliminate the risk. It may be achieved through different ways, such as the use of insurance, performance bonds etc. For example, the organization can outsource the production of a needed hardware to a vendor when it lacks capability to design and produce it.

- Mitigate. This option aims to reduce the probability and/or impact to an acceptable threshold. For example, practitioners may reduce the probability of producing low quality software by executing more test cases.
- Accept. This option is adopted when it is not possible to eliminate all risks of a project due to limited resources or inability to develop any strategies to treat a risk. Practitioners do nothing about the risk but may continuously monitor it.

The responses for risk also include develop some contingent activities that will be executed when certain events occur when risks cannot be totally eliminated. For example, when an intermediate milestone is missed we would add more workers to meet the deadline.

Assessing options of treatment involves selecting the most appropriate option by balancing the costs of implementing each option against the benefits derived from it. Generally, the cost of managing risks should not surpass the expected benefits.

Since most projects have limited resources, some minor risks would be accepted without taking any response actions and other risks will be mitigated to reduce or eliminate its impact on the project. Organizations usually focus on top risks to improve the performance of risk management and avoid wasting resources on treating trivial risks.

To make the best use of resources, a scheduling strategy is usually used to determine the risks to be mitigated and when to mitigate them. The generally used strategy for scheduling risk mitigation is “risk value first strategy”. That is, risks are prioritized for response action based on its risk value. For example, we can first use RE to compute the risk value. Then risks are scheduled for mitigation according to their risk values so that risks with higher risk value will be treated earlier.

The outcome of risk response planning is a detailed mitigation plan which includes who, when and how to treat identified risks with assigned resources. Note that not all risks will be mitigated because minor risks can be accepted, and some risks may not be scheduled for mitigating according to the adopted scheduling strategy and available resources.

2.3.5 Risk Monitoring and Control

Risk monitoring and control aims to tracking the change of all identified risks and identifying new risks, monitoring residual risks, and evaluating risk response effectiveness and performance of risk management [10]. It is essential to ensure that the risk management plan is still valid as project progresses from one checkpoint to the next.

The status of identified risks should be monitored until they are expired as risks may change due to a change in internal or external context during the project lifecycle, or the execution of mitigation activities. With the change in the internal or external context, new risks may appear and should be identified accordingly. So, it is necessary to periodically identify new risks, re-assess identified risks and prioritize them.

Key indicators should be defined to monitor and measure the effectiveness and the performance of risk management. Following metrics are commonly used [27].

Suppose project *Z* has a set of n risks *RS(Z, t)* at time t.

1. Risk Number at time t, RN(t), is the total number of risks in *RS(Z, t)*.

$$RN(t) = |RS(Z,t)| = n \tag{2.5}$$

2. Total Risk Value at time t, TRV(t), is the total risk value of all risks at time t [46].

$$TRV(t) = \sum_{R_i \in RS(Z,t)} RV(R_i) \tag{2.6}$$

3. Average Total Risk Value at time t, ATRV(t), is the average of TRV(t) [27].

$$ATRV(t) = \frac{1}{n} TRV(t) \tag{2.7}$$

4. Risk Value of TOP N risks at time t, RVTN(t) is the total risk value of Top N risks at time t [27, 46].

$$RVTN(t) = \sum_{R_i \in RSN(Z,t)} RV(R_i) \tag{2.8}$$

where $RSN(Z,t) \subseteq RS(Z, t)$, and $\forall\ R_i(P_i, I_i) \in RSN(Z, t)$, $R_j(P_j, I_j) \in RS(Z, t) - RSN(Z, t)$, then $RV(R_i) > RV(R_j)$.

These metrics give an overall picture of project risk. They can be used at different times during the lifecycle of risk management to facilitate the analysis of effectiveness and performance of risk treatment.

Note that we can also define similar metrics from the perspective of project objective such as on-time completion and within budget. As the importance of each project objective may be different, monitoring the risk management from the perspective of certain project objective is meaningful too [27].

Based on explicitly modeling the occurrence time of the risk, Leung proposed some indicators, Risk containment rate (CR), Problem rate (PR), and Risk resolution rate (RR), to measure the performance of risk management [47].

2.4 Time Elements in Risk Management

In risk management, time elements exist at both the project level and risk level. Time elements of risk management (project-level) are different times that directly associate with the process of risk management. Time elements of risk (risk-level) are different times that directly associate with the risk from its first identification to its expiration.

According to [10], a project is defined as “a temporary endeavor undertaken to create a unique product, service, or result.” The temporary nature of project indicates that it has a definite beginning and end. Project management [10] is conducted during the lifecycle of project and hence associates with a definite time period. As one area of project management, risk management also has a definite beginning and end. So, some time elements are essential for project risk management.

All well accepted risk management paradigms, frameworks and standards clearly define the lifecycle of risk management. In practice, for each project, we can clearly define the time duration for all five risk management processes and the time for periodical risk review. However, there is no explicit model for many time elements of individual risk.

“IEEE Standard for Software Life Cycle Processes - Risk Management” [11] points out that practitioners should estimate the expected timing of the risk and document it during the risk analysis process. Then, practitioners need to schedule the treatment of each risk accordingly in the risk response planning process. PMI risk management model [10] also points out that: “Risks requiring near-term responses may be considered more urgent to address” and “… In some qualitative analyses the assessment of risk urgency can be combined with the risk ranking…”. That is, it is essential that the risk mitigation should be scheduled with due consideration of the expected occurrence time of the risk. However, both the PMI framework and the IEEE standard lack principles and guidelines on how to schedule risk mitigation with due consideration of many key times of risk. Consequently, these time elements are rarely used in practice. This may lead to improper risk mitigation activities and an ineffective risk management.

Very few studies have explicitly modeled the time elements of risk. Leung proposed variants of risk, presented a model of risk lifecycle, and gave the relationship between the risk variants by explicit consideration of the occurrence time of risk [47].

According to [47], a risk may become an *expired-risk* (a *containment* or a *problem*) with the passage of time, and it may also become a *certainty* (a *non-issue* or an *issue*) in the future. A risk becomes an *expired-risk* when its latest time of occurrence has passed (a *containment*) or it has occurred (a *problem*). There are 2 types of problems: problems that have been resolved (*resolution*) and problems that remain active (*active problem*). A risk becomes a *non-issue* when its probability of occurrence becomes 0, and it becomes an *issue* when its probability of occurrence becomes 100% by a certain time in the future.

Table 2-4 summarizes the key characteristics of variants of risk. A risk will go through several states starting from its first identification to its final deposition. Figure 2-4 shows the possible transition of a risk to its variants. A risk may go through different states before it becomes an *expired-risk* or a *certainty*.

Table 2-4 Key Characteristics of Risk Variants

Variants	**Probability (P_x)**	**Impact (I_x)**	**Time of occurrence**
Expired-risk	0 or 100%	0 or I_x	Past
Containment	0	0	Past
Problem	100%	I_x	Past
Active Problem	100%	I_x	Past
Resolution	100%	I_x	Past
Risk	(0, 100%)	I_x	Future
Certainty	0 or 100%	0 or I_x	Future
Non-issue	0	0	Future
Issue	100%	I_x	Future

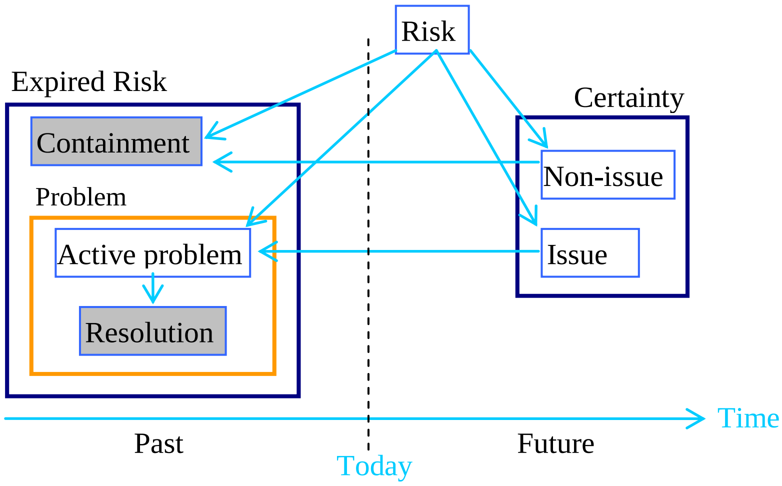


Figure 2-4 Transition of Risk to Its Variants [47]

In summary, existing paradigms, models and standards clearly point out the need to consider time elements of risk management process. However, the modeling of the time elements at the risk level is inadequate. Considering that the management of time elements of risk is necessary in risk management, the failure to consider them in practice leads to improper risk prioritization and an ineffective risk mitigation schedule.

2.5 Stochastic Simulation for Risk Management

2.5.1 Simulation of Risk Management Process

Stochastic simulation is widely used in engineering for different purposes. For the simulation of software process, Kellner et al. [48] summaries the questions and issues that simulation can be used to address. Software process simulation can be used for following six purposes: (1) strategic management, (2) planning, (3) control and operational management, (4) process improvement and technology adoption, (5) understanding, and (6) training and learning.

Simulation can enhance the understanding of many process issues. Moreover, it can help practitioners understand the inherent uncertainty in forecasting process outcomes. The prediction of risk management outcome is highly desirable. Finally, it can help in communication and common understanding within a team. A stochastic simulation model can help to achieve above mentioned objectives. Furthermore, simulation results can help to make decision based on different management strategies. However, the modeling and simulation for software project risk management process is quite limited. Hu et.al [49] proposed an intelligent model that can predict and control software development risks from the project perspective, but they did not focus on risk management process. Chinbat and Takakuwa [50] developed a simulation model to facilitate risk management in a mining project, without consideration of many time elements of risk.

In this study, we first build a stochastic simulation model with due consideration of time elements of risk that have not been modeled by existing models. There are two important issues in developing a simulation model: (1) how to generate values for different model parameters, and (2) how to verify and validate the simulation model.

2.5.2 Random Variate Generation

The most widely used method for generating random numbers was proposed by Lehmer [51], known as the congruential method. Other nonlinear congruential methods [52, 53] can also be used to build a random number generator. Based on a random number generator, the Inverse Transform method and the Acceptance-Rejection method can be used to build generators for continuous non-uniform variate [21, 54], and the Inversion method and the Allas method can be used to build generators for discrete variate [54].

For random variate generation, an open source Java library, SSJ, is available at [55]. SSJ provides a set of packages which aims to facilitate simulation programming in the Java language. Early description of SSJ appeared in [56, 57]. It "provides facilities for generating uniform and non-uniform random variates, computing different measures related to probability distributions, performing goodness-of-fit tests, applying Monte Carlo methods, collecting statistics (elementary), and programming discrete-event simulations with both events and processes" [55]. We will directly use SSJ to build our simulator without further validation because it has been successfully used in many real-life projects [58, 59].

2.5.3 Verification and Validation of Simulation Model

Model verification and validation are critical for developing a simulation model. Model verification is "the process of determining that a model implementation accurately represents the developer's conceptual description of the model and the solution to the model" [60]. Model validation is "the process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model" [60]. Every simulation project presents a unique challenge on verification and validation of the model.

2.5.3.1 Approaches for Model Verification and Validation

To verify and validate a simulation model, Sargent [61] summarizes four different approaches. They are:

1. The model developers make the decision whether a simulation model is valid. This is the most common approach used in practice.
2. The model users heavily involved with the model development team in deciding the validity of the simulation model.
3. The independent approach uses a third party to decide whether the simulation model is valid.
4. In the scoring approach, scores (or weights) are subjectively assessed for different aspects of the validation process and then combined to form an overall score. A simulation model is considered valid if its overall score is greater than the passing score. This approach is seldom used in practice because of some shortcomings, such as the passing score is often decided in a subjective way and a model may have defects even if it gains a score greater than the passing score [61].

2.5.3.2 Paradigm for Model Verification and Validation

There are two paradigms that relate verification and validation to the model development process: the simple view and the complex view. A study has concluded that the simple way is better than the complex way in illuminating model verification and validation [62]. Figure 2-5 shows the process of building a model and then performing model verification and validation.

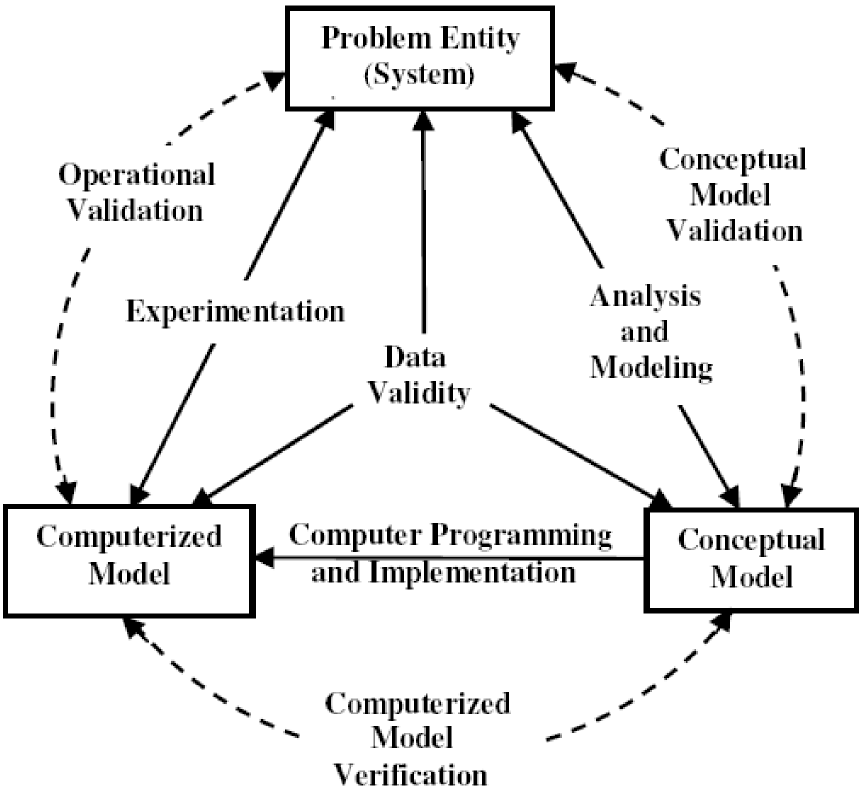


Figure 2-5 Paradigm for Model Verification and Validation [61]

In Figure 2-5, the problem entity represents the system, idea, situation, policy, or phenomena to be modeled. The conceptual model is the mathematical/logical/verbal representation of the problem entity developed for a particular study. The computerized model is an implementation of the conceptual model on a computer [61].

Developing a valid model is an iterative process. A conceptual model is developed in the analysis and modeling process, followed by conceptual model validation. This process is repeated until we obtain a satisfactory conceptual model. Next, the computerized model is developed based on the conceptual model according to the computer programming and implementation process, then followed by computerized model verification. This process is repeated until we obtain a satisfactory computerized model. At last, operational validity is conducted on the computerized model. Note that verification and validation must be performed again if any model change is introduced.

2.5.3.3 Conceptual model validation

Conceptual model validation aims to determine whether the theories and assumptions underlying the conceptual model are correct and whether the model's representation of the problem entity is reasonable for the intended purpose of the model [61]. In conceptual model validation, examiners not only determine whether the structure, logic, and mathematical and causal relationships of the conceptual model are appropriate, but also determine whether the appropriate detail and aggregate relationships have been used for the intended purpose. Face validity is a primary technique used for conceptual model validation. It involves asking experts whether the model is reasonable.

2.5.3.4 Computerized model verification

Computerized model verification aims to ensure that the computer programming and implementation of the conceptual model is correct [61]. Computerized model verification is primarily concerned with determining whether the simulation functions (i.e. random variate generators) and the computerized model have been programmed and implemented correctly.

There are two basic approaches for testing simulation software: static testing and dynamic testing. In static testing, the computer program is analyzed to determine if it is correct by using different techniques, such as structured walkthroughs and correctness proofs. In dynamic testing, different testing methods, such as equivalence partitioning, boundary value analysis and decision table testing, can be used to determine whether the implementations are correct.

2.5.3.5 Operational validation

Operational validation aims to determine whether the accuracy of model's output behavior is adequate for its intended purpose and application domain [61]. Whether the problem entity is observable is the major attribute affecting operational validation. The problem entity is observable if it is possible to collect data on its operational behavior. Table 2-5 gives a classification of the validation techniques used for operational validation based on different decision approaches and whether the problem entity is observable.

Table 2-5 Classification of Operational Validation [61]

	Observable System	**Non-observable System**
Subjective Approach	• Comparison Using Graphical Displays • Explore Model Behavior	• Explore Model Behavior • Comparison to Other Models
Objective Approach	• Comparison Using Statistical Tests and Procedures	• Comparison to Other Models Using Statistical Tests

In Table 2-5, "Comparison" means comparing the output behavior of simulation model to either the output behavior of system or that of another model using graphical analyzes or statistical tests. "Explore model behavior" means examining the output behavior of the simulation model by using appropriate validation techniques, such as sensitivity analysis. The sensitive analysis involves changing the values of the input and internal parameters of a model to determine the effect on its output behavior. The same behaviors should occur in the model as those in the real system.

Chapter 3 Modeling Time Elements of Risk

Managing time elements of risk is necessary for an effective risk management, as pointed out by the PMI framework [10] and the IEEE standard [11]. However, there are very few studies explicitly model the many time elements of risk. Also, there is a lack of theories for performing risk management with due consideration of these time elements.

We first use a simple example to show the necessity of explicit modeling and managing time elements of risk. Suppose there are three risks which would occur during design, coding and testing phase of a hypothetical software development project respectively. Also, we suppose that we can only treat one risk at a time and it takes the same amount of time to mitigate each risk (see Figure 3-1).

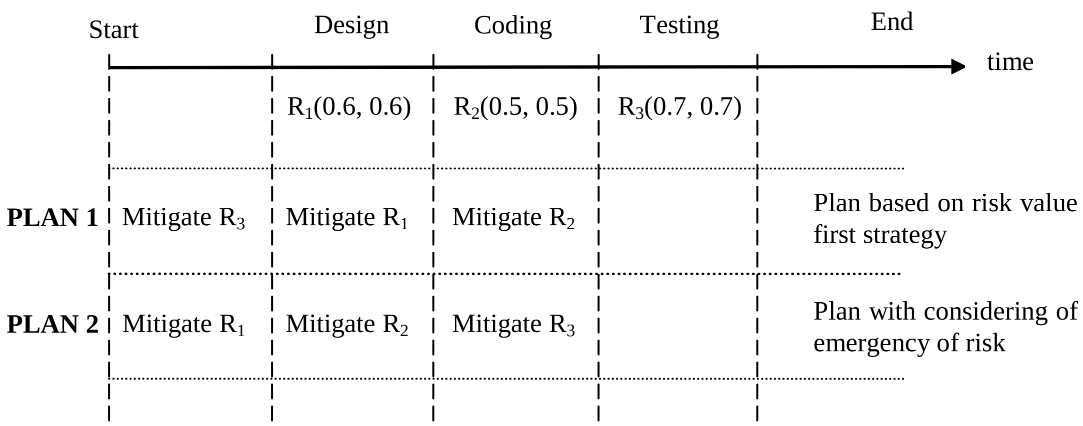


Figure 3-1 An Example Showing the Necessity of Managing Time Elements

PLAN 1 applies the risk value first strategy to schedule the risk mitigation. Since R_3 has the highest risk value and R_2 has the lowest risk value, R_3 is treated first and R_2 is treated at last. Suppose the mitigation of each risk eliminates the risk at the end of risk mitigation. Then, R_3 will never occur (risk mitigation eliminates R_3 before it would occur) while R_1 and R_2 would occur during the time period of their risk mitigation. However, PLAN 1 does not consider the time that the risk would occur. PLAN 2 considers the time elements that are ignored by PLAN 1. All risks will be eliminated before they would occur according to PLAN 2. Thus, it is better than PLAN 1.

Although it is a hypothetical example, it shows that the failure to consider time elements of risk may result in an ineffective risk mitigation plan and consequently leads to a less effective risk management. This example clearly illustrates the necessity of modeling and using time elements in risk management.

In this chapter, we identify the time elements of risk and analyze the relationships between these time elements. Based on their relationship, we identify 8 different cases and one special case covering all possible scenarios. Next, we present the possible transition between these cases. At last, we develop the status change diagram of risk and analyze the possible status change paths.

3.1 Time Elements of Risk

3.1.1 Identification of Time Elements

Not all risks have a mitigation plan and will be mitigated. We focus on the subset of *RS(Z, t)*, *MRS(Z, t)*, in which all risks have a mitigation plan. *MRS(Z, t)* is defined as follow:

Definition 3. Given a set $MRS(Z, t)$ and $MRS(Z, t) \subseteq RS(Z, t)$, $\forall R_j \in RS(Z, t)$ and $1 \leq j \leq |RS(Z, t)|$, if R_j has a mitigation plan then $R_j \in MRS(Z, t)$.

The lifecycle of a risk starts from its identification to its final expiration. In risk management, we first identify risks at very beginning of the lifecycle of risk management and periodically identify new risks at specified time of periodical reviews. So, the identification time of an identified risk can be the time at the first risk identification or the time at periodical reviews. There are two cases for the expiration of a risk. First, the risk occurs and becomes a *problem*. In this case, some contingency activities will be executed to resolve the problem. The other case is that a risk will never occur after a certain time point and becomes a *containment*. In both cases, the risk becomes a risk variant and expired.

Risk management activities include:

1. Analyze and understand the risk.
2. Identify the response options and select one for implementation.
3. Periodically re-assess the risk, and monitor its status and associated response actions.

So, there are two important time periods during the lifecycle of a risk. They are the time period of occurrence and the time period of mitigation. The time period of occurrence is important since the risk would occur only in this period. The time period of mitigation is important because risk mitigation helps to prevent risks from damaging the project by taken planned mitigation actions.

The time period of occurrence is the duration that a risk would occur. This time period can be determined when the risk is first identified. Before this time period the risk event has no chance to occur. After this time period the event will never occur. For example, it is natural that a risk “unacceptable user interface” would only occur during the user acceptance test phase. Note that the occurrence period of some risks could be the same as the project lifecycle. For example, the risk “turnover of key project team member” would occur from the beginning to the end of the project.

The time period of mitigation is the duration for executing planned mitigation activity of a risk. It is natural that every activity has a time period of execution. For example, to prevent the risk “unacceptable user interface” from occurring, the mitigation activity may be letting user involve in the development of user interface during the coding phase, which is the time period of mitigation for this case.

In summary, in the lifecycle of a risk, we identify following important time elements: time of risk identification, time period of occurrence, time period of mitigation, time of risk occurrence and time of risk expiration. Each time period has a start time and an end time. Let T_{eo} and T_{lo} denote the earliest time of occurrence and the latest time of occurrence respectively, and T_{ms} and T_{mc} denote the start time and the close time of mitigation respectively.

Table 3-1 summaries all identified time elements of risk. Note that T_{exp} can be either T_{oc} if the risk occurs or T_{lo} if the risk does not occur.

Table 3-1 Identified Time Elements

No.	**Time Element**	**Notation**		**Description**
1	Time of risk identification	T_{id}		the time that a risk is identified
2	Time period of mitigation	$(T_{ms},T_{mc}]$	T_{ms}	the planned mitigation start time
			T_{mc}	the planned mitigation close time
3	Time period of occurrence	$(T_{eo},T_{lo}]$	T_{eo}	the earliest time of occurrence
			T_{lo}	the latest time of occurrence
4	Time of risk occurrence	T_{oc}		the time that a risk occurs
5	Time of risk expired	T_{exp}		the time that a risk expired

3.1.2 Relationship between Time Elements

In this section, we analyze the relationship between the identified time elements shown in Table 3-1. Since T_{exp} can be one of T_{oc} and T_{lo}, we only need to analyze the relationship between the first 4 time elements.

First of all, the risk would only occur in the time period of occurrence. So, for the 3rd set of time elements and the 4th time element, we have

$$T_{eo} < T_{oc} \leq T_{lo} \quad (3.1)$$

Next, we analyze the relationships between: (1) the 1st time element T_{id} and the 2nd set of time elements $(T_{ms}, T_{mc}]$, (2) T_{id} and the set of time elements $\{T_{eo}, T_{oc}, T_{lo}\}$, and (3) $(T_{ms}, T_{mc}]$ and the set of time elements $\{T_{eo}, T_{oc}, T_{lo}\}$.

1. Relationship between T_{id} and $(T_{ms}, T_{mc}]$

   We only can plan for mitigating a risk after it has been identified. So, if a risk has a mitigation plan, we have

$$T_{id} < T_{ms} < T_{mc} \quad (3.2)$$

2. Relationship between T_{id} and $\{T_{eo}, T_{oc}, T_{lo}\}$

   T_{eo} and T_{lo} are the basic attributes of a risk and only depend on the characteristic of the risk. For example, the risk "unacceptable user interface" would only occur during the user acceptance test phase. We may identify the risk before the user acceptance test phase, or during the user acceptance test phase. That is T_{id} could be earlier than T_{eo} or later than T_{eo}. Generally, we identify a risk before its occurrence and its latest time of occurrence. After the occurrence of a risk or its latest time of occurrence, the risk has occurred or will never occur, then the identification of the risk is too late for the purpose of managing it. So, T_{id} should be earlier than T_{oc} and T_{lo} for an identified risk. If we identify a risk after its expiration, then we cannot manage the "risk" because it expires and becomes a risk variant. So, for all identified risks, we have

$$T_{id} < T_{oc} < T_{lo} \quad (3.3)$$

In summary, the identification of a risk may be earlier or later than T_{eo} and earlier than both T_{oc} and T_{lo} for a meaningful risk management. If we identify a risk after its expiration, then we fail to manage it in this case.

3. Relationship between (T_{ms}, T_{mc}] and $\{T_{eo}, T_{oc}, T_{lo}\}$

   Since $T_{id} < T_{ms} < T_{mc}$ and T_{id} may be earlier or later than T_{eo}, both T_{ms} and T_{mc} could be earlier or later than T_{eo}. For example, for the risk "unacceptable user interface", we could start the mitigation and complete the mitigation before the user acceptance test phase when $T_{id} < T_{eo}$. It is also possible that we start and complete the mitigation during the user acceptance test phase when $T_{id} \geq T_{eo}$.

   Since the risk may occur at any time during the time period of occurrence, a risk can occur before T_{ms}, during (T_{ms},T_{mc}], and after T_{mc} if the time period of mitigation overlaps with the time period of occurrence. Note that we cannot mitigate a risk after it has occurred.

   The planned mitigation close time should not be later than the latest time of occurrence. That is we should complete mitigation before the latest time of occurrence because after that time the risk has already happened or it will never happen, further mitigation will not make sense. So

$$T_{ms} < T_{mc} \leq T_{lo} \tag{3.4}$$

Figure 3-2 summaries relationships between all time elements according to above analysis, where " − " means there is no fixed relationship between the two time elements. All the relationships of identified risks shown in Figure 3-2 can be expressed as:

$$\begin{aligned} &T_{eo} < T_{oc} \leq T_{lo} \\ &T_{id} < T_{ms} < T_{mc} \leq T_{lo} \\ &T_{id} < T_{oc} \leq T_{lo} \end{aligned} \tag{3.5}$$

	T_{id}	T_{ms}	T_{mc}	T_{eo}	T_{lo}	T_{oc}
T_{id}		<	<	—	<	<
T_{ms}			<	—	<	—
T_{mc}				—	≤	—
T_{eo}					<	<
T_{lo}						≥
T_{oc}						

Figure 3-2 Relationships between Time Elements

3.2 Risk Mitigation Cases

3.2.1 Identification of Risk Mitigation Cases

Risk mitigation is the means of preventing risks from damaging the project. From the result of section 3.1, both T_{ms} and T_{mc} could be earlier or later than T_{eo}. Intuitively, we prefer to complete the risk mitigation before the occurrence of the risk. That is we prefer to schedule T_{mc} before or at least not later than T_{oe} so that the mitigated risk has a lower probability to occur and/or has a lower impact on the project if it occurs, or it is eliminated so that it cannot occur anymore. However, it may be impossible to schedule T_{mc} earlier than T_{oe} for all risks. Besides the reason that we may identify the risk after its earliest time of occurrence, there are other reasons that prevent scheduling T_{mc} earlier than T_{eo}.

1. The option used in mitigation prevents the completion of mitigation before T_{eo}. For example, the mitigation activity for the risk of staff turnover is to keep high morale and keep the work interesting. The activity should be continuously implemented until the end of the project, and thus it could not be completed before the earliest occurrence time of the risk.

2. The limited resources may prevent the completion of the mitigation before T_{eo}.

For example, there are two risks that would occur in the near future but only one staff is available, then only one risk can be treated before its earliest time of occurrence.

3. The project constraints or other factors prevent starting the mitigation at the preferred time. Consequently, the mitigation of a risk cannot be completed before T_{eo}.
   For example, a project has a risk that testers could not find most defects due to lack of testing experience. We can use a new testing tool to help catching more defects and reduce the probability of occurrence of the risk. However, the testing tool could not be available until we start testing or after we start testing. So, we could not complete the training of testers before testing.

According to the relationship between T_{eo}, T_{lo}, T_{ms}, and T_{mc}, each risk belonging to *MRS(**Z**, t)* can be mapped to one of eight cases (Case 1-8) as shown in Figure 3-3.

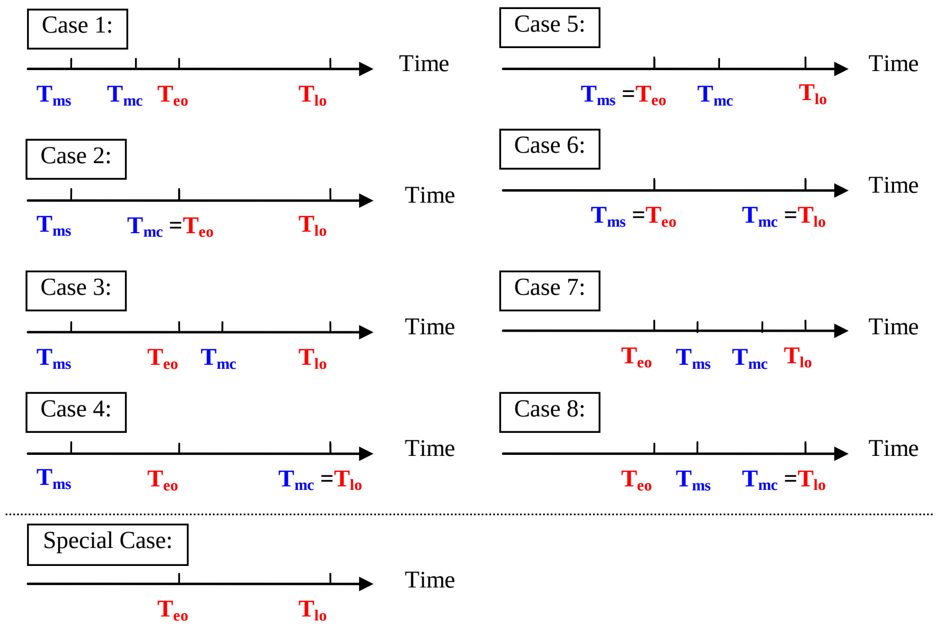


Figure 3-3 Risk Mitigation Cases

We next demonstrate that these eight cases exhaust all possible situations. There are three and only three relationships between T_{ms} and T_{eo}. That is T_{ms} could be earlier than ($T_{ms} < T_{eo}$), equal to ($T_{ms} = T_{eo}$), or later than T_{eo} ($T_{ms} > T_{eo}$). For convenient sake, we call $T_{ms} < T_{eo}$ as "Early Start", $T_{ms} = T_{eo}$ as "Timely Start" and $T_{ms} > T_{eo}$ as "Late Start". Also, we call $T_{mc} < T_{eo}$ as "Early Complete", $T_{mc} = T_{eo}$ as "Timely Complete", $T_{eo} < T_{mc} < T_{lo}$ as "Late Complete" and $T_{mc} = T_{lo}$ as "Latest Complete".

When $T_{ms} < T_{eo}$, there are only four different cases (Case 1 - 4):

Case 1: $T_{mc} < T_{eo}$ (Early Start and Early Complete). The mitigation is started and completed before the risk would occur.

Case 2: $T_{mc} = T_{eo}$ (Early Start and Timely Complete). The mitigation is started before the risk would occur and is completed at the earliest time that the risk would occur.

Case 3: $T_{eo} < T_{mc} < T_{lo}$ (Early Start and Late Complete). The mitigation is started before the risk would occur and is completed during the time period that the risk would occur.

Case 4: $T_{mc} = T_{lo}$ (Early Start and Latest Complete). The mitigation is started before the risk would occur and is completed at its latest time of occurrence.

When $T_{ms} = T_{eo}$, there are only two different cases (Case 5 - 6):

Case 5: $T_{eo} < T_{mc} < T_{lo}$ (Timely Start and Late Complete). The mitigation is started at the earliest time that the risk would occur and is completed during the time period that the risk would occur.

Case 6: $T_{mc} = T_{lo}$ (Timely Start and Latest Complete). The mitigation is started at the earliest time that the risk would occur and is completed at its latest time of occurrence.

When $T_{ms} > T_{eo}$, there are only two different cases (Case 7 - 8):

Case 7: $T_{eo} < T_{mc} < T_{lo}$ (Late Start and Late Complete). The mitigation is started and completed during the time period that the risk would occur.

Case 8: $T_{mc} = T_{lo}$ (Late Start and Latest Complete). The mitigation is started during the time period that the risk would occur and is completed at its latest time of occurrence.

In summary, $\forall R_i \in MRS(Z, t)$, R_i can be mapped to one of Case 1 – 8. Note that not all risks would have a mitigation plan since we may choose to accept minor risks. This situation is shown as Special Case in Figure 3-3. That is $\forall R_j \in RS(Z, t) – MRS(Z, t)$, R_j maps to Special Case. We are not interested in the Special Case since the management for this case is simple. We only need to monitor the risk and implement the contingency plan when the risk occurs. Thus, our study will mainly focus on Case 1-8.

Intuitively, Case 1 and Case 2 are preferred because risks are mitigated before they would occur. The risk has a lower probability to occur and/or has a lower impact when it occurs if the mitigation meets its objectives to reduce probability and/or impact. Moreover, the risk will become a *containment* if mitigation eliminates the risk. Case 7 and Case 8 are unfavourable for risk management since the mitigation action starts too late. The risk may occur before we start mitigation and we cannot do anything in the duration from T_{eo} to T_{ms}. The other four cases, Case 3 – 6, may be better than Case 7 and Case 8. In these cases, we can at least start mitigation before or at the earliest time that the risk would occur. It is better than doing nothing for the risk.

3.2.2 Transition between Mitigation Cases

Note that a risk may be mapped to different mitigation cases at different time. That is the risk may switch from one case to another when time elapses because T_{ms}, T_{mc}, T_{eo} and T_{lo} may change. For example, T_{mc} may change to a later time because we could not complete the mitigation on time. Another example is tools or people may be available earlier than planned, then the mitigation can start earlier (T_{ms} is earlier than planned). Besides T_{ms} and T_{mc}, T_{eo} and T_{lo} of a risk may also change. For example, both T_{eo} and T_{lo} of the risk "unacceptable user interface" may change to a later time if the user acceptance test phase is postponed to a later time.

Four operations may cause a risk switching from one mitigation case to another. They are:

OP1: Change T_{ms} to an earlier time

OP2: Change T_{mc} to an earlier time

OP3: Change T_{ms} to a later time

OP4: Change T_{mc} to a later time

There are three reasons that we want to identify the above operations from the perspective of changing time of risk mitigation:

1. The transition from one mitigation case to another is the result of changes in relative relationships between the time period of mitigation and the time period of occurrence.
2. The change in T_{eo} or T_{lo} is equivalent to relative changes in T_{ms} and/or T_{mc}. Since there are only 8 different cases, any possible transition between two of them due to the change in T_{eo} or T_{lo} can be mapped to some changes to T_{ms} and/or T_{mc}. As shown in Figure 3-4, we can find a path between any two different mitigation cases. Thus if a change in T_{eo} or T_{lo} leads to a transition between two mitigation cases, then we can always find the equivalent changes in T_{ms} and/or T_{mc} according to the path that connects these two cases. For example, T_{eo} changing to an earlier time can result in mitigation Case 2 change to Case 3. This change is equivalent to OP4 (T_{mc} changes to a later time) according to the path from Case 2 to Case3.
3. The time period of mitigation is under the control of the project team, whereas the time period of occurrence is random and not easy to control.

With due consideration of OP1 to OP4, and mitigation cases shown in Figure 3-3, Figure 3-4 shows the transition of different mitigation cases. For example, Case 3 can change to Case 2 after OP2. It can also change to Case 4 and Case 5 after OP4 and OP3 respectively. Moreover, Case 3 can also change to Case 6 if we change both T_{ms} and T_{mc} to a later time respectively.

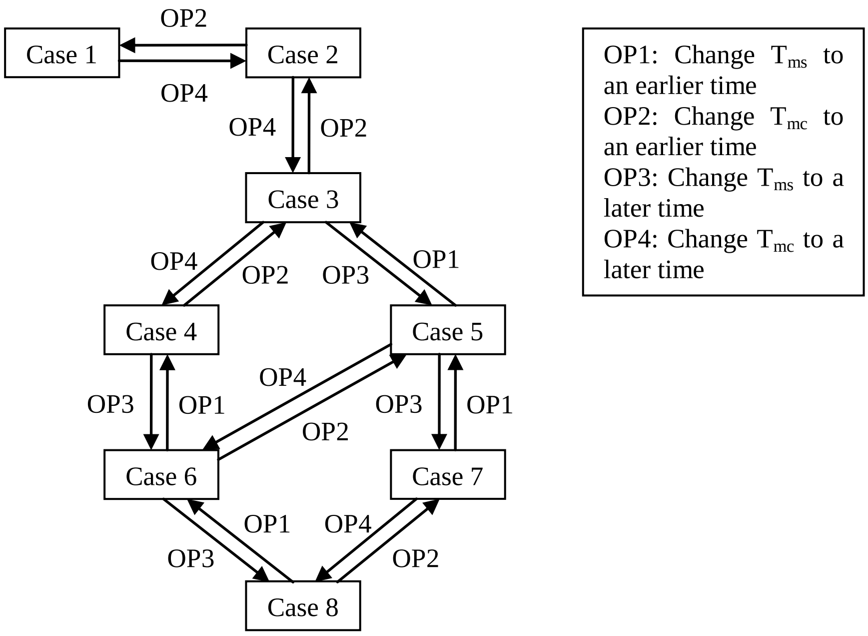


Figure 3-4 Mitigation Cases Transition Graph

This graph can facilitate the management of risk mitigation. Some transitions in the graph are preferred for the mitigation of a risk and others are not. According to different types of transition, practitioner can use the graph to guide their practice in risk mitigation. A formal analysis of the transition graph and some suggestions for risk management practice will be given in Chapter 5.

Note that all four operations can be applied to every mitigation case theoretically. But, in Figure 3-4, each mitigation case is associated with one to three operations. The reason for not showing all operations for each mitigation case is that a mitigation case can change to another mitigation case only with the operations shown in Figure 3-4. For example, Case 4 can change to Case 3 and Case 6 after applying OP2 and OP3 respectively. However, this does not mean OP1 and OP4 cannot be applied to Case 4. We do not show the results of applying OP1 and OP4 on Case 4 because these two operations do not change Case 4 to any other mitigation cases. In Case 4, T_{ms} is earlier than T_{eo}. If we change T_{ms} to an earlier time (OP1), it remains earlier than T_{eo}. Thus, Case 4 does not change with this operation. Also, T_{mc} is the same as T_{lo} in Case 4. It is meaningless if we change T_{mc} to a time later than T_{lo} (see (3.4)) by applying OP4 because the risk cannot be mapped to any mitigation cases.

3.3 Status Change Patterns

A risk may change its status during its life cycle. For a given risk R_i, different status change patterns indicate different degrees of negative impact on the project. A higher impact indicates a lower performance in risk mitigation. Thus, management could understand the performance of risk mitigation by understanding the status change pattern of the risk. A formal analysis on the relationships between the status change patterns and performance of risk mitigation will be given in Chapter 5.

According to (3.5), we know that $T_{id} < T_{ms} < T_{mc} \le T_{lo}$. Then, the risk lifecycle can be divided into three periods as the lifecycle of a risk starts from T_{id} and does not end later than T_{lo}. Let T be the current time,

1. When $T_{id} < T < T_{ms}$, the risk has been identified but has not started mitigation. This status is named as *Identified*.
2. When $T_{ms} < T < T_{mc}$, the risk is under mitigation. This status is named as *Mitigating*.
3. When $T_{mc} < T < T_{lo}$, the risk has been mitigated. This status is named as *Mitigated*.

Figure 3-5 shows the status transition diagram of a risk with due consideration of all variants of the risk [47]. As shown in Figure 3-5, a risk may go through all three statuses (*Identified*, *Mitigating* and *Mitigated*) before it becomes a risk variant. The status of a risk is *Identified* when it is first identified. Then its status will switch to *Mitigating* when time goes forward to T_{ms}. Similarly, its status will change to *Mitigated* when time reaches T_{mc}.

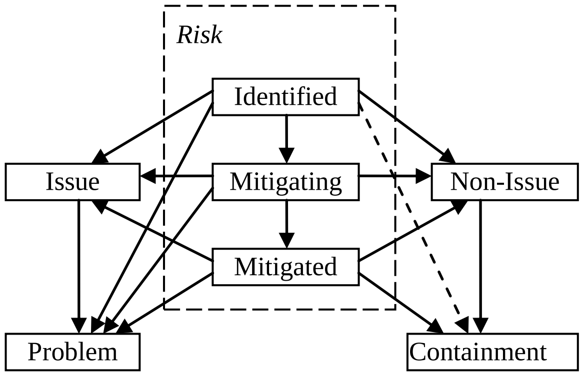


Figure 3-5 Status Transition Diagram

For any risk in *RS(Z, t),* it will become an *Issue* or *Non-issue* at any time after it is identified if it surely will or will not occur in the future, and it will become a *Problem* or *Containment* eventually when time elapses.

For any risk in *RS(Z, t)*, it will become a *problem* if it occurs at a certain time. From Figure 3-3, we can easily find that a risk may occur any time when it has a *Mitigated* (see Case1-2), *Mitigating* (see Case3-6) or *Identified* (see Case7-8 and Special Case) status.

We can be sure that a risk will not occur only after T_{ol}. We know that T_{mc} should not be later than T_{ol}. Then, for a risk with a mitigation plan (belongs to *MRS(Z, t)*), it can become a *Containment* only after it is mitigated. For a risk without a mitigation plan (belongs to *RS(Z, t)- MRS(Z, t)*), it can become a *Containment* directly from the *Identified* status. The latter case is shown in dash arrow in Figure 3-5.

As we are only interested in whether a risk occurs and the change of status when trying to understand the performance of risk mitigation, a simplified version of the transition diagram (as shown in Figure 3-6) is sufficient for our analysis. We can ignore two variants of risk, *Issue* and *Non-Issue*, since they will eventually become *Problem* and *Containment* respectively. So, we simplify Figure 3-5 by deleting *Issue* and *Non-Issue* and their associated arrows to get Figure 3-6 which can be used to identify the status change paths.

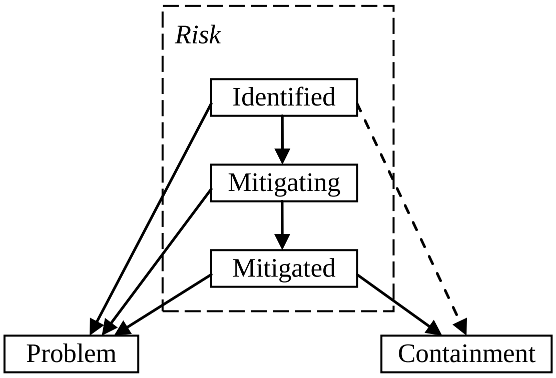


Figure 3-6 Simplified Status Transition Diagram

Four status change paths can be identified from Figure 3-6, as shown in column 2 of Table 3-2. Note that we do not consider the path 'Identified → Containment' since the risks following this path do not have a mitigation plan. Any risk with a mitigation plan can only follow one of the above 4 paths.

Table 3-2 Status Change Paths of Risk in *MRS(Z, t)*

Pattern Name	**Status Change Path**	**Possible Mitigation Case**	**Preference Level**
Unmitigated Problem	Identified → Problem	Case7-8	Very Low
Mitigating Problem	Identified → Mitigating → Problem	Case3-6	Low
Mitigated Problem	Identified → Mitigating → Mitigated → Problem	Case1-2	Medium
Normal Containment	Identified → Mitigating → Mitigated → Containment	Case1-8	High

Table 3-2 shows the identified status change paths, possible mitigation cases taking the paths, and the preference level which indicates the performance of mitigation in terms of actual impact on the project. A higher preference level indicates a higher performance and a lower impact on project. The objective of risk mitigation is preventing risk from damaging the project. It is better that a risk results in a low impact on the project. Therefore, for a certain risk, the performance of its mitigation is higher if it results in lower impact on the project.

Intuitively, for a risk $R_i(P_i, I_i) \in MRS(Z, t)$, the *Normal Containment* has the highest preference level since R_i does not occur and has no impact on the project after the mitigation. The *Mitigated Problem* has a medium preference level since the impact of R_i is reduced after the mitigation. The *Mitigating Problem* has a low preference level than that of a *Mitigated Problem* as we have not completed the risk mitigation yet. The *Unmitigated Problem* has the lowest preference since the impact of R_i have not been reduced. A formal analysis on these status change paths will be conducted in Chapter 5 to compare their performance in risk mitigation. Further, some suggestions on the risk mitigation practice will be given based on the results of formal analysis.

Chapter 4 A Stochastic Simulation Model

We like to build a stochastic simulation model to analyze the introduced time elements. In this chapter, we first build the conceptual model of risk management process in section 4.1. We will identify the inputs and outputs of the model, derive the simulation algorithms, and present the model assumptions. Before using this model in our study, it needs to be evaluated. In section 4.2, we evaluate the model using the paradigm presented in section 2.5.3.

Note that this simulation model can be used not only in our study but also for many risk management issues, such as understanding of risk management process, predicting risk management outcome, and making informed risk management decision. First, users could understand the process of risk management by learning the model. It can be used to understand the inherent uncertainty in forecasting process outcomes, and in communication and common understanding within a team. Second, users can predict expected impact of identified risks on the project by running simulations. Finally, applying the simulation model can help to select the best management strategy among different management strategies based on the simulation results.

4.1 Conceptual Model for Risk Management Process

As mentioned in section 2.2, all well accepted risk management models and standards can be mapped to each other to a large extent. Thus we can use PMI model as the model for risk management process. We use a two levels approach to develop the model. The first level is the risk level, where we focus on a single risk. The second level is the project level, where we consider all risks of the whole project.

Before building the conceptual model, we first give a definition that will be used in model building.

For any $R_i \in RS(Z, t)$, both P_i and I_i would change with time. First of all, the mitigation activity would reduce P_i and I_i of a risk. Besides the risk mitigation, other factors may also change P_i and I_i. For example, the environment of the project may change with time and this may cause change to P_i and I_i. In general, among all factors which may cause changes to P_i and I_i, the risk mitigation action is the most important one.

Definition 4. For any $R_i(P_i, I_i) \in RS(Z, t)$,

$$P_i = pf_i(t) = p_i^+ + mp_i(t) + op_i(t) \tag{4.1}$$

$$I_i = ig_i(t) = i_i^+ + mi_i(t) + oi_i(t) \tag{4.2}$$

where $pf_i(t)/ig_i(t)$ is the estimated probability/impact value at time t, p_i^+/i_i^+ is the estimated probability/impact value when the risk was first identified, $mp_i(t)/mi_i(t)$ is the offset from p_i^+/i_i^+ caused by mitigation at time t, and $op_i(t)/oi_i(t)$ is the offset from p_i^+/i_i^+ caused by other factors. Note that $mp_i(t)/mi_i(t)$ and $op_i(t)/oi_i(t)$ could be zero, positive or negative.

4.1.1 Parameters Identification

In our model, we only focus on those internal parameters which affect the process of risk management and the life cycle of risk, and exclude external factors. These external factors basically are environments of risk management that are defined in the process of risk management planning (see 2.3.1).

Although the process of risk management involves external factors, these factors will eventually result in changes of internal parameters and generate different scenarios. For example, we may mitigate all risks if we have enough resources and may only mitigate top 10 risks if we lack resources. In our study, we focus on whether a risk has a mitigation plan, and exclude the factor of available resources. Because the influence of available resources will eventually result in some or all identified risks to be mitigated, the simulation model is therefore based on whether a risk has a mitigation plan. In summary, we exclude external factors from our model and address their influence indirectly through changes of internal parameters.

Next we explore the risk management lifecycle phase by phase to identify key parameters of our model, SMRMP (Simulation Model of Risk Management Process).

4.1.1.1 Risk Management Planning

The purpose of risk management planning is establishing the risk management context in which the process of risk management will take place, and defining risk management activities. In this phase, practitioners should define the approaches, tools, and data sources that may be used for risk management, identify risk management team and their responsibilities, reserve funds needed for risk management, and define the period of risk management and time to perform periodical risk management review.

Two sets of time points are extracted as project-level parameters of the model. They are $\{\boldsymbol{strm}, \boldsymbol{etrm}\}$ and $\{\boldsymbol{stpr_m}, \boldsymbol{etpr_m} \mid 1 \leq \mathrm{m} \leq \boldsymbol{npr}\}$, where ***strm*** and ***etrm*** are start time and end time of risk management respectively, $\boldsymbol{stpr_m}$ and $\boldsymbol{etpr_m}$ ($1 \leq m \leq \boldsymbol{npr}$) are the start and end time for the m^{th} periodical review respectively and ***npr*** is the total number of periodical reviews. Time interval ($\boldsymbol{stpr_m}$, $\boldsymbol{etpr_m}$] represents the period of m^{th} periodical review.

In this phase, there are no risk-level parameters since risk identification has not been done yet.

4.1.1.2 Risk Identification

The purpose of risk identification is identifying those risks which may affect the project and registering their characteristics. Risk identification is an iterative process since new risks may appear or become known as the project progresses. Usually, we firstly identify risks at the very beginning of risk management.

At the project-level, we extract the start time and the end time for risk identification, ***stri*** and ***etri***, and the number of identified new risks, ***nrri***, as parameters of our model. Time interval (***stri***, ***etri***] is the risk identification period. For each identified risk, we record its identification time $\boldsymbol{tid_i}$ when it is first identified.

4.1.1.3 Risk Analysis

Risk analysis aims to prioritize risks and provide data to assist in managing them, which relies on the estimation of risk probability and impact. In this phase, the practitioners should prioritize all identified risks. For each risk, there are two basic attributes, namely, probability and impact. The priority of risk is not considered a basic attribute since it is often determined by probability and impact [17, 41, 44].

Four risk-level parameters can be extracted in this phase. They are $\boldsymbol{p_i^+}$, $\boldsymbol{i_i^+}$, $\boldsymbol{teo_i}$ and $\boldsymbol{tlo_i}$, where $\boldsymbol{p_i^+}$ and $\boldsymbol{i_i^+}$ are probability and impact of risk R_i when it is first identified, and $\boldsymbol{teo_i}$ and $\boldsymbol{tlo_i}$ are the earliest occurrence time and the latest occurrence time of R_i respectively. Time interval ($\boldsymbol{teo_i}$, $\boldsymbol{tlo_i}$] is the occurrence period of R_i. In risk analysis, practitioners should aim to correctly estimate these parameters.

In this phase, no project-level parameters are identified since risk analysis mainly focuses on individual risks.

4.1.1.4 Risk Response Planning

This phase aims to develop options and actions for each risk to reduce its threats to project objectives. This is based on the available human resources, funds and priority of risks. The decision on the specific risks to be mitigated and when to mitigate them will be made.

A risk R_i has a time period for its mitigation if it has a mitigation plan. Then we can extract two risk-level parameters, $\boldsymbol{tms_i}$ and $\boldsymbol{tmc_i}$, which are the mitigation start time and the mitigation close time of R_i respectively. Time interval $(\boldsymbol{tms_i}, \boldsymbol{tmc_i}]$ is the mitigation period of R_i. After risk mitigation, the probability and impact of the risk are expected to be reduced to a lower value. So, two additional parameters, $\boldsymbol{p_i^-}$ and $\boldsymbol{i_i^-}$, are extracted as risk-level parameters, which represent the expected probability and the expected impact of R_i after the mitigation respectively. These four parameters ($\boldsymbol{tms_i}$, $\boldsymbol{tmc_i}$, $\boldsymbol{p_i^-}$ and $\boldsymbol{i_i^-}$) are meaningful only for risks with a mitigation plan.

4.1.1.5 Risk Monitoring and Control

In this phase, practitioners implement the risk response plan, track identified risks, identify new risks and re-assess all identified risks, and correct variations from mitigation plans.

New risks are identified during the period of m^{th} periodical review. Thus we extract a set of parameters, $\{\boldsymbol{nrpr_m} \mid 1 \le \mathrm{m} \le \boldsymbol{npr}\}$ as project-level parameters, where $\boldsymbol{nrpr_m}$ is the number of new risks identified in the m^{th} periodical review.

Note that we are interested in active risks in risk monitoring and control and just document those expired risks. The number of active risks can be computed from the number of newly identified risks in periodical review and unexpired risks identified in the first risk identification. So, we do not consider the number of active risks and number of expired risks as input parameters of the model because they can be computed if needed.

Table 4-1 summarizes all identified parameters of SMRMP. The start time and end time of risk management are set to 0 and L respectively by assuming the risk management is started at time 0 and end at time L (L is a positive number). Thus, the values of all other parameters, including $stri$, $etri$, $stpr_m$, $etpr_m$, tid_i, teo_i, tlo_i, tms_i and tmc_i, are bigger than 0. Moreover, we have $etri > stri$, $etpr_m > stpr_m$, $tlo_i > teo_i$, and $tid_i \le tms_i < tmc_i \le tlo_i$ according to established relationships between time elements (see section 3.1.2). We consider that periodical review should be performed at least once and the number of risks identified in risk identification and periodical review should be nonnegative; therefor npr>0, $nrri$>0 and $nrpr_m$>0 respectively. p_i^+/p_i^- ranges in [0, 1) as it is a probability. i_i^+/i_i^- ranges in [0, 1] as the impact of a risk can be normalized.

Table 4-1 Parameters of SMRMP

No.	Notation	Value	Level	Description
1	***strm***	0[*1]	project-level	start time of risk management
2	***etrm***	L[*1]	project-level	end time of risk management
3	***stri***	>0	project-level	start time of the risk identification
4	***etri***	> *stri*>0	project-level	end time of the risk identification
5	***nrri***	≥0	project-level	number of risks identified in risk identification
6	***npr***	>0	project-level	number of periodical reviews
7	$\boldsymbol{stpr_m}$	>0	project-level	start time of the m[th] periodical review
8	$\boldsymbol{etpr_m}$	>$stpr_m$>0	project-level	end time of the m[th] periodical review
9	$\boldsymbol{nrpr_m}$	≥0	project-level	number of risks identified in the m[th] periodical review
10	$\boldsymbol{tid_i}$	>0	risk-level	the time that R_i is identified
11	$\boldsymbol{teo_i}$	>0	risk-level	earliest time of occurrence of R_i
12	$\boldsymbol{tlo_i}$	>teo_i>0	risk-level	latest time of occurrence of R_i
13	$\boldsymbol{p_i^+}$	∈ (0, 1)	risk-level	probability of R_i when it is first identified
14	$\boldsymbol{i_i^+}$	∈ (0, 1][*2]	risk-level	impact of R_i when it is first identified
15	$\boldsymbol{tms_i}$	≥ tid_i>0	risk-level	mitigation start time of R_i
16	$\boldsymbol{tmc_i}$	∈ (tms_i, tlo_i]	risk-level	mitigation close time of R_i
17	$\boldsymbol{p_i^-}$	∈ [0, 1)	risk-level	expected probability of R_i after the mitigation
18	$\boldsymbol{i_i^-}$	∈ [0, 1][*2]	risk-level	expected impact of R_i after the mitigation

*1 we assume the risk management starts at time 0 and ends at time L (see section 4.1.5)
*2 we can normalize the impact of a risk into (0, 1]

4.1.2 Outputs of the Model

The objective of risk management is to reduce the negative impact of risks on the objectives of the project. Thus, practitioners are most concern with those risks that will likely occur during the project and their impacts on the project.

We use $\boldsymbol{occ_i}$ to represent whether R_i occurs or not, and $\boldsymbol{toc_i}$ and $\boldsymbol{imp_i}$ to represent the occurrence time of R_i and its impact on the project if R_i occurs. We use ***nocc*** and ***oimp*** to represent the total number of all occurred risks and their overall impact. $\boldsymbol{occ_i}$, $\boldsymbol{toc_i}$ and $\boldsymbol{imp_i}$ are risk-level outputs, and ***nocc*** and ***oimp*** are project-level outputs.

Table 4-2 summarizes all outputs of SMRMP. occ_i has value of "Yes" if R_i occurs and "No" otherwise. We have $teo_i < toc_i \le tlo_i$ according to established relationships between time elements (see section 3.1.2). imp_i is $ig_i(toc_i)$ if R_i occurs at toc_i, where $ig_i(t)$ is the impact function of R_i. Both the number of occurred risks and overall impact of occurred risks are nonnegative.

Table 4-2 Outputs of SMRMP

No.	Notation	Value	Level	Description
1	$\boldsymbol{occ_i}$	Yes/No	risk-level	represent whether R_i occurs or not
2	$\boldsymbol{toc_i}$	$\in (teo_i, tlo_i]$	risk-level	occurrence time of R_i if it occurs
3	$\boldsymbol{imp_i}$	$=ig_i(toc_i)$	risk-level	impact of R_i if it occurs at toc_i
4	***nocc***	≥ 0	project-level	number of all occurred risks
5	***oimp***	≥ 0	project-level	overall impact of all risks

4.1.3 Relationship between Parameters

There are some natural relationships between the identified parameters. With due consideration of (3.5) in section 3.1.2, and the parameters ***strm*** and ***etrm*** (representing the start and end of risk management respectively), we have

1. *Risk occurrence*. For any $R_i(P_i, I_i) \in RS(Z, t)$,

$$strm < teo_i < toc_i \le tlo_i < etrm \quad (4.3)$$

$$strm < tid_i < toc_i \le tlo_i < etrm \quad (4.4)$$

   This means that a risk would occur only in its occurrence period. Moreover, for any identified risk in $RS(Z, t)$, it would occur only after its identification.

2. *Risk mitigation*. For any $R_i(P_i, I_i) \in MRS(Z, t)$,

$$strm \leq tid_i \leq tms_i < tmc_i \leq tlo_i \leq etrm \tag{4.5}$$

This means that (1) the mitigation for a risk must not start before it has been identified, and (2) a risk should not be mitigated after its latest occurrence time since after that time the risk has already happened or it will never happen, and further mitigation will not make sense.

4.1.4 Simulation Algorithm

After identifying the input parameters and outputs of the simulation model, we now discuss the algorithms that compute output of the simulation from the input parameters.

Before presenting the algorithms of simulating a project, we give some definitions to facilitate the presentation, and the verification and validation of the model. Since the probability and impact of a risk may change with time, we use EOR (Definition 6) and EAI (Definition 7) to measure the expected occurrence rate and expected impact during $(teo_i, tlo_i]$. Since a risk cannot be repeated in real-life projects, we define IIR (Definition 5) to facilitate the computation of EOR and EAI.

Definition 5. Independent and Identical Risks (IIR): If R_1 and R_2 are independent risks and have the exactly same values in all risk-level parameters, then they are independent and identical risks (IIR).

Definition 6. Expected Occurrence Rate (EOR): Suppose there are N IIRs, if M risks occurred among all N risks when N is sufficiently large, then EOR=M/N.

Definition 7. Expected Actual Impact (EAI): Suppose there are N IIRs, if M risks occurred among all N risks when N is sufficiently large, then EAI=$\frac{\sum_M imp_i}{N}$, where $\sum_M imp_i$ is the total impact of M occurred risks.

Next we develop a method to determine whether a risk will occur in the simulation. Since a risk R_i only would occur during its occurrence period, our analysis focuses on this period (teo_i, tlo_i]. Suppose we have N IIRs, and for each risk R_i, we have $pf_i(teo_i)= p_i^*$ and $ig_i(teo_i)= i_i^*$.

$pf_i(t)$ and $ig_i(t)$ may change during the occurrence period (teo_i, tlo_i]. There are four possible cases:

1. both $pf_i(t)$ and $ig_i(t)$ do not change;
2. $pf_i(t)$ does not changes and $ig_i(t)$ changes;
3. $pf_i(t)$ changes and $ig_i(t)$ does not change;
4. both $pf_i(t)$ and $ig_i(t)$ change.

Consider the first case that both $pf_i(t)$ and $ig_i(t)$ do not change during (teo_i, tlo_i], $pf_i(t)$ and $ig_i(t)$ are constants during (teo_i, tlo_i] and equal to p_i^* and i_i^* respectively. We can easily conclude that the number of occurred risks $M=N\times p_i^*$ since R_i has the same probability to occur during (teo_i, tlo_i], and $\sum_M imp_i = M\times i_i^* = N\times p_i^* \times i_i^*$ since each risk has the same impact i_i^* at any time during (teo_i, tlo_i]. Thus, EOR= p_i^* and EAI= $p_i^* \times i_i^*$.

If we divide (teo_i, tlo_i] into n equal time interval with n+1 time points, t_0, t_1, t_2,...,t_{n-1}, and t_n, and use notation $M(T_j)$ to denote the number of risks occurred in time interval T_j (from t_{j-1}, to t_j, $1\le j\le n$) among all M occurred risks, then $M(T_j) = \frac{M}{n} = \frac{N\times p_i^*}{n}$ ($1\le j\le n$) since all time intervals have the same probability of risk occurrence.

Next, we consider the other 3 cases. Figure 4-1 shows a changed $pf_i(t)$ curve during (teo_i, tlo_i]. The horizontal line (shown as dash) shows the case that $pf_i(t)$ does not change. As shown in Figure 4-1, the occurrence period is divided into *n* equal time intervals. No matter $pf_i(t)$ changes or not, if *n* is sufficiently large, then the change of $pf_i(t)$ in T_j($1\le j\le n$) is extremely small and its value can be considered as $pf_i(t_j)$.

Similarly, no matter $ig_i(t)$ changes or not, if n is sufficiently large, then the change of $ig_i(t)$ in $T_j(1 \le j \le n)$ is extremely small and its value can be considered as $ig_i(t_j)$.

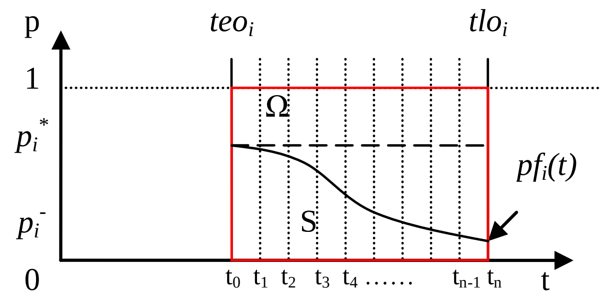


Figure 4-1 Changed $pf_i(t)$During Occurrence Period

As mentioned earlier, when the probability of risk occurrence is p_i^* we have $\frac{N \times p_i^*}{n}$ risks occurred in time interval T_j. Then we have $M(T_j) = \frac{N \times p_i^*}{n} \times \frac{pf_i(t_j)}{p_i^*} = \frac{N \times pf_i(t_j)}{n}$ when the probability of risk occurrence changed from p_i^* to $pf_i(t_j)$. Thus,

$$M = \sum_{j=1}^{n} M(T_j) = \sum_{j=1}^{n} \frac{N \times pf_i(t_j)}{n} \tag{4.6}$$

$$\sum_M imp_i = \sum_{j=1}^{n} M(T_j) \times ig_i(t_j) = \sum_{j=1}^{n} \frac{N \times pf_i(t_j) \times ig_i(t_j)}{n} \tag{4.7}$$

Then when n tends to infinite, we have

$$
\begin{aligned}
M &= \lim_{n\to\infty}\sum_{j=1}^{n}\frac{N\times pf_i(t_j)}{n} \\
&= N\times\lim_{n\to\infty}\sum_{j=1}^{n}\frac{pf_i(t_j)}{n} \\
&= N\times\frac{\lim_{n\to\infty}\sum_{j=1}^{n}\frac{tlo_i - teo_i}{n}\times pf_i(t_j)}{tlo_i - teo_i} \\
&= N\times\frac{\int_{teo_i}^{tlo_i} pf_i(t)\,dt}{tlo_i - teo_i}
\end{aligned}
\tag{4.8}
$$

Similarly, we also have

$$
\sum\nolimits_M imp_i = N\times\frac{\int_{teo_i}^{tlo_i} pf_i(t)\times ig_i(t)\,dt}{tlo_i - teo_i} \tag{4.9}
$$

Finally, according to Definition 6 and Definition 7, we have

$$
EOR = \frac{M}{N} = \frac{\int_{teo_i}^{tlo_i} pf_i(t)\,dt}{tlo_i - teo_i} \tag{4.10}
$$

$$
EAI = \frac{\sum\nolimits_M imp_i}{N} = \frac{\int_{teo_i}^{tlo_i} pf_i(t)\times ig_i(t)\,dt}{tlo_i - teo_i} \tag{4.11}
$$

When $pf_i(t)$ and $ig_i(t)$ are constants during (teo_i, tlo_i], for example they equal to p_i^* and i_i^* respectively, then (4.10) and (4.11) give EOR= p_i^* and EAI= $p_i^* \times i_i^*$ respectively. They are exactly the same results obtained earlier for the first case. So, we can use (4.10) and (4.11) for all cases. That is, no matter $pf_i(t)$ and $ig_i(t)$ change or not during (teo_i, tlo_i], (4.10) and (4.11) are applicable. They can be applied to all mitigation cases (Case 1-8 and Special Case) shown earlier in Figure 3-3.

If we simulate a risk R_i N times, we expect the risk would occur EOR×N times when N is sufficiently large.

Let Ω denotes the rectangle shown in Figure 4-1, $\Omega = \{(t, p) \mid teo_i < t < tlo_i, 0 \le p \le 1\}$, and S denotes the area under $pf_i(t)$, $S = \{(t, p) \mid teo_i \le t \le tlo_i, 0 \le p \le pf_i(t)\}$. According to (4.10), we have

$$EOR = \frac{S}{\Omega} \tag{4.12}$$

Consequently, we can use "the hit or miss Monte Carlo method" [21] to simulate the behavior of R_i, because if we randomly select N points from Ω (performing N trials), then EOR can be estimated by N_H/N, where N_H is the number of points located in S. If the randomly generated point *x* is located in S, then a risk occurs in the trial. Otherwise, the risk does not occur. The t dimension of *x* gives the occurrence time if the risk occurs.

According to [21], if we use M' to denote the number of times that a risk occurred in N trials (N is sufficiently large), then EOR'=M'/N is distributed according to the normal distribution with a mean EOR. We also expect that EAI'= $\sum_{M'} imp_i$ /N is distributed according to the normal distribution with a mean EAI, where $\sum_{M'} imp_i$ is the total impact of M' times of occurrence of risk in N trials.

Now, we have a method to determine whether a risk occurs or not and its occurrence time if it occurs. We next work out all outputs (shown earlier in Table 4-2) of a project.

Algorithm 4.1 and Algorithm 4.2 give the algorithms for generating risk-level outputs and project-level outputs based on the model input parameters respectively.

Algorithm 4.1: Simulating(R_i)

1. Obtain $P_i = pf_i(t)$ and $I_i = ig_i(t)$ of risk R_i;
2. Randomly throw a point $tp_x(t_x, p_x)$ in rectangle
   $\Omega = \{(t, p) \mid teo_i < t < tlo_i, 0 \le p \le 1\}$;
3. IF $tp_x(t_x, p_x)$ locates in area $S = \{(t, p) \mid teo_i \le t \le tlo_i, 0 \le p \le pf_i(t)\}$
   THEN $\boldsymbol{occ_i}$ =Yes; $\boldsymbol{toc_i} = t_x$; $\boldsymbol{imp_i} = ig_i(t_x)$;
   ELSE $\boldsymbol{occ_i}$ =No;

Algorithm 4.2: Simulating($\boldsymbol{Z}$)

1. For each $R_i \in \bigcup_{t=\{etri, etpr_m\}} RS(\boldsymbol{Z}, t)$, run **Simulating**($R_i$);
2. ***nocc*** = 0; ***oimp*** = 0;
3. For each $R_i \in \bigcup_{t=\{etri, etpr_m\}} RS(\boldsymbol{Z}, t)$,
   IF $\boldsymbol{occ_i}$ is "Yes"
   THEN ***nocc*** = ***nocc*** +1; ***oimp*** = ***oimp*** + $\boldsymbol{imp_i}$;

In Algorithm 4.2, $\bigcup_{t=\{etri, etpr_m\}} RS(\boldsymbol{Z}, t)$ represents the union of risk sets at the end of risk identification and periodical reviews. We identify risks first in risk identification and identify new risks at the following periodical reviews. Thus, $\left|\bigcup_{t=\{etri, etpr_m\}} RS(Z, t)\right|$ is the number of identified risks during risk management.

Algorithm 4.1 takes constant time if we consider that generating a random number requires constant time. Algorithm 4.2 has complexity of $O\left(\left|\bigcup_{t=\{etri, etpr_m\}} RS(Z, t)\right|\right)$ because the time for simulating a risk is a constant.

4.1.5 Assumptions for Analysis

In simulating a system, it is inevitable to make some assumptions because we cannot consider all details of the system. For example, we know many factors besides risk mitigation would affect probability and impact of a risk. However, we cannot model all those factors and accurately predict their influences on the risk.

In our study, we make following assumptions.

1. ***Time slicing***

   For a given project *Z*, the time period of its risk management is equally divided into L time intervals with a set of L+1 time points, $TP(Z) = \{0, 1, 2, ..., L\}$. All management activities start at one of these time points and take integral multiple of intervals. Then we can assign *strm* =0, *etrm* =L and a value from *TP(Z)* to other time parameters.

   For example, the risk identification of a project is started at time 1 (*stri*=1) and completed at time 5 (*etri*=5). Then the risk identification period is (1, 5].

   The length of time interval is decided by practitioners based on their project management practice. For example, if practitioners are reviewing the project daily, then the time interval is one day. If practitioners are reviewing a large project weekly, then the time interval is one week.

2. ***Null effect of non-mitigation factors***

   For any $R_i(P_i, I_i) \in RS(Z, t)$, we assume that $op_i(t) = 0$ and $oi_i(t) = 0$. That is we assume that the factors not related to risk mitigation, such as change of external and internal risk management environments, will not change the probability and impact of a risk.

   Thus, we have

$$P_i = pf_i(t) = p_i^+ + mp_i(t) \text{ when } t \le tlo_i \text{ and} \tag{4.13}$$

$$I_i = ig_i(t) = i_i^+ + mi_i(t) \text{ when } t \le tlo_i \tag{4.14}$$

Consequently, for any $R_j(P_j, I_j) \in RS(Z, t)\text{-}MRS(Z, t)$,

$$P_j = pf_j(t) = p_j^+ \text{ when } t \le tlo_j \text{ and} \tag{4.15}$$

$$I_j = ig_j(t) = i_j^+ \text{ when } t \le tlo_j \tag{4.16}$$

since $mp_i(t)$ and $mi_i(t)$ equal to 0 in this case. (4.15) and (4.16) are probability and impact functions for "Special Case" shown in Figure 3-3.

This assumption means that the probability and impact of a risk will not be affected by other factors except by risk mitigation. As we mentioned earlier, the probability and impact of a risk would change due to risk mitigation and other non-mitigation factors. In general, the risk mitigation is the most important factor among many factors. As our model will not consider the non-mitigation factors, we assume their influences on P_i and I_i are null.

3. *Non-negative effect of mitigation*

For any $R_i(P_i, I_i) \in MRS(Z, t)$, we assume that

$$mp_i(t) \le 0 \text{ when } tms_i < t < tmc_i \text{ and} \tag{4.17}$$

$$mi_i(t) \le 0 \text{ when } tms_i < t < tmc_i \tag{4.18}$$

This assumption means that risk mitigation will not increase the probability and impact of a risk. It is reasonable since risk mitigation should not increase the risk and is often effective in reducing the risk. Based on the "*Null effect of non-mitigation factors*" assumption and "*Non-negative effect of mitigation*" assumption, we can deduce $p_i^- \le p_i^+$ and $i_i^- \le i_i^+$.

4. *Linear effect of mitigation*

For any $R_i(P_i, I_i) \in MRS(Z, t)$, we assume that

$$mp_i(t) = \frac{p_i^+ - p_i^-}{tms_i - tmc_i}\left(t - tms_i\right) \quad tms_i < t < tmc_i \text{ and} \tag{4.19}$$

$$mi_i(t) = \frac{i_i^+ - i_i^-}{tms_i - tmc_i}\left(t - tms_i\right) \quad tms_i < t < tmc_i \tag{4.20}$$

This assumption means that the probability and impact of a risk will linearly decrease during its mitigation period from $\boldsymbol{p_i}^+$ to $\boldsymbol{p_i}^-$ and from $\boldsymbol{i_i}^+$ to $\boldsymbol{i_i}^-$ respectively. Different risks may follow different functions from $\boldsymbol{p_i}^+$/ $\boldsymbol{i_i}^+$ to $\boldsymbol{p_i}^-$/ $\boldsymbol{i_i}^-$. Among all the effect models, our proposed one is the most straightforward and the simplest one. The assumption is reasonable since we expect the effect of mitigation on P_i and I_i increase with time, and each time unit spent on mitigation leads to the same amount of reduction. For the initial investigation, we will use this linear effect model. In future work, we will try different effect models.

Based on assumption 2, 3 and 4, and due consideration that mitigation only takes effect during the mitigation period, we have

$$P_i = pf_i(t) = \begin{cases} p_i^+ & t \le tms_i \\ p_i^+ + \dfrac{p_i^+ - p_i^-}{tms_i - tmc_i}\left(t - tms_i\right) & tms_i < t < tmc_i \\ p_i^- & tmc_i \le t \le tlo_i \end{cases} \tag{4.21}$$

$$I_i = ig_i(t) = \begin{cases} i_i^+ & t \le tms_i \\ i_i^+ + \dfrac{i_i^+ - i_i^-}{tms_i - tmc_i}\left(t - tms_i\right) & tms_i < t < tmc_i \\ i_i^- & tmc_i \le t \le tlo_i \end{cases} \tag{4.22}$$

(4.21) and (4.22) are probability and impact functions for Case 1-8 shown in Figure 3-3.

4.1.6 Proposed SMRMP Model

We summarize all identified parameters, outputs, parameter relationships, assumptions, and the simulation algorithms of SMRMP in Figure 4-2.

Model users should go through the whole process of risk management to determine the values of model parameters based on the parameter relationships and model assumptions. For each phase of risk management process, model users should assign values to the corresponding parameters, including project-level parameters and risk-level parameters. The process may iterate a number of times according to the number of periodical reviews (*npr*). After inputting all model parameters, users can run the simulation on each risk, and get outputs which can help to predict the expected impact on projects, and then make informed risk management decision, such as selecting a strategy for scheduling risk mitigation from different strategies (see Chapter 5).

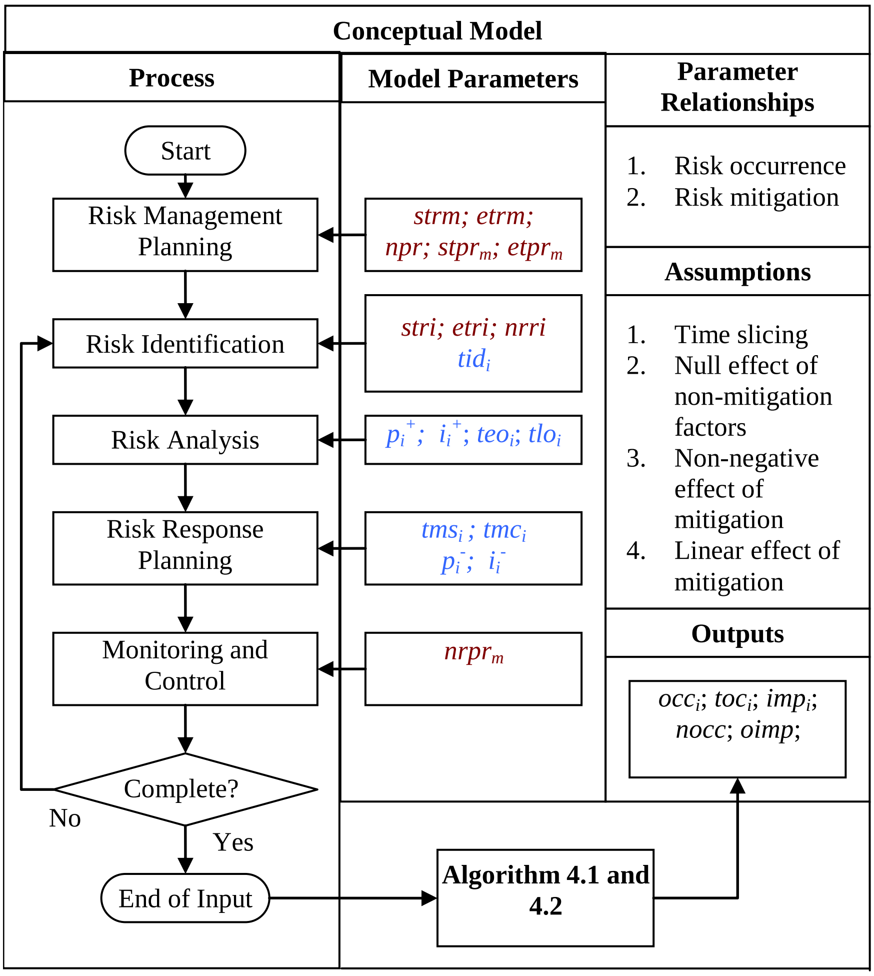


Figure 4-2 Conceptual Model for Risk Management Process (SMRMP)

Note that the simulation algorithms are independent of model assumptions because their deduction does not rely on these assumptions. The model assumptions only affect the probability and impact function during the occurrence period. As mentioned earlier, the simulation algorithms can work with different probability and impact functions. Thus, we can use the same simulation algorithms for other sets of assumptions.

4.2 Model Verification and Validation

As mentioned in section 2.5.3, the most common approach for validation is the development team makes the decision whether the developed model is valid [61]. In this study, the author, not a third party, apply different validation techniques to validate the proposed model.

The verification and validation of a simulation model includes *Conceptual model validation*, *Computerized model verification* and *Operational validation*. Next, we evaluate the proposed SMRMP model from these three aspects.

4.2.1 Conceptual Model Validation

For conceptual model validity, we applied *Face Validity* technique to validate the conceptual model. This technique involves asking experts whether the model is reasonable. It is a primary technique used for conceptual model validation [61]. We have asked two experts in software risk management for their professional advices and commented on the proposed conceptual model in the process of model building. One expert has over 20 years of research experiences in software engineering and over 10 years experiences in risk management. The other expert has over 15 years of project management experiences and almost 10 years experiences in risk management. After several iterations of conceptual model building, they agreed that the proposed model was reasonable.

4.2.2 Computerized Model Verification

The model is implemented in Java. It is abstracted to 5 classes as shown in Figure 4-3. Project risk management includes risk identification at the beginning of the project and several periodical reviews. Periodical review also associates with identifying new risks. Thus the “Project” class consists of many “Identification”, and each “Identification” class consists of many “Risk”. Both “RiskWithMitigation” and “RiskWithoutMitigation” are subclasses of “Risk” and represent risks in risk set *MRS(**Z**,t)* and *RS(**Z**,t)- MRS(**Z**,t)* respectively.

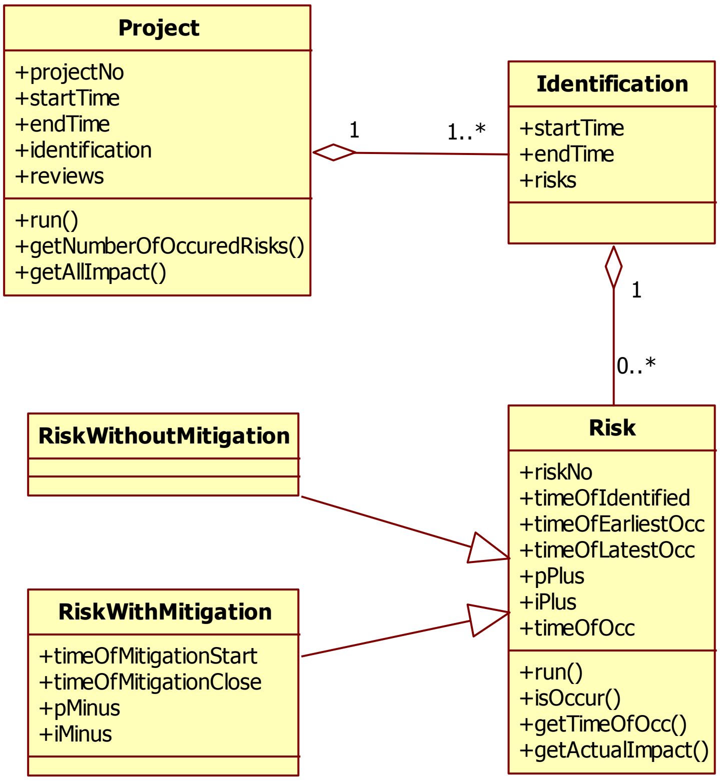


Figure 4-3 Class Diagram of Implementation of SMRMP

As shown in Figure 4-3, all input parameters of SMRMP are abstracted as attributes of these five classes. The project-level parameters are abstracted as attributes of “Project” and “Identification”. The risk-level parameters are abstracted as attributes of “Risk”, “RiskWithMitigation” and “RiskWithoutMitigation”. The project-level outputs and risk-level outputs of SMRMP can be accessed through methods in

"Project" and "Risk" respectively. Algorithm 4.1 and 4.2 are implemented as run() methods in "Risk" and "Project" respectively.

For the computerized model verification, the simulation functions were tested to see whether they were correct. We applied both static and dynamic testing.

In static testing, we reviewed all source code to ensure it was correct. Then, in dynamic testing, we focused on testing at the risk-level since all project-level outputs can be simply computed with summation outputs of all risks. Further, since the purpose of the test was to show the computer implementation of the conceptual model was correct, we focused on those test cases with valid inputs. For example, using $\boldsymbol{p_i}^+ \in (0, 1)$ according to Table 4-1. Then we considered only one partition for $\boldsymbol{p_i}^+$, that is (0, 1), and did not consider other partitions such as $\boldsymbol{p_i}^+ \leq 0$ and $\boldsymbol{p_i}^+ \geq 1$. Since combining parameters teo_i, tlo_i, tms_i and tmc_i would lead to 9 possible cases for each risk (see Figure 3-3), there were 9 equivalence classes if we considered these 4 parameters together. For the rest of risk-level parameters, each one has only one equivalence class. Finally we used 9 test cases for equivalence class testing. Table 4-3 lists all the test cases.

Table 4-3 Test Cases for Testing Computerized Model

TC	RC	Parameters									Expected Result	
		tid_i	teo_i	tlo_i	tms_i	tmc_i	p_i^+	i_i^+	p_i^-	i_i^-	EOR	EAI
1	1	5	50	90	10	20	0.5	0.5	0.2	0.1	0.2	0.02
2	2	5	50	90	10	50	0.4	0.4	0.3	0.3	0.3	0.09
3	3	5	50	90	40	60	0.6	0.4	0.4	0.2	0.4125	0.0883
4	4	5	50	90	40	90	0.8	0.6	0.3	0.1	0.5	0.1633
5	5	5	50	90	50	60	0.4	0.2	0.3	0.2	0.3125	0.0625
6	6	5	50	90	50	90	0.5	0.6	0.5	0.2	0.5	0.2
7	7	5	50	90	60	70	0.3	0.3	0.0	0.2	0.1125	0.0325
8	8	5	50	90	60	90	0.5	0.3	0.2	0.0	0.3875	0.0825
9	Spe	5	50	90	-	-	0.2	0.2	-	-	0.2	0.04

TC: Test Case
RC: Risk Mitigation Cases shown in Figure 3-3
Spe: Special case in Figure 3-3
"-" means infeasible input

As mentioned earlier in section 4.1.4, if we use M' to denote the number of times that a risk occurred in N trials (N is sufficiently large), then EOR' and EAI' are expected to be distributed according to the normal distribution with mean EOR and EAI respectively. For our simulation, we take N=100000. Then we test whether EOR'and EAI' are distributed according to the normal distribution with the mean equal to EOR and EAI respectively. We run each test case for 10 iterations, and perform N=100000 trials in each iteration. The result is shown in Table 4-4.

Next we use T-test to test whether the sample means (EOR' and EAI') are different from the expected means (EOR and EAI). For each test case k ($1 \le k \le 9$), we have following hypotheses

$$H_{k0} : EOR' = EOR \quad \text{and} \qquad (4.23)$$
$$H_{k1} : EOR' \neq EOR$$

$$H'_{k0} : EAI' = EAI \qquad (4.24)$$
$$H'_{k1} : EAI' \neq EAI$$

The results of applying T-test are also shown in Table 4-4. From the results we can find that all null hypotheses are accepted. That is, we statistically accept EOR'=EOR and EAI'=EAI for all test cases. Since all test cases passed, we conclude that the implementation of conceptual model is correct.

Table 4-4 Results of Running Test Cases and T-test

TC	Expected result		Iterations=10 (N=100000) *										T-test				
			1	2	3	4	5	6	7	8	9	10	Mean*	t	Significance	95% Confidence Interval of the Difference Lower ($\times 10^{-4}$)	Upper ($\times 10^{-4}$)
1	EOR	0.2	0.2007	0.1991	0.1994	0.2006	0.1998	0.1983	0.1991	0.2004	0.2003	0.1991	0.1997	-1.261	0.239	-8.94	2.54
	EAI	0.02	0.0201	0.0199	0.0199	0.0201	0.0200	0.0198	0.0199	0.0200	0.0200	0.0199	0.0200	-1.309	0.223	-1.09	0.29
2	EOR	0.3	0.3005	0.2995	0.3013	0.2992	0.3008	0.3004	0.2981	0.2996	0.3006	0.3032	0.3003	0.737	0.480	-6.62	13.02
	EAI	0.09	0.0901	0.0898	0.0904	0.0898	0.0902	0.0901	0.0894	0.0899	0.0902	0.0910	0.0901	0.669	0.520	-2.14	3.94
3	EOR	0.4125	0.4120	0.4135	0.4158	0.4135	0.4146	0.4142	0.4112	0.4104	0.4127	0.4130	0.4131	1.158	0.277	-5.6	17.4
	EAI	0.0883	0.0882	0.0885	0.0891	0.0885	0.0887	0.0888	0.0881	0.0879	0.0884	0.0884	0.8846	1.445	0.182	-0.9	4.11
4	EOR	0.5	0.5018	0.4997	0.5023	0.4979	0.4993	0.5016	0.4990	0.5013	0.5008	0.4982	0.5002	0.382	0.711	-9.36	13.16
	EAI	0.1633	0.1640	0.1631	0.1641	0.1626	0.1632	0.1639	0.1632	0.1643	0.1635	0.1627	0.1635	0.851	0.417	-2.7	5.9
5	EOR	0.3125	0.3124	0.3138	0.3113	0.3112	0.3100	0.3102	0.3148	0.3109	0.3144	0.3125	0.3122	-0.644	0.536	-15.8	8.8
	EAI	0.0625	0.0625	0.0628	0.0623	0.0622	0.0620	0.0620	0.0630	0.0622	0.0629	0.0625	0.0624	-0.523	0.614	-3.19	1.99
6	EOR	0.5	0.5024	0.4990	0.4986	0.4998	0.4998	0.5007	0.5009	0.5004	0.5006	0.4999	0.5002	0.624	0.548	-5.51	9.71
	EAI	0.2	0.2006	0.1997	0.1997	0.1997	0.2002	0.2005	0.1999	0.2002	0.2008	0.1997	0.2001	0.750	0.472	-2.02	4.02
7	EOR	0.1125	0.1113	0.1121	0.1119	0.1133	0.1120	0.1130	0.1126	0.1127	0.1129	0.1113	0.1123	-0.860	0.412	-6.9	3.1
	EAI	0.0325	0.0322	0.0324	0.0323	0.0327	0.0323	0.0327	0.0325	0.0326	0.0326	0.0321	0.0324	-0.896	0.394	-2.12	0.92
8	EOR	0.3875	0.3872	0.3887	0.3867	0.3895	0.3884	0.3872	0.3896	0.3878	0.3853	0.3892	0.3880	1.053	0.320	-5.28	14.48
	EAI	0.0825	0.0823	0.0827	0.0825	0.0829	0.0827	0.0823	0.0833	0.0826	0.0822	0.0829	0.0826	1.313	0.222	-1.01	3.81
9	EOR	0.2	0.2018	0.2002	0.1985	0.1988	0.2011	0.1980	0.1998	0.2015	0.1991	0.2009	0.2000	-0.071	0.945	-9.86	9.26
	EAI	0.04	0.0404	0.0400	0.0397	0.0398	0.0402	0.0396	0.0399	0.0403	0.0398	0.0402	0.0400	-0.116	0.910	-2.05	1.85

* error<0.0001

4.2.3 Operational Validation

As shown in Table 2-5 of section 2.5.3, many different approaches can be used to evaluate the operational validity of a simulation model. However, we can only use the "Explore Model Behavior" approach to evaluate the proposed model because

1. Since risk management involves uncertainties, the only meaningful way to compare results from SMRMP and results from a real project is that we compare them statistically. Although we can observe the results from a real project, we cannot repeat it many times. Thus no statistical comparison can be done.
2. There is no other simulation model that considers the time elements of risk. So, we cannot compare results from SMRMP against those from other simulation models.

The only option to evaluate the operational validity of SMRMP is "Explore Model Behavior" with due consideration of available approaches shown in Table 2-5. According to [61], we applied "parameter variability-sensitivity analysis" technique to examine the output behavior of SMRMP. This technique consists of changing the input values of a model to determine their effect upon the output.

For a given project, once all risks have been identified, the total number of risks and tid_i, teo_i, tlo_i, p_i^+, and i_i^+ of each risk can be determined. Three aspects under the control of practitioners are the number of risks to be mitigated ("extent of mitigation"), expected values of p_i^- and i_i^- at the end of mitigation for each risk R_i ("mitigation effect"), and tms_i and tmc_i of R_i ("mitigation schedule"). According to these aspects, we can design different scenarios corresponding to different inputs values. These different scenarios may lead to different outputs. We can then predict the outputs of different scenarios in a comparative way according to their inputs. At last, we check the outputs of simulation against our expectation to determine whether the model is working as expected. This approach can be used to evaluate the operational validity of the model.

For the first aspect of "extent of mitigation", we consider 3 levels. They are "full mitigation" (mitigating all risks), "random mitigation" (each risk has 0.5 probability to be mitigated), and "zero mitigation" (no risk will be mitigated). For risk mitigation, "full mitigation" is the best result and "zero mitigation" is the worst result.

We also consider 3 levels for the second aspect of "mitigation effect". They are "full reduction" ($p_i^- = 0$ and $i_i^- = 0$), "random reduction" ($p_i^- = rand \times p_i^+$ and $i_i^- = rand \times i_i^+$, where *rand* is a random number in [0, 1]) and "zero reduction" ($p_i^- = p_i^+$ and $i_i^- = i_i^+$). For risk mitigation, "full reduction" is the best effect and "zero reduction" is the worst effect.

We consider two levels for the last aspect of "mitigation schedule". They are "well schedule" ($tmc_i \leq teo_i$, complete the mitigation before a risk would occur) and "random schedule" (tms_i and tmc_i are randomly selected in [tid_i, tlo_i]). For risk mitigation, "well schedule" is better than "random schedule".

Note that the "zero mitigation" cannot be combined with any levels of "mitigation effect" and "mitigation schedule". However, it can be treated as an independent scenario. Adding this scenario to the other 12 combinations ($2 \times 3 \times 2$), we get a total of 13 different scenarios as shown in Table 4-5.

Table 4-5 Scenarios for Operational Validation

Scenario	**extent of mitigation**	**mitigation effect**	**mitigation schedule**
1	zero mitigation	-	-
2	random mitigation	zero reduction	random schedule
3	random mitigation	zero reduction	well schedule
4	full mitigation	zero reduction	random schedule
5	full mitigation	zero reduction	well schedule
6	random mitigation	random reduction	random schedule
7	random mitigation	random reduction	well schedule
8	full mitigation	random reduction	random schedule

9	full mitigation	random reduction	well schedule
10	random mitigation	full reduction	random schedule
11	random mitigation	full reduction	well schedule
12	full mitigation	full reduction	random schedule
13	full mitigation	full reduction	well schedule

"-" means infeasible combination

Let SCE_i ($L1_i$, $L2_i$, $L3_i$) ($1 \leq i \leq 13$) denotes the i^{th} scenario, where $L1_i$, $L2_i$, $L3_i$ are its levels in three aspects respectively. We consider SCE_i better than SCE_j if SCE_i has fewer occurred risks and lower overall impact on the project than SCE_j.

First of all, we can predict that SCE_1, SCE_2, SCE_3, SCE_4 and SCE_5 have similar expected outputs since the risk mitigation does not generate any effects (SCE_2, SCE_3, SCE_4 and SCE_5 are the same as doing nothing to mitigate any risks (SCE_1)). We group them together and treat them as one scenario when comparing the outputs from different scenarios. SCE_1, SCE_2, SCE_3, SCE_4 and SCE_5 are all worse than the other 8 scenarios since they do not reduce any risk of the project.

Next we do pairwise comparison for the other 8 scenarios based on the criterion that SCE_i is better than SCE_j only when $L1_i \geq L1_j$, $L2_i \geq L2_j$, and $L3_i \geq L3_j$, where the notation "≥" means that a scenario has a better than or the same level as the other scenario in an aspect. We cannot predict a scenario is better than another even if it has better levels in any two aspects but a worse one in the remaining aspect because we do not know the exact contribution of each aspect to the outputs of our model. Consequently, we can predict a scenario is better than another only if it has better or same levels in all three aspects.

Figure 4-4 shows an upper triangle matrix which enumerates all results of pairwise comparisons of 13 scenarios, where "-" means we cannot predict the result of that pairwise comparison. The number in the matrix gives the better scenario when comparing two different scenarios. For example, the number at the 3rd row and 5th column of the matrix is 9, representing that scenario 9 is better than scenario 7.

	1-5	6	7	8	9	10	11	12	13
1-5		6	7	8	9	10	11	12	13
6			7	8	9	10	11	12	13
7				—	9	—	11	—	13
8					9	—	—	12	13
9						—	—	—	13
10							11	12	13
11								—	13
12									13
13									

Figure 4-4 Pairwise Comparison of Different Scenarios

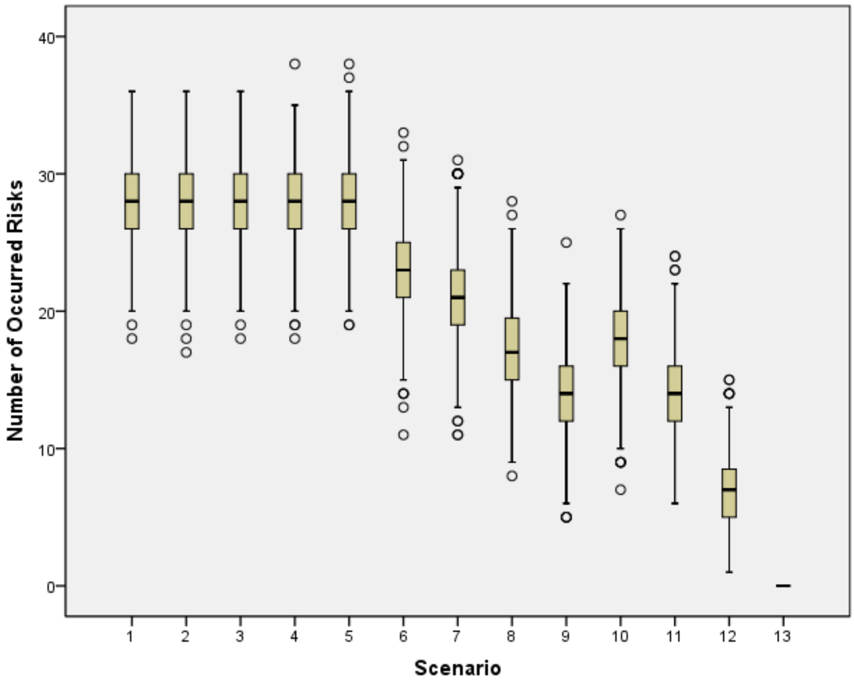
We first randomly generate a project with 50 risks to test whether the simulation result supports the relationship shown in Figure 4-4. Table 4-6 shows the values of test input. These inputs represent a project with time length of 100. Risk identification is done in interval (1, 5) and identifies 45 risks. Four periodical reviews are performed in (15, 20), (35, 40), (55, 60) and (75, 80) respectively, and identifies 2, 1, 1 and 1 new risks accordingly. Suppose all risks are identified at the end of the risk identification and the periodical reviews. The teo_i, tlo_i, p_i^+, and i_i^+ of each risk are r.v (random variate) uniformly distributed in corresponding intervals (see Table 4-6). Other parameters not listed in the Table 4-6 are determined based on different scenarios accordingly.

Table 4-6 Inputs for Operational Validation Test

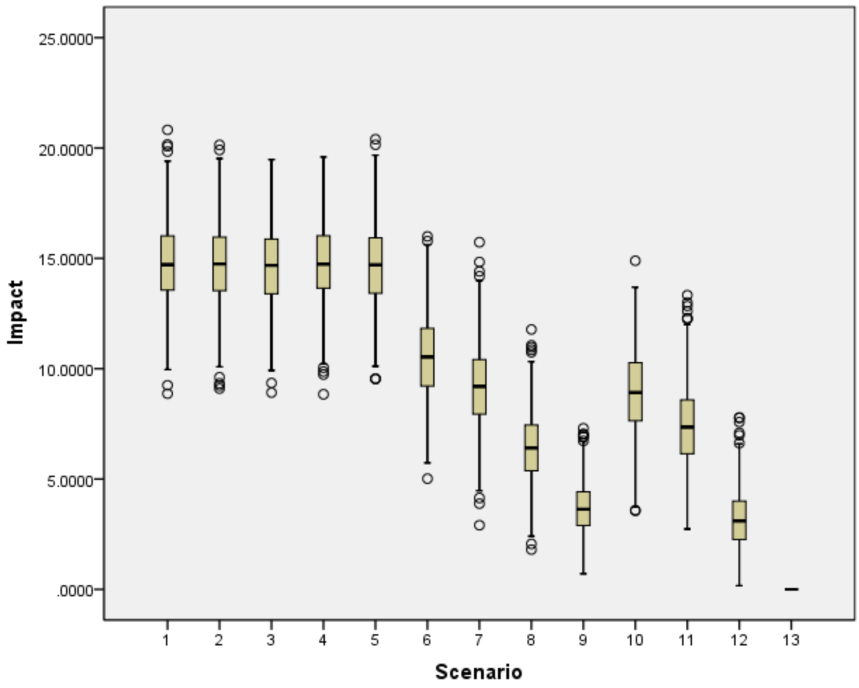
P-level input	*Strm*	*etrm*	*stri*	*etri*	*nrri*	*npr*
Value	0	100	1	5	45	4
P-level input	$stpr_1$	$etpr_1$	$nrpr_1$	$stpr_2$	$etpr_2$	$nrpr_2$
Value	15	20	2	35	40	1
P-level input	$stpr_3$	$etpr_3$	$nrpr_3$	$stpr_4$	$etpr_4$	$nrpr_4$
Value	55	60	1	75	80	1
R-level input	tid_i	teo_i	tlo_i	p_i^+	i_i^+	
Value	∈ (5, 20, 40, 60, 80)	r.v ∈ (tid_i, tlo_i)	r.v ∈ (tid_i, *etrm*)	r.v ∈ (0, 1)	r.v ∈ (0, 1)	

We run the simulation 1000 times for each scenario. Figure 4-5 shows the outputs of all simulations and Table 4-7 shows the average outputs of 1000 simulations. In Figure 4-5, each box plot has five main values: Low (minimum observation), Q1 (lower quartile), Median, Q3 (upper quartile) and High (maximum observation). The circle represents outliners of the data set. For example, the box plot for scenario 1 in Figure 4-5-a shows that Low is 20 (at least 20 risks occurred), Q1 is 26, Median is 28, Q3 is 30 and High is 36 (at most 36 risks occurred).

The results shown in Figure 4-5 and Table 4-7 comply with the upper triangle matrix shown in Figure 4-4. First of all, SCE_1, SCE_2, SCE_3, SCE_4 and SCE_5 have similar outputs both in the average *nocc* (number of all occurred risks) and the average *oimp* (overall impact). And all of them are worse than Scenario 6-13. For the other scenarios, we find that (1) SCE_6 is worse than Scenario 7-13; (2) SCE_7 is worse than SCE_9, SCE_{11} and SCE_{13}; (3) SCE_8 is worse than SCE_9, SCE_{12} and SCE_{13}; (4) SCE_9 is worse than SCE_{13}; (5) SCE_{10} is worse than SCE_{11}, SCE_{12} and SCE_{13}; (6) SCE_{11} is worse than SCE_{13}; and (7) SCE_{12} is worse than SCE_{13}.



a. Number of risks occurred in different scenarios



b. Impact of different scenarios

Figure 4-5 Result of Simulating Different Scenarios

Table 4-7 Average Outputs of 1000 Simulations for Different Scenarios

Scenario	**1**	**2**	**3**	**4**	**5**
average ***nocc***	27.88	27.971	27.802	27.927	27.877
average ***oimp***	14.7181	14.7179	14.6250	14.7658	14.6884
Scenario	**6**	**7**	**8**	**9**	**10**
average ***nocc***	22.692	20.951	17.417	13.887	17.53
average ***oimp***	10.5457	9.1840	6.4138	3.6961	8.9498
Scenario	**11**	**12**	**13**		
average ***nocc***	14.021	7.063	0.0		
average ***oimp***	7.4145	3.1471	0.0000		

In summary, the results shown in Figure 4-5 and Table 4-7 indicate that the model behavior is correct.

Following the same process, we also run another 9 randomly generated projects according to Table 4-6 and obtain the testing results as shown in Table 4-8.

Table 4-8 Testing Results of another 9 Projects

Project		SCE_1	SCE_2	SCE_3	SCE_4	SCE_5	SCE_6	SCE_7	SCE_8	SCE_9	SCE_{10}	SCE_{11}	SCE_{12}	SCE_{13}
1	average ***nocc***	26.061	25.955	25.949	26.085	25.946	21.182	19.49	16.244	12.876	16.161	13.203	6.322	0.0
	average ***oimp***	11.9333	11.8106	11.7843	11.9336	11.8253	8.5751	7.3320	5.1943	2.9159	7.2220	5.9930	2.5714	0.0000
2	average ***nocc***	28.308	28.34	28.185	28.298	28.405	22.624	21.412	17.28	14.245	17.406	14.171	6.307	0.0
	average ***oimp***	14.2833	14.3522	14.2405	14.2920	14.3416	9.9834	9.0132	5.8322	3.5807	8.4949	7.1784	2.6236	0.0000
3	average ***nocc***	26.172	26.111	26.029	26.129	26.186	20.853	19.59	15.471	13.293	15.397	13.069	4.846	0.0
	average ***oimp***	15.0337	15.0759	14.9569	14.9850	15.0302	10.4276	9.3923	5.7587	3.8561	8.5078	7.5424	2.1431	0.0000
4	average ***nocc***	26.046	25.951	25.864	26.058	25.887	21.091	19.539	16.181	12.964	15.972	13.06	5.889	0.0
	average ***oimp***	14.7424	14.6476	14.6198	14.7332	14.6359	10.4426	9.2066	6.2256	3.6836	8.7359	7.3902	2.7817	0.0000
5	average ***nocc***	27.188	27.583	27.412	27.473	27.304	22.274	20.466	16.398	13.693	16.678	13.552	5.95	0.0
	average ***oimp***	13.5836	13.7792	13.7170	13.7004	13.6773	9.6498	8.5204	5.3941	3.4400	8.0508	6.7782	2.2845	0.0000
6	average ***nocc***	25.505	25.488	25.41	25.475	25.58	20.0	19.0	14.728	12.79	14.77	12.715	4.173	0.0
	average ***oimp***	13.0792	13.0441	13.0188	13.0885	13.1226	8.7954	8.0707	4.6899	3.2960	7.2516	6.5273	1.5601	0.0000
7	average ***nocc***	24.626	24.677	24.648	24.829	24.619	19.835	18.479	14.964	12.374	14.83	12.38	5.043	0.0
	average ***oimp***	13.4370	13.4456	13.3971	13.4868	13.4384	9.3281	8.3675	5.2637	3.3673	7.7060	6.7088	2.0529	0.0000
8	average ***nocc***	26.057	25.892	25.834	25.809	25.886	20.652	19.494	15.667	13.042	15.658	13.252	5.555	0.0
	average ***oimp***	14.2559	14.1760	14.1915	14.1488	14.1893	9.8391	8.9260	5.6270	3.5414	8.2601	7.2758	2.3128	0.0000
9	average ***nocc***	25.586	25.537	25.626	25.675	25.712	20.672	19.269	15.572	12.69	15.655	12.632	5.794	0.0
	average ***oimp***	11.9558	11.9047	11.9555	11.9841	11.9648	8.3729	7.4893	4.8024	2.9591	7.0055	5.8334	2.0734	0.0000

The results shown in Table 4-8 also support that the model behavior is correct. Thus the model is considered operational valid.

From the results of *Conceptual model validation* (section 4.2.1), *Computerized model verification* (section 4.2.2) and *Operational validation* (section 4.2.3), we conclude that our SMRMP model is valid.

Chapter 5 Risk Management with Time Elements

In traditional risk management practices, practitioners do not explicitly model and use many time elements in managing risks. The ignorance of these time elements may lead to an ineffective risk management. In this chapter, we first study the management of introduced time elements in risk management process. Then we formally analyze the influence of introduced time elements on risk management both at the risk-level and project-level in section 5.2 and 5.3 respectively, and finally propose new practices for more effective risks management with due consideration of time elements. All the analysis is based on SMRMP that has been validated in Chapter 4.

5.1 Managing Time Elements

First of all, all identified time elements should be mapped to the risk management process to facilitate project management. Table 5-1 summarizes the actions that need to be taken for managing different time elements during different processes of risk management lifecycle. These actions include documenting, estimating, monitoring, scheduling and rescheduling. The blank in the table means no action needed to be taken.

Risk Management Planning aims to define how to conduct risk management throughout the project and to establish the risk management context. There are no time elements of risk need to be managed in this process since risks have not been identified yet.

In the process of risk identification, risks are identified and documented. The identification of a risk corresponds to the start of its lifecycle. This time should be documented for each risk.

Table 5-1 Managing Time Elements in Risk Management Process

		Time elements of risk			
		Time of risk identification	Time period of occurrence	Time period of mitigation	Time of risk occurrence
	Notation	T_{id}	$(T_{eo}, T_{lo}]$	$(T_{ms}, T_{mc}]$	T_{oc}
	Parameter as SMRMP	$\boldsymbol{tid_i}$	$(\boldsymbol{teo_i}, \boldsymbol{tlo_i}]$	$(\boldsymbol{tms_i}, \boldsymbol{tmc_i}]$	$\boldsymbol{toc_i}$
Risk management process	Risk management planning				
	Risk identification	Documenting			
	Risk analysis		Estimating and documenting		
	Risk response planning			Scheduling and documenting	
	Risk monitoring and control	Documenting	Monitoring; Estimating and documenting	Monitoring; Rescheduling and documenting	Documenting

Risk analysis aims to understand the identified risks and provide data to assist in managing them. Besides the probability and impact of the risk, the time period of occurrence should be estimated and recorded according to the risk event. For example, the risk “unacceptable user interface” would only occur during the user acceptance test phase. So, T_{eo} and T_{lo} of this risk are the start and the end of the user acceptance test respectively.

In the process of risk response planning, different mitigation options are developed for the treatment of all identified risks. Some minor risks would be accepted without taking any response actions and other risks will be mitigated to reduce or eliminate their impact on the project. Organizations usually schedule the risk mitigation by applying a certain scheduling strategy with due consideration of often limited resources. Then, a time period will be allocated for mitigating each individual risk according to the scheduling strategy. So, the time period of mitigation of each individual risk should be scheduled in the risk response planning phase and be documented for mitigation implementation.

In the process of risk monitoring and control, the time elements are managed as follows.

1. Document the identification time of newly identified risks in periodical reviews.
2. Document the expiration time of risk. The expiration time of a risk is its occurrence time if it occurs, or T_{lo} if it does not occur after T_{lo}.
3. Estimate and document the time period of occurrence of newly identified risks.
4. Monitor changes in T_{eo}, T_{lo}, T_{ms} and T_{mc} of each risk. The changes in these time elements may lead to rescheduling of risk mitigation.
5. Reschedule the time period of mitigation for risks if needed and document the new time period of mitigation.

For the following cases, we may need to reschedule the risk mitigation.

1. New risks are identified in periodical reviews. For example, a serious risk has been identified and need to be treated with high priority. Then we should reschedule the risk mitigation.
2. A risk expires and is removed from *RS(Z, t)*. If a risk with planned mitigating actions occurs before the end of mitigation or before the start of mitigation, then there is no need to mitigate it anymore. Thus we need to reschedule the risk mitigation to make best use of resources.
3. Changes in T_{eo} and T_{lo}, or changes in T_{ms} and T_{mc} of risk. For example, the mitigation of a risk is completed before planned. Then we need to reschedule risk mitigation to make best use of resources. As we will show in section 5.3, the scheduling of risk mitigation should consider the time period of

occurrence. Thus any change in the time period of occurrence may induce rescheduling of risk mitigation.

From Table 5-1, we can find that one important action for managing time elements is scheduling of risk mitigation. As mentioned in section 2.3.4, the generally used risk scheduling strategy, risk value first strategy, does not consider the time elements of risk and their relationships. However, we have shown the necessity of considering time elements when scheduling risk mitigation in Chapter 3. Next, we analyze the influence of time elements on risk management at the risk-level and project-level in section 5.2 and 5.3 respectively.

5.2 Analysis at Risk-Level

In chapter 3, we identify 8 different mitigation cases and a transition graph between these mitigation cases. We also identify 4 status change paths. In this section, we conduct analysis based on assumptions presented in section 4.1.5, and show how to use the transition graph and status change paths to facilitate the risk management.

For convenient sake, all four assumptions are repeated below.

1. Time slicing
2. Null effect of non-mitigation factors
3. Non-negative effect of mitigation
4. Linear effect of mitigation

5.2.1 Analysis Results

For any $R_i(P_i, I_i) \in MRS(Z, t)$, we have following results based on these four assumptions and (4.10) - (4.12).

Theorem 1. For any $R_i(P_i, I_i) \in MRS(Z, t)$, it has the same EOR in both Mitigation Case 1 and 2. Also, it has the same EAI in both Mitigation Case 1 and 2.

Proof: No matter R_i maps to Mitigation Case 1 or Mitigation Case 2, we have

$P_i = pf_i(t) = p_i^-$ when $teo_i \le t \le tlo_i$ and

$I_i = ig_i(t) = i_i^-$ when $teo_i \le t \le tlo_i$

Since $EOR = \dfrac{\int_{teo_i}^{tlo_i} pf_i(t)\,dt}{tlo_i - teo_i}$ from (4.10) and $EAI = \dfrac{\int_{teo_i}^{tlo_i} pf_i(t) \times ig_i(t)\,dt}{tlo_i - teo_i}$ from (4.11), we always have $EOR = p_i^-$ and $EOI = i_i^-$ when R_i maps to Mitigation Case 1 or Mitigation Case 2. ■

This theorem indicates that Mitigation Case 1 and Mitigation Case 2 are equivalent for risk mitigation. A risk R_i that shifts between Mitigation Case 1 and Mitigation Case 2 does not change the expected probability of occurrence and expected impact. It does not matter that we change T_{mc} from T_{eo} to an earlier time and consequently shift R_i from Mitigation Case 2 to Mitigation Case 1. Also, it does not matter that we change T_{mc} from a time earlier than T_{eo} to T_{eo} and consequently shift R_i from Mitigation Case 1 to Mitigation Case 2. In summary, Theorem 1 points out that if we complete the mitigation of a risk R_i no later than T_{eo}, then it does not matter the exact time of completing the risk mitigation.

To facilitate the discussion, we named the transition between Mitigation Case 1 and Mitigation Case 2 as "Null Effect Transition".

As introduced earlier in section 3.2.2, there are four operations that cause a risk switching from one mitigation case to another. Let:

1. OP1 changes T_{ms} of R_i from tms_i to an earlier time $tms_i^{\,e}$, and results in $pf_i(t)$ and $ig_i(t)$ change to $pf_i^1(t)$ and $ig_i^1(t)$ respectively.
2. OP2 changes T_{mc} of R_i from tmc_i to an earlier time $tmc_i^{\,e}$, and results in $pf_i(t)$ and $ig_i(t)$ change to $pf_i^2(t)$ and $ig_i^2(t)$ respectively.
3. OP3 changes T_{ms} of R_i from tms_i to a later time $tms_i^{\,l}$, and results in $pf_i(t)$ and $ig_i(t)$ change to $pf_i^3(t)$ and $ig_i^3(t)$ respectively.

4. OP4 changes T_{mc} of R_i from tmc_i to a later time $tmc_i^{\ l}$, and results in $pf_i(t)$ and $ig_i(t)$ change to $pf_i^4(t)$ and $ig_i^4(t)$ respectively.

Then we have following four lemmas.

Lemma 1. For any $R_i(P_i, I_i) \in MRS(Z, t)$, OP1 decreases $pf_i(t)$ and $ig_i(t)$ of R_i during ($tms_i^{\ e}$, tmc_i) if risk mitigation takes effect.

Proof: Based on four assumptions listed above, we have

$$pf_i(t) = \begin{cases} p_i^+ & t \le tms_i \\ p_i^+ + \dfrac{p_i^+ - p_i^-}{tms_i - tmc_i}\left(t - tms_i\right) & tms_i < t < tmc_i \\ p_i^- & tmc_i \le t \le tlo_i \end{cases}$$ and

$$pf_i^1(t) = \begin{cases} p_i^+ & t \le tms_i^e \\ p_i^+ + \dfrac{p_i^+ - p_i^-}{tms_i^e - tmc_i}\left(t - tms_i^e\right) & tms_i^e < t < tmc_i \\ p_i^- & tmc_i \le t \le tlo_i \end{cases}$$

Since $tms_i^{\ e}$ is earlier than tms_i, then when $tms_i^e < t \le tms_i$

$$pf_i(t) - pf_i^1(t) = p_i^+ - \left(p_i^+ + \frac{p_i^+ - p_i^-}{tms_i^e - tmc_i}\left(t - tms_i^e\right)\right)$$
$$= -\frac{\left(p_i^+ - p_i^-\right)\left(t - tms_i^e\right)}{tms_i^e - tmc_i} > 0$$

because $t - tms_i^e > 0$, $tms_i^e - tmc_i < 0$ when $tms_i^e < t \le tms_i$, and $p_i^+ - p_i^- > 0$ if risk mitigation takes effect,

When $tms_i < t < tmc_i$, we have

$$pf_i(t) - pf_i^1(t) = \left(p_i^+ + \frac{p_i^+ - p_i^-}{tms_i - tmc_i}\left(t - tms_i\right)\right) - \left(p_i^+ + \frac{p_i^+ - p_i^-}{tms_i^e - tmc_i}\left(t - tms_i^e\right)\right)$$
$$= \frac{\left(p_i^+ - p_i^-\right)\left(tms_i - tms_i^e\right)\left(tmc_i - t\right)}{\left(tms_i - tmc_i\right)\left(tms_i^e - tmc_i\right)} > 0$$

because $tms_i - tms_i^e > 0$, $tmc_i - t > 0$, and $\left(tms_i - tmc_i\right)\left(tms_i^e - tmc_i\right) > 0$ when $tms_i^e < t \le tms_i$, and $p_i^+ - p_i^- > 0$ if risk mitigation takes effect.

In summary, we have $pf_i(t) > pf_i^1(t)$ when $tms_i^e < t \le tmc_i$.

Also, based on four assumptions listed above, we have

$$ig_i(t) = \begin{cases} i_i^+ & t \le tms_i \\ i_i^+ + \dfrac{i_i^+ - i_i^-}{tms_i - tmc_i}\left(t - tms_i\right) & tms_i < t < tmc_i \\ i_i^- & tmc_i \le t \le tlo_i \end{cases} \quad \text{and}$$

$$ig_i^1(t) = \begin{cases} i_i^+ & t \le tms_i^e \\ i_i^+ + \dfrac{i_i^+ - i_i^-}{tms_i^e - tmc_i}\left(t - tms_i^e\right) & tms_i^e < t < tmc_i \\ i_i^- & tmc_i \le t \le tlo_i \end{cases}$$

From similar analysis as the case for *pf*$_i$*(t)*, we have $ig_i(t) > ig_i^1(t)$ when $tms_i^e < t \le tmc_i$. ■

Based on similar proof as lemma 1, we can prove lemma 2 to lemma 4.

Lemma 2. For any $R_i(P_i, I_i) \in MRS(Z, t)$, OP2 decreases $pf_i(t)$ and $ig_i(t)$ of R_i during (tms_i , tmc_i) if risk mitigation takes effect.

Lemma 3. For any $R_i(P_i, I_i) \in MRS(Z, t)$, OP3 increases $pf_i(t)$ and $ig_i(t)$ of R_i during (tms_i , tmc_i) if risk mitigation takes effect.

Lemma 4. For any $R_i(P_i, I_i) \in MRS(Z, t)$, OP4 increases $pf_i(t)$ and $ig_i(t)$ of R_i during (tms_i , tmc_i^l) if risk mitigation takes effect.

Actually, lemma 1 to lemma 4 can be easily understood with the illustration of Figure 5-1. For example, $pf_i(t)$ changes to $pf_i^1(t)$ (shown in dash line) if we shift T_{ms} from tms_i to tms_i^e by applying OP1. It is clear that $pf_i^1(t)$ is less than $pf_i(t)$ during (tms_i^e, tmc_i).

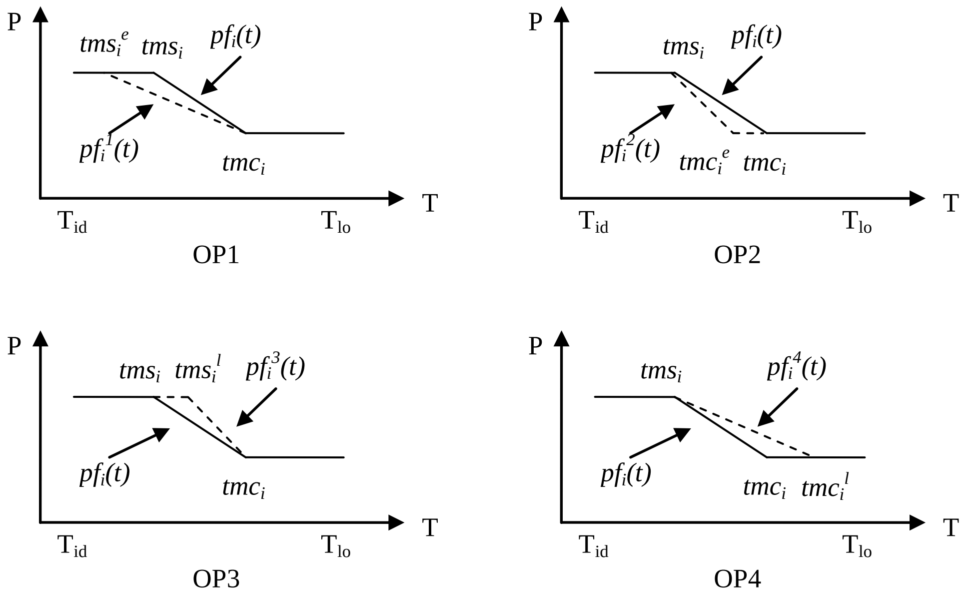


Figure 5-1 Probability Functions after Applying Four Different Operations

According to $EOR = \frac{\int_{teo_i}^{tlo_i} pf_i(t)\,dt}{tlo_i - teo_i}$ from (4.10) and $EAI = \frac{\int_{teo_i}^{tlo_i} pf_i(t) \times ig_i(t)\,dt}{tlo_i - teo_i}$ from (4.11), any decrease of $pf_i(t)$ and $ig_i(t)$ during the time period of occurrence will reduce EOR and EAI, and any increase of $pf_i(t)$ and $ig_i(t)$ during the time period of occurrence will enlarge EOR and EAI. So, we can consider OP1 and OP2 as positive operations since they reduce $pf_i(t)$ and $ig_i(t)$ in a certain time period, and OP3 and OP4 as negative operations since they increase $pf_i(t)$ and $ig_i(t)$ in a certain time period.

From the above results, the Risk Transition Graph of Figure 3-4 can be split into two sub-graphs such that one graph includes only OP1 and OP2 (positive transition sub-graph as shown in Figure 5-2), and the other includes only OP3 and OP4 (negative transition sub-graph as shown in Figure 5-3).

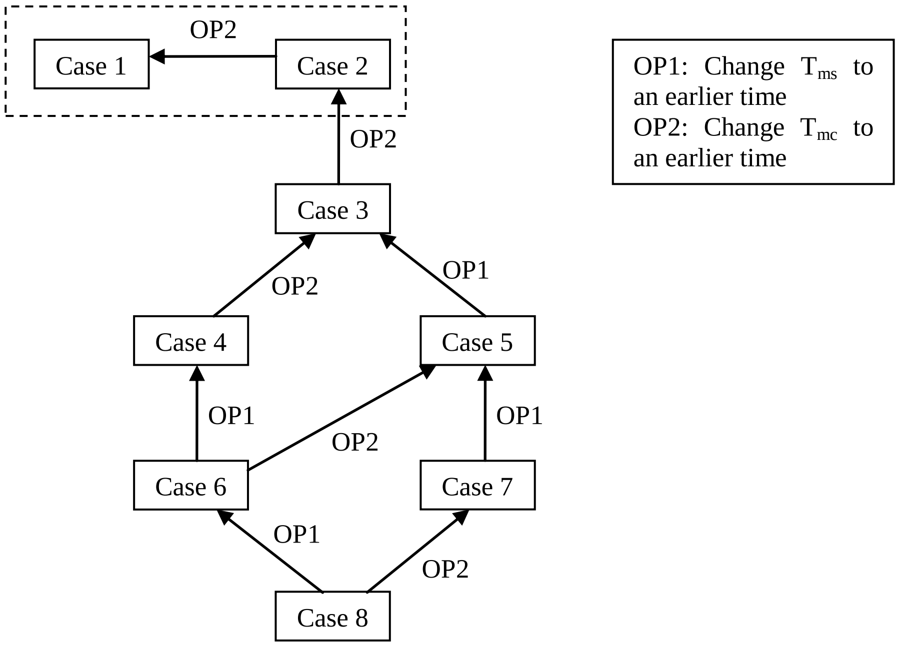


Figure 5-2 Positive Transition Sub-graph

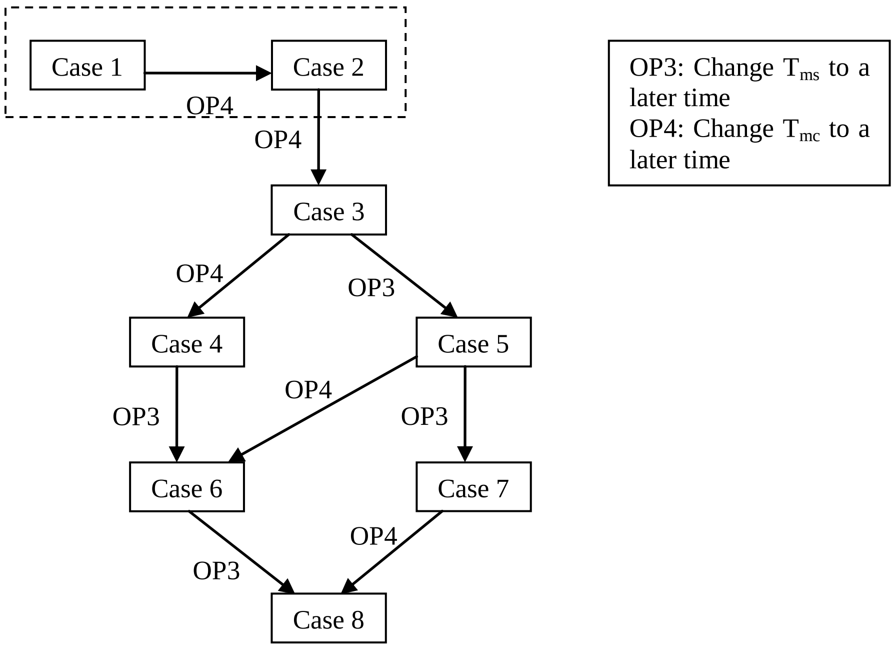


Figure 5-3 Negative Transition Sub-graph

Let the successor mitigation cases of a mitigation case be those mitigation cases reachable from it in the transition sub-graph. For example, the successor mitigation cases of Mitigation Case 6 of Figure 5-2 are Mitigation Case 5, 4, 3, 2 and 1.

Theorem 2. For $R_i(P_i, I_i) \in MRS(Z, t)$, any transition between a mitigation case and its successor mitigation cases in the Positive Transition Sub-graph, except for the Null Effect Transition, decrease EOR and EAI of R_i.

Proof: All transitions between a mitigation case and its successor mitigation cases in the Positive Transition Sub-graph, except for the Null Effect Transition (shown as dash rectangle in Figure 5-2), reduce $pf_i(t)$ and $ig_i(t)$ of R_i during the time period of occurrence. Hence, these transitions decrease EOR and EAI of R_i. ■

Theorem 3. For $R_i(P_i, I_i) \in MRS(Z, t)$, any transition between a mitigation case and its successor mitigation cases in the Negative Transition Sub-graph, except for the Null Effect Transition, increase EOR and EAI of R_i.

Proof: All transitions between a mitigation case and its successor mitigation cases in the Negative Transition Sub-graph, except for the Null Effect Transition (shown as dash rectangle in Figure 5-3), increase $pf_i(t)$ and $ig_i(t)$ of R_i during the time period of occurrence. Hence, these transitions increase EOR and EAI of R_i. ■

To facilitate the discussion, we name all transitions that decrease EOR and EAI of a risk as Positive Effect Transition, and all transitions that increase EOR and EAI of a risk as Negative Effect Transition.

Theorem 2 and 3 indicate that

1. Except for transitions between Mitigation Case 1 and Mitigation Case 2, all other transitions in the Positive Transition Sub-graph decrease the expected

probability and impact of a risk and all transitions in the Negative Transition Sub-graph increase the expected probability and impact of a risk.

2. For a risk R_i, except for Mitigation Case 1 and Mitigation Case 2, every mitigation case has a higher EOR and EAI than its successor mitigation cases in Positive Transition Sub-graph, and a lower EOR and EAI than its successor mitigation cases in Negative Transition Sub-graph.

Table 5-2 summarizes all Null (N) effect transitions, Positive Effect (PE) Transitions and Negative Effect (NE) Transitions, with " − " represents a transition that we cannot predict its effect. For example, the transition from Mitigation Case 6 to Mitigation Case 7 can be the result of applying OP2 and OP3, where OP2 produces a positive effect transition whereas OP3 gives a negative effect transition. Hence, we cannot specify the exact type of the transition from Mitigation Case 6 to Mitigation Case 7.

Table 5-2 Summary of Different Transitions

		Ending Mitigation Case							
		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8
Starting Mitigation Case	Case 1		N	NE	NE	NE	NE	NE	NE
	Case 2	N		NE	NE	NE	NE	NE	NE
	Case 3	PE	PE		NE	NE	NE	NE	NE
	Case 4	PE	PE	PE		-	NE	-	NE
	Case 5	PE	PE	PE	-		NE	NE	NE
	Case 6	PE	PE	PE	PE	PE		-	NE
	Case 7	PE	PE	PE	-	PE	-		NE
	Case 8	PE	PE	PE	PE	PE	PE	PE	

Consequently, we have following relationships.

$$\begin{aligned} &Case\,1 = Case\,2 > Case\,3 > Case\,4 > Case\,6 > Case\,8 \\ &Case\,1 = Case\,2 > Case\,3 > Case\,5 > Case\,6 > Case\,8 \qquad (5.1) \\ &Case\,1 = Case\,2 > Case\,3 > Case\,5 > Case\,7 > Case\,8 \end{aligned}$$

Where “=” means two mitigation cases have the same EOR and EAI, and have the same preference. Notation “>” means the mitigation case on the left has a lower EOR and EAI than those of the mitigation case on the right, and is more preferred.

According to Table 3-2, a risk that maps to different mitigation cases may have different status change paths during its lifecycle (see section 3.3). There are four different change paths for a risk $R_i \in MRS(Z, t)$. Next we analyze the performance of different paths in terms of impact on project.

The impact of a risk following the Normal Containment path (Identified → Mitigating → Mitigated → Containment) is zero since the risk does not occur and has no impact on the project. Thus

$$Impact(Normal\ Containment) = 0 \quad (5.2)$$

The impact of a risk following the Mitigated Problem path (Identified → Mitigating → Mitigated → Problem) is the reduced impact (i_i^-) of the risk after its mitigation. Thus

$$Impact(Mitigated\ Problem) = i_i^- \quad (5.3)$$

The impact of a risk following the Mitigating Problem path (Identified → Mitigating → Problem) is $i_i^* = ig_i(toc_i)$, where toc_i is the occurrence time of R_i and $tms_i < toc_i < tmc_i$. We have $i_i^- < i_i^* < i_i^+$ according to our assumptions, where i_i^+ is the impact of R_i when it is first identified. Thus

$$Impact(Mitigating\ Problem) = i_i^* \text{ and } i_i^- < i_i^* < i_i^+ \quad (5.4)$$

The impact of a risk following the Unmitigated Problem path (Identified → Problem) is the impact of R_i when it is first identified. Thus

$$Impact(Unmitigated\ Problem) = i_i^+ \quad (5.5)$$

That is, there is no change in the impact for this case.

Comparing the impacts of different paths, we can easily find that Normal Containment has better performance than Mitigated Problem, Mitigated Problem is better than Mitigating Problem, and Mitigating Problem is better than Unmitigated Problem.

5.2.2 Recommendations on risk mitigation

Based on above results, we give following recommendations on risk mitigation:

1. Try to associate more risks with highly preferred mitigation cases, such as Mitigation Case 1 and Mitigation Case 2. If we have different ways to treat a risk that map to different mitigation cases, we should choose the one that maps the risk to a more preferred mitigation case.

   For example, suppose a project has a risk that testers could not find most defects due to lack of testing experiences. We can offer training to all testers to enhance their capability or use a new testing tool to help them do more effective testing. Suppose these two options have the same effect. However, if the testing tool cannot be available until we start testing or after we start testing and testers need time to learn how to use the tool, whereas the training can be completed before the testing phase, we should choose offering the training rather than waiting for the testing tool since the former choice results in a better mitigation case (Mitigation Case 1 rather than one of Mitigation Case 5-8 for the latter case).

2. Try to switch the risk from a mitigation case to a more preferred mitigation case according to Table 5-2 or (5.1) by applying Positive operation. That is we should try to complete the mitigation of a risk earlier than its planned time. We should also try to start the mitigation of a risk earlier than its planned time.

3. Avoid switching the risk from a mitigation case to a less preferred mitigation case according to Table 5-2 or (5.1) by applying Negative operation. That is

we should not postpone the start of mitigation and should not extend the deadline of a planned mitigation.

4. It does not matter that we apply a Positive operation or a Negative operation to schedule the mitigation of a risk when they lead to a Null Effect Transition. Practitioners can take advantage of Null Effect Transition in practice.
   For example, we can postpone the mitigation of R_i and shift its mitigation case from Case 1 to Case 2, and then use the reserved time to mitigate another risk R_j with an earlier start. These actions reduce the EOR and EAI of R_j and do not change the EOR and EAI of R_i. Consequently, we get a lower EOR and EAI overall.

5. The status change path of a risk can be used to reflect the performance of risk mitigation. A higher preferred path (see Table 3-2 for the preference of a path) indicates a higher performance in risk mitigation as it leads to a lower impact on the project. Thus we should prevent risks from taking the less preferred path by taking positive operations. For example, if we start the mitigation of a risk earlier, we may switch a risk from taking the path of "Unmitigated Problem" to the path "Mitigated Problem". This will reduce the negative impact on the project.

5.3 Analysis at Project-Level

5.3.1 Scheduling Strategy for Risk Mitigation

In risk mitigation, we aim at highly preferred mitigation cases, such as Mitigation Case 1 and Mitigation Case 2. However, it may not be possible to have all risks mapped to one of these two cases due to resource constraint. So, we need strategies to schedule risk mitigation. In this section, we first give a definition of scheduling strategy for risk mitigation, and propose a metric to measure its performance. Then we identify several scheduling strategies with due consideration of time elements.

5.3.1.1 Definition of Scheduling Strategy for Risk Mitigation

To facilitate the definition of scheduling strategy for risk mitigation, we first define the set of risks need to be treated at time *t* and the resource assigned for risk mitigation.

Definition 8. Given a risk set *TRS(Z, t)* and *TRS(Z, t)*⊆ *RS(Z, t)*, $\forall R_j \in TRS(Z, t)$, R_j is a risk which does not have a mitigation plan and waiting for treatment, and $\forall R_k \in RS(Z, t) - TRS(Z, t)$, R_k is a risk which is acceptable and need not to be treated or has been scheduled for mitigation.

We abstract the human resource for risk mitigation as a set of processors which have different capabilities to mitigate risk.

Definition 9. For a given project *Z*, a set of *k* processors at time t, *ProS(Z, t)* = $\{processor_i \mid 0 < i \le k\}$, are available for risk mitigation. $\forall processor_i \in ProS(Z, t)$, $CAP(processor_i) = c_i$, where $CAP(processor_i)$ is the capability of $processor_i$ for risk treatment and c_i is a real number greater than 0.

The capability of a processor can be considered as 1 if it represents the capability of a team member that has normal capability for risk mitigation. Then the capabilities of all processors can be estimated according to capabilities of different team members.

For R_i assigned to $processor_j$ ($0<j\le k$),

$$tmc_i - tms_i = \frac{Effort_i}{c_j} \qquad (5.6)$$

where $Effort_i$ is the estimated effort for the treatment of R_i.

Note that the processor is assumed to process one risk at a time. However, it is possible that a team member may treat two (or more) different risks at the same time in practice. In this case, this team member can be abstracted as two (or more) processors with capability equal to the capability of the team member. From this point of view, we can consider each processor can process one risk at a time.

For convenient sake, we assume all processors in *ProS(Z, t)* have the same capability equal to 1, and each processor processes one risk at a time. Then the effort of mitigating a risk can be estimated according to the capability of the processor and the time needed to mitigate the risk. Note that the time unit should be consistent with the time unit adopted in the simulation model.

The mitigation scheduling of a project *Z* aims to allocate a set of *m* risks ($|TRS(Z, t)|=m$) to a set of *k* processors ($|ProS(Z, t)|=k$), to minimize the expected impact on *Z*. Suppose there is only one processor (k=1), then there are *m*! different sequences to allocate risks to this single processor. We can choose the schedule with the minimal expected impact among all *m*! different sequences. However, this approach is unreasonable in practice because the time for finding the best option from *m*! options is non-polynomial. The situation become more complicated when there are more processors (k>1). Thus there is a need to develop scheduling strategies to determine the sequence for treating the risks in *TRS(Z, t)*.

Based on *TRS(Z, t)* and *ProS(Z, t)*, we define scheduling strategy for risk mitigation as follows.

Definition 10. Scheduling strategy for risk mitigation is an algorithm that takes *TRS(Z, t)* and *ProS(Z, t)* as input and generates a scheduled risk mitigation plan as its output. For each $R_i \in TRS(Z, t)$, it decides whether R_i is to be mitigated, and then chooses $processor_j \in ProS(Z, t)$ to mitigate R_i during a selected time period.

Since risk mitigation aims to prevent the project from impacted by the risks, the performance of a scheduling strategy *S* can be measured by the expected impact of all risks in *TRS(Z, t)*, $EAI\left(S \mid TRS(Z,t)\right)$, after *S* has been applied to *TRS(Z, t)*. $EAI\left(S \mid TRS(Z,t)\right)$ is defined in Definition 11.

Definition 11. Let $EAI\left(S \mid TRS(Z,t)\right)$ be the expected impact of all risks in *TRS(Z, t)* after a scheduling strategy *S* has been applied to *TRS(Z, t)*.

$$EAI\left(S \mid TRS(Z,t)\right) = \sum_{R_i \in TRS(Z,t)} EAI(R_i) \tag{5.7}$$

where $EAI(R_i)$ is EAI of R_i. $EAI\left(S \mid TRS(Z,t)\right)$ ranges in (0, | *TRS(Z, t)*|) because EAI of each risk ranges in (0, 1).

A higher value of $EAI\left(S \mid TRS(Z,t)\right)$ means a higher expected impact on the project and indicates a lower performance. On the contrary, a lower value means a lower expected impact on the project and indicates a higher performance. Thus we define the performance of a scheduling strategy as follows.

Definition 12. Let $Perf(S)$ represents the performance of a scheduling strategy *S* applied to the risk set *TRS(Z, t)*. For two scheduling strategies S_i and S_j,

$Perf(S_i) > Perf(S_j)$ when $EAI\left(S_i \mid TRS(Z,t)\right) < EAI\left(S_j \mid TRS(Z,t)\right)$;

$Perf(S_i) = Perf(S_j)$ when $EAI\left(S_i \mid TRS(Z,t)\right) = EAI\left(S_j \mid TRS(Z,t)\right)$;

$Perf(S_i) < Perf(S_j)$ when $EAI\left(S_i \mid TRS(Z,t)\right) > EAI\left(S_j \mid TRS(Z,t)\right)$.

5.3.1.2 New scheduling strategies for Risk Mitigation

Traditionally, risk value first strategy (V strategy, see section 2.3.4) is used in practice. However, it does not consider the time elements of risk. Besides the V strategy, based on the analysis in section 5.2, we propose several new strategies.

1. Emergency first strategy (E strategy).
   Emergency first strategy first orders all risks according to their T_{eo}, then risks with an earlier T_{eo} will be treated earlier.

For example, suppose teo_i=30 and teo_j=50 are earliest occurrence time of R_i and R_j respectively, then R_i will be mitigated first.

The principle behind this strategy is that we should mitigate the risk before it would occur. Then, many risks can be mapped to a mitigation case with high preference. The best case of applying this strategy is all risks are mitigated before they would occur. No risk will occur if all mitigations are successful in eliminating the risks. The example shown in Chapter 3 is a good example of applying this strategy.

2. Lowest effort first strategy (L strategy).

   Lowest effort first strategy first orders all risks according to the efforts needed for mitigating the risk, then risks requiring a lower effort will be treated earlier.

   For example, suppose 40 Man-hour and 80 Man-hour are needed effort to mitigate R_i and R_j respectively, then R_i will be mitigated first.

   The principle behind this strategy is that we can mitigate more risks within the same time period because a lower effort usually indicates a shorter time period of risk mitigation. Consequently, we may prevent more risks from occurring and this leads to a low overall impact of the project.

3. Combined strategies.

   We consider applying combination of V, E and L strategies at the same time by constructing some combined strategies.

   For example, we can combine the risk value first strategy and emergency first strategy together. The resulting strategy first prioritizes all risks based on their risk value and T_{eo} respectively, producing two risk lists. For risk R_i, a score is calculated by combining its priority values from these two risk lists. Using the calculated scores, all risks can be finally prioritized and then scheduled so that a risk with a higher priority will be treated earlier.

As there are three basic strategies, V strategy, E strategy and L strategy, we can create four combined strategies, VE strategy (combined V strategy with E strategy), VL strategy (combined V strategy with L strategy), EL strategy (combined E strategy with L strategy) and VEL strategy (combined all three basic strategies). We assign weights, w_1, w_2 and w_3, to the priority according to the three basic strategies. In this study, we apply equal weights to these three strategies as there are no prior studies showing that one basic strategy is better than another. The combined strategy is equivalent to VE Strategy when $w_1= w_2$ and $w_3=0$, VL Strategy when $w_1= w_3$ and $w_2=0$, EL Strategy when $w_2= w_3$ and $w_1=0$ and VEL Strategy when $w_1= w_2= w_3$. We can create more combined strategies by using unequal weights in the future.

Table 5-3 shows examples of applying different strategies to schedule risk mitigation. The number shown under basic strategies is the priority that the risk is scheduled (a lower value indicates a higher priority). For example, R_1 is scheduled first, and then followed by R_2, R_3 and R_4 when applying V strategy. The score value under combined strategies is calculated by adding the priority of corresponding basic strategies. For example, for VE strategy, the score of the 5th column is the result of adding the priority in V strategy (the 2nd column) and that in E strategy (the 3rd column). Then all risks are prioritized based on their scores. Note that if two or more risks have the same score, then they can be prioritized in any order. Since we have to choose one order to mitigate the risks, in our study, the risk with a smaller risk index will get a higher priority when several risks have the same score. For example, R_2 and R_3 have the same score of 4 under VL strategy. Then R_2 is assigned a higher priority than R_3 and will be mitigated earlier than R_3.

Table 5-3 Examples of Mitigation Strategies

Risk	Basic Strategy			Combined Strategy							
	V	E	L	VE		VL		EL		VEL	
	Priority	Priority	Priority	Score	Priority	Score	Priority	Score	Priority	Score	Priority
R_1	1	2	4	3	1	5	3	6	3	7	2
R_2	2	3	2	5	3	4	1	5	2	7	3
R_3	3	1	1	4	2	4	2	2	1	5	1
R_4	4	4	3	8	4	7	4	7	4	11	4

We next formally define the identified scheduling strategies. Suppose $TRS(Z,t)=\{R_1,R_2,......,R_N\}$. Let *Rank*($R_i$|*RL*) be the rank of R_i in the prioritized risk list (*RL*) of *n* risks, with rank of 1 indicating the first risk of *RL* and rank of *n* indicating the last risk of *RL*. That is a lower rank value indicates a higher priority.

Recall that RV_i, teo_i and $Effort_i$ ($1\le i\le N$) represent the risk value, earliest time of occurrence and estimated mitigation effort of R_i respectively. Algorithm 5.1, 5.2 and 5.3 shows three different ways to prioritize *TRS(Z, t)*.

Algorithm 5.1 produces a risk list such that a risk with a higher risk value will have a higher priority.

Algorithm 5.1: Prioritization_RV (*TRS(Z, t)*)

1. Prioritize risks in *TRS(Z, t)* to get a risk list *RL* such that for any R_i and R_j ($1\le i<j\le N$)∈ *TRS(Z, t)*,
   IF $RV_i \ge RVj$ **THEN** $Rank(R_i|RL) < Rank(R_j|RL)$;
   IF $RV_i < RV_j$ **THEN** $Rank(R_i|RL) > Rank(R_j|RL)$;
2. **Return** *RL*.

As mentioned earlier, two risks with the same score will be prioritized according to their risk indexes. Thus, in Algorithm 5.1, R_i has a higher priority than R_j when $RV_i = RV_j$ and $1\le i<j\le N$. Similarly, in Algorithm 5.2, 5.3, and 5.9, if two risks have the

same T_{eo}, estimated mitigation effort, and computed score respectively, then they will be prioritized according to their risk indexes too.

Algorithm 5.2 produces a risk list such that a risk with an earlier T_{eo} will have a higher priority.

Algorithm 5.2: Prioritization_TEO (*TRS(Z, t)*)

1. Prioritize risks in *TRS(Z, t)* to get a risk list *RL* such that for any R_i and R_j $(1 \leq i < j \leq N) \in TRS(Z, t)$,
   IF $teo_i \leq teo_j$ **THEN** $Rank(R_i|RL) < Rank(R_j|RL)$;
   IF $teo_i > teo_j$ **THEN** $Rank(R_i|RL) > Rank(R_j|RL)$;
2. **Return** *RL*.

Algorithm 5.3 produces a risk list such that a risk with a smaller mitigation effort will have a higher priority.

Algorithm 5.3: Prioritization_EFFORT (*TRS(Z, t)*)

1. Prioritize risks in *TRS(Z, t)* to get a risk list *RL* such that for any R_i and R_j $(1 \leq i < j \leq N) \in TRS(Z, t)$,
   IF $Effort_i \leq Effort_j$ **THEN** $Rank(R_i|RL) < Rank(R_j|RL)$;
   IF $Effort_i > Effort_j$ **THEN** $Rank(R_i|RL) > Rank(R_j|RL)$;
2. **Return** *RL*.

V strategy is defined as Algorithm 5.4.

Algorithm 5.4: V strategy (*TRS(Z, t)*, *ProS(Z, t)*)

1. *RL* = Prioritization_RV (*TRS(Z, t)*).
2. Allocation(*RL*, *ProS(Z, t)*).

Allocation(*RL*, *ProS(Z, t)*) is shown as Algorithm 5.5, which allocates the prioritized risks to the processors in *ProS(Z, t)* such that the risk with a higher priority will be allocated first.

Algorithm 5.5: Allocation(*RL, ProS(Z, t)*)

1. Get the first risk R_i in the prioritized risk list *RL*.
2. Find a set of processors, $ProS_i \subseteq ProS(Z, t)$, which can process R_i.
3. **IF** $ProS_i$ is not empty,

   THEN select a $processor_j$ which is the first one that completes its currently assigned work in $ProS_i$, and assign R_i to $processor_j$.
4. Remove R_i from *RL*.
5. **IF** *RL* is not empty, **THEN** go to step 1.

Note that a processor is not able to process risk R_i if it cannot complete the mitigation of R_i before its latest time of occurrence. For example, suppose a processor completes its currently assigned work at t=50. If tlo_i=40, then the processor is not able to process R_i since the mitigation after the latest time of occurrence does not make sense. Another example is that suppose tlo_i=60 and the time length for mitigating R_i is 20. In this case, if the mitigation is started at t=50, the processor cannot complete the mitigation before tlo_i (actually it completes the mitigation at t=50+20=70).

There may exist more than one processor that can process risk R_i at the same time. Then, we should select the first processor that completes its work because the risk in *RL* should be treated as early as possible. For example, assume some risks have been assigned to $processor_1$ and $processor_2$, $processor_1$ will complete its currently assigned works at t=20 and $processor_2$ will complete its currently assigned works at t=40. Suppose teo_i, tlo_i and $Effort_i$ are 40, 60 and 10 respectively. Then, both $processor_1$ and $processor_2$ can process R_i because they can complete the mitigation of R_i (at t=30 and t=50 respectively) before tlo_i =60. In this case, we should select $processor_1$ to mitigate R_i because it completes its currently assigned work earlier (at t=20) and consequently the mitigation of R_i can be started earlier if it is assigned to $processor_1$.

Also, there may not exist any processors that can process risk R_i if they are all busy. In this case, R_i is removed from RL directly.

E strategy and L strategy are defined as Algorithm 5.6 and 5.7 respectively.

Algorithm 5.6: E strategy (*TRS(Z, t)*, *ProS(Z, t)*)

1. *RL* = Prioritization_TEO (*TRS(Z, t)*).
2. Allocation(*RL*, *ProS(Z, t)*).

Algorithm 5.7: L strategy (*TRS(Z, t)*, *ProS(Z, t)*)

1. *RL* = Prioritization_EFFORT (*TRS(Z, t)*).
2. Allocation(*RL*, *ProS(Z, t)*).

Algorithm 5.8 defines VE strategy.

Algorithm 5.8: VE strategy (*TRS(Z, t)*, *ProS(Z, t)*)

1. RL_1 = Prioritization_RV (*TRS(Z, t)*).
2. RL_2 = Prioritization_TEO (*TRS(Z, t)*).
3. *RL*= CombinedRL(RL_1, RL_2).
4. Allocation(*RL*, *ProS(Z, t)*).

CombinedRL(RL_1, RL_2,…, RL_l) is shown as Algorithm 5.9, which produces a risk list such that the risk with a lower score (which is computed by its rank from input risk lists, RL_1, RL_2,…, RL_l) will have a higher priority.

Algorithm 5.9: CombinedRL(RL_1, RL_2,…, RL_l)

// RL_1, RL_2,…, RL_l are prioritized risk lists of *TRS(Z, t)*

1. Prioritize risks in *TRS(Z, t)* to get a risk list *RL* such that for any R_i and R_j ($1 \le i < j \le N$)$\in$ *TRS(Z, t)*,

   IF $Rank(R_i|RL_1)+ Rank(R_i|RL_2)+\ldots+ Rank(R_i|RL_l) \le Rank(R_j|RL_1)+ Rank(R_j|RL_2) +\ldots+ Rank(R_j|RL_l)$

   THEN $Rank(R_i|RL) < Rank(R_j|RL)$;

   IF $Rank(R_i|RL_1)+ Rank(R_i|RL_2)+\ldots+ Rank(R_i|RL_l) > Rank(R_j|RL_1)+ Rank(R_j|RL_2) +\ldots+ Rank(R_j|RL_l)$

   THEN $Rank(R_i|RL) > Rank(R_j|RL)$;

2. **Return** *RL*.

VL, EL and VEL strategy are defined as Algorithm 5.10, 5.11 and 5.12 respectively.

Algorithm 5.10: VL strategy (*TRS(Z, t)*, *ProS(Z, t)*)

1. RL_1 = Prioritization_RV (*TRS(Z, t)*).
2. RL_2 = Prioritization_EFFORT (*TRS(Z, t)*).
3. *RL*= CombinedRL(RL_1, RL_2).
4. Allocation(*RL*, *ProS(Z, t)*).

Algorithm 5.11: EL strategy (*TRS(Z, t)*, *ProS(Z, t)*)

1. RL_1 = Prioritization_TEO (*TRS(Z, t)*).
2. RL_2 = Prioritization_EFFORT (*TRS(Z, t)*).
3. *RL*= CombinedRL(RL_1, RL_2).
4. Allocation(*RL*, *ProS(Z, t)*).

Algorithm 5.12: VEL strategy (*TRS(Z, t)*, *ProS(Z, t)*)

1. RL_1 = Prioritization_RV (*TRS(Z, t)*).
2. RL_2 = Prioritization_TEO (*TRS(Z, t)*).
3. RL_3 = Prioritization_EFFORT (*TRS(Z, t)*).
4. RL= CombinedRL(RL_1, RL_2, RL_3).
5. Allocation(*RL*, *ProS(Z, t)*).

In summary, all 7 scheduling strategies follow a two-step process:

1. Prioritize risks according to the scheduling strategy.
2. Allocate prioritized risks to processors such that the risk with a higher priority will be mitigated first.

5.3.2 Performance of Different Mitigation Scheduling Strategies

We are interested in the following research questions when applying different scheduling strategies.

1. Is the traditionally used strategy, V strategy, a good choice for scheduling risk mitigation?
2. Is there a best scheduling strategy for most projects?
3. Is there a worst scheduling strategy for most projects?
4. What are the relative performances of scheduling strategies?

Next, we compare the performance of different strategies for different cases by running simulations based on SMRMP. Let *imp(R)* denotes the impact of a given risk *R* in one simulation (run Algorithm 4.1 with *R* as input once). $\sum_{i=1}^{N} imp(R)_i / N$ is the average impact of *R* in N simulations, where $imp(R)_i$ is the impact of *R* in the i^th simulation ($1<i\leq N$). From Chapter 4, if N is sufficiently large, then $\sum_{i=1}^{N} imp(R)_i / N$ follows a normal distribution with mean EAI(R). That is $\sum_{i=1}^{N} imp(R)_i / N$ can be used to approximate EAI(*R*) when N is sufficiently large.

Let *imp(S|TRS(Z,t))* denotes the total impact of all risks of *TRS(Z,t)* in one simulation with strategy *S*. Then, $\sum_{i=1}^{N} imp(S \mid TRS(Z,t))_i / N$ can be used to approximate $EAI\left(S \mid TRS(Z,t)\right)$ when N is sufficiently large. $imp(S|TRS(Z,t))_i$ is the total impact of all risks of *TRS(Z,t)* in the i^th simulation (1<i≤N). For example, after applying V strategy to *TRS(Z,t)* and running simulation for 1000 times, the average *imp(V|TRS(Z,t))* from these simulations can be used to measure the performance of V strategy.

Definition 13. Let average overall impact, AVEOI(*S*) denotes the average *imp(S|TRS(Z,t))* of running a large number (N) of simulations on *TRS(Z,t)* with strategy *S*. AVEOI(*S*) is computed as

$$AVEOI(S) = \frac{\sum_{i=1}^{N} imp(S \mid TRS(Z,t))_i}{N} \tag{5.8}$$

If all risks of project *Z* need to be scheduled for mitigation, then *imp(S|TRS(Z,t))* can be replaced by ***oimp*** of SMRMP because ***oimp*** is the total impact of the project.

Since AVEOI(*S*) is an approximation of $EAI\left(S \mid TRS(Z,t)\right)$, it can be used to measure the performance of *S*. That is a lower AVEOI(*S*) indicates *S* has a higher performance and a higher AVEOI(*S*) indicates *S* has a lower performance.

We are also interested in the difference in performance of two strategies when they are applied to the same project.

Definition 14. Suppose S_i and S_j are two scheduling strategies that are applied to project *Z*, with AVEOI(S_i) ≥ AVEOI(S_j). PIP (Percentage of Improved Performance) is defined as

$$PIP\left(S_i, S_j\right) = \frac{AVEOI(S_i) - AVEOI(S_j)}{AVEOI(S_i)} \tag{5.9}$$

PIP(S_i,S_j) measures the relative improvement of impact of S_j over that of S_i. PIP(S_i,S_j) ranges in [0, 1]. PIP(S_i,S_j) equals 0 when AVEOI(S_i) = AVEOI(S_j), indicating that S_i and S_j have the same performance. It equals 1 when AVEOI(S_j) = 0. The higher the value of PIP(S_i,S_j), the larger the improvement of S_j over S_i.

5.3.2.1 Cases for Simulation

In this section, we identify the cases used for comparing performance of different scheduling strategies. Risk mitigation can be viewed as using a set of processors to mitigate a given set of risks. The processor takes risks as input and mitigates them. So, the risk set is the input to the risk mitigation. For output, we are most interested in the effectiveness of risk mitigation. Next, we identify different cases from these two aspects of input and output of risk mitigation.

The input to risk mitigation is a set of risks *TRS(Z, t)*. The external context of these risks is a project *Z* of a certain project type [63], size and application domain. The basic internal attributes of risk are probability and impact. First, we explore the external context and internal attributes of risk to identify key parameters for simulation.

After identifying the response option of mitigating a risk, the next issue is to determine when and which processor should work on mitigating the risk. Thus, the scheduling problem can be formulated as how to order the mitigation of a set of risks given a set of processors. Consequently, the type of project, (i.e. software development project, system enhancement project and so on [63]), and the domain of the project (i.e. banking, telecommunication, medical and so on) are not important in the context of our study.

A large project having a large number of risks and a large mitigation team is similar with a small project having a small number of risks and a small mitigation team when scheduling risk mitigation. For example, suppose a large project has 100 risks and 100 processors, and another project have 20 risks and 20 processors. In both cases, each risk can be allocated to a unique processor and all risks can be treated at the same time. Therefore, compared with the ratio of the number of risks to the number of processors, the project size is less important for scheduling risk mitigation because it may indicate the number of risks only and cannot represent the size of mitigation team.

Definition 15. RRP (Ratio of Risks to Processors) is defined as

$$RRP = \frac{|TRS(Z,t)|}{|ProS(Z,t)|} \tag{5.10}$$

where *TRS(Z, t)* and *ProS(Z, t)* are the set of risks waiting for mitigation and the set of processors respectively.

RRP is more meaningful than the number of risks for scheduling risk mitigation because it integrates both the number of risks and number of processors. Thus, RRP is a better parameter for the simulation when compared to the number of risks.

In our study, we will not consider the case when RRP is very small because:

1. In this case, different scheduling strategies have similar performance since there will be little difference between them when there are sufficient number of processors. In the extreme case, the risk mitigation schedules of different strategies are exactly the same when the number of processors is the same as the number of risks (RRP=1).
2. In practice, most projects have a relatively small number of processors compared to the number of identified risks. Thus RRP is often not small.

It is meaningful that we use different RRP values obtained from different contexts to represent different cases. We obtain RRP values from different combinations of project sizes and mitigation team (processor) sizes. We assume the number of risks is related to the project size so that larger projects will have more risks. In this study, we consider two categories of project size, large project and small project, and consider three categories of team size, large team, medium team and small team. We will consider more categories of project size and team size in future study. Note that we will not consider following two combinations: (1) small project and a large mitigation team, leading to a very small RRP, as we mentioned earlier and (2) large project and a small mitigation team, leading to a very large RRP, because effective risk mitigation is hard to be achieved in this case. Thus we consider four most common cases: 1. small project (with a small number of risks) and a small mitigation team, 2. small project and a medium mitigation team, 3. large project (with a large number of risks) and a medium mitigation team and 4. large project and a large mitigation team. We choose following values for RRP for the simulations.

1. | *TRS(Z, t)*|=20, | *ProS(Z, t)*|=2, with RRP=10 (small project with a small mitigation team)
2. | *TRS(Z, t)*|=20, | *ProS(Z, t)*|=4 with RRP=5 (small project with a medium mitigation team)
3. | *TRS(Z, t)*|=60, | *ProS(Z, t)*|=4, with RRP=15 (large project with a medium mitigation team)
4. | *TRS(Z, t)*|=60, | *ProS(Z, t)*|=15, with RRP=4 (large project with a large mitigation team)

Larger projects usually require a longer development lifecycle. So, projects of different sizes would have different time periods of risk management. However, the time unit used in SMRMP is a relative time scale, as it can represent one day, one week or one month. Hence, different time periods can be normalized into 100 time units from [0, 1] to [99, 100]. Consequently, we can consider that ***strm*** =0 and ***etrm*** =100.

For the internal attributes of risk, we consider the distribution (DoP) of the probability (*P*) and the distribution (DoI) of impact (*I*) of risks. To be meaningful, we consider four different distributions which represent majority of risks having large RV, medium RV, small RV and randomly distributed RV respectively.

A. Both *P* and *I* follow the distribution shown in Figure 5-4-A. This distribution implies that most risks have medium *P* and *I*.

B. Both *P* and *I* follow the distribution shown in Figure 5-4-B. This distribution implies that most risks have high *P* and *I*.

C. Both *P* and *I* follow the distribution shown in Figure 5-4-C. This distribution implies that most risks have low *P* and *I*.

D. Both *P* and *I* follow the distribution shown in Figure 5-4-D. This distribution implies that the P and I of risks are randomly selected in (0, 1).

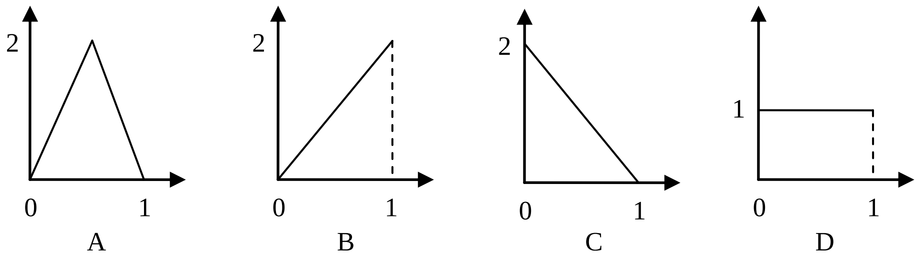


Figure 5-4 Different Distributions of *P* and *I*

Note that the distribution of probability and the distribution of impact need not be the same. In our study, the probability and impact of a risk are independent even if they follow the same distribution. In future study, we will consider more cases with different distributions of probability and distributions of impact.

The other attributes of risk, such as the time period of occurrence and efforts to mitigate a risk are randomly generated (details will be provided in section 5.3.2.2).

To model the effectiveness of risk mitigation, we consider two cases:

1. Full reduction. Each processor can eliminate the assigned risks.
2. Random reduction. Each processor randomly reduces the probability and impact of assigned risks. That is each processor reduces the probability and impact of R_i from p_i^+ and i_i^+ to $p_i^- = r_1 \times p_i^+$ and $i_i^- = r_2 \times i_i^+$ respectively, where r_1 and r_2 are random numbers in [0, 1].

Note that we will not consider the case of Zero reduction that a processor does not reduce the probability and impact of assigned risks because this case is same as no mitigation. Naturally all scheduling strategies give the same performance for this case.

In summary, with due consideration of different inputs (external context and internal attributes of *TRS(Z, t)*), and outputs (effectiveness of mitigation) of processor, we obtain totally 4×4×2=32 different cases as shown in Table 5-4.

Table 5-4 Different Cases for Comparing Performance of Scheduling Strategies

Case	**| *TRS(Z, t)* |**	**| *ProS(Z, t)* |**	**RRP**	**DoP/DoI**	**Effectiveness of mitigation**
1	20	2	10	A	Full reduction
2	20	2	10	A	Random reduction
3	20	2	10	B	Full reduction
4	20	2	10	B	Random reduction
5	20	2	10	C	Full reduction
6	20	2	10	C	Random reduction
7	20	2	10	D	Full reduction
8	20	2	10	D	Random reduction
9	20	4	5	A	Full reduction
10	20	4	5	A	Random reduction
11	20	4	5	B	Full reduction
12	20	4	5	B	Random reduction
13	20	4	5	C	Full reduction
14	20	4	5	C	Random reduction
15	20	4	5	D	Full reduction
16	20	4	5	D	Random reduction
17	60	4	15	A	Full reduction
18	60	4	15	A	Random reduction
19	60	4	15	B	Full reduction
20	60	4	15	B	Random reduction
21	60	4	15	C	Full reduction
22	60	4	15	C	Random reduction
23	60	4	15	D	Full reduction
24	60	4	15	D	Random reduction
25	60	15	4	A	Full reduction

26	60	15	4	A	Random reduction
27	60	15	4	B	Full reduction
28	60	15	4	B	Random reduction
29	60	15	4	C	Full reduction
30	60	15	4	C	Random reduction
31	60	15	4	D	Full reduction
32	60	15	4	D	Random reduction

5.3.2.2 Parameters of SMRMP

To simulate different cases, we first identify the values of parameters of SMRMP. Based on settings discussed in last section, we select values or probability distributions for the parameters of SMRMP (see Table 4-1). For each case shown in Table 5-4, we set the parameters of SMRMP as follows.

1. Parameters of SMRMP at project-level.
    - ***strm*** =0 and ***etrm*** =100.
    - We consider that all risks are identified in the first risk identification and no new risks are identified in periodical reviews. The reason is in comparing performance of different scheduling strategies, it is not important to consider the effect of the periodical reviews, since we can apply scheduling strategies to the risk set *TRS(Z, t)* at any time. At the beginning of the project, we can select a scheduling strategy based on risks identified in risk identification to generate a schedule for risk mitigation. Then we can repeat the strategy selection at the end of each periodical review if new risks have been identified. Consequently, we ignore the number of periodical reviews and the time periodical reviews are performed in our simulation. We just assume all risks are identified at the beginning of risk management. For convenient sake, we set the start time of risk identification to 0 (***stri***=0) and the end time of risk identification to 1(***etri***=1) respectively.

2. Parameters of SMRMP at risk-level.
   - $\boldsymbol{tid_i}$ of any risk R_i is 1 since ***etri***=1.
   - $\boldsymbol{p_i^+}$ and $\boldsymbol{i_i^+}$ of risk R_i are generated according to the distribution of the case (shown in column five of Table 5-4).
   - $\boldsymbol{p_i^-}$ and $\boldsymbol{i_i^-}$ of risk R_i are generated according to mitigation effectiveness of the case (shown in column six of Table 5-4).
   - The time period of occurrence of all risks is randomly generated within the lifecycle of risk management, because risks can occur at any phase of the project. Suppose we identify risk R_i before it would occur, then [$\boldsymbol{teo_i}$, $\boldsymbol{tlo_i}$] should be in the range [1, 100] since $\boldsymbol{tid_i}$ =1 and ***etrm*** =100.
   - The effort of mitigating a risk is randomly generated within the available time for its mitigation. Since the effort for mitigating a randomly generated risk is unpredictable, we consider that a randomly generated mitigation effort is a good choice. According to the effort, the scheduling strategy is applied to determine whether R_i can be mitigated by a specific processor and the time to mitigate it. Thus, the time period of risk mitigation will be determined according to the selected scheduling strategy.

Table 5-5 summarizes the settings of parameters of SMRMP.

Table 5-5 Parameters of SMRMP for Simulations

Parameters	Level	Description	Value or distributions
[***strm, etrm***]	project-level	time period of risk management	[0, 100]
[***stri, etri***]	project-level	time period of risk identification	[0, 1]
nrri	project-level	number of risks identified in the risk identification	determined by the case (see Table 5-4), could be 20 or 60
npr	project-level	number of periodical reviews	0*
[$\boldsymbol{stpr_m}$, $\boldsymbol{etpr_m}$]	project-level	period of the m^{th} periodical review	0*
$\boldsymbol{nrpr_m}$	project-level	number of risks identified in the m^{th} periodical review	0
$\boldsymbol{tid_i}$	risk-level	the time that R_i is identified	1
[$\boldsymbol{teo_i}$, $\boldsymbol{tlo_i}$]	risk-level	time period of occurrence	randomly generated in [1, 100]

$\boldsymbol{p_i}^+$ and $\boldsymbol{i_i}^+$	risk-level	probability and impact of R_i when it is first identified	follow the distribution of the case (see Table 5-4)
$\boldsymbol{p_i}^-$ and $\boldsymbol{i_i}^-$	risk-level	probability and impact of R_i after the mitigation	determined by the case (see Table 5-4)
[$\boldsymbol{tms_i}$, $\boldsymbol{tmc_i}$]	risk-level	time period of mitigation	determined by the randomly generated effort and scheduling

* we do not consider periodical reviews

5.3.2.3 Results of Simulation

We generate 1000 projects for each case and apply all 7 scheduling strategies to each project. Therefore there are 7000 combinations of projects and scheduling strategies for each case. We run 1000 simulations for each combination to compare the performance of different scheduling strategies. Figure 5-5 shows the process of simulating a case shown earlier in Table 5-4.

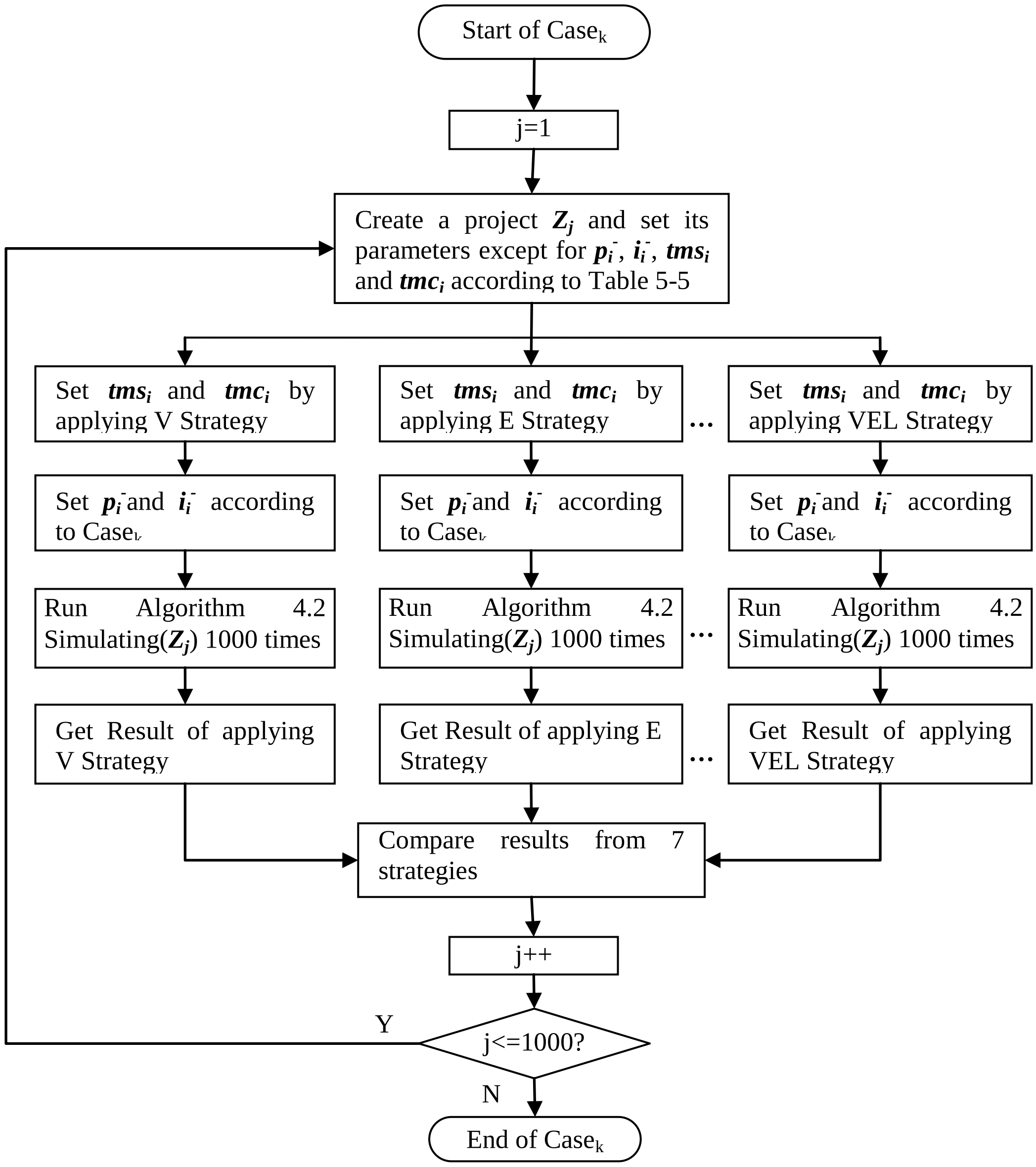


Figure 5-5 Process of Simulating a Case Shown in Table 5-4

5.3.2.3.1 Results for Project001 of $Case_1$

We use $Case_1$ as an example to illustrate the simulation process shown in Figure 5-5. We first generate a project “Project001” according to Table 5-5. Figure 5-6 shows the risks of “Project001”.

No	tid	teo	tlo	p+	i+	effort
1	1	18	70	0.4183	0.1362	61
2	1	16	71	0.8372	0.2574	19
3	1	35	73	0.2371	0.6405	42
4	1	2	40	0.7795	0.656	39
5	1	3	10	0.3298	0.7105	5
6	1	56	82	0.8447	0.3874	75
7	1	5	22	0.3157	0.5891	13
8	1	13	28	0.5995	0.1888	4
9	1	36	56	0.1859	0.4726	29
10	1	34	38	0.5277	0.2874	21
11	1	51	94	0.7185	0.5368	60
12	1	12	67	0.7094	0.376	11
13	1	40	65	0.6201	0.4052	2
14	1	13	94	0.5714	0.1485	80
15	1	34	65	0.3547	0.5597	38
16	1	31	93	0.6948	0.1646	11
17	1	17	56	0.355	0.1296	52
18	1	27	29	0.6973	0.342	20
19	1	49	71	0.2985	0.8298	69
20	1	19	45	0.5081	0.0846	16

Figure 5-6 Risks of “Project001”

Then we apply different scheduling strategies to this project to get the schedule of risk mitigation. For example, Figure 5-7 shows the schedule generated from V strategy for “Project001”. Appendix C shows schedules generated from different scheduling strategies for “Project001”.

No	tid	teo	tlo	p+	i+	effort	priority	tms	tmc	p-	i-
1	1	18	70	0.4183	0.1362	61	18				
2	1	16	71	0.8372	0.2574	19	9				
3	1	35	73	0.2371	0.6405	42	12				
4	1	2	40	0.7795	0.656	39	1	1	40	0	0
5	1	3	10	0.3298	0.7105	5	8				
6	1	56	82	0.8447	0.3874	75	3				
7	1	5	22	0.3157	0.5891	13	11				
8	1	13	28	0.5995	0.1888	4	15				
9	1	36	56	0.1859	0.4726	29	16				
10	1	34	38	0.5277	0.2874	21	13				
11	1	51	94	0.7185	0.5368	60	2	1	61	0	0
12	1	12	67	0.7094	0.376	11	4	40	51	0	0
13	1	40	65	0.6201	0.4052	2	5	51	53	0	0
14	1	13	94	0.5714	0.1485	80	17				
15	1	34	65	0.3547	0.5597	38	10				
16	1	31	93	0.6948	0.1646	11	14	53	64	0	0
17	1	17	56	0.355	0.1296	52	19				
18	1	27	29	0.6973	0.342	20	7				
19	1	49	71	0.2985	0.8298	69	6				
20	1	19	45	0.5081	0.0846	16	20				

Figure 5-7 Schedule of Applying V Strategy to “Project001”

After generating the mitigation schedules with different strategies, we run the project 1000 times to get the ***oimp*** of each run and finally AVEOI. The results are shown in Figure 5-8 and Table 5-6.

Table 5-6 AVEOI of Applying Different Strategies to "Project001"

	V	**E**	**L**	**VE**	**VL**	**EL**	**VEL**
AVEOI	2.8604	2.6103	2.446	2.4169	2.3486	2.307	2.295

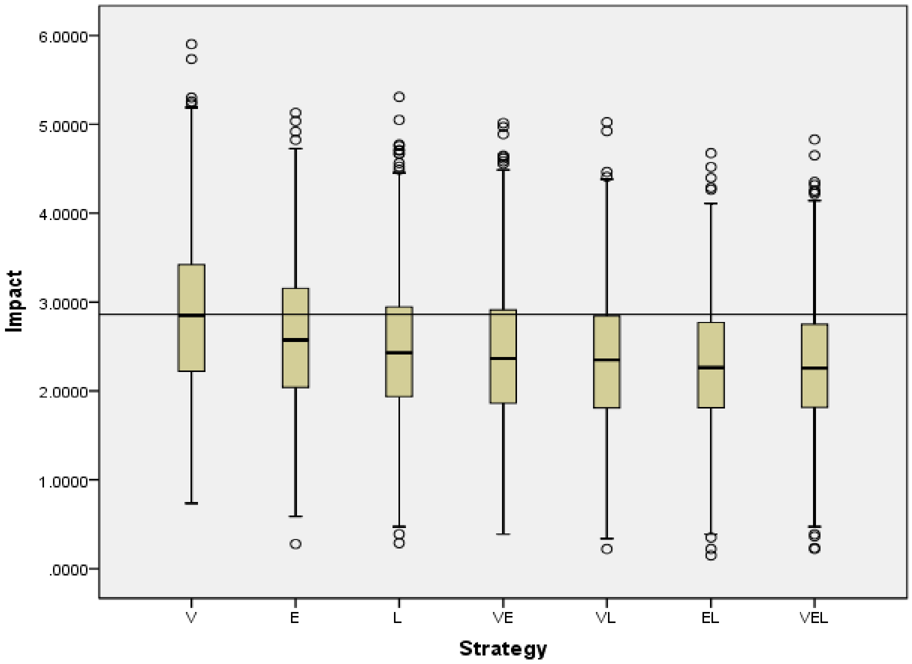


Figure 5-8 Impact of Applying Different Strategies

From Table 5-6 and Figure 5-8 we find that V strategy has the worst performance and VEL strategy has the best performance as AVEOI of V strategy is the largest (2.8604) and that of VEL strategy is the smallest (2.295). According to AVEOI of different scheduling strategies, we find that *Perf(VEL)> Perf(EL)> Perf(VL)> Perf(VE)> Perf(L)> Perf(E)> Perf(V)* for "Project001" of $Case_1$.

Table 5-7 shows the PIP between the best strategy (VEL strategy) and other strategies. In Table 5-7, B, W, V, E, L, VE, VL, EL and VEL denote the best, the worst, V, E, L, VE, VL, EL and VEL strategy respectively. For example, the result under B-W gives the percentage improvement in performance of the best strategy relative to the worst strategy. From Table 5-7, we find that the best strategy is 20% better than V strategy (the worst strategy).

Table 5-7 PIP between the Best and Other Strategies (Project001)

B-W	B-V	B-E	B-L	B-VE	B-VL	B-EL	B-VEL
0.20	0.20	0.12	0.06	0.05	0.02	0.01	0.00

5.3.2.3.2 Results for $Case_1$

Keeping all project level parameters unchanged, we generate another 999 projects that include 20 risks and repeat the simulation process. Finally, we get AVEOI of different strategies from all 1000 projects (detailed results are shown in Appendix D).

We find that each strategy can be the best strategy for some projects. Also, it can be the worst strategy for other projects. For example, the V Strategy is the best strategy for 78 projects, and the worst strategy for another 83 projects among all 1000 projects. Table 5-8 shows the number of projects that each strategy is the best/worst strategy among 7 strategies of V, E, L, VE, VL, EL and VEL. Since there are other strategies besides these 7 strategies, we cannot conclude they are the best/worst among all possible strategies.

Table 5-8 Number of Projects A Strategy is The Best/Worst in $Case_1$

	V	E	L	VE	VL	EL	VEL
Best	78	9	72	50	399	83	309
Worst	83	753	42	90	4	25	3

Figure 5-9 shows the distribution of the best strategy among different strategies. From Figure 5-9 we find that E Strategy has the lowest chance, only 1% (9 projects out of 1000 projects), to be the best strategy in $Case_1$. V strategy has 7.8% chance (78 projects out of 1000 projects) to be the best strategy for $Case_1$. The VL and VEL strategies have a significantly higher chance to be the best strategy than the other strategies. They have about 40% chance (399 projects out of 1000 projects) and 31% chance (309 projects out of 1000 projects) to be the best strategy respectively. However, none of the strategies can be the best strategy for most projects among all 1000 sample projects of $Case_1$.

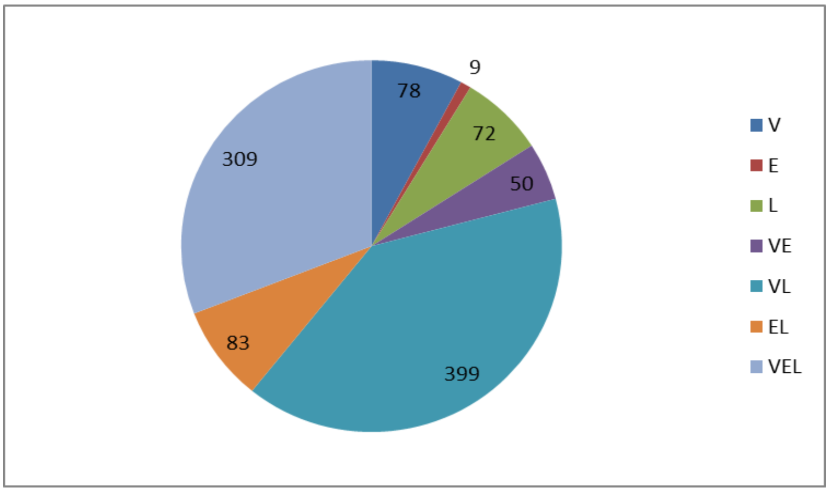


Figure 5-9 Distribution of the Best Strategy for $Case_1$

Figure 5-10 shows the distribution of the worst strategy among different strategies. From Figure 5-10 we find that E strategy has the highest chance (75%) to be the worst strategy. It is the worst strategy for 753 projects out of 1000 projects for $Case_1$. V strategy has 8.3% chance to be the worst. Among all sample strategies, VL strategy and VEL strategy have a significantly lower chance to be the worst strategy than the other strategies. Both of them have less than 1% chance to be the worst strategy for $Case_1$.

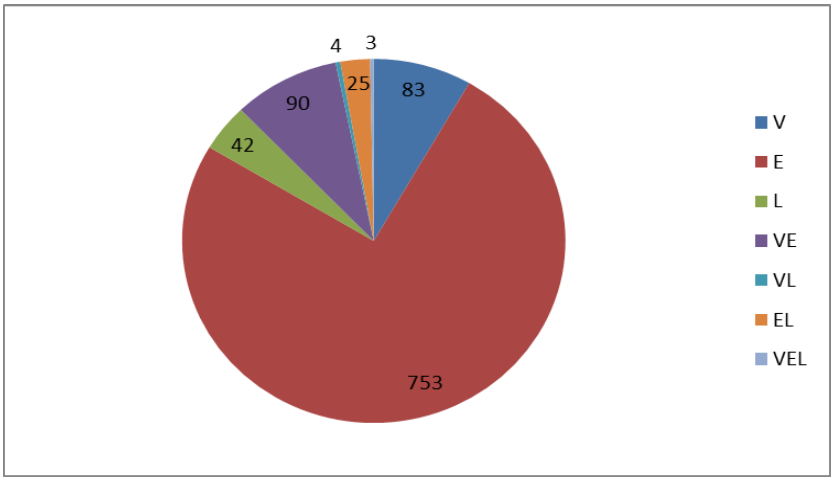


Figure 5-10 Distribution of the Worst Strategy for $Case_1$

Since the best strategy for one project may not be the best for other projects, we use the average AVEOI of 1000 projects of $Case_1$ (shown in Table 5-9) to compare the performance of 7 identified strategies. From Table 5-9, we find that *Perf(VL)> Perf(VEL)> Perf(L)> Perf(EL)> Perf(V)> Perf(VE)> Perf(E)* for $Case_1$.

Table 5-9 Average AVEOI of 1000 Projects of $Case_1$

	V	**E**	**L**	**VE**	**VL**	**EL**	**VEL**
AVEOI	3.0763	3.6941	2.9838	3.1618	2.7561	3.0433	2.7924

We are also interested to find out the difference in performance when the same strategy is applied to all projects. Table 5-10 shows the average PIP of 1000 projects of $Case_1$ between the best strategy and other strategies. From Table 5-10, we find that: On average, always applying the best strategy can improve the performance by 29% over the worst strategy, by 14% over the traditional V strategy and by at least 4% over other strategies.

Table 5-10 Average PIP between the Best and Other Strategies ($Case_1$)

B-W	**B-V**	**B-E**	**B-L**	**B-VE**	**B-VL**	**B-EL**	**B-VEL**
0.29	0.14	0.28	0.11	0.16	0.04	0.13	0.05

Base on above findings, we conclude that, for $Case_1$:

1. The traditional strategy, V strategy, is a less preferred strategy. It has only 7.8% chance to be the best strategy and has 8.3% chance to be the worst strategy. That is we have a similar chance to get a worst performance and a best performance when V strategy is applied to $Case_1$. Its average performance is lower than VL, VEL, L and EL strategy.
2. VL and VEL are two preferred strategies. They have similar average performance (with average AVEOI 2.7561 and 2.7924 respectively) and are better than other strategies.
3. E strategy is the least preferred strategy for scheduling risk mitigation. It leads to the worst performance for most projects (753 projects out of 1000 projects). Its average performance is the lowest one among all 7 strategies.
4. *Perf(VL)> Perf(VEL)> Perf(L)> Perf(EL)> Perf(V)> Perf(VE)> Perf(E)* on average.
5. None of the strategies can be the best strategy for most projects (i.e. more than 50% of projects).
6. On average, always applying the best strategy can improve the performance by 29% over the worst strategy, by 14% over the traditional V strategy and by at least 4% over other strategies.

5.3.2.3.3 Results for all cases

Besides $Case_1$, we run simulations on the rest of 31 cases of Table 5-4. For each case, we can get the distribution of the best and the worst strategy of all tested strategies. Table 5-11 shows the distribution of the best strategy among all tested strategies for different cases. Table 5-12 shows the distribution of the worst strategy. Figure 5-11 and Figure 5-12 shows the results from Table 5-11 and Table 5-12 in graphical representation respectively. In Table 5-11/Table 5-12, the strategy with the highest chance to be the best/worst for each case is highlighted in bold.

Table 5-11 Distribution of the Best Strategy in All Cases

CASE	V	E	L	VE	VL	EL	VEL
1	78	9	72	50	**399**	83	309
2	102	3	124	65	**357**	81	268
3	35	0	131	39	**377**	114	304
4	75	7	172	57	**314**	130	245
5	300	1	13	104	**345**	17	220
6	277	1	56	117	**303**	36	210
7	173	2	22	89	**406**	20	288
8	189	1	63	104	**333**	48	262
9	160	27	24	144	255	55	**335**
10	165	33	75	140	**271**	82	234
11	112	45	37	138	274	91	**303**
12	118	30	87	138	**263**	102	262
13	**444**	6	3	243	147	6	151
14	**366**	11	20	204	195	34	170
15	**371**	9	5	204	203	13	195
16	**267**	11	27	212	255	39	189
17	6	0	37	6	**625**	12	314
18	28	0	111	16	**502**	31	312
19	1	0	79	3	**584**	26	307
20	9	0	152	11	**478**	61	289
21	264	0	0	17	**495**	0	224
22	254	0	12	30	**450**	4	250
23	58	0	3	9	**652**	0	278
24	104	0	19	32	**546**	8	291
25	165	11	2	**358**	184	8	272
26	196	12	19	**250**	242	36	245
27	95	12	1	**336**	220	13	323
28	114	24	16	248	247	65	**286**
29	**663**	0	0	279	38	0	20
30	**480**	2	4	245	153	7	109
31	**527**	1	0	344	62	0	66
32	**423**	6	2	284	156	6	123

Table 5-12 Distribution of the Worst Strategy in All Cases

CASE	V	E	L	VE	VL	EL	VEL
1	83	**753**	42	90	4	25	3
2	102	**667**	43	116	12	49	11
3	172	**681**	20	99	1	26	1
4	142	**634**	21	136	17	33	17
5	11	**788**	110	26	1	61	3
6	27	**729**	100	50	9	76	9
7	40	**797**	71	36	3	52	1
8	47	**715**	70	69	11	68	20
9	91	**587**	212	31	17	59	3
10	106	**503**	125	73	49	105	39
11	130	**608**	170	34	15	37	6
12	140	**514**	120	78	41	64	43
13	6	**598**	280	6	7	103	0
14	25	**527**	207	29	36	151	25
15	17	**587**	262	13	11	107	3
16	48	**533**	194	36	38	119	32
17	14	**971**	0	15	0	0	0
18	18	**944**	2	32	0	4	0
19	34	**943**	1	22	0	0	0
20	48	**907**	1	41	1	2	0
21	0	**989**	9	0	0	2	0
22	2	**952**	19	7	0	20	0
23	1	**985**	5	4	0	5	0
24	6	**972**	6	8	0	8	0
25	28	**497**	414	1	1	59	0
26	47	**480**	274	28	24	127	20
27	81	**486**	378	1	7	47	0
28	85	**485**	245	35	32	101	17
29	0	**452**	445	0	0	103	0
30	1	**495**	312	2	13	161	16
31	0	**481**	448	0	0	71	0
32	7	**482**	341	2	14	147	7

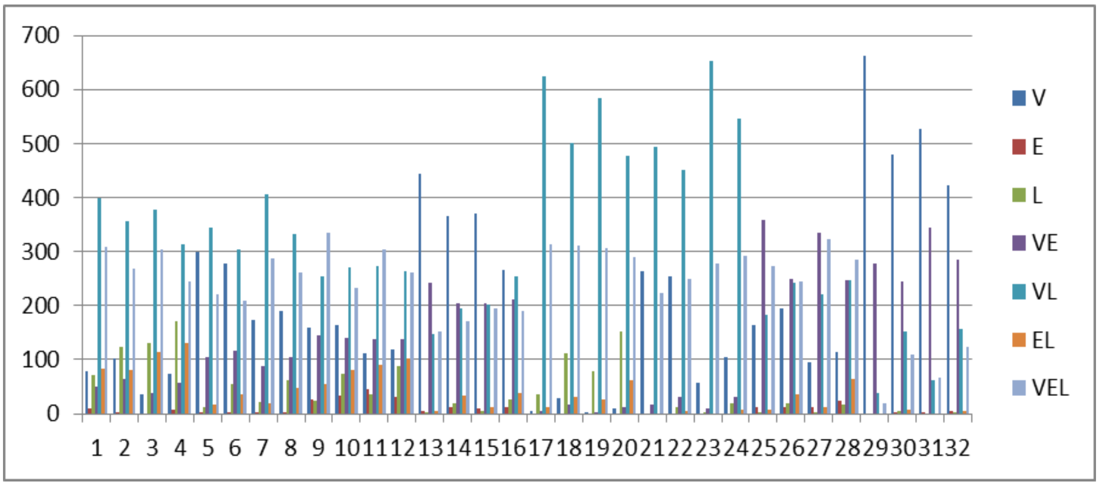


Figure 5-11 Distribution of the Best Strategy

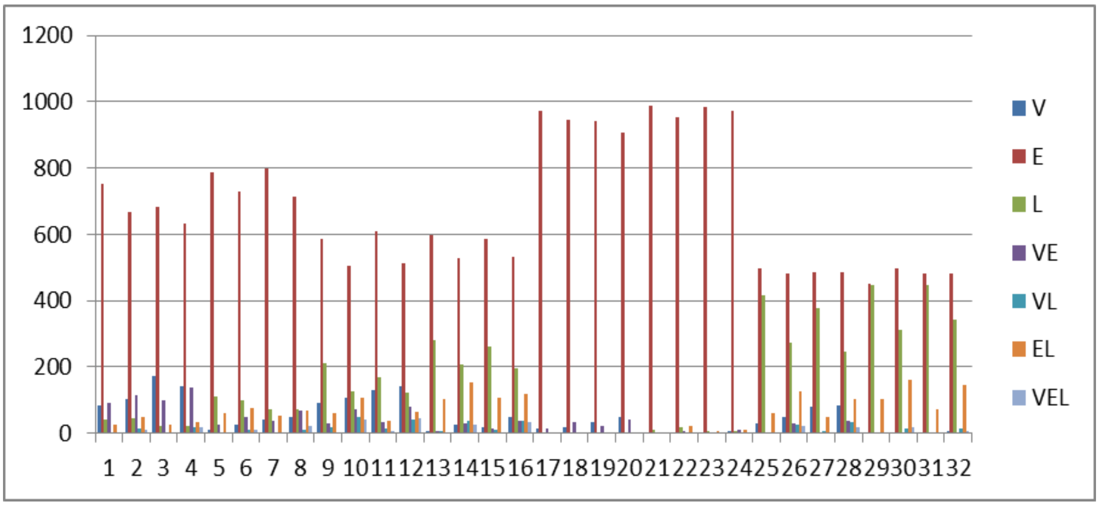


Figure 5-12 Distribution of the Worst Strategy

Table 5-13 summarizes the chance of different strategies to be the best/worst strategy among 32 cases. For example, the chance for V strategy to be the best strategy in 32 different cases ranges in [0.1%, 66%]. V strategy has 21% chance to be the best strategy on average (that is it is the best strategy for 21% of all 32000 sample projects).

Table 5-13 Summary of Different Strategies to be the Best/Worst in 32 Cases

		V	E	L	VE	VL	EL	VEL
Chance to be the best	*Range* (%)	0.1-66	0-5	0-17	0.3-36	4-65	0-13	2-34
	Average (%)	21	0.8	4	14	32	4	24
Number of cases to be the best		8	0	0	3	18	0	3
Chance to be the worst	*Range* (%)	0-17	45-99	0-45	0-14	0-16	0-4	0-43
	Average (%)	5	68	15	4	1	6	0.8
Number of cases to be the worst		0	32	0	0	0	0	0

Table 5-14 shows average AVEOI of 7 identified strategies from all 32 cases. The strategy with the best/worst performance is highlighted in green/red color. From the last row of Table 5-14, we find that *Perf(VL)> Perf(VEL)> Perf(V)> Perf(VE)> Perf(L)> Perf(EL)> Perf(E)* for all sample projects.

Table 5-14 Average AVEOI of All Cases

CASE	V	E	L	VE	VL	EL	VEL
1	3.0763	3.6941	2.9838	3.1618	2.7561	3.0433	2.7924
2	3.6083	4.0847	3.5129	3.7009	3.3486	3.5821	3.3969
3	5.7206	6.5225	5.2552	5.7286	4.9813	5.3762	5.0232
4	6.6023	7.2415	6.2199	6.6578	6.0583	6.3211	6.1154
5	1.0561	1.5977	1.2820	1.1823	1.0272	1.3050	1.0800
6	1.3949	1.8201	1.5468	1.5004	1.3735	1.5853	1.4143
7	2.7744	3.7026	2.9887	2.9245	2.5425	3.0704	2.6242
8	3.3610	4.0874	3.5146	3.5041	3.2020	3.5629	3.2616
9	2.0468	2.5290	2.2147	2.0279	1.9208	2.1536	1.8991
10	2.8651	3.2433	2.9648	2.8814	2.7547	2.9615	2.7621
11	3.8845	4.5698	3.9784	3.8060	3.5378	3.8628	3.5109
12	5.1954	5.7503	5.1979	5.1327	4.8946	5.1482	4.8789
13	0.6235	1.1340	0.9764	0.7102	0.7129	0.9674	0.7467
14	1.0521	1.4377	1.3119	1.1272	1.1154	1.2957	1.1352
15	1.6208	2.4988	2.2053	1.7466	1.6879	2.1540	1.7466
16	2.5613	3.2565	2.9791	2.6424	2.5835	2.9482	2.6418
17	10.3581	12.3063	9.8289	10.6776	9.2012	10.1019	9.3711
18	11.6361	13.1202	11.1962	11.9292	10.7618	11.4870	10.9117
19	19.2489	21.9674	17.5611	19.5718	16.8054	18.1178	17.1114

20	21.2754	23.3217	19.9657	21.5013	19.4323	20.4195	19.6666
21	3.7681	5.5185	4.3815	4.2071	3.6088	4.5187	3.7536
22	4.5394	5.8005	4.9503	4.9105	4.3961	5.0638	4.5307
23	9.4541	12.4521	9.9070	10.0992	8.5720	10.2161	8.8606
24	10.9376	13.1410	11.2432	11.4465	10.2501	11.5029	10.5118
25	4.7845	5.8008	5.6929	4.5625	4.7148	5.3859	4.6146
26	7.5423	8.3811	8.1786	7.4743	7.4615	8.0046	7.4240
27	9.0630	10.3390	10.0847	8.4681	8.5935	9.5178	8.3895
28	13.8145	14.9427	14.5074	13.5001	13.4334	14.1286	13.2956
29	1.3322	2.6192	2.5768	1.4971	1.6994	2.4307	1.7905
30	2.7759	3.7421	3.6191	2.9122	3.0124	3.5433	3.0804
31	3.5733	5.8449	5.7261	3.7143	4.0931	5.3907	4.1871
32	6.6622	8.4140	8.2005	6.8259	6.9885	7.9754	7.0949
Average	5.8815	7.0276	6.1485	5.9916	5.5475	6.1607	5.6132

From Table 5-14, we find that E strategy always has the lowest performance, independent of RRP, DoP/DoI, and the mitigation effectiveness. However, RRP, DoP/DoI and mitigation effectiveness may have an impact in determining which strategy is the best. From the results of Table 5-14, we map the best strategy of each case to a combination of RRP, Effectiveness and DoP/DoI. The result is shown in Table 5-15. In Table 5-15, the 1st column shows the value of RRP and the effectiveness of “Full” or “Random” reduction.

Table 5-15 Influence of RRP, Effectiveness and DoP/DoI on the Best Strategy

RRP, Effectiveness	**DoP/DoI**			
	A	B	C	D
10,Full	VL	VL	VL	VL
10,Random	VL	VL	VL	VL
15,Full	VL	VL	VL	VL
15,Random	VL	VL	VL	VL
5,Full	VEL	VEL	V	V
5,Random	VL	VEL	V	V
4,Full	VE	VEL	V	V
4,Random	VEL	VEL	V	V

From Table 5-15, we find that:

- RRP has the most impact on the best strategy. VL strategy is the best strategy when RRP is relatively large (RRP=10 or 15). The best strategy changes to other strategies when RRP changes to a relatively small value (RRP=4 or 5) with only one exception (RRP=5, "Random reduction", DoP/DoI = "A").
- DoP/DoI also affects the best strategy. It has a low impact when RRP is relatively large because VL strategy is always the best. However, it changes the best strategy from V strategy to other strategies when RRP is relatively small.
- Mitigation effectiveness has little impact on the best strategy. If we keep RRP and DoP/DoI unchanged, then the change in mitigation effectiveness almost does not lead to a change in the best strategy.

Table 5-16 shows the average PIP between the best strategy and the worst strategy and other 7 identified strategies. From Table 5-16, we find that: On average, always applying the best strategy can improve the performance by 10% over the traditional V strategy, by 31% over the worst strategy, and by at least 8% over other strategies.

Table 5-16 Average PIP between the Best and Other Strategies

B-W	**B-V**	**B-E**	**B-L**	**B-VE**	**B-VL**	**B-EL**	**B-VEL**
0.31	0.10	0.28	0.19	0.13	0.08	0.19	0.09

Next we answer the research questions listed at the beginning of section 5.3.2.

1. Is the traditionally used strategy, V strategy, a good choice for scheduling risk mitigation?

   Although V strategy has 66% chance to be the best strategy in $Case_{29}$, it has a lower chance to be the best strategy than other strategies in 75% cases (24 cases out of 32 cases, see Table 5-11). That is applying other strategies has a higher chance to get a better performance than applying V strategy in most cases. Actually, it is the best strategy for only 21% of all 32000 sample projects, and has a lower chance to be the best strategy than VL and VEL strategy. It also has a higher chance to be the worst strategy than three other strategies (VE, VL and VEL).

The best strategy can improve the performance by 10% over V strategy on average (see Table 5-16). That is applying the best strategy for each project will improve the performance of always applying the V strategy by 10%. Moreover, V strategy has a lower performance than VL and VEL strategy on average.

Thus, V strategy is not a good choice for scheduling risk mitigation.

2. Is there a best scheduling strategy for most projects?
   From Table 5-11 and Figure 5-11, we find that none of the 7 strategies can be a "dominate strategy" for projects of a certain case. The dominate strategy of a case is the strategy that is the best strategy for most projects (i.e. more than 70% projects) of the case. Actually, only in few cases, $Case_{17}$-$Case_{19}$, $Case_{23}$, $Case_{24}$, $Case_{29}$ and $Case_{31}$, there exists a strategy with more than 50% chance to be the best strategy, with the highest chance being 66%. There are 25 cases (78% of 32 cases) with no strategy achieving best performance for more than 50% of projects. That is we cannot find a dominate strategy for every case.

   From Table 5-13, we find that VL strategy has the highest chance to be the best strategy for all sample projects and in 18 cases out of 32 cases. It is the best strategy for 32% projects of all 32000 sample projects. It has only 1% chance to be the worst strategy. This performance is similar to that of VEL strategy (0.8%) and is lower than that of the other 5 strategies. However, VL strategy is the best strategy for less than half of projects (only 32% projects) from all cases. Thus, none of the 7 strategies can be the best strategy for most projects of all different cases.

In summary, there is no strategy that can be the best strategy for most projects of all cases or for most projects of a certain case. This indicates that we should not always apply the same strategy to all projects or to all the projects of a certain case.

3. Is there a worst scheduling strategy for most projects?
   From Table 5-12, Table 5-13 and Figure 5-12, we find that E strategy has the highest chance to be the worst strategy in all 32 cases. It has at least 45% chance and 68% chance on average to be the worst strategy for all cases, and the chance is greater than 90% for $Case_{17}$ - $Case_{24}$. Moreover, E strategy has a lower performance than all other strategies. So, it is the least preferred strategy for scheduling risk mitigation. However, it can be the best strategy for some projects. Among 32000 sample projects, it is the best strategy for 0.8% projects.

4. What are the relative performances of scheduling strategies?
   From Table 5-14, we find that *Perf(VL)> Perf(VEL)> Perf(V)> Perf(VE)> Perf(L)> Perf(EL)> Perf(E).*

   From Table 5-16, we find that: On average, always applying the best strategy can improve the performance by 10% over V strategy, by 31% over the worst strategy and by at least 8% over other strategies.

5.3.2.4 Validity of simulation results

In this section, we discuss the validity of our simulation.

First of all, the projects used in the simulation are not real-life projects, and are generated according to various parameters representing 32 different cases. Compared to the variety of real projects, these 32 cases may not cover all different projects.

Second, we run simulation based on four assumptions. Two of them, "*Null effect of non-mitigation factors*" and "*Linear effect of mitigation*", may be a little strong for real-life projects (see section 5.4 for additional discussion).

At last, we generate 1000 projects for each case and run 1000 simulations on each project-strategy combination. It is likely that we can get a more accurate result if we run more simulations on each project-strategy combination and generate more projects for each case.

In fact, we have examined the influence of different number of simulations and different number of projects on the simulation results. Table 5-17 shows the chance that each strategy to be the best and worst strategy after running each project-strategy combination of $Case_1$ for different number of simulations (500, 1000 and 2000). For example, V strategy is the best strategy for 66 projects out of all 1000 projects of $Case_1$ when we simulate each project-strategy combination for 500 times, giving a chance of 0.066 to be the best strategy. This chance becomes 0.078 and 0.066 respectively when we run simulation for 1000 and 2000 times respectively. In Table 5-17, "**Max-Min**" measures the maximum difference between running simulation for different number of times.

Table 5-17 Influences of Running Different Number of Simulations ($Case_1$)

	Simulation	**V**	**E**	**L**	**VE**	**VL**	**EL**	**VEL**
Chance to be the best strategy	**500**	0.066	0.003	0.073	0.059	0.404	0.091	0.304
	1000	0.078	0.009	0.072	0.05	0.399	0.083	0.309
	2000	0.066	0.008	0.07	0.058	0.375	0.099	0.324
Max-Min		0.012	0.006	0.003	0.009	**0.029**	0.016	0.02
Chance to be the worst strategy	**500**	0.09	0.727	0.038	0.098	0.004	0.039	0.004
	1000	0.083	0.753	0.042	0.09	0.004	0.025	0.003
	2000	0.087	0.741	0.049	0.091	0.003	0.028	0.001
Max-Min		0.007	0.026	0.011	0.008	0.001	0.014	0.003

Table 5-18 shows the results from generating different number of projects (500, 1000 and 2000) for $Case_1$ when keeping the number of simulation to 1000.

Table 5-18 Influences of Generating Different Number of Projects ($Case_1$)

	Projects	**V**	**E**	**L**	**VE**	**VL**	**EL**	**VEL**
Chance to be the best strategy	**500**	0.074	0.006	0.072	0.05	0.404	0.078	0.316
	1000	0.078	0.009	0.072	0.05	0.399	0.083	0.309
	2000	0.068	0.0055	0.0665	0.0615	0.391	0.0775	0.33
Max-Min		0.01	0.0035	0.0055	0.0115	0.013	0.0055	0.021
Chance to be the worst strategy	**500**	0.114	0.748	0.052	0.066	0	0.02	0
	1000	0.083	0.753	0.042	0.09	0.004	0.025	0.003
	2000	0.0865	0.7585	0.0445	0.0845	0.0015	0.0225	0.002
Max-Min		**0.031**	0.0105	0.01	0.024	0.004	0.005	0.003

From Table 5-17 and Table 5-18, we find that the maximum difference between the results of running different number of simulations is 0.029, and the maximum difference between the results of running different number of projects is 0.031. Since the maximum difference is around 3%, increase the number of simulations and the number of projects for each case do not change the conclusions drawn from our study.

5.3.3 Practice for Scheduling Risk Mitigation

Based on the simulation results, we make some recommendations on performing risk mitigation scheduling.

According to our simulation, we found:

1. V strategy is not a good choice for scheduling risk mitigation and the best strategy can increase the performance by 10% over V strategy on average. Moreover, V strategy has a lower performance than VL and VEL strategy on average. That means we should not always use V strategy.

2. None of the strategies can be the best strategy for most projects of different cases.
3. None of the strategies can be a dominate strategy for projects of a certain case.
4. On average, always applying the best strategy can improve the performance by 31% over the worst strategy and by at least 8% over other strategies.

Thus, rather than using a particular strategy to schedule the risk mitigation for all projects or to schedule the risk mitigation of projects of a specific case, it is better to study each project and then select the best strategy among different strategies. Running simulations with SMRMP can help to find the best strategy.

We have built a tool, MSST (Mitigation Strategy Selection Tool) to facilitate applying SMRMP to find the best scheduling strategy. The tool consists of three modules: (1) An interface module for setting the parameters of SMRMP and the processor set *ProS(Z, t)*. (2) A module for scheduling the project according to the mitigation strategy. This module implements Algorithm 5.1-5.12. (3) An implementation of SMRMP, according to section 4.2.2. Practitioners can use MSST to schedule risk mitigation of their projects and can improve their risk management performance.

Figure 5-13 shows the process of applying SMRMP to schedule risk mitigation.

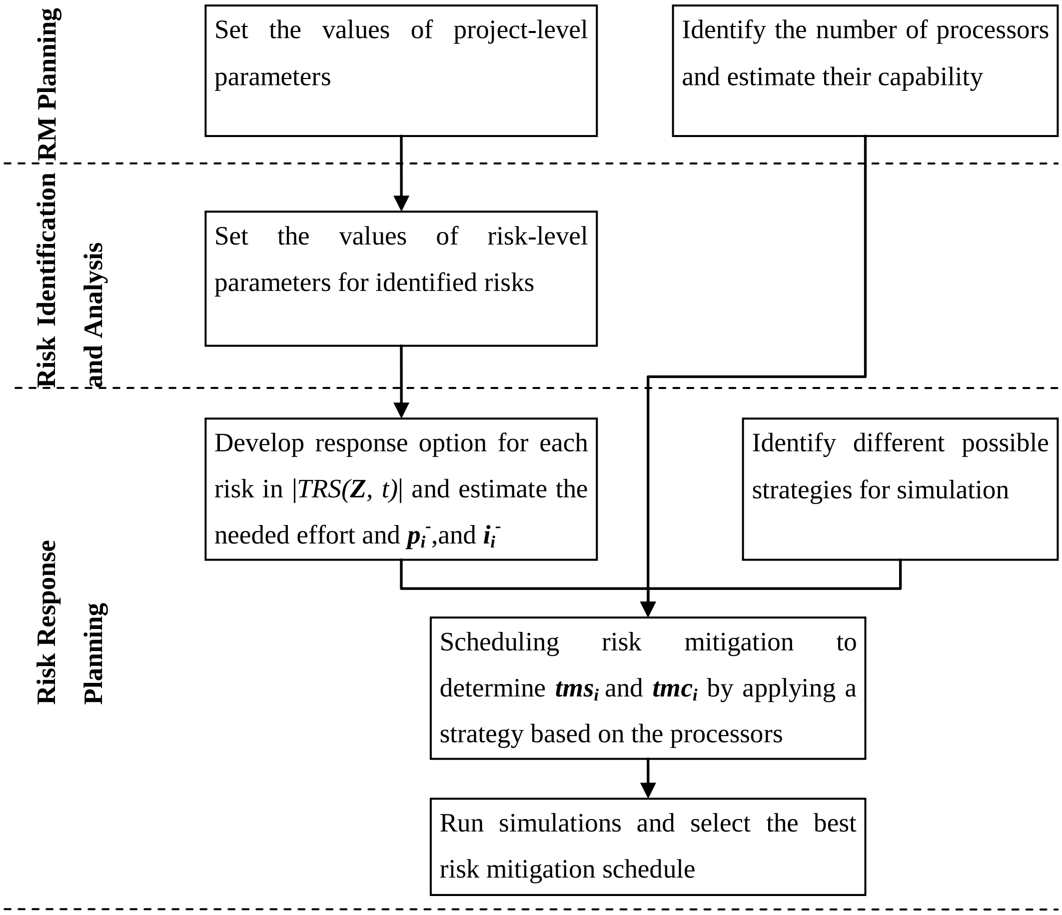


Figure 5-13 Process of Scheduling Risk Mitigation

The process includes following steps:

1. In risk management planning, the user sets the project-level parameters of SMRMP which include [***strm, etrm***] (time period of risk management), and [***stri, etri***] (time period of risk identification). The user should also identify the number of processors and their capability of treating risks according to the available human resource.
2. In risk identification, the user sets the value of ***nrri*** (number of risks identified in the risk identification) and values of risk-level parameters including tid_i (the time that R_i is identified), [teo_i, tlo_i] (time period of occurrence), p_i^+ and i_i^+ (probability and impact of R_i when it is first identified).

3. In risk response planning, the user develops response options for unacceptable risks (*TRS(Z, t)*) and estimates the expected $\boldsymbol{p_i^-}$ and $\boldsymbol{i_i^-}$ (probability and impact of R_i after the mitigation).
4. Then, the user selects scheduling strategies, such as V, E, L, VE strategy, and applies selected strategies to *TRS(Z, t)* to get the schedule of risk mitigation based on the available processors.
5. At last, from simulations of different strategies, the user can select the mitigation schedule with the best performance.

Note that the above process can be repeated if the user wants to reschedule risk mitigation after a risk periodical review. The key point here is applying different strategies on a set of risks based on a set of available processors to get different schedules, and then running simulation to select the best schedule.

The above process will not impose too much extra workload on the user, since the first 3 steps are also performed in the traditional risk management practice.

Another advantage of applying this method is the process will not change even if new scheduling strategies are developed in future because they just offer more choices for step 4.

5.4 Discussion on Reduced Assumptions

In this section, we consider the effect of excluding some assumptions on the results of our study. We like to know whether our results can be applied in a larger scope with fewer assumptions.

The two assumptions "*Null effect of non-mitigation factors*" and "*Linear effect of mitigation*" made in our study may be a little strong. In real-life project, non-mitigation factors may affect the probability and impact of a risk, and the effect of risk mitigation may not be linear. In this section, we remove "*Null effect of non-mitigation factors*" and "*Linear effect of mitigation*" and then conduct analysis based on remaining two assumptions ("*Time slicing*" and "*Non-negative effect of mitigation*").

First of all, the simulation algorithms are independent of model assumptions because their deductions do not rely on these assumptions (see section 4.1.4). This means that the simulation algorithms remain valid even if we remove the "*Null effect of non-mitigation factors*" assumption and "*Linear effect of mitigation*" assumption. The reason that we adopt these two assumptions in the thesis is to obtain a relatively simple probability function ($pf_i(t)$) and impact function ($ig_i(t)$) of risk. We cannot run simulations without knowing $pf_i(t)$ and $ig_i(t)$.

According to section 4.1.4, we have $EOR = \frac{\int_{teo_i}^{tlo_i} pf_i(t)\, dt}{tlo_i - teo_i}$ (4.10) and $EAI = \frac{\int_{teo_i}^{tlo_i} pf_i(t) \times ig_i(t)\, dt}{tlo_i - teo_i}$ (4.11). Thus we can decrease EOR by reducing $pf_i(t)$ and decrease EAI by reducing $pf_i(t)$ or $ig_i(t)$ during the time period of risk occurrence ([$\boldsymbol{teo_i}$, $\boldsymbol{tlo_i}$]). Additionally, since $pf_i(t) = p_i + mp_i(t) + op_i(t)$ (4.1) and $ig_i(t) = i_i + mi_i(t) + oi_i(t)$ (4.2), we can reduce $pf_i(t)/ig_i(t)$ by reducing $mp_i(t)/mi_i(t)$ independent of $op_i(t)/oi_i(t)$ (where $mp_i(t)/mi_i(t)$ is the offset from p_i/i_i caused by mitigation at time t, and $op_i(t)/oi_i(t)$ is the offset from p_i/i_i caused by other factors). That is, no matter how other factors (represented by $op_i(t)$ and $oi_i(t)$) affect the probability/impact of a risk, we can analyze the performance of risk mitigation practice by just focus on the effect caused by the change of risk mitigation.

Suppose two different risk mitigation practices lead to $mp_i^{'}(t)$ *and* $mp_i^{''}(t)$ respectively. Then the difference in their probability functions is independent of the effect from other factors, as shown blow:

$$\begin{aligned} pf_i^{'}(t) - pf_i^{''}(t) &= (p_i + mp_i^{'}(t) + op_i(t)) - (p_i + mp_i^{''}(t) + op_i(t)) \\ &= mp_i^{'}(t) - mp_i^{''}(t) \end{aligned} \qquad (5.11)$$

For the same reason, if two mitigation practices lead to $mi_i^{'}(t)$ *and* $mi_i^{''}(t)$ respectively, then the difference in their impact functions is independent of the effect from other factors, as shown blow:

$$ig_i^{'}(t) - ig_i^{''}(t) = mi_i^{'}(t) - mi_i^{''}(t) \quad (5.12)$$

So, to analyze the difference between the performance of applying two different risk mitigation practices to risk R_i, we can focus on the change to $mp_i(t)$ and $mi_i(t)$, and ignore $op_i(t)$ and $oi_i(t)$.

After excluding "*Null effect of non-mitigation factors*" assumption and "*Linear effect of mitigation*" assumption, the following analysis will be based on the two remaining assumptions, "*Time slicing*" and "*Non-negative effect of mitigation*".

For a given risk, if the risk mitigation period overlaps the risk occurrence period, then

1. We can get a better performance in risk mitigation if we make risk mitigation takes effect earlier without changing the time period of risk mitigation.
2. We can get a better performance in risk mitigation if we start the risk mitigation earlier when we cannot make risk mitigation takes effect earlier (change the shape of $mp_i(t)/mi_i(t)$).

Figure 5-14 illustrates the reason for the above results. As shown in Figure 5-14-A, if we change $mp_i(t)$ to $mp_i^{'}(t)$ while keeping effectiveness of risk mitigation unchanged, then $pf_i(t)$ is reduced during [$\boldsymbol{teo_i}$, $\boldsymbol{tlo_i}$]. Consequently, EOR and EAI are reduced accordingly and thus we get a better performance in risk mitigation.

As shown in Figure 5-14-B, if we make risk mitigation take effect sooner by changing $mp_i(t)$ to $mp_i^{'}(t)$ while not changing the time period of risk mitigation, then $pf_i(t)$ is also reduced during [$\boldsymbol{teo_i}$, $\boldsymbol{tlo_i}$]. Thus we also get a better performance in risk mitigation in this situation.

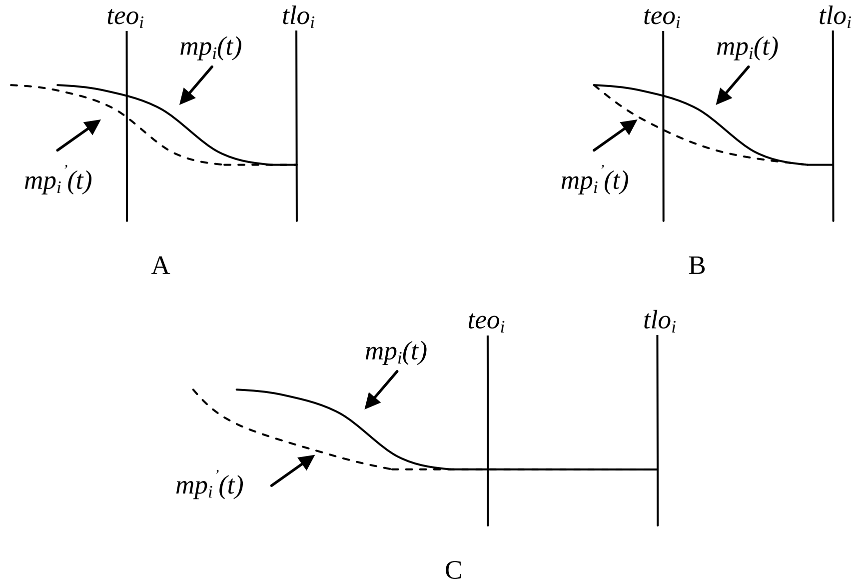


Figure 5-14 Different Changes in $mp_i(t)$

However, we cannot get a better performance by starting the risk mitigation earlier and/or making risk mitigation take effect earlier if the risk mitigation period does not overlap the risk occurrence period. The reason is that $pf_i(t)$ is not reduced during [$\boldsymbol{teo_i}$, $\boldsymbol{tlo_i}$] as shown in Figure 5-14-C.

Therefore, the practices "associate more risks with highly preferred mitigation cases" and "switch the risk from a mitigation case to a more preferred mitigation case" proposed earlier are still valid after excluding the two assumptions: "*Null effect of non-mitigation factors*" and "*Linear effect of mitigation*". That is we should try to start the risk mitigation of a risk as early as possible and complete the risk mitigation as soon as possible.

Even if we may identify better scheduling strategy, we can continue to use SMRMP to select the best scheduling strategy for risk mitigation. Since the simulation algorithms are independent of the model assumptions, the process of applying SMRMP to select the best scheduling strategy for risk mitigation will not be affected by excluding these two assumptions. The extra work that the user needs to do is estimate the $pf_i(t)$ and $ig_i(t)$ after excluding these two assumptions. Therefore, the removal of the two assumptions will not impact the practices of “associate more risks with highly preferred mitigation cases”, “switch the risk from a mitigation case to a more preferred mitigation case” and “using MSST to find the best strategy for scheduling risk mitigation”.

Chapter 6 Conclusion and Future Study

In this thesis, we first explicitly modeled the time elements of risk which have been ignored by practitioners and researchers. We identified key time elements of a risk during its life cycle and analyzed their relationships. According to different relationships between the time period of risk mitigation and time period of risk occurrence, we identified 8 different mitigation cases and a special case covering all possible scenarios. Next, we defined the transition between these mitigation cases by applying 4 different operations. Also, we identified the possible status change patterns that a risk may follow during its life cycle.

Second, to facilitate the analysis of introduced time elements, we built a stochastic simulation model, and validated and verified it based on the paradigm proposed by Sargent. This simulation model can be used not only for our study but also for many risk management issues, such as understanding of risk management process, predicting risk management outcome, and making informed risk management decision.

Third, we identified and summarized the management of introduced time elements in the risk management life cycle. Then, we formally analyzed how time elements influence risk mitigation both at risk-level and project-level.

From the analysis at risk-level, we found that

1. For any $R_i(P_i, I_i) \in MRS(Z, t)$, it has the same EOR and EOI in both Mitigation Case 1 and Mitigation Case 2.
2. For $R_i(P_i, I_i) \in MRS(Z, t)$, any transition between a mitigation case and its successor mitigation cases in the Positive Transition Sub-graph, except for the Null Effect Transition, decrease both EOR and EAI of R_i.

3. For $R_i(P_i, I_i) \in MRS(Z, t)$, any transition between a mitigation case and its successor mitigation cases in the Negative Transition Sub-graph, except for the Null Effect Transition, increase both EOR and EAI of R_i.

From the analysis at project-level, we found that, for all tested cases

1. The traditionally strategy, V strategy, is not a good choice for scheduling risk mitigation. The best strategy can improve the performance of V strategy by 10% on average. That means we should not always use V strategy.
2. There is no strategy that can be the best strategy for most projects or for most projects of a certain case. This indicates we should not always apply the same strategy to all projects or to the projects of a certain case.
3. For scheduling risk mitigation, E Strategy is the least preferred strategy among 7 identified strategies.
4. On average, always applying the best strategy can increase the performance of always applying traditional V strategy by 10%, the worst strategy by 31%, and other strategies by at least 8%.

From the results of analysis, we also made some recommendations for risk mitigation to enhance the effectiveness of risks management.

At last, we find that our proposed recommendations for risk mitigation, such as "start the risk mitigation of a risk as early as possible and complete the risk mitigation as soon as possible" and "apply SMRMP to find the best strategy for scheduling risk mitigation", are still valid after removing two assumptions ("*Null effect of non-mitigation factors*" and "*Linear effect of mitigation*") made in our analysis.

Our study has some limitations.

1. The "*Null effect of non-mitigation factors*" assumption and "*Linear effect of mitigation*" assumption are a bit strong for real projects. However, from discussion in section 5.4, we expect some recommendations for risk mitigation are still valid even if we remove them.

2. We conduct our study under only one risk reduction model, linear model, based on the "*Linear effect of mitigation*" assumption.
3. Compared to the variety of real-life projects, we only run simulation for 32 different cases covering a total of 32000 projects.

In the future, we shall

1. Perform a clustering analysis on the data obtained from the simulation to find a better classification of sample projects so that a dominate strategy can be found for each class.

   In our study, we find that none of the strategies can be a dominate strategy for projects of a certain case. We have built a tool, MSST, to facilitate the users to select the best strategy for a project. Another solution is performing clustering analysis to find the common features of applying a specific strategy. Consequently, the practitioners can directly apply a strategy to their project according to the features of the project.

2. Expand our study by running more simulation with due consideration of effects of non-mitigation factors.

   In our study, we run simulation under the assumption of "*Null effects of non-mitigation factors*". However, probability and impact of a risk may be affected by non-mitigation factors. Thus, further work is needed to run more simulations taking into account the non-mitigation factors. For example, we may model the effects of non-mitigation factors on probability and impact using a random model.

3. Expand our study with some non-linear risk reduction models.

   In our study, we run simulation under the assumption of "*Linear effect of mitigation*". However, probability and impact may not be always reduced linearly by risk mitigation. Thus, further work is needed to run more simulations with other risk reduction models, such as polynomial models. For example, we may consider (1) risk mitigation takes significant effect at its beginning and the effect decrease with time, or (2) the effect of risk mitigation increases with time.

4. Expand our study by considering more cases.

   In our study, we run simulation for 32 different cases. More cases can be identified. For example, we can try many more different RRPs.

5. Identify new mitigation scheduling strategies.

   In our study, we only test 7 strategies, including 3 basic strategies and 4 combined strategies. In the future, we will try to identify better strategies.

6. Promote the application of proposed practices in real-life projects.

   The purpose of our research is to enhance risk management practices with due consideration of time elements. We propose some new practices to improve the effectiveness of risk management. However, the proposed practices have not been applied in real-life projects yet. Further work is needed to promote the application of proposed practices in real-life projects to confirm its value. To facilitate the application of proposed practices, the tool MSST which implements SMRMP should also be improved with easy to use interface and better flexibility.

Appendix

Appendix A. Abbreviation

AS NZS	Australian/New Zealand Standard
AVEOI	Average Overall Impact
CR	Risk containment rate
DoI	Distribution of Impact
DoP	Distribution of Probability
EAI	Expected Actual Impact
EOR	Expected Occurrence Rate
IEEE	Institute of Electrical and Electronics Engineers
IIR	Independent and Identical Risks
ISO	International Organization for Standardization
IT	Information Technology
MSST	Mitigation Strategy Selection Tool
NASA	National Aeronautics and Space Administration
PDCA	Plan-Do-Check-Act
PIP	Percentage of Improved Performance
PMI	Project Management Institute
PR	Problem rate
RE	Risk Exposure
RF	Risk Factor
RI	Risk Intensity
RR	Risk resolution rate
RRP	Ratio of Risks to Processors
RV	Risk Value
SEI	Software Engineering Institute
SMRMP	Simulation Model of Risk Management Process
TBQ	Taxonomy-Based Questionnaire

Appendix B. Notation

Notation	Descrition	Index
ATRV(t)	Average Total Risk Value at time t	25
AVEOI(*S*)	Average Overall Impact of Strategy *S*	106
EAI	Expected Actual Impact	59
EAI$(S \mid TRS(Z,t))$	EAI of all risks in $TRS(Z, t)$ after a strategy *S* has been applied to $TRS(Z, t)$	97
EOR	Expected Occurrence Rate	58
$etpr_m$	end time of the mth periodical review	56
etri	end time of the risk identification	56
etrm	end time of risk management	56
$ig_i(t)$	impact function of R_i	52
i_i^-	expected impact of R_i after the mitigation	56
i_i^+	estimated impact value when R_i was first identified	52
imp_i	impact of R_i if it occurs at toc_i	57
$mi_i(t)$	offset from i_i^+ caused by mitigation at time t	52
$mp_i(t)$	offset from p_i^+ caused by mitigation at time t	52
$MRS(Z, t)$	a set of risks which have a mitigation plan	36
nocc	number of all occurred risks	57
npr	number of periodical reviews	56
$nrpr_m$	number of risks identified in the mth periodical review	56
nrri	number of risks identified in risk identification	56
occ_i	represent whether R_i occurs or not	57
$oi_i(t)$	offset from i_i^+ caused by other factors	52
oimp	overall impact of all risks	57
$op_i(t)$	offset from p_i^+ caused by other factors	52
$Perf(S)$	performance of a scheduling strategy *S*	97
$pf_i(t)$	probability function of R_i	52
p_i^-	expected probability of R_i after the mitigation	56
p_i^+	estimated probability value when R_i was first identified	52
PIP(S_i,S_j)	Percentage of Improved Performance of S_j over S_i	106
$ProS(Z, t)$	a set of processors which can mitigate risks	95
RE	Risk Exposure	21
RF	Risk Factor	21
RI	Risk Intensity	21

$R_i(P_i, I_i)$	risk R_i with probability P_i and impact I_i	11
RN(t)	Risk Number at time t	24
RRP	Ratio of Risks to Processors	108
RS(Z, t)	a set of identified risks of project *Z* at time t	11
RSN(Z,t)	top N risks of *RS(Z, t)*	25
RV	Risk Value	10
RVTN(t)	Risk Value of TOP N risks at time t	25
$stpr_m$	start time of the m^{th} periodical review	56
stri	start time of the risk identification	56
strm	start time of risk management	56
T_{eo}	earliest time of occurrence	38
teo_i	earliest time of occurrence of R_i	56
T_{exp}	time that a risk expired	38
T_{id}	time that a risk is identified	38
tid_i	time that R_i is identified	56
T_{lo}	latest time of occurrence	38
tlo_i	latest time of occurrence of R_i	56
T_{mc}	planned mitigation close time	38
tmc_i	mitigation close time of R_i	56
T_{ms}	planned mitigation start time	38
tms_i	mitigation start time of R_i	56
T_{oc}	time that a risk occurs	38
toc_i	occurrence time of R_i if it occurs	57
TRS(Z, t)	a set of risks which do not have a mitigation plan	95
TRV(t)	Total Risk Value at time t	24

Appendix C. Schedule of Applying 7 Different Strategies to "Project001"

1. Schedule of Applying V Strategy to "Project001"

No	tid	teo	tlo	p+	i+	effort	priority	tms	tmc	p-	i-
1	1	18	70	0.4183	0.1362	61	18				
2	1	16	71	0.8372	0.2574	19	9				
3	1	35	73	0.2371	0.6405	42	12				
4	1	2	40	0.7795	0.656	39	1	1	40	0	0
5	1	3	10	0.3298	0.7105	5	8				
6	1	56	82	0.8447	0.3874	75	3				
7	1	5	22	0.3157	0.5891	13	11				
8	1	13	28	0.5995	0.1888	4	15				
9	1	36	56	0.1859	0.4726	29	16				
10	1	34	38	0.5277	0.2874	21	13				
11	1	51	94	0.7185	0.5368	60	2	1	61	0	0
12	1	12	67	0.7094	0.376	11	4	40	51	0	0
13	1	40	65	0.6201	0.4052	2	5	51	53	0	0
14	1	13	94	0.5714	0.1485	80	17				
15	1	34	65	0.3547	0.5597	38	10				
16	1	31	93	0.6948	0.1646	11	14	53	64	0	0
17	1	17	56	0.355	0.1296	52	19				
18	1	27	29	0.6973	0.342	20	7				
19	1	49	71	0.2985	0.8298	69	6				
20	1	19	45	0.5081	0.0846	16	20				

2. Schedule of Applying E Strategy to "Project001"

No	tid	teo	tlo	p+	i+	effort	priority	tms	tmc	p-	i-
1	1	18	70	0.4183	0.1362	61	9				
2	1	16	71	0.8372	0.2574	19	7	30	49	0	0
3	1	35	73	0.2371	0.6405	42	15				
4	1	2	40	0.7795	0.656	39	1	1	40	0	0
5	1	3	10	0.3298	0.7105	5	2	1	6	0	0
6	1	56	82	0.8447	0.3874	75	20				
7	1	5	22	0.3157	0.5891	13	3	6	19	0	0
8	1	13	28	0.5995	0.1888	4	5				
9	1	36	56	0.1859	0.4726	29	16				
10	1	34	38	0.5277	0.2874	21	13				
11	1	51	94	0.7185	0.5368	60	19				
12	1	12	67	0.7094	0.376	11	4	19	30	0	0
13	1	40	65	0.6201	0.4052	2	17	49	51	0	0
14	1	13	94	0.5714	0.1485	80	6				
15	1	34	65	0.3547	0.5597	38	14				
16	1	31	93	0.6948	0.1646	11	12	40	51	0	0
17	1	17	56	0.355	0.1296	52	8				
18	1	27	29	0.6973	0.342	20	11				
19	1	49	71	0.2985	0.8298	69	18				
20	1	19	45	0.5081	0.0846	16	10				

3. Schedule of Applying L Strategy to “Project001”

No	tid	teo	tlo	p+	i+	effort	priority	tms	tmc	p-	i-
1	1	18	70	0.4183	0.1362	61	17				
2	1	16	71	0.8372	0.2574	19	8	19	38	0	0
3	1	35	73	0.2371	0.6405	42	14				
4	1	2	40	0.7795	0.656	39	13				
5	1	3	10	0.3298	0.7105	5	3	3	8	0	0
6	1	56	82	0.8447	0.3874	75	19				
7	1	5	22	0.3157	0.5891	13	6				
8	1	13	28	0.5995	0.1888	4	2	1	5	0	0
9	1	36	56	0.1859	0.4726	29	11				
10	1	34	38	0.5277	0.2874	21	10				
11	1	51	94	0.7185	0.5368	60	16	32	92	0	0
12	1	12	67	0.7094	0.376	11	4	5	16	0	0
13	1	40	65	0.6201	0.4052	2	1	1	3	0	0
14	1	13	94	0.5714	0.1485	80	20				
15	1	34	65	0.3547	0.5597	38	12				
16	1	31	93	0.6948	0.1646	11	5	8	19	0	0
17	1	17	56	0.355	0.1296	52	15				
18	1	27	29	0.6973	0.342	20	9				
19	1	49	71	0.2985	0.8298	69	18				
20	1	19	45	0.5081	0.0846	16	7	16	32	0	0

4. Schedule of Applying VE Strategy to “Project001”

No	tid	teo	tlo	p+	i+	effort	priority	tms	tmc	p-	i-
1	1	18	70	0.4183	0.1362	61	16				
2	1	16	71	0.8372	0.2574	19	5	12	31	0	0
3	1	35	73	0.2371	0.6405	42	17				
4	1	2	40	0.7795	0.656	39	1	1	40	0	0
5	1	3	10	0.3298	0.7105	5	3				
6	1	56	82	0.8447	0.3874	75	10				
7	1	5	22	0.3157	0.5891	13	4				
8	1	13	28	0.5995	0.1888	4	7				
9	1	36	56	0.1859	0.4726	29	20				
10	1	34	38	0.5277	0.2874	21	14				
11	1	51	94	0.7185	0.5368	60	8	31	91	0	0
12	1	12	67	0.7094	0.376	11	2	1	12	0	0
13	1	40	65	0.6201	0.4052	2	9	40	42	0	0
14	1	13	94	0.5714	0.1485	80	11				
15	1	34	65	0.3547	0.5597	38	12				
16	1	31	93	0.6948	0.1646	11	15	42	53	0	0
17	1	17	56	0.355	0.1296	52	18				
18	1	27	29	0.6973	0.342	20	6				
19	1	49	71	0.2985	0.8298	69	13				
20	1	19	45	0.5081	0.0846	16	19				

5. Schedule of Applying VL Strategy to "Project001"

No	tid	teo	tlo	p+	i+	effort	priority	tms	tmc	p-	i-
1	1	18	70	0.4183	0.1362	61	19				
2	1	16	71	0.8372	0.2574	19	6	12	31	0	0
3	1	35	73	0.2371	0.6405	42	15				
4	1	2	40	0.7795	0.656	39	4				
5	1	3	10	0.3298	0.7105	5	3	3	8	0	0
6	1	56	82	0.8447	0.3874	75	11				
7	1	5	22	0.3157	0.5891	13	7				
8	1	13	28	0.5995	0.1888	4	8				
9	1	36	56	0.1859	0.4726	29	16				
10	1	34	38	0.5277	0.2874	21	13				
11	1	51	94	0.7185	0.5368	60	9	28	88	0	0
12	1	12	67	0.7094	0.376	11	2	1	12	0	0
13	1	40	65	0.6201	0.4052	2	1	1	3	0	0
14	1	13	94	0.5714	0.1485	80	20				
15	1	34	65	0.3547	0.5597	38	12				
16	1	31	93	0.6948	0.1646	11	10	31	42	0	0
17	1	17	56	0.355	0.1296	52	18				
18	1	27	29	0.6973	0.342	20	5	8	28	0	0
19	1	49	71	0.2985	0.8298	69	14				
20	1	19	45	0.5081	0.0846	16	17				

6. Schedule of Applying EL Strategy to "Project001"

No	tid	teo	tlo	p+	i+	effort	priority	tms	tmc	p-	i-
1	1	18	70	0.4183	0.1362	61	13				
2	1	16	71	0.8372	0.2574	19	6	16	35	0	0
3	1	35	73	0.2371	0.6405	42	17				
4	1	2	40	0.7795	0.656	39	5				
5	1	3	10	0.3298	0.7105	5	1	1	6	0	0
6	1	56	82	0.8447	0.3874	75	20				
7	1	5	22	0.3157	0.5891	13	4	6	19	0	0
8	1	13	28	0.5995	0.1888	4	2	1	5	0	0
9	1	36	56	0.1859	0.4726	29	16				
10	1	34	38	0.5277	0.2874	21	11				
11	1	51	94	0.7185	0.5368	60	18	32	92	0	0
12	1	12	67	0.7094	0.376	11	3	5	16	0	0
13	1	40	65	0.6201	0.4052	2	9	30	32	0	0
14	1	13	94	0.5714	0.1485	80	14				
15	1	34	65	0.3547	0.5597	38	15				
16	1	31	93	0.6948	0.1646	11	7	19	30	0	0
17	1	17	56	0.355	0.1296	52	12				
18	1	27	29	0.6973	0.342	20	10				
19	1	49	71	0.2985	0.8298	69	19				
20	1	19	45	0.5081	0.0846	16	8				

7. Schedule of Applying VEL Strategy to “Project001”

No	tid	teo	tlo	p+	i+	effort	priority	tms	tmc	p-	i-
1	1	18	70	0.4183	0.1362	61	20				
2	1	16	71	0.8372	0.2574	19	7	18	37	0	0
3	1	35	73	0.2371	0.6405	42	14				
4	1	2	40	0.7795	0.656	39	3				
5	1	3	10	0.3298	0.7105	5	2	1	6	0	0
6	1	56	82	0.8447	0.3874	75	15				
7	1	5	22	0.3157	0.5891	13	4	6	19	0	0
8	1	13	28	0.5995	0.1888	4	5	12	16	0	0
9	1	36	56	0.1859	0.4726	29	18				
10	1	34	38	0.5277	0.2874	21	10				
11	1	51	94	0.7185	0.5368	60	12	30	90	0	0
12	1	12	67	0.7094	0.376	11	1	1	12	0	0
13	1	40	65	0.6201	0.4052	2	6	16	18	0	0
14	1	13	94	0.5714	0.1485	80	19				
15	1	34	65	0.3547	0.5597	38	11				
16	1	31	93	0.6948	0.1646	11	9	19	30	0	0
17	1	17	56	0.355	0.1296	52	16				
18	1	27	29	0.6973	0.342	20	8				
19	1	49	71	0.2985	0.8298	69	17				
20	1	19	45	0.5081	0.0846	16	13				

Appendix D. Simulation results of 1000 projects of $Case_1$

Project	V	E	L	VE	VL	EL	VEL	B-W	B-V	B-E	B-L	B-VE	B-VL	B-EL	B-VEL
001	2.8604	2.6103	2.446	2.4169	2.3486	2.307	2.295	0.20	0.20	0.12	0.06	0.05	0.02	0.01	0.00
002	3.1337	3.5668	2.6789	3.7719	2.7147	3.1515	2.6588	0.30	0.15	0.25	0.01	0.30	0.02	0.16	0.00
003	2.785	3.0754	3.0235	2.6027	2.6727	2.9095	2.5118	0.18	0.10	0.18	0.17	0.03	0.06	0.14	0.00
004	2.8141	3.7264	2.7337	2.8956	2.3983	2.4832	2.5135	0.36	0.15	0.36	0.12	0.17	0.00	0.03	0.05
005	3.4439	4.9542	3.4961	4.1833	3.2381	3.92	3.0439	0.39	0.12	0.39	0.13	0.27	0.06	0.22	0.00
006	2.3149	3.7221	2.1335	2.444	2.1351	2.2284	2.1042	0.43	0.09	0.43	0.01	0.14	0.01	0.06	0.00
007	1.8623	2.3967	2.1398	1.493	1.5845	2.3	1.5056	0.38	0.20	0.38	0.30	0.00	0.06	0.35	0.01
008	2.809	3.5496	3.2482	2.8182	2.7405	2.7061	2.7124	0.24	0.04	0.24	0.17	0.04	0.01	0.00	0.00
009	3.8802	3.6959	3.6123	3.5053	3.2462	3.5286	3.6584	0.16	0.16	0.12	0.10	0.07	0.00	0.08	0.11
010	3.818	4.0632	3.1705	3.8587	3.2912	3.5487	3.5331	0.22	0.17	0.22	0.00	0.18	0.04	0.11	0.10
011	2.1809	2.683	2.2884	2.1476	1.7074	2.1116	1.8211	0.36	0.22	0.36	0.25	0.20	0.00	0.19	0.06
012	2.8605	3.2135	2.3074	1.9737	2.2951	2.7596	1.9305	0.40	0.33	0.40	0.16	0.02	0.16	0.30	0.00
013	2.5259	3.3827	2.8716	3.1321	2.8529	3.2921	2.5402	0.25	0.00	0.25	0.12	0.19	0.11	0.23	0.01
014	1.9169	2.1095	1.7499	1.7547	1.827	1.6462	1.8595	0.22	0.14	0.22	0.06	0.06	0.10	0.00	0.11
015	4.1786	3.5374	3.4565	3.6971	3.0333	2.8661	2.8091	0.33	0.33	0.21	0.19	0.24	0.07	0.02	0.00
016	3.5357	4.3663	3.1902	4.09	3.2233	3.4807	3.3047	0.27	0.10	0.27	0.00	0.22	0.01	0.08	0.03
017	3.9594	4.0238	2.8578	4.7333	3.1628	3.2587	2.8901	0.40	0.28	0.29	0.00	0.40	0.10	0.12	0.01
018	2.966	2.834	2.0093	2.8328	2.3536	2.0734	2.4057	0.32	0.32	0.29	0.00	0.29	0.15	0.03	0.16
019	2.5726	3.3443	2.1603	3.3845	2.0406	2.829	2.2726	0.40	0.21	0.39	0.06	0.40	0.00	0.28	0.10
020	1.9037	2.7056	1.9154	1.975	1.8505	2.2876	1.7839	0.34	0.06	0.34	0.07	0.10	0.04	0.22	0.00
021	3.8641	4.8495	3.4552	4.2096	3.8045	4.4122	3.5247	0.29	0.11	0.29	0.00	0.18	0.09	0.22	0.02
022	1.9903	3.7239	1.8351	2.4952	1.6392	2.3308	1.6094	0.57	0.19	0.57	0.12	0.36	0.02	0.31	0.00
023	2.8114	3.5755	2.345	2.3743	2.44	2.8971	2.1607	0.40	0.23	0.40	0.08	0.09	0.11	0.25	0.00
024	2.0958	3.1709	1.9886	2.5566	1.8311	2.0534	1.694	0.47	0.19	0.47	0.15	0.34	0.07	0.18	0.00
025	2.0402	2.0553	2.0922	2.0307	1.9707	2.4246	1.7742	0.27	0.13	0.14	0.15	0.13	0.10	0.27	0.00
026	2.5366	2.6251	2.4323	2.8532	2.4921	2.5619	2.4562	0.15	0.04	0.07	0.00	0.15	0.02	0.05	0.01
027	3.4279	4.8454	3.9909	3.8402	3.0931	4.343	3.5412	0.36	0.10	0.36	0.22	0.19	0.00	0.29	0.13
028	3.4848	3.4433	3.0913	3.6202	2.9379	3.163	2.9036	0.20	0.17	0.16	0.06	0.20	0.01	0.08	0.00
029	3.348	3.8554	3.0764	3.1119	2.936	3.2481	3.1384	0.24	0.12	0.24	0.05	0.06	0.00	0.10	0.06
030	2.158	3.7216	2.1919	2.5832	1.957	1.8807	1.8402	0.51	0.15	0.51	0.16	0.29	0.06	0.02	0.00
031	2.7839	2.3434	2.3712	2.152	2.0109	2.1831	2.1026	0.28	0.28	0.14	0.15	0.07	0.00	0.08	0.04
032	2.6194	3.0234	2.6077	2.6683	2.1204	2.5407	2.4173	0.30	0.19	0.30	0.19	0.21	0.00	0.17	0.12
033	3.4451	3.8716	3.4549	3.6656	3.4686	3.7849	3.522	0.11	0.00	0.11	0.00	0.06	0.01	0.09	0.02
034	3.4812	3.8943	3.1133	3.8228	2.7401	3.1503	3.3568	0.30	0.21	0.30	0.12	0.28	0.00	0.13	0.18
035	2.6657	3.0143	2.8737	3.0316	2.457	2.7333	2.6823	0.19	0.08	0.18	0.15	0.19	0.00	0.10	0.08
036	2.2547	2.439	1.6364	1.6928	1.6363	1.8638	1.5818	0.35	0.30	0.35	0.03	0.07	0.03	0.15	0.00
037	2.8413	4.0673	2.8643	2.7089	2.6609	2.6012	2.3746	0.42	0.16	0.42	0.17	0.12	0.11	0.09	0.00
038	3.5954	4.0199	3.3368	3.9996	3.3129	3.7802	3.4481	0.18	0.08	0.18	0.01	0.17	0.00	0.12	0.04
039	3.6071	3.4891	2.7367	3.1375	2.813	2.8818	3.0036	0.24	0.24	0.22	0.00	0.13	0.03	0.05	0.09
040	3.2036	4.1858	2.4416	3.2184	2.7144	3.263	2.7118	0.42	0.24	0.42	0.00	0.24	0.10	0.25	0.10
041	2.48	3.6407	2.9888	3.7412	2.6378	3.2575	2.5632	0.34	0.00	0.32	0.17	0.34	0.06	0.24	0.03
042	2.7709	3.3764	3.121	3.4254	2.8962	3.3987	2.9957	0.19	0.00	0.18	0.11	0.19	0.04	0.18	0.08
043	3.5287	4.2975	3.6565	3.9708	3.2988	4.0587	3.3929	0.23	0.07	0.23	0.10	0.17	0.00	0.19	0.03
044	3.3456	3.9999	2.9662	3.3961	2.9469	2.9645	2.7558	0.31	0.18	0.31	0.07	0.19	0.06	0.07	0.00
045	3.8901	4.4993	4.5135	4.4406	4.0795	4.2816	4.3581	0.14	0.00	0.14	0.14	0.12	0.05	0.09	0.11
046	3.2647	4.1153	3.0482	3.2824	2.8655	3.1091	2.704	0.34	0.17	0.34	0.11	0.18	0.06	0.13	0.00
047	2.7622	3.021	3.276	2.8699	2.7659	2.8783	2.8703	0.16	0.00	0.09	0.16	0.04	0.00	0.04	0.04
048	3.6339	4.3616	3.4186	3.6457	3.3552	3.8933	3.3631	0.23	0.08	0.23	0.02	0.08	0.00	0.14	0.00
049	3.1358	3.9156	3.3187	3.288	3.3585	3.5433	3.0124	0.23	0.04	0.23	0.09	0.08	0.10	0.15	0.00
050	2.5621	3.7752	2.6025	3.1851	2.2771	2.6839	2.3673	0.40	0.11	0.40	0.13	0.29	0.00	0.15	0.04
051	2.0875	3.2559	2.2586	1.8419	2.0317	2.1911	1.8548	0.43	0.12	0.43	0.18	0.00	0.09	0.16	0.01
052	2.7744	4.0712	3.1405	2.9904	2.4621	3.0432	2.7024	0.40	0.11	0.40	0.22	0.18	0.00	0.19	0.09
053	3.7607	4.4594	3.6817	3.289	3.255	3.5199	3.327	0.27	0.13	0.27	0.12	0.01	0.00	0.08	0.02
054	3.3602	3.0658	3.3089	2.9483	3.2779	2.7905	2.7647	0.18	0.18	0.10	0.16	0.06	0.16	0.01	0.00
055	2.2898	2.2779	2.6928	2.2904	2.4185	2.3116	2.3986	0.15	0.01	0.00	0.15	0.01	0.06	0.01	0.05
056	2.5448	3.0732	2.6004	3.0276	2.1784	2.6301	2.4334	0.29	0.14	0.29	0.16	0.28	0.00	0.17	0.10
057	3.3709	3.927	2.4915	2.7124	2.4175	2.5167	2.2111	0.44	0.34	0.44	0.11	0.18	0.09	0.12	0.00
058	1.7441	2.6348	2.0017	1.6249	1.807	2.0662	1.6451	0.38	0.07	0.38	0.19	0.00	0.10	0.21	0.01
059	2.4225	3.2337	2.7515	3.0698	2.3497	2.8346	2.5589	0.27	0.03	0.27	0.15	0.23	0.00	0.17	0.08
060	2.749	3.506	2.7587	2.7708	2.4719	3.2714	2.5994	0.29	0.10	0.29	0.10	0.11	0.00	0.24	0.05

061	4.1124	3.6858	3.6802	3.7277	3.547	3.6653	3.6223	0.14	0.14	0.04	0.04	0.05	0.00	0.03	0.02
062	3.7257	4.8022	3.4424	3.8464	3.4078	3.8279	3.5375	0.29	0.09	0.29	0.01	0.11	0.00	0.11	0.04
063	3.5221	3.2153	2.9666	3.6902	2.6587	3.128	2.7828	0.28	0.25	0.17	0.10	0.28	0.00	0.15	0.04
064	2.3891	3.6068	2.9075	2.5276	2.4708	2.8123	2.4936	0.34	0.00	0.34	0.18	0.05	0.03	0.15	0.04
065	3.4295	4.5036	3.9092	3.7712	3.4974	4.0962	3.5573	0.24	0.00	0.24	0.12	0.09	0.02	0.16	0.04
066	3.4879	4.3513	3.7615	3.7237	3.6903	4.1872	3.7087	0.20	0.00	0.20	0.07	0.06	0.05	0.17	0.06
067	2.1682	3.1969	1.9973	2.1163	1.6649	2.1525	1.7443	0.48	0.23	0.48	0.17	0.21	0.00	0.23	0.05
068	2.4911	3.9967	2.4004	3.5393	2.4045	3.0868	2.3056	0.42	0.07	0.42	0.04	0.35	0.04	0.25	0.00
069	2.6111	3.6204	2.2197	2.6678	2.5133	2.6149	2.8165	0.39	0.15	0.39	0.00	0.17	0.12	0.15	0.21
070	4.1067	4.5331	3.9444	4.6347	3.7172	3.6859	3.399	0.27	0.17	0.25	0.14	0.27	0.09	0.08	0.00
071	4.3563	4.2142	3.9217	4.4921	3.4449	3.9299	4.0212	0.23	0.21	0.18	0.12	0.23	0.00	0.12	0.14
072	2.4397	3.4748	3.0823	2.4971	3.0302	2.9298	2.4894	0.30	0.00	0.30	0.21	0.02	0.19	0.17	0.02
073	3.791	4.3699	3.5046	3.9155	3.0299	3.6725	3.1099	0.31	0.20	0.31	0.14	0.23	0.00	0.17	0.03
074	3.5303	4.4212	3.0663	3.0692	2.8007	3.1146	3.1531	0.37	0.21	0.37	0.09	0.09	0.00	0.10	0.11
075	2.4742	2.6977	2.1032	2.0401	2.2849	2.283	2.0379	0.24	0.18	0.24	0.03	0.00	0.11	0.11	0.00
076	3.085	2.7955	2.3105	3.3798	2.4785	2.4616	2.2616	0.33	0.27	0.19	0.02	0.33	0.09	0.08	0.00
077	3.4066	3.5026	3.451	3.9964	3.0809	3.4286	3.4124	0.23	0.10	0.12	0.11	0.23	0.00	0.10	0.10
078	3.2438	4.5031	3.6623	3.5986	3.0991	3.5993	3.3281	0.31	0.04	0.31	0.15	0.14	0.00	0.14	0.07
079	2.1917	3.5149	2.2678	2.5332	2.0291	2.1265	1.704	0.52	0.22	0.52	0.25	0.33	0.16	0.20	0.00
080	1.2973	2.9311	1.6278	1.2116	1.2311	1.1574	1.2466	0.61	0.11	0.61	0.29	0.04	0.06	0.00	0.07
081	2.2696	2.5889	2.5178	2.0544	2.1169	1.9982	1.9357	0.25	0.15	0.25	0.23	0.06	0.09	0.03	0.00
082	3.3741	4.0123	3.8687	3.527	3.3174	3.4353	3.135	0.22	0.07	0.22	0.19	0.11	0.05	0.09	0.00
083	2.446	2.9166	2.4719	2.8987	2.242	2.3815	2.3255	0.23	0.08	0.23	0.09	0.23	0.00	0.06	0.04
084	3.7033	4.188	3.6349	3.4902	3.2275	3.4953	3.1796	0.24	0.14	0.24	0.13	0.09	0.01	0.09	0.00
085	2.2538	3.0246	2.0957	2.1847	2.2901	2.2955	1.9987	0.34	0.11	0.34	0.05	0.09	0.13	0.13	0.00
086	3.6774	3.7662	4.1064	3.5051	3.3287	3.3956	3.3208	0.19	0.10	0.12	0.19	0.05	0.00	0.02	0.00
087	4.1352	5.5212	3.9106	4.562	3.706	3.6395	3.6311	0.34	0.12	0.34	0.07	0.20	0.02	0.00	0.00
088	2.3918	2.625	2.0799	2.0987	2.1984	2.2194	2.1225	0.21	0.13	0.21	0.00	0.01	0.05	0.06	0.02
089	3.281	3.3064	3.4309	3.789	2.8762	3.4695	2.8549	0.25	0.13	0.14	0.17	0.25	0.01	0.18	0.00
090	3.7489	3.8302	3.7189	3.7047	3.4384	3.7402	3.5239	0.10	0.08	0.10	0.08	0.07	0.00	0.08	0.02
091	3.7047	2.8007	2.8403	2.9049	2.7023	2.5593	3.1948	0.31	0.31	0.09	0.10	0.12	0.05	0.00	0.20
092	2.7131	2.7426	2.0639	2.5868	2.1508	2.0523	2.0546	0.25	0.24	0.25	0.01	0.21	0.05	0.00	0.00
093	2.6555	3.3816	2.8453	2.9797	2.5355	3.1452	2.8947	0.25	0.05	0.25	0.11	0.15	0.00	0.19	0.12
094	3.8844	3.9655	3.6589	3.7869	3.5329	3.5065	3.3525	0.15	0.14	0.15	0.08	0.11	0.05	0.04	0.00
095	3.7987	3.9728	4.0782	3.7232	3.4995	4.1689	3.6652	0.16	0.08	0.12	0.14	0.06	0.00	0.16	0.05
096	2.8905	4.02	3.1227	3.8591	2.7928	3.4391	3.0635	0.31	0.03	0.31	0.11	0.28	0.00	0.19	0.09
097	2.7259	4.9791	3.188	4.5302	2.7968	3.2388	2.6086	0.48	0.04	0.48	0.18	0.42	0.07	0.19	0.00
098	2.8051	3.1733	2.5271	2.706	2.4147	2.549	2.4617	0.24	0.14	0.24	0.04	0.11	0.00	0.05	0.02
099	3.0438	3.4598	2.9769	3.0749	2.7413	2.7382	2.5425	0.27	0.16	0.27	0.15	0.17	0.07	0.07	0.00
100	2.8726	3.9263	3.1754	2.882	2.8469	2.9259	2.7249	0.31	0.05	0.31	0.14	0.05	0.04	0.07	0.00
101	2.4967	4.6949	2.3942	3.9279	2.3045	3.8296	2.9509	0.51	0.08	0.51	0.04	0.41	0.00	0.40	0.22
102	2.507	2.2648	2.5679	2.3866	2.0559	2.2909	2.3371	0.20	0.18	0.09	0.20	0.14	0.00	0.10	0.12
103	4.1604	4.9542	4.0415	4.3826	3.7869	4.3647	4.1023	0.24	0.09	0.24	0.06	0.14	0.00	0.13	0.08
104	3.4325	4.3162	3.9685	3.5685	3.4993	3.8443	3.6733	0.20	0.00	0.20	0.14	0.04	0.02	0.11	0.07
105	3.2146	3.5042	2.6819	3.2751	2.2773	2.6896	2.1548	0.39	0.33	0.39	0.20	0.34	0.05	0.20	0.00
106	2.5089	2.8342	2.2997	1.8421	2.1079	2.357	1.727	0.39	0.31	0.39	0.25	0.06	0.18	0.27	0.00
107	3.4081	4.3228	3.9353	3.7899	3.4021	4.3152	3.4728	0.21	0.00	0.21	0.14	0.10	0.00	0.21	0.02
108	3.1407	3.262	2.9266	3.1971	2.5959	2.5664	2.8546	0.21	0.18	0.21	0.12	0.20	0.01	0.00	0.10
109	2.8831	3.8937	2.9221	3.2086	2.7859	3.2337	3.1181	0.28	0.03	0.28	0.05	0.13	0.00	0.14	0.11
110	3.2326	4.1872	3.8797	3.5438	3.3176	3.754	3.2543	0.23	0.00	0.23	0.17	0.09	0.03	0.14	0.01
111	3.0655	4.2602	2.8854	3.0845	2.7085	2.6413	2.8544	0.38	0.14	0.38	0.08	0.14	0.02	0.00	0.07
112	3.7581	3.8051	2.9284	3.944	2.6509	3.1599	3.0607	0.33	0.29	0.30	0.09	0.33	0.00	0.16	0.13
113	2.7197	3.253	2.0649	2.8201	2.0838	1.6164	1.7859	0.50	0.41	0.50	0.22	0.43	0.22	0.00	0.09
114	2.908	3.0867	2.8203	3.0202	2.455	2.761	2.4634	0.20	0.16	0.20	0.13	0.19	0.00	0.11	0.00
115	3.5655	3.5754	3.0653	3.5084	3.019	3.3607	3.6021	0.16	0.15	0.16	0.02	0.14	0.00	0.10	0.16
116	2.3265	4.5302	1.7393	3.6278	2.0353	2.0327	2.4022	0.62	0.25	0.62	0.00	0.52	0.15	0.14	0.28
117	2.1156	2.2059	2.013	2.0944	2.0347	2.279	2.0578	0.12	0.05	0.09	0.00	0.04	0.01	0.12	0.02
118	2.9432	3.217	2.6084	2.528	2.2274	2.6589	2.6586	0.31	0.24	0.31	0.15	0.12	0.00	0.16	0.16
119	3.2095	3.6579	3.236	3.8047	2.8653	3.3369	2.9855	0.25	0.11	0.22	0.11	0.25	0.00	0.14	0.04
120	2.0795	2.8134	2.0682	2.0921	2.0498	2.6255	2.115	0.27	0.01	0.27	0.01	0.02	0.00	0.22	0.03
121	3.3678	5.0352	3.823	3.7658	3.1562	3.3824	3.3205	0.37	0.06	0.37	0.17	0.16	0.00	0.07	0.05
122	3.6127	4.4912	4.2402	3.9007	3.8629	4.1423	3.652	0.20	0.00	0.20	0.15	0.07	0.06	0.13	0.01
123	2.7179	3.7381	3.2852	3.3882	2.9745	3.2246	2.7602	0.27	0.00	0.27	0.17	0.20	0.09	0.16	0.02
124	3.6336	4.9989	3.6569	3.8057	3.6156	3.5934	3.2081	0.36	0.12	0.36	0.12	0.16	0.11	0.11	0.00
125	2.9803	3.561	2.8332	3.0287	3.1177	2.9775	3.0545	0.20	0.05	0.20	0.00	0.06	0.09	0.05	0.07
126	4.3264	4.7337	3.9364	4.5459	4.0099	4.2404	4.3827	0.17	0.09	0.17	0.00	0.13	0.02	0.07	0.10

127	3.5921	4.0111	2.7871	3.5521	2.8688	3.0897	2.7657	0.31	0.23	0.31	0.01	0.22	0.04	0.10	0.00
128	3.271	4.0476	3.0533	3.4091	3.0254	3.5215	2.6452	0.35	0.19	0.35	0.13	0.22	0.13	0.25	0.00
129	2.8629	3.7634	2.368	2.4711	2.5001	2.977	2.2318	0.41	0.22	0.41	0.06	0.10	0.11	0.25	0.00
130	3.3342	3.5768	2.5078	2.7899	2.452	2.4171	2.5466	0.32	0.28	0.32	0.04	0.13	0.01	0.00	0.05
131	2.9293	3.8133	2.6875	3.1492	2.454	3.5054	2.6084	0.36	0.16	0.36	0.09	0.22	0.00	0.30	0.06
132	4.4567	5.3309	4.3317	4.8144	3.8609	4.2321	4.2384	0.28	0.13	0.28	0.11	0.20	0.00	0.09	0.09
133	3.2583	3.9087	3.1616	2.8269	2.5701	3.1466	2.9663	0.34	0.21	0.34	0.19	0.09	0.00	0.18	0.13
134	2.9256	3.6315	3.0607	3.5967	2.8571	3.1884	2.8114	0.23	0.04	0.23	0.08	0.22	0.02	0.12	0.00
135	3.2005	3.5714	2.847	3.3344	2.726	3.1127	2.8674	0.24	0.15	0.24	0.04	0.18	0.00	0.12	0.05
136	2.868	3.3666	3.162	3.0379	2.8857	3.1242	2.7591	0.18	0.04	0.18	0.13	0.09	0.04	0.12	0.00
137	3.0823	3.9582	3.3555	3.266	2.6926	3.5427	2.8834	0.32	0.13	0.32	0.20	0.18	0.00	0.24	0.07
138	5.0251	5.4993	4.9119	5.2016	4.7883	4.8492	5.1836	0.13	0.05	0.13	0.03	0.08	0.00	0.01	0.08
139	3.9288	4.0802	3.2666	3.6629	3.2521	3.8214	3.2376	0.21	0.18	0.21	0.01	0.12	0.00	0.15	0.00
140	2.9937	2.8198	3.0259	3.2537	2.5979	2.5629	2.5433	0.22	0.15	0.10	0.16	0.22	0.02	0.01	0.00
141	2.6614	3.9423	2.346	2.7135	2.3664	2.7736	2.3409	0.41	0.12	0.41	0.00	0.14	0.01	0.16	0.00
142	2.6043	3.2301	1.9459	2.7742	1.9351	3.0755	1.8281	0.43	0.30	0.43	0.06	0.34	0.06	0.41	0.00
143	2.7841	3.2689	3.3938	3.2235	2.4557	3.0709	3.0163	0.28	0.12	0.25	0.28	0.24	0.00	0.20	0.19
144	1.5937	1.8982	1.7415	1.5607	1.5617	1.8214	1.5433	0.19	0.03	0.19	0.11	0.01	0.01	0.15	0.00
145	3.4536	4.2505	3.8207	4.0484	3.5249	4.3821	3.4946	0.21	0.00	0.19	0.10	0.15	0.02	0.21	0.01
146	2.7011	3.2085	3.1481	2.9992	2.6896	2.7517	2.6727	0.17	0.01	0.17	0.15	0.11	0.01	0.03	0.00
147	2.6615	3.0268	2.9702	2.1621	2.1314	2.8331	2.4198	0.30	0.20	0.30	0.28	0.01	0.00	0.25	0.12
148	3.7679	4.836	2.7912	3.5457	2.7957	2.9013	2.7332	0.43	0.27	0.43	0.02	0.23	0.02	0.06	0.00
149	2.5794	2.0283	2.1583	2.0745	2.1948	2.2782	1.8507	0.28	0.28	0.09	0.14	0.11	0.16	0.19	0.00
150	1.9488	2.7044	1.941	2.5172	1.6103	1.9539	1.9278	0.40	0.17	0.40	0.17	0.36	0.00	0.18	0.16
151	2.7288	3.4499	2.5535	2.3563	2.389	2.9028	2.2918	0.34	0.16	0.34	0.10	0.03	0.04	0.21	0.00
152	3.7857	3.7826	2.8582	3.1014	2.8744	3.2837	3.1019	0.25	0.25	0.24	0.00	0.08	0.01	0.13	0.08
153	3.9424	4.723	3.9881	3.8398	3.8752	3.7153	3.8386	0.21	0.06	0.21	0.07	0.03	0.04	0.00	0.03
154	3.0231	4.4308	2.9588	4.1389	2.7748	3.2348	3.1704	0.37	0.08	0.37	0.06	0.33	0.00	0.14	0.12
155	3.1466	3.5118	2.6574	3.1463	2.3376	2.9034	2.5384	0.33	0.26	0.33	0.12	0.26	0.00	0.19	0.08
156	3.3693	3.5938	2.5725	3.5363	2.8767	2.6032	2.6252	0.28	0.24	0.28	0.00	0.27	0.11	0.01	0.02
157	3.0949	3.7069	2.667	3.6509	2.3067	3.0572	2.701	0.38	0.25	0.38	0.14	0.37	0.00	0.25	0.15
158	3.7413	4.5389	3.4364	4.1408	3.0241	3.8665	2.8513	0.37	0.24	0.37	0.17	0.31	0.06	0.26	0.00
159	3.6318	4.2535	2.9675	3.2246	3.0625	3.1743	3.295	0.30	0.18	0.30	0.00	0.08	0.03	0.07	0.10
160	3.3773	3.4525	3.4441	3.1272	3.044	3.4619	3.4407	0.12	0.10	0.12	0.12	0.03	0.00	0.12	0.12
161	2.907	3.6293	2.9719	2.3577	2.5293	2.7195	2.3586	0.35	0.19	0.35	0.21	0.00	0.07	0.13	0.00
162	4.0346	4.9758	3.9324	4.0248	3.6312	4.5636	3.8711	0.27	0.10	0.27	0.08	0.10	0.00	0.20	0.06
163	2.7843	3.8846	2.5371	3.4812	2.5806	3.3868	2.7172	0.35	0.09	0.35	0.00	0.27	0.02	0.25	0.07
164	3.2354	3.4254	2.7962	3.0707	2.413	2.6299	2.2074	0.36	0.32	0.36	0.21	0.28	0.09	0.16	0.00
165	3.3803	3.8852	3.3149	3.0076	2.7834	3.3334	2.7743	0.29	0.18	0.29	0.16	0.08	0.00	0.17	0.00
166	3.2222	5.0111	3.1237	3.3208	3.2737	3.2135	3.1366	0.38	0.03	0.38	0.00	0.06	0.05	0.03	0.00
167	2.9153	3.4738	2.8868	2.8649	2.9574	2.8539	2.8877	0.18	0.02	0.18	0.01	0.00	0.03	0.00	0.01
168	2.9308	3.3739	2.6509	3.0844	2.8145	2.4951	2.5171	0.26	0.15	0.26	0.06	0.19	0.11	0.00	0.01
169	4.366	5.208	4.3125	4.4145	3.7312	4.0223	4.0323	0.28	0.15	0.28	0.13	0.15	0.00	0.07	0.07
170	2.2835	3.045	2.405	2.2094	2.4404	2.2091	2.2375	0.27	0.03	0.27	0.08	0.00	0.09	0.00	0.01
171	3.7112	4.3975	3.4478	4.1174	3.6764	3.5478	3.8436	0.22	0.07	0.22	0.00	0.16	0.06	0.03	0.10
172	3.5279	3.9676	3.3609	2.9357	2.7311	3.3975	2.726	0.31	0.23	0.31	0.19	0.07	0.00	0.20	0.00
173	3.4029	4.6094	4.3499	3.6067	3.6978	4.2767	3.7267	0.26	0.00	0.26	0.22	0.06	0.08	0.20	0.09
174	3.9018	4.8635	3.5919	4.8896	3.3851	4.4074	3.9433	0.31	0.13	0.30	0.06	0.31	0.00	0.23	0.14
175	3.595	4.195	3.6156	3.7261	3.1509	3.331	3.265	0.25	0.12	0.25	0.13	0.15	0.00	0.05	0.03
176	3.3711	4.067	3.2626	3.4822	3.3581	3.5174	3.2585	0.20	0.03	0.20	0.00	0.06	0.03	0.07	0.00
177	3.5587	3.6538	3.5099	3.7075	3.5336	3.1674	3.4724	0.15	0.11	0.13	0.10	0.15	0.10	0.00	0.09
178	3.0305	3.4804	2.7208	2.7209	2.4693	2.9629	2.5826	0.29	0.19	0.29	0.09	0.09	0.00	0.17	0.04
179	3.2253	4.3825	3.7802	2.985	3.3582	3.7353	2.9981	0.32	0.07	0.32	0.21	0.00	0.11	0.20	0.00
180	2.5375	3.86	2.7964	2.682	2.5258	3.2415	2.4433	0.37	0.04	0.37	0.13	0.09	0.03	0.25	0.00
181	2.2607	3.2478	2.9121	2.7485	2.2622	2.7865	2.7939	0.30	0.00	0.30	0.22	0.18	0.00	0.19	0.19
182	3.5709	4.0786	3.1096	3.5985	2.6758	3.3335	2.9097	0.34	0.25	0.34	0.14	0.26	0.00	0.20	0.08
183	2.997	3.99	3.1235	3.2346	2.671	3.0902	2.9135	0.33	0.11	0.33	0.14	0.17	0.00	0.14	0.08
184	2.7245	3.8883	3.1816	2.4631	2.4417	3.1301	2.4507	0.37	0.10	0.37	0.23	0.01	0.00	0.22	0.00
185	3.8687	3.6546	3.0513	3.4489	2.7139	3.123	2.776	0.30	0.30	0.26	0.11	0.21	0.00	0.13	0.02
186	3.2069	3.9365	3.4953	3.7348	2.9371	3.3879	3.1964	0.25	0.08	0.25	0.16	0.21	0.00	0.13	0.08
187	3.3397	3.2211	3.1726	2.9265	2.7398	2.9804	3.0022	0.18	0.18	0.15	0.14	0.06	0.00	0.08	0.09
188	3.2295	3.5686	3.2453	2.863	2.7441	2.9282	2.5426	0.29	0.21	0.29	0.22	0.11	0.07	0.13	0.00
189	3.0594	3.1447	2.9981	2.6976	2.5534	2.573	2.5595	0.19	0.17	0.19	0.15	0.05	0.00	0.01	0.00
190	4.1368	4.5594	3.2076	4.6079	2.9956	3.3845	3.565	0.35	0.28	0.34	0.07	0.35	0.00	0.11	0.16
191	3.612	3.9233	3.3725	3.6901	2.7743	3.4093	3.1684	0.29	0.23	0.29	0.18	0.25	0.00	0.19	0.12
192	3.387	3.3626	3.8618	3.5207	3.2406	3.3064	3.191	0.17	0.06	0.05	0.17	0.09	0.02	0.03	0.00

193	3.2615	4.1587	3.0619	4.0901	3.1424	2.9884	3.0763	0.28	0.08	0.28	0.02	0.27	0.05	0.00	0.03
194	2.6893	2.3964	2.3247	2.0419	2.2287	2.0623	2.004	0.25	0.25	0.16	0.14	0.02	0.10	0.03	0.00
195	3.9905	3.5999	3.2299	3.042	2.7727	3.1916	2.8211	0.31	0.31	0.23	0.14	0.09	0.00	0.13	0.02
196	4.2307	4.3984	3.6411	3.6512	3.1733	3.6103	3.0987	0.30	0.27	0.30	0.15	0.15	0.02	0.14	0.00
197	2.3072	3.1746	2.3677	2.0651	1.9251	2.4589	2.0427	0.39	0.17	0.39	0.19	0.07	0.00	0.22	0.06
198	3.7481	3.6399	3.136	3.5564	3.154	3.1269	3.0887	0.18	0.18	0.15	0.02	0.13	0.02	0.01	0.00
199	3.3694	3.21	2.4189	2.7107	2.593	2.8236	2.4461	0.28	0.28	0.25	0.00	0.11	0.07	0.14	0.01
200	2.2976	2.1672	2.0132	2.1172	2.1597	1.8603	1.8651	0.19	0.19	0.14	0.08	0.12	0.14	0.00	0.00
201	2.291	3.8403	2.5351	2.4638	2.5012	2.4674	2.1461	0.44	0.06	0.44	0.15	0.13	0.14	0.13	0.00
202	3.499	3.6404	3.2248	3.1386	2.9131	3.3276	3.3022	0.20	0.17	0.20	0.10	0.07	0.00	0.12	0.12
203	3.014	4.6279	3.4758	2.1858	2.4346	3.4758	2.3416	0.53	0.27	0.53	0.37	0.00	0.10	0.37	0.07
204	3.3909	4.8415	3.8407	3.7824	2.8394	3.8957	3.5643	0.41	0.16	0.41	0.26	0.25	0.00	0.27	0.20
205	2.7428	3.8652	2.619	2.6657	2.1663	2.8088	2.4361	0.44	0.21	0.44	0.17	0.19	0.00	0.23	0.11
206	3.2648	3.9393	3.585	3.3801	3.0669	3.6929	3.0497	0.23	0.07	0.23	0.15	0.10	0.01	0.17	0.00
207	3.5228	4.3029	3.1823	3.9499	3.0429	3.1909	3.2421	0.29	0.14	0.29	0.04	0.23	0.00	0.05	0.06
208	3.5459	3.5153	3.1094	2.9104	2.7829	3.0669	2.495	0.30	0.30	0.29	0.20	0.14	0.10	0.19	0.00
209	2.0149	3.5472	2.0249	2.4678	2.1554	2.3188	2.2013	0.43	0.00	0.43	0.00	0.18	0.07	0.13	0.08
210	3.2624	3.4317	3.3443	3.5481	3.0334	2.9877	2.9053	0.18	0.11	0.15	0.13	0.18	0.04	0.03	0.00
211	2.3605	3.5074	2.3078	2.2004	2.0535	2.3016	2.1145	0.41	0.13	0.41	0.11	0.07	0.00	0.11	0.03
212	2.9285	3.7652	2.9311	2.8225	2.5408	2.8658	2.6804	0.33	0.13	0.33	0.13	0.10	0.00	0.11	0.05
213	4.1492	4.9756	3.5549	4.2614	3.1025	4.0333	3.2171	0.38	0.25	0.38	0.13	0.27	0.00	0.23	0.04
214	2.3017	3.7417	2.9032	3.4632	2.4501	2.7074	2.6416	0.38	0.00	0.38	0.21	0.34	0.06	0.15	0.13
215	3.0212	3.4849	2.1908	2.3684	1.9483	2.1169	1.8324	0.47	0.39	0.47	0.16	0.23	0.06	0.13	0.00
216	3.6918	3.9893	3.3623	4.6007	3.5166	3.9163	3.2693	0.29	0.11	0.18	0.03	0.29	0.07	0.17	0.00
217	4.3991	5.2468	3.4007	4.1109	3.0697	4.8526	3.4509	0.41	0.30	0.41	0.10	0.25	0.00	0.37	0.11
218	3.1133	3.7438	3.0097	3.1799	2.6603	3.4455	2.6261	0.30	0.16	0.30	0.13	0.17	0.01	0.24	0.00
219	2.8438	4.089	2.8954	3.4617	3.1187	3.4566	3.2234	0.30	0.00	0.30	0.02	0.18	0.09	0.18	0.12
220	2.7785	2.5239	2.8658	2.5519	2.5704	2.6503	2.5617	0.12	0.09	0.00	0.12	0.01	0.02	0.05	0.01
221	2.8637	3.5469	2.7643	2.858	2.51	3.2007	2.8845	0.29	0.12	0.29	0.09	0.12	0.00	0.22	0.13
222	2.3368	3.9013	2.83	2.8002	2.7303	2.5393	2.4763	0.40	0.00	0.40	0.17	0.17	0.14	0.08	0.06
223	3.0283	3.3861	2.5886	3.565	2.3407	2.9806	2.9595	0.34	0.23	0.31	0.10	0.34	0.00	0.21	0.21
224	2.7751	2.6355	2.7414	2.2732	2.7947	2.5999	2.353	0.19	0.18	0.14	0.17	0.00	0.19	0.13	0.03
225	3.291	4.2229	3.3221	3.8072	3.3062	3.763	3.2341	0.23	0.02	0.23	0.03	0.15	0.02	0.14	0.00
226	4.7041	4.7069	3.8529	4.2966	3.8692	3.9895	3.5584	0.24	0.24	0.24	0.08	0.17	0.08	0.11	0.00
227	4.0463	5.1565	4.7255	4.8629	4.0519	5.0035	4.5089	0.22	0.00	0.22	0.14	0.17	0.00	0.19	0.10
228	2.8351	3.0802	3.105	2.8381	2.5241	2.6673	2.801	0.19	0.11	0.18	0.19	0.11	0.00	0.05	0.10
229	2.0483	2.3183	1.885	1.8088	1.4712	1.9615	1.8025	0.37	0.28	0.37	0.22	0.19	0.00	0.25	0.18
230	3.1995	4.6599	3.2839	3.536	2.9709	3.3429	2.9028	0.38	0.09	0.38	0.12	0.18	0.02	0.13	0.00
231	2.3476	2.6285	2.77	2.6023	2.3117	2.5821	2.6664	0.17	0.02	0.12	0.17	0.11	0.00	0.10	0.13
232	2.7685	3.453	3.1383	2.4606	2.427	2.8884	2.4692	0.30	0.12	0.30	0.23	0.01	0.00	0.16	0.02
233	2.7472	4.0752	2.7103	2.6307	2.8835	2.5915	2.6173	0.36	0.06	0.36	0.04	0.01	0.10	0.00	0.01
234	3.3185	3.7386	3.7211	3.5674	3.5345	3.9314	3.4831	0.16	0.00	0.11	0.11	0.07	0.06	0.16	0.05
235	2.4579	2.9259	2.2808	2.3373	2.305	1.9586	1.9697	0.33	0.20	0.33	0.14	0.16	0.15	0.00	0.01
236	2.971	3.6775	3.5332	2.9898	3.0773	3.5922	2.8904	0.21	0.03	0.21	0.18	0.03	0.06	0.20	0.00
237	3.1075	4.1603	3.7015	3.1593	2.8435	3.4413	3.4026	0.32	0.08	0.32	0.23	0.10	0.00	0.17	0.16
238	3.0351	3.0709	3.0395	2.9762	3.0415	3.0121	3.0166	0.03	0.02	0.03	0.02	0.00	0.02	0.01	0.01
239	2.2795	2.138	1.6367	1.6569	1.6926	1.8458	1.566	0.31	0.31	0.27	0.04	0.05	0.07	0.15	0.00
240	2.1083	2.2401	2.3742	2.3602	1.94	2.1606	2.1987	0.18	0.08	0.13	0.18	0.18	0.00	0.10	0.12
241	3.2718	3.8914	3.1165	4.0039	3.2261	3.2309	3.2334	0.22	0.05	0.20	0.00	0.22	0.03	0.04	0.04
242	1.5838	2.9554	1.2751	1.6003	1.5797	2.0657	1.2094	0.59	0.24	0.59	0.05	0.24	0.23	0.41	0.00
243	2.3562	2.7465	2.7749	2.6048	2.6367	2.6787	2.4809	0.15	0.00	0.14	0.15	0.10	0.11	0.12	0.05
244	3.5292	5.1347	3.3792	4.1082	3.1018	4.2546	3.7757	0.40	0.12	0.40	0.08	0.24	0.00	0.27	0.18
245	3.2504	3.6357	3.0421	3.3702	2.7395	3.5445	2.7123	0.25	0.17	0.25	0.11	0.20	0.01	0.23	0.00
246	2.2142	3.9855	2.4003	2.7091	2.0642	2.8883	2.3641	0.48	0.07	0.48	0.14	0.24	0.00	0.29	0.13
247	1.9929	2.3886	2.566	2.3852	2.2518	2.3532	2.1373	0.22	0.00	0.17	0.22	0.16	0.11	0.15	0.07
248	2.315	2.8115	2.6046	2.8889	1.8236	2.343	2.2416	0.37	0.21	0.35	0.30	0.37	0.00	0.22	0.19
249	4.281	4.1591	4.2039	4.3789	3.7599	3.9876	3.915	0.14	0.12	0.10	0.11	0.14	0.00	0.06	0.04
250	2.7735	4.5631	3.019	3.2964	2.6099	3.0976	2.9858	0.43	0.06	0.43	0.14	0.21	0.00	0.16	0.13
251	3.9342	5.4529	3.9405	4.0924	4.0561	4.2486	4.0611	0.28	0.00	0.28	0.00	0.04	0.03	0.07	0.03
252	3.3158	3.4101	3.2572	3.0828	2.9337	3.1405	3.0562	0.14	0.12	0.14	0.10	0.05	0.00	0.07	0.04
253	2.7189	3.8753	2.5219	2.6231	2.1638	2.5189	2.4771	0.44	0.20	0.44	0.14	0.18	0.00	0.14	0.13
254	3.8424	3.7909	3.7244	3.6457	3.377	3.5089	3.4218	0.12	0.12	0.11	0.09	0.07	0.00	0.04	0.01
255	1.979	3.5803	1.7031	2.6729	1.6751	2.4089	1.75	0.53	0.15	0.53	0.02	0.37	0.00	0.30	0.04
256	3.0444	3.2898	2.9583	2.8976	2.7225	3.0197	2.6288	0.20	0.14	0.20	0.11	0.09	0.03	0.13	0.00
257	4.3635	5.5646	4.5766	4.6777	4.6901	4.8804	4.6198	0.22	0.00	0.22	0.05	0.07	0.07	0.11	0.06
258	1.3228	2.5803	1.45	1.493	1.3219	1.4316	1.2016	0.53	0.09	0.53	0.17	0.20	0.09	0.16	0.00

259	3.8952	4.1364	2.7984	3.566	2.61	2.5481	2.3265	0.44	0.40	0.44	0.17	0.35	0.11	0.09	0.00
260	3.0026	3.7026	3.1852	3.298	2.6299	2.9701	2.4847	0.33	0.17	0.33	0.22	0.25	0.06	0.16	0.00
261	3.1452	4.6486	3.1053	3.6458	3.0449	2.8167	2.9312	0.39	0.10	0.39	0.09	0.23	0.07	0.00	0.04
262	3.1911	3.8694	2.9582	3.4003	2.4391	2.8822	2.3489	0.39	0.26	0.39	0.21	0.31	0.04	0.19	0.00
263	3.7605	4.1435	3.6933	4.0508	3.4898	3.8966	3.3202	0.20	0.12	0.20	0.10	0.18	0.05	0.15	0.00
264	3.4858	4.9997	3.3281	4.7122	3.0955	4.1395	3.4511	0.38	0.11	0.38	0.07	0.34	0.00	0.25	0.10
265	2.3661	4.2461	2.5741	2.5786	2.1018	2.503	2.5349	0.51	0.11	0.51	0.18	0.18	0.00	0.16	0.17
266	2.5669	3.2369	2.3448	2.5485	2.3917	2.3851	2.3771	0.28	0.09	0.28	0.00	0.08	0.02	0.02	0.01
267	2.3838	3.2752	2.29	2.3385	1.798	2.4597	1.913	0.45	0.25	0.45	0.21	0.23	0.00	0.27	0.06
268	3.5233	4.0656	3.455	3.0601	3.4257	3.5923	3.2378	0.25	0.13	0.25	0.11	0.00	0.11	0.15	0.05
269	3.0171	3.7792	3.1493	3.1955	3.0044	3.6806	3.2896	0.21	0.00	0.21	0.05	0.06	0.00	0.18	0.09
270	2.9598	3.3297	3.4632	3.0319	3.1229	3.5395	3.2218	0.16	0.00	0.11	0.15	0.02	0.05	0.16	0.08
271	3.0569	4.8323	2.86	3.2439	2.6272	3.5387	2.8452	0.46	0.14	0.46	0.08	0.19	0.00	0.26	0.08
272	3.043	3.8352	2.577	2.0718	2.0743	2.463	2.0773	0.46	0.32	0.46	0.20	0.00	0.00	0.16	0.00
273	2.8899	3.9531	2.7777	3.6823	2.7432	2.9026	2.9191	0.31	0.05	0.31	0.01	0.26	0.00	0.05	0.06
274	5.1066	4.7282	4.2254	4.4129	3.8856	4.182	4.2119	0.24	0.24	0.18	0.08	0.12	0.00	0.07	0.08
275	3.0157	3.7109	2.6656	2.8342	2.611	2.6141	2.645	0.30	0.13	0.30	0.02	0.08	0.00	0.00	0.01
276	2.5519	3.3027	2.3951	2.825	2.2289	2.8128	2.577	0.33	0.13	0.33	0.07	0.21	0.00	0.21	0.14
277	2.7338	3.8031	2.8614	2.9434	2.8039	3.2624	2.7093	0.29	0.01	0.29	0.05	0.08	0.03	0.17	0.00
278	3.1908	4.1548	3.3313	3.338	3.0885	3.1439	2.9852	0.28	0.06	0.28	0.10	0.11	0.03	0.05	0.00
279	2.4405	3.7264	2.0589	1.742	1.7829	2.2995	1.6978	0.54	0.30	0.54	0.18	0.03	0.05	0.26	0.00
280	3.0513	4.2971	3.6378	3.5942	3.1038	3.3592	3.0869	0.29	0.00	0.29	0.16	0.15	0.02	0.09	0.01
281	2.9966	3.1891	2.8495	3.2232	2.5634	2.5251	2.423	0.25	0.19	0.24	0.15	0.25	0.05	0.04	0.00
282	2.5097	3.2485	2.6372	3.0708	2.5457	3.0177	2.3782	0.27	0.05	0.27	0.10	0.23	0.07	0.21	0.00
283	2.0549	3.0107	2.2704	2.4418	1.9847	2.6421	2.3488	0.34	0.03	0.34	0.13	0.19	0.00	0.25	0.16
284	3.1736	4.0492	2.8139	3.6823	2.7331	3.8856	2.4781	0.39	0.22	0.39	0.12	0.33	0.09	0.36	0.00
285	4.0631	4.7067	4.4547	4.2624	3.9477	4.4007	4.0559	0.16	0.03	0.16	0.11	0.07	0.00	0.10	0.03
286	2.0794	2.9443	2.281	1.9249	1.9628	2.2886	1.9665	0.35	0.07	0.35	0.16	0.00	0.02	0.16	0.02
287	3.3129	3.4617	2.8306	3.2589	2.8804	3.294	2.4488	0.29	0.26	0.29	0.13	0.25	0.15	0.26	0.00
288	3.4193	3.2528	2.9208	2.8854	2.8549	3.1169	3.0299	0.17	0.17	0.12	0.02	0.01	0.00	0.08	0.06
289	2.7958	3.7703	3.4367	2.6183	3.0132	2.6216	2.9185	0.31	0.06	0.31	0.24	0.00	0.13	0.00	0.10
290	3.2937	3.7195	2.4232	3.0247	2.6009	2.3802	2.5705	0.36	0.28	0.36	0.02	0.21	0.08	0.00	0.07
291	0.9836	2.161	1.0215	1.1296	1.0097	1.0379	1.0203	0.54	0.00	0.54	0.04	0.13	0.03	0.05	0.04
292	3.6134	3.8999	3.1597	3.9333	3.3091	3.3831	3.4133	0.20	0.13	0.19	0.00	0.20	0.05	0.07	0.07
293	2.5083	2.6289	1.9558	2.3779	2.2933	2.6415	1.9925	0.26	0.22	0.26	0.00	0.18	0.15	0.26	0.02
294	2.6805	3.8333	3.4149	2.6442	2.7887	3.1057	2.8546	0.31	0.01	0.31	0.23	0.00	0.05	0.15	0.07
295	3.7972	3.8128	3.1231	3.0141	3.2591	2.8689	2.9844	0.25	0.24	0.25	0.08	0.05	0.12	0.00	0.04
296	3.6801	3.8789	3.2179	3.4603	2.9373	3.5473	3.2562	0.24	0.20	0.24	0.09	0.15	0.00	0.17	0.10
297	2.2872	3.6498	2.687	2.7377	2.3604	2.8999	2.3598	0.37	0.00	0.37	0.15	0.16	0.03	0.21	0.03
298	3.5527	3.8972	3.3238	3.8285	3.3573	3.5062	3.2852	0.16	0.08	0.16	0.01	0.14	0.02	0.06	0.00
299	3.1902	4.5481	3.7082	3.3425	3.1388	3.5439	3.1043	0.32	0.03	0.32	0.16	0.07	0.01	0.12	0.00
300	3.1262	4.2649	2.946	3.1814	2.6276	3.2934	2.8441	0.38	0.16	0.38	0.11	0.17	0.00	0.20	0.08
301	3.4241	3.5551	2.9144	3.2096	2.7958	2.99	2.5932	0.27	0.24	0.27	0.11	0.19	0.07	0.13	0.00
302	3.1883	3.3146	2.9246	2.7223	2.6566	2.5891	2.5784	0.22	0.19	0.22	0.12	0.05	0.03	0.00	0.00
303	2.9941	3.3603	2.8038	3.1749	2.8577	2.5826	2.6679	0.23	0.14	0.23	0.08	0.19	0.10	0.00	0.03
304	2.4362	2.5584	3.3103	2.2874	2.4548	3.2421	2.4194	0.31	0.06	0.11	0.31	0.00	0.07	0.29	0.05
305	2.5968	2.475	2.8473	2.4096	2.4366	2.3147	2.4108	0.19	0.11	0.06	0.19	0.04	0.05	0.00	0.04
306	2.794	3.1766	3.3081	2.7104	2.9048	2.8432	2.7478	0.18	0.03	0.15	0.18	0.00	0.07	0.05	0.01
307	3.5516	4.3021	2.9157	4.3297	3.0917	3.1361	2.8969	0.33	0.18	0.33	0.01	0.33	0.06	0.08	0.00
308	3.2225	3.1353	2.7129	2.9068	2.5089	3.048	2.7135	0.22	0.22	0.20	0.08	0.14	0.00	0.18	0.08
309	2.2501	3.0763	2.6648	2.508	2.4423	2.9509	2.4003	0.27	0.00	0.27	0.16	0.10	0.08	0.24	0.06
310	2.9226	3.9455	3.1826	3.4482	3.0939	3.1705	3.1373	0.26	0.00	0.26	0.08	0.15	0.06	0.08	0.07
311	3.3853	4.3464	3.5675	3.3104	3.1502	3.4371	2.9063	0.33	0.14	0.33	0.19	0.12	0.08	0.15	0.00
312	1.8524	2.0956	2.1952	2.0309	2.2468	2.0741	1.9947	0.18	0.00	0.12	0.16	0.09	0.18	0.11	0.07
313	4.8251	4.0096	4.0404	4.388	3.7148	3.7705	3.5607	0.26	0.26	0.11	0.12	0.19	0.04	0.06	0.00
314	2.3634	2.9632	2.3992	2.7564	2.1751	2.3371	2.11	0.29	0.11	0.29	0.12	0.23	0.03	0.10	0.00
315	3.1596	1.7945	2.4068	2.197	2.1661	2.0559	2.0787	0.43	0.43	0.00	0.25	0.18	0.17	0.13	0.14
316	3.0435	3.6997	3.034	3.2567	3.0299	3.2933	3.2899	0.18	0.00	0.18	0.00	0.07	0.00	0.08	0.08
317	3.0665	3.3636	2.9296	3.3897	2.811	2.7436	2.7358	0.19	0.11	0.19	0.07	0.19	0.03	0.00	0.00
318	3.2299	3.3273	3.2211	3.0257	3.0902	3.1949	3.117	0.09	0.06	0.09	0.06	0.00	0.02	0.05	0.03
319	2.9187	5.3945	2.883	3.1302	2.5547	3.2198	2.643	0.53	0.12	0.53	0.11	0.18	0.00	0.21	0.03
320	4.2217	4.1693	4.2462	4.0099	3.9728	3.7026	3.9399	0.13	0.12	0.11	0.13	0.08	0.07	0.00	0.06
321	3.6527	4.3541	2.8548	3.3047	3.2178	3.4094	3.08	0.34	0.22	0.34	0.00	0.14	0.11	0.16	0.07
322	2.6459	2.8866	2.5929	2.8977	2.4912	2.6882	2.59	0.14	0.06	0.14	0.04	0.14	0.00	0.07	0.04
323	3.4977	2.4383	2.6154	2.5926	2.9238	2.5901	2.5472	0.30	0.30	0.00	0.07	0.06	0.17	0.06	0.04
324	2.4816	4.0508	2.5963	2.6513	2.182	2.576	2.4536	0.46	0.12	0.46	0.16	0.18	0.00	0.15	0.11

325	3.7115	3.7444	3.088	3.8181	2.9518	3.3449	2.6093	0.32	0.30	0.30	0.16	0.32	0.12	0.22	0.00
326	2.7185	3.3997	2.9735	3.4008	3.2526	3.0857	3.1355	0.20	0.00	0.20	0.09	0.20	0.16	0.12	0.13
327	4.7814	4.6662	4.2951	4.2467	4.0649	4.5481	4.0879	0.15	0.15	0.13	0.05	0.04	0.00	0.11	0.01
328	3.6475	3.2179	2.8333	3.5204	3.0196	3.0118	2.8327	0.22	0.22	0.12	0.00	0.20	0.06	0.06	0.00
329	4.117	3.7736	4.0722	4.2599	4.0341	4.0919	3.7839	0.11	0.08	0.00	0.07	0.11	0.06	0.08	0.00
330	4.0055	5.4266	3.9072	4.8586	3.8213	4.4331	3.4661	0.36	0.13	0.36	0.11	0.29	0.09	0.22	0.00
331	2.5043	2.1689	2.4268	2.5244	2.352	2.0315	2.2579	0.20	0.19	0.06	0.16	0.20	0.14	0.00	0.10
332	2.6733	3.2094	2.7985	2.7805	2.4618	2.3791	2.5032	0.26	0.11	0.26	0.15	0.14	0.03	0.00	0.05
333	2.8124	3.7178	2.6813	3.7686	2.6944	2.3176	2.4909	0.39	0.18	0.38	0.14	0.39	0.14	0.00	0.07
334	2.8979	3.4628	2.7865	3.5419	2.9525	3.4817	2.9875	0.21	0.04	0.20	0.00	0.21	0.06	0.20	0.07
335	3.5864	3.901	3.6859	3.3996	3.1112	3.1968	3.0228	0.23	0.16	0.23	0.18	0.11	0.03	0.05	0.00
336	2.8986	3.1475	2.8573	2.6984	2.586	2.8208	2.7641	0.18	0.11	0.18	0.09	0.04	0.00	0.08	0.06
337	2.0459	3.3483	2.444	2.6879	1.8949	2.4938	1.9419	0.43	0.07	0.43	0.22	0.30	0.00	0.24	0.02
338	2.5681	2.874	2.7479	2.6755	2.5332	2.7043	2.4585	0.14	0.04	0.14	0.11	0.08	0.03	0.09	0.00
339	3.5475	4.5501	2.8879	3.8445	2.818	2.7593	2.5775	0.43	0.27	0.43	0.11	0.33	0.09	0.07	0.00
340	4.0849	4.6821	3.6245	4.7455	3.5172	3.7418	3.5542	0.26	0.14	0.25	0.03	0.26	0.00	0.06	0.01
341	2.9456	3.5585	2.4052	2.269	2.221	2.1969	2.2282	0.38	0.25	0.38	0.09	0.03	0.01	0.00	0.01
342	3.0743	4.2492	2.9793	3.5456	3.3501	3.6438	3.1859	0.30	0.03	0.30	0.00	0.16	0.11	0.18	0.06
343	2.7943	4.0609	3.1078	3.6513	2.4799	2.9146	2.2523	0.45	0.19	0.45	0.28	0.38	0.09	0.23	0.00
344	3.6174	4.2013	3.2414	4.4115	3.102	3.1179	3.2171	0.30	0.14	0.26	0.04	0.30	0.00	0.01	0.04
345	3.0585	3.4001	3.3417	2.8444	2.8308	3.2519	2.629	0.23	0.14	0.23	0.21	0.08	0.07	0.19	0.00
346	3.9958	5.1202	4.0435	3.735	3.2615	4.3995	3.6892	0.36	0.18	0.36	0.19	0.13	0.00	0.26	0.12
347	4.3565	4.6502	3.0221	4.6205	3.3715	2.9736	3.3102	0.36	0.32	0.36	0.02	0.36	0.12	0.00	0.10
348	4.0436	4.6925	3.4956	4.0885	3.3842	3.7236	3.5531	0.28	0.16	0.28	0.03	0.17	0.00	0.09	0.05
349	4.1114	4.4755	3.4878	3.5686	3.3088	3.4227	3.4189	0.26	0.20	0.26	0.05	0.07	0.00	0.03	0.03
350	3.044	2.7794	2.696	3.1763	2.6534	2.5549	2.4869	0.22	0.18	0.11	0.08	0.22	0.06	0.03	0.00
351	1.7601	3.5871	1.9503	2.1511	1.9285	2.5546	2.0626	0.51	0.00	0.51	0.10	0.18	0.09	0.31	0.15
352	3.2748	3.7907	3.4214	3.4529	3.2838	3.4587	3.6388	0.14	0.00	0.14	0.04	0.05	0.00	0.05	0.10
353	4.4307	4.3157	3.9928	3.5205	3.6931	4.1233	3.9103	0.21	0.21	0.18	0.12	0.00	0.05	0.15	0.10
354	1.998	2.2468	1.9133	2.4173	1.9566	1.8964	1.6234	0.33	0.19	0.28	0.15	0.33	0.17	0.14	0.00
355	3.8129	4.2794	3.7847	3.8073	3.4973	4.0634	3.3082	0.23	0.13	0.23	0.13	0.13	0.05	0.19	0.00
356	1.3642	2.7191	1.4439	1.0172	0.9117	1.164	1.1057	0.66	0.33	0.66	0.37	0.10	0.00	0.22	0.18
357	3.3812	4.4596	3.7527	3.7057	3.2564	3.4394	3.7445	0.27	0.04	0.27	0.13	0.12	0.00	0.05	0.13
358	2.7962	3.3536	3.1351	3.2831	2.6221	3.1929	3.089	0.22	0.06	0.22	0.16	0.20	0.00	0.18	0.15
359	4.1567	5.3435	3.4114	3.9326	3.1951	3.9809	3.0622	0.43	0.26	0.43	0.10	0.22	0.04	0.23	0.00
360	3.2325	3.5944	3.57	2.5344	2.3912	3.1511	2.5384	0.33	0.26	0.33	0.33	0.06	0.00	0.24	0.06
361	2.6511	3.3669	2.3338	2.347	2.0004	2.2747	1.9788	0.41	0.25	0.41	0.15	0.16	0.01	0.13	0.00
362	1.7918	4.4622	1.5317	1.7342	1.5031	1.4565	1.4682	0.67	0.19	0.67	0.05	0.16	0.03	0.00	0.01
363	2.9437	4.0327	2.8704	3.1062	3.1902	3.2625	2.9392	0.29	0.02	0.29	0.00	0.08	0.10	0.12	0.02
364	3.8893	4.0936	4.3573	3.9597	3.7526	4.393	4.1886	0.15	0.04	0.08	0.14	0.05	0.00	0.15	0.10
365	3.0493	3.6466	2.7562	3.2452	2.8643	2.5218	2.6144	0.31	0.17	0.31	0.09	0.22	0.12	0.00	0.04
366	4.357	4.3269	4.251	4.3282	3.9566	3.8702	3.8264	0.12	0.12	0.12	0.10	0.12	0.03	0.01	0.00
367	3.1259	3.2583	2.2975	2.675	2.2457	2.4379	2.1252	0.35	0.32	0.35	0.07	0.21	0.05	0.13	0.00
368	3.5167	3.9963	2.9026	3.622	2.9555	3.175	3.5086	0.27	0.17	0.27	0.00	0.20	0.02	0.09	0.17
369	2.6743	3.8621	3.0379	3.1098	2.9812	2.8146	2.8437	0.31	0.00	0.31	0.12	0.14	0.10	0.05	0.06
370	2.581	2.0079	1.9367	2.3492	2.1633	1.7637	1.954	0.32	0.32	0.12	0.09	0.25	0.18	0.00	0.10
371	2.0587	2.4004	2.2875	2.2621	1.9945	2.2111	1.9899	0.17	0.03	0.17	0.13	0.12	0.00	0.10	0.00
372	2.4297	3.2586	1.979	2.7291	1.9495	2.3264	2.556	0.40	0.20	0.40	0.01	0.29	0.00	0.16	0.24
373	3.0313	3.6133	2.8203	3.0098	2.3478	2.9715	2.4	0.35	0.23	0.35	0.17	0.22	0.00	0.21	0.02
374	2.4697	3.2725	2.8865	2.6395	2.4901	2.7711	2.4006	0.27	0.03	0.27	0.17	0.09	0.04	0.13	0.00
375	2.7264	3.4259	2.664	2.9009	2.579	2.7489	2.5408	0.26	0.07	0.26	0.05	0.12	0.01	0.08	0.00
376	2.4903	3.6338	2.1127	3.3776	1.8891	2.4887	2.0823	0.48	0.24	0.48	0.11	0.44	0.00	0.24	0.09
377	2.9498	3.8985	2.4959	2.7653	2.8227	2.6664	2.5138	0.36	0.15	0.36	0.00	0.10	0.12	0.06	0.01
378	3.9527	5.0408	4.3421	4.9198	3.6552	4.3448	4.0574	0.27	0.08	0.27	0.16	0.26	0.00	0.16	0.10
379	2.5184	3.2392	2.5048	2.5362	2.2814	2.8034	2.5066	0.30	0.09	0.30	0.09	0.10	0.00	0.19	0.09
380	2.7911	3.7267	3.2524	3.0893	2.6769	3.3125	2.9737	0.28	0.04	0.28	0.18	0.13	0.00	0.19	0.10
381	3.1427	3.413	3.1428	3.3576	2.6888	2.8781	2.6254	0.23	0.16	0.23	0.16	0.22	0.02	0.09	0.00
382	2.57	3.4574	2.8784	2.8196	2.3641	2.3674	2.6866	0.32	0.08	0.32	0.18	0.16	0.00	0.00	0.12
383	2.6352	4.2456	2.8851	3.6431	2.6677	2.5307	2.5908	0.40	0.04	0.40	0.12	0.31	0.05	0.00	0.02
384	2.3305	3.2521	2.3527	2.5011	2.3799	2.6938	2.5554	0.28	0.00	0.28	0.01	0.07	0.02	0.13	0.09
385	3.0402	3.7867	3.346	3.5833	2.9098	3.3469	2.9206	0.23	0.04	0.23	0.13	0.19	0.00	0.13	0.00
386	3.7971	4.6951	4.0979	4.0374	3.8744	4.0431	3.8764	0.19	0.00	0.19	0.07	0.06	0.02	0.06	0.02
387	2.8879	3.4786	3.1194	2.8581	3.0229	2.8944	2.8687	0.18	0.01	0.18	0.08	0.00	0.05	0.01	0.00
388	2.3005	3.4639	2.4523	2.3376	2.2489	2.33	2.1947	0.37	0.05	0.37	0.11	0.06	0.02	0.06	0.00
389	2.844	3.6543	3.2419	3.2965	2.92	3.4523	3.2949	0.22	0.00	0.22	0.12	0.14	0.03	0.18	0.14
390	3.1193	3.0784	2.4782	2.9566	2.7754	2.7015	2.3974	0.23	0.23	0.22	0.03	0.19	0.14	0.11	0.00

391	2.9468	2.3442	2.525	2.9132	2.2522	2.2262	2.1732	0.26	0.26	0.07	0.14	0.25	0.04	0.02	0.00
392	3.6796	4.2319	3.5363	4.3009	3.9026	3.6993	3.6534	0.18	0.04	0.16	0.00	0.18	0.09	0.04	0.03
393	2.9038	4.0867	3.1716	3.4503	2.5773	2.9355	3.1093	0.37	0.11	0.37	0.19	0.25	0.00	0.12	0.17
394	2.565	3.1661	1.8272	2.0916	1.4942	2.0493	1.899	0.53	0.42	0.53	0.18	0.29	0.00	0.27	0.21
395	3.6627	4.4196	3.5191	3.7741	3.4632	3.8064	3.4505	0.22	0.06	0.22	0.02	0.09	0.00	0.09	0.00
396	2.9989	3.6724	2.5454	2.4558	2.0954	2.3024	1.9798	0.46	0.34	0.46	0.22	0.19	0.06	0.14	0.00
397	2.3589	3.9841	2.7405	2.7115	2.3468	3.0608	2.5858	0.41	0.01	0.41	0.14	0.13	0.00	0.23	0.09
398	2.5361	2.6231	2.0673	2.6989	2.2769	2.2487	2.0723	0.23	0.18	0.21	0.00	0.23	0.09	0.08	0.00
399	3.2251	4.1704	2.9535	2.9344	2.1464	2.8925	2.0573	0.51	0.36	0.51	0.30	0.30	0.04	0.29	0.00
400	1.9921	2.8696	1.8003	2.659	1.78	2.2819	2.2606	0.38	0.11	0.38	0.01	0.33	0.00	0.22	0.21
401	5.0499	5.481	4.8368	4.7283	4.4376	4.7954	4.2736	0.22	0.15	0.22	0.12	0.10	0.04	0.11	0.00
402	3.2888	3.7309	3.0135	2.8639	2.4623	2.6634	2.6197	0.34	0.25	0.34	0.18	0.14	0.00	0.08	0.06
403	3.6415	4.3557	3.5862	3.8089	3.5481	3.688	3.7816	0.19	0.03	0.19	0.01	0.07	0.00	0.04	0.06
404	3.2657	3.8065	2.3037	2.9265	2.8058	2.984	3.189	0.39	0.29	0.39	0.00	0.21	0.18	0.23	0.28
405	2.8941	4.0443	2.7764	4.0122	2.4242	2.7752	2.7065	0.40	0.16	0.40	0.13	0.40	0.00	0.13	0.10
406	2.2228	2.9864	2.126	2.5669	2.1529	2.2663	2.2075	0.29	0.04	0.29	0.00	0.17	0.01	0.06	0.04
407	2.6696	3.4286	2.6823	2.2649	2.0672	2.7646	2.2031	0.40	0.23	0.40	0.23	0.09	0.00	0.25	0.06
408	3.2805	3.6821	3.1024	3.5605	3.0384	3.3462	3.2325	0.17	0.07	0.17	0.02	0.15	0.00	0.09	0.06
409	2.9229	3.6247	3.0167	2.7173	2.429	3.3742	2.5801	0.33	0.17	0.33	0.19	0.11	0.00	0.28	0.06
410	4.1318	5.0683	3.6214	3.5882	3.3484	3.7422	3.4238	0.34	0.19	0.34	0.08	0.07	0.00	0.11	0.02
411	3.523	4.6574	3.4974	3.5873	3.3702	3.2773	3.5924	0.30	0.07	0.30	0.06	0.09	0.03	0.00	0.09
412	2.1814	3.8218	2.5131	2.3966	2.0187	2.0755	1.7632	0.54	0.19	0.54	0.30	0.26	0.13	0.15	0.00
413	3.5279	4.2257	2.9895	3.2272	2.7544	2.8929	2.896	0.35	0.22	0.35	0.08	0.15	0.00	0.05	0.05
414	3.0403	5.2341	3.2491	2.7842	2.7879	3.6257	2.7426	0.48	0.10	0.48	0.16	0.01	0.02	0.24	0.00
415	2.7612	4.2927	3.1854	2.6436	2.7151	3.763	2.6588	0.38	0.04	0.38	0.17	0.00	0.03	0.30	0.01
416	2.8457	2.7606	3.032	2.4651	2.487	2.8654	2.6552	0.19	0.13	0.11	0.19	0.00	0.01	0.14	0.07
417	3.6071	4.1309	3.5856	3.7386	3.8571	4.0751	4.0214	0.13	0.01	0.13	0.00	0.04	0.07	0.12	0.11
418	3.7708	4.789	3.8438	3.7205	3.6102	4.3547	3.6381	0.25	0.04	0.25	0.06	0.03	0.00	0.17	0.01
419	3.3697	4.2264	2.7556	3.6671	2.7311	2.7757	2.7705	0.35	0.19	0.35	0.01	0.26	0.00	0.02	0.01
420	2.7704	3.1591	3.0518	3.2021	3.0205	3.1504	3.0493	0.13	0.00	0.12	0.09	0.13	0.08	0.12	0.09
421	3.1057	3.8168	2.7224	2.8568	2.3841	2.5837	2.7114	0.38	0.23	0.38	0.12	0.17	0.00	0.08	0.12
422	3.4657	4.2458	3.9057	3.5135	3.5682	3.9977	3.4051	0.20	0.02	0.20	0.13	0.03	0.05	0.15	0.00
423	4.0767	4.0525	3.1989	3.8554	3.1444	3.2475	3.4084	0.23	0.23	0.22	0.02	0.18	0.00	0.03	0.08
424	3.4208	4.3745	3.9177	3.9535	3.6759	4.3809	3.4793	0.22	0.00	0.22	0.13	0.13	0.07	0.22	0.02
425	2.7918	4.3045	2.7099	3.3273	2.7375	2.7405	2.5528	0.41	0.09	0.41	0.06	0.23	0.07	0.07	0.00
426	2.5833	3.2009	2.6455	2.5139	2.6132	2.7125	2.5765	0.21	0.03	0.21	0.05	0.00	0.04	0.07	0.02
427	2.7301	4.1328	3.3488	3.2968	3.0618	3.726	3.0087	0.34	0.00	0.34	0.18	0.17	0.11	0.27	0.09
428	3.6849	3.7241	2.9613	3.6921	2.6782	2.8971	2.8399	0.28	0.27	0.28	0.10	0.27	0.00	0.08	0.06
429	3.5121	4.308	3.4731	3.3069	3.1223	3.3626	3.3153	0.28	0.11	0.28	0.10	0.06	0.00	0.07	0.06
430	2.8821	3.4506	2.8329	2.6252	2.4217	2.5516	2.6394	0.30	0.16	0.30	0.15	0.08	0.00	0.05	0.08
431	4.0558	4.1964	4.1255	3.9198	3.8302	4.1552	3.9427	0.09	0.06	0.09	0.07	0.02	0.00	0.08	0.03
432	2.633	2.902	2.8988	2.7485	2.7622	3.0256	2.597	0.14	0.01	0.11	0.10	0.06	0.06	0.14	0.00
433	3.2107	3.5006	3.1223	3.0184	2.5841	2.9732	3.256	0.26	0.20	0.26	0.17	0.14	0.00	0.13	0.21
434	3.4844	4.2252	3.0467	3.6022	3.0979	3.5069	3.2182	0.28	0.13	0.28	0.00	0.15	0.02	0.13	0.05
435	3.1311	3.4921	2.6587	2.3588	2.3849	2.796	2.3979	0.32	0.25	0.32	0.11	0.00	0.01	0.16	0.02
436	3.5655	3.9006	3.5648	3.7155	2.9193	3.2589	3.0808	0.25	0.18	0.25	0.18	0.21	0.00	0.10	0.05
437	3.4943	3.6642	3.3444	3.929	3.2711	3.3123	3.3559	0.17	0.06	0.11	0.02	0.17	0.00	0.01	0.03
438	2.7137	3.4823	3.2301	2.9219	2.773	3.0556	2.4259	0.30	0.11	0.30	0.25	0.17	0.13	0.21	0.00
439	2.0922	3.173	2.3152	2.0027	1.9882	2.3675	1.9055	0.40	0.09	0.40	0.18	0.05	0.04	0.20	0.00
440	3.535	3.5197	3.4219	3.2241	3.0571	3.3951	3.244	0.14	0.14	0.13	0.11	0.05	0.00	0.10	0.06
441	2.901	3.0283	2.1645	2.9778	1.9171	2.427	2.182	0.37	0.34	0.37	0.11	0.36	0.00	0.21	0.12
442	3.7003	4.3363	4.3097	4.3936	3.6214	4.0989	4.1099	0.18	0.02	0.16	0.16	0.18	0.00	0.12	0.12
443	3.4422	4.1694	3.7302	3.6623	3.2059	3.9084	3.6711	0.23	0.07	0.23	0.14	0.12	0.00	0.18	0.13
444	3.1993	3.2646	3.3283	3.4879	3.0491	3.0556	2.9253	0.16	0.09	0.10	0.12	0.16	0.04	0.04	0.00
445	2.1625	1.9027	2.3791	1.9641	1.8201	1.8981	1.8977	0.23	0.16	0.04	0.23	0.07	0.00	0.04	0.04
446	2.7972	4.0247	3.0086	3.1973	2.3196	2.8618	2.2954	0.43	0.18	0.43	0.24	0.28	0.01	0.20	0.00
447	3.802	5.3245	3.4965	4.6542	3.1042	3.9171	3.5656	0.42	0.18	0.42	0.11	0.33	0.00	0.21	0.13
448	3.0322	3.555	3.4003	2.7443	2.9776	3.0398	3.0042	0.23	0.09	0.23	0.19	0.00	0.08	0.10	0.09
449	3.4046	2.7991	2.2712	2.1834	2.4573	2.3457	2.028	0.40	0.40	0.28	0.11	0.07	0.17	0.14	0.00
450	3.6884	3.794	3.3105	3.4807	2.9372	3.2985	2.907	0.23	0.21	0.23	0.12	0.16	0.01	0.12	0.00
451	2.7068	3.3395	2.9344	3.3466	2.4516	2.7496	2.7183	0.27	0.09	0.27	0.16	0.27	0.00	0.11	0.10
452	3.7366	4.774	3.7966	3.3968	3.6188	3.7457	3.7502	0.29	0.09	0.29	0.11	0.00	0.06	0.09	0.09
453	2.5	3.8462	2.9827	3.4278	2.6029	2.6092	2.5485	0.35	0.00	0.35	0.16	0.27	0.04	0.04	0.02
454	2.4376	3.24	2.1225	2.4416	2.2624	2.5905	1.9352	0.40	0.21	0.40	0.09	0.21	0.14	0.25	0.00
455	3.04	2.994	2.2511	2.8539	2.2946	2.4626	2.2693	0.26	0.26	0.25	0.00	0.21	0.02	0.09	0.01
456	4.3243	4.9278	3.3371	3.7542	3.2034	3.3261	3.2505	0.35	0.26	0.35	0.04	0.15	0.00	0.04	0.01

457	2.3693	3.3167	2.6698	3.5025	2.2893	2.3839	2.4047	0.35	0.03	0.31	0.14	0.35	0.00	0.04	0.05
458	2.7528	4.4546	2.7924	3.9445	2.8008	2.4705	2.5893	0.45	0.10	0.45	0.12	0.37	0.12	0.00	0.05
459	3.2393	3.6787	3.5434	3.5467	3.4206	3.4555	3.5029	0.12	0.00	0.12	0.09	0.09	0.05	0.06	0.08
460	1.8059	2.521	2.8293	2.1121	1.6735	2.2593	2.2396	0.41	0.07	0.34	0.41	0.21	0.00	0.26	0.25
461	2.5703	2.9638	3.0541	2.8464	2.6357	2.8123	2.7319	0.16	0.00	0.13	0.16	0.10	0.02	0.09	0.06
462	3.0456	4.1635	3.1701	2.8584	2.4767	3.5405	2.1384	0.49	0.30	0.49	0.33	0.25	0.14	0.40	0.00
463	2.7077	3.3921	2.8797	3.4206	2.4475	2.7317	2.4538	0.28	0.10	0.28	0.15	0.28	0.00	0.10	0.00
464	3.8335	4.7849	3.4401	3.7647	3.7376	3.2608	3.4323	0.32	0.15	0.32	0.05	0.13	0.13	0.00	0.05
465	3.5379	4.2555	3.2572	3.6184	3.2756	3.132	3.2443	0.26	0.11	0.26	0.04	0.13	0.04	0.00	0.03
466	3.1179	3.7774	2.8725	3.758	2.7222	2.7983	2.6569	0.30	0.15	0.30	0.08	0.29	0.02	0.05	0.00
467	3.5915	4.6237	3.7029	3.8547	3.5128	3.5771	3.6934	0.24	0.02	0.24	0.05	0.09	0.00	0.02	0.05
468	2.4577	3.3673	2.6469	3.5257	2.4672	2.8118	2.4811	0.30	0.00	0.27	0.07	0.30	0.00	0.13	0.01
469	2.7261	2.4903	2.6635	2.3738	2.5442	2.2127	2.814	0.21	0.19	0.11	0.17	0.07	0.13	0.00	0.21
470	3.3212	3.7213	3.3877	3.2688	3.1759	3.465	3.2303	0.15	0.04	0.15	0.06	0.03	0.00	0.08	0.02
471	3.7567	4.5841	3.4957	4.1613	3.7106	3.6282	3.5866	0.24	0.07	0.24	0.00	0.16	0.06	0.04	0.03
472	2.9942	3.3217	2.7812	2.8591	2.441	2.6385	2.6142	0.27	0.18	0.27	0.12	0.15	0.00	0.07	0.07
473	2.7495	3.8478	2.3755	2.3942	2.0537	2.1113	1.8537	0.52	0.33	0.52	0.22	0.23	0.10	0.12	0.00
474	3.0654	3.061	2.2871	3.1995	2.2196	2.1067	1.9916	0.38	0.35	0.35	0.13	0.38	0.10	0.05	0.00
475	3.6217	4.082	3.3921	4.0532	3.0235	3.7023	3.3053	0.26	0.17	0.26	0.11	0.25	0.00	0.18	0.09
476	4.0446	4.4133	3.5694	4.1106	3.4634	3.7202	3.7609	0.22	0.14	0.22	0.03	0.16	0.00	0.07	0.08
477	2.898	3.6862	3.1414	3.4451	3.0776	3.6886	3.2359	0.21	0.00	0.21	0.08	0.16	0.06	0.21	0.10
478	3.2158	3.7811	2.652	3.823	2.7445	3.2642	2.4811	0.35	0.23	0.34	0.06	0.35	0.10	0.24	0.00
479	3.0331	3.1682	2.3267	1.9785	1.8383	2.4898	1.9739	0.42	0.39	0.42	0.21	0.07	0.00	0.26	0.07
480	3.1591	3.5297	3.2978	2.8837	2.812	3.0992	2.6844	0.24	0.15	0.24	0.19	0.07	0.05	0.13	0.00
481	2.189	2.5907	2.1408	1.846	1.8813	2.4225	2.0099	0.29	0.16	0.29	0.14	0.00	0.02	0.24	0.08
482	4.814	4.5645	3.7891	4.8023	4.0044	3.9802	4.7272	0.21	0.21	0.17	0.00	0.21	0.05	0.05	0.20
483	2.8619	3.8701	3.1799	3.7309	3.346	3.3723	3.7168	0.26	0.00	0.26	0.10	0.23	0.14	0.15	0.23
484	3.0642	2.8556	2.7141	2.8467	2.8024	2.4313	2.6307	0.21	0.21	0.15	0.10	0.15	0.13	0.00	0.08
485	1.9747	3.2364	2.1954	2.3583	1.9468	2.2909	2.238	0.40	0.01	0.40	0.11	0.17	0.00	0.15	0.13
486	2.7248	3.3475	2.2785	3.1256	2.4254	2.3908	2.2335	0.33	0.18	0.33	0.02	0.29	0.08	0.07	0.00
487	3.0674	4.3123	2.8799	3.4365	2.7505	2.796	2.9785	0.36	0.10	0.36	0.04	0.20	0.00	0.02	0.08
488	2.2657	1.7658	1.3713	1.3317	1.3699	1.3959	1.1243	0.50	0.50	0.36	0.18	0.16	0.18	0.19	0.00
489	4.2979	4.2714	3.6569	4.2444	3.5145	3.8473	3.561	0.18	0.18	0.18	0.04	0.17	0.00	0.09	0.01
490	3.3965	4.1761	3.8944	3.9101	3.6433	4.1806	3.8368	0.19	0.00	0.19	0.13	0.13	0.07	0.19	0.11
491	2.2788	2.9052	2.0248	1.9082	1.9549	2.0047	2.1841	0.34	0.16	0.34	0.06	0.00	0.02	0.05	0.13
492	2.3437	2.386	2.1283	2.221	1.7838	2.326	2.0007	0.25	0.24	0.25	0.16	0.20	0.00	0.23	0.11
493	2.94	4.608	3.1787	4.1683	2.6839	3.2314	3.0526	0.42	0.09	0.42	0.16	0.36	0.00	0.17	0.12
494	3.3313	3.765	3.0656	3.1876	3.0047	3.2799	3.2138	0.20	0.10	0.20	0.02	0.06	0.00	0.08	0.07
495	3.3908	3.6845	3.0392	3.7433	2.2119	2.8094	2.7106	0.41	0.35	0.40	0.27	0.41	0.00	0.21	0.18
496	2.5119	3.2711	2.4971	2.5148	2.7119	2.6156	2.5128	0.24	0.01	0.24	0.00	0.01	0.08	0.05	0.01
497	3.3152	3.7442	2.8867	3.2308	2.5559	2.4007	2.505	0.36	0.28	0.36	0.17	0.26	0.06	0.00	0.04
498	3.9115	5.1668	3.5967	3.7666	3.7583	3.8402	3.661	0.30	0.08	0.30	0.00	0.05	0.04	0.06	0.02
499	2.7116	4.0379	2.9069	2.6987	2.6095	3.4886	2.7038	0.35	0.04	0.35	0.10	0.03	0.00	0.25	0.03
500	3.0079	4.2726	3.9562	2.9928	2.7956	4.0006	2.7781	0.35	0.08	0.35	0.30	0.07	0.01	0.31	0.00
501	2.9689	3.8693	3.1028	2.7542	2.7638	2.9422	2.7625	0.29	0.07	0.29	0.11	0.00	0.00	0.06	0.00
502	3.3019	3.6816	3.2416	2.701	3.125	3.5338	2.9638	0.27	0.18	0.27	0.17	0.00	0.14	0.24	0.09
503	2.2595	2.7604	2.6481	2.5511	2.2218	2.6946	2.5723	0.20	0.02	0.20	0.16	0.13	0.00	0.18	0.14
504	2.6952	3.7285	2.788	2.309	2.322	2.7421	2.3554	0.38	0.14	0.38	0.17	0.00	0.01	0.16	0.02
505	2.8826	3.4965	2.3818	3.095	2.1906	2.8467	2.649	0.37	0.24	0.37	0.08	0.29	0.00	0.23	0.17
506	3.516	4.2416	3.4284	3.4504	3.2669	3.3484	3.4558	0.23	0.07	0.23	0.05	0.05	0.00	0.02	0.05
507	3.0689	3.6211	2.421	2.9928	2.6872	2.7384	2.3672	0.35	0.23	0.35	0.02	0.21	0.12	0.14	0.00
508	4.1931	4.3539	3.8173	4.1064	3.7915	4.093	4.0097	0.13	0.10	0.13	0.01	0.08	0.00	0.07	0.05
509	3.5608	3.0431	2.8385	2.6354	2.7088	2.767	2.5052	0.30	0.30	0.18	0.12	0.05	0.08	0.09	0.00
510	2.4934	3.0957	2.5931	2.8469	2.1186	2.8306	2.4679	0.32	0.15	0.32	0.18	0.26	0.00	0.25	0.14
511	2.4361	3.6269	2.719	2.7179	2.2788	2.6316	2.1435	0.41	0.12	0.41	0.21	0.21	0.06	0.19	0.00
512	2.4772	4.0566	3.0514	3.1943	2.1128	2.8957	2.5279	0.48	0.15	0.48	0.31	0.34	0.00	0.27	0.16
513	3.4679	2.6571	2.7715	2.5998	2.4337	3.1627	2.6034	0.30	0.30	0.08	0.12	0.06	0.00	0.23	0.07
514	3.3142	4.2882	3.5296	3.6588	3.3902	3.4155	3.5428	0.23	0.00	0.23	0.06	0.09	0.02	0.03	0.06
515	3.0371	3.8406	3.0089	2.9731	2.7902	3.3414	2.5988	0.32	0.14	0.32	0.14	0.13	0.07	0.22	0.00
516	2.8523	4.0749	3.0377	3.3628	2.8856	3.0274	3.2109	0.30	0.00	0.30	0.06	0.15	0.01	0.06	0.11
517	3.5236	3.4816	2.7673	3.2419	2.8283	2.8682	3.0485	0.21	0.21	0.21	0.00	0.15	0.02	0.04	0.09
518	3.524	4.34	3.8893	3.6752	3.0912	3.5277	3.2889	0.29	0.12	0.29	0.21	0.16	0.00	0.12	0.06
519	2.0688	3.6042	2.3413	2.6408	1.9455	2.88	2.3175	0.46	0.06	0.46	0.17	0.26	0.00	0.32	0.16
520	3.4057	4.0439	3.5141	4.1205	3.9935	3.7534	3.2222	0.22	0.05	0.20	0.08	0.22	0.19	0.14	0.00
521	2.9559	3.3241	2.9938	2.8408	2.9039	2.8838	2.8639	0.15	0.04	0.15	0.05	0.00	0.02	0.01	0.01
522	3.1405	3.7043	3.2432	3.5854	2.7699	3.1364	2.6402	0.29	0.16	0.29	0.19	0.26	0.05	0.16	0.00

523	3.9612	2.9582	2.738	3.3271	2.9045	2.7746	2.711	0.32	0.32	0.08	0.01	0.19	0.07	0.02	0.00
524	1.9875	2.7158	2.0062	2.3338	2.0333	2.4205	2.0553	0.27	0.00	0.27	0.01	0.15	0.02	0.18	0.03
525	3.8102	5.1712	4.6518	4.5301	3.838	4.2376	3.6468	0.29	0.04	0.29	0.22	0.19	0.05	0.14	0.00
526	3.2565	3.5927	3.0091	3.0146	2.6565	2.8705	2.7484	0.26	0.18	0.26	0.12	0.12	0.00	0.07	0.03
527	2.4052	2.9342	2.3383	2.2277	2.1295	2.143	2.236	0.27	0.11	0.27	0.09	0.04	0.00	0.01	0.05
528	4.6641	5.2844	4.2427	4.4507	4.0386	4.4988	3.988	0.25	0.14	0.25	0.06	0.10	0.01	0.11	0.00
529	3.2393	3.8139	3.1105	3.3757	2.7724	3.0713	2.7702	0.27	0.14	0.27	0.11	0.18	0.00	0.10	0.00
530	3.2837	4.1514	3.027	3.2036	2.5697	3.4398	2.8612	0.38	0.22	0.38	0.15	0.20	0.00	0.25	0.10
531	3.056	3.5671	3.0844	3.4685	2.5566	3.2138	3.057	0.28	0.16	0.28	0.17	0.26	0.00	0.20	0.16
532	3.1023	3.9513	2.6568	3.2565	2.7286	3.4136	2.5264	0.36	0.19	0.36	0.05	0.22	0.07	0.26	0.00
533	2.143	3.8313	2.9305	3.3267	2.3261	3.405	2.0863	0.46	0.03	0.46	0.29	0.37	0.10	0.39	0.00
534	2.324	2.5989	2.7076	2.2933	2.2863	2.4932	2.2296	0.18	0.04	0.14	0.18	0.03	0.02	0.11	0.00
535	3.2274	4.8535	3.381	4.0354	3.1548	3.7818	3.1601	0.35	0.02	0.35	0.07	0.22	0.00	0.17	0.00
536	3.9154	4.4063	3.6642	3.9764	3.2291	3.7126	3.4796	0.27	0.18	0.27	0.12	0.19	0.00	0.13	0.07
537	3.1485	3.2027	3.0801	3.2691	3.1211	3.0468	3.0656	0.07	0.03	0.05	0.01	0.07	0.02	0.00	0.01
538	2.9469	3.0259	3.1865	3.2779	2.6679	3.0789	2.8244	0.19	0.09	0.12	0.16	0.19	0.00	0.13	0.06
539	4.1841	4.6963	4.0065	4.3474	4.0073	3.957	4.1585	0.16	0.05	0.16	0.01	0.09	0.01	0.00	0.05
540	3.4972	4.3408	3.463	3.5213	3.4869	3.3099	3.496	0.24	0.05	0.24	0.04	0.06	0.05	0.00	0.05
541	4.0523	4.1783	3.2595	4.1141	3.1728	3.5345	3.3501	0.24	0.22	0.24	0.03	0.23	0.00	0.10	0.05
542	2.3456	3.1005	2.3785	2.9566	2.3539	2.4839	2.2966	0.26	0.02	0.26	0.03	0.22	0.02	0.08	0.00
543	3.3877	3.5716	3.215	2.966	3.2601	3.3539	3.0903	0.17	0.12	0.17	0.08	0.00	0.09	0.12	0.04
544	2.5716	4.1356	3.0444	1.8629	2.1393	2.3074	2.0417	0.55	0.28	0.55	0.39	0.00	0.13	0.19	0.09
545	2.9099	3.6092	2.425	2.7167	2.3961	2.3105	2.2734	0.37	0.22	0.37	0.06	0.16	0.05	0.02	0.00
546	4.3933	4.5925	4.7075	4.496	3.6314	4.5682	4.3001	0.23	0.17	0.21	0.23	0.19	0.00	0.21	0.16
547	3.0735	4.2702	2.5592	3.1153	2.5649	2.7807	2.3461	0.45	0.24	0.45	0.08	0.25	0.09	0.16	0.00
548	3.4768	3.872	3.3089	3.6176	3.08	3.025	3.2126	0.22	0.13	0.22	0.09	0.16	0.02	0.00	0.06
549	3.5148	3.8675	3.3498	3.5204	3.3021	3.2882	3.1827	0.18	0.09	0.18	0.05	0.10	0.04	0.03	0.00
550	2.8224	3.6003	2.58	3.4765	2.965	3.0787	2.3966	0.33	0.15	0.33	0.07	0.31	0.19	0.22	0.00
551	2.8464	3.8262	3.0804	3.0375	2.9586	3.2797	2.7424	0.28	0.04	0.28	0.11	0.10	0.07	0.16	0.00
552	2.5012	3.8651	2.4832	2.4894	2.1871	2.6303	2.3378	0.43	0.13	0.43	0.12	0.12	0.00	0.17	0.06
553	2.7362	3.5255	2.7794	3.1352	2.495	3.1106	2.1717	0.38	0.21	0.38	0.22	0.31	0.13	0.30	0.00
554	2.9449	3.9736	2.9309	3.9552	3.0915	3.1992	2.629	0.34	0.11	0.34	0.10	0.34	0.15	0.18	0.00
555	2.3852	2.5115	2.342	2.0856	1.6391	2.2781	2.1962	0.35	0.31	0.35	0.30	0.21	0.00	0.28	0.25
556	3.1163	1.9495	2.1613	2.4386	2.352	2.0161	2.1309	0.37	0.37	0.00	0.10	0.20	0.17	0.03	0.09
557	2.3045	2.8294	2.3793	2.495	2.0006	2.433	2.1732	0.29	0.13	0.29	0.16	0.20	0.00	0.18	0.08
558	1.9677	2.1489	2.0846	2.557	2.173	1.8488	1.9403	0.28	0.06	0.14	0.11	0.28	0.15	0.00	0.05
559	3.0216	4.0692	2.7446	2.6363	2.3374	2.6594	2.2607	0.44	0.25	0.44	0.18	0.14	0.03	0.15	0.00
560	2.6806	3.4554	2.5692	3.0746	2.1234	2.8457	2.7034	0.39	0.21	0.39	0.17	0.31	0.00	0.25	0.21
561	3.8557	4.6439	3.6992	4.3477	3.481	4.0163	3.4712	0.25	0.10	0.25	0.06	0.20	0.00	0.14	0.00
562	2.8835	3.5624	3.1757	2.9867	2.8725	2.9129	2.2225	0.38	0.23	0.38	0.30	0.26	0.23	0.24	0.00
563	3.0097	3.8134	2.2867	2.5422	2.3554	2.1965	2.2256	0.42	0.27	0.42	0.04	0.14	0.07	0.00	0.01
564	3.744	4.3349	3.1657	3.6556	3.2096	3.8178	3.1218	0.28	0.17	0.28	0.01	0.15	0.03	0.18	0.00
565	4.1388	4.7181	4.1095	4.3431	3.721	4.113	3.9145	0.21	0.10	0.21	0.09	0.14	0.00	0.10	0.05
566	2.6178	2.362	2.4143	2.2699	2.5313	2.3747	2.1748	0.17	0.17	0.08	0.10	0.04	0.14	0.08	0.00
567	2.7298	2.6087	2.5088	2.0078	2.0027	2.0726	2.1005	0.27	0.27	0.23	0.20	0.00	0.00	0.03	0.05
568	2.7243	3.5381	2.7961	2.7322	2.7372	2.4386	2.4331	0.31	0.11	0.31	0.13	0.11	0.11	0.00	0.00
569	2.9108	4.1056	2.716	2.5203	2.4261	2.8826	2.0793	0.49	0.29	0.49	0.23	0.17	0.14	0.28	0.00
570	3.9834	4.2663	3.5104	3.7541	3.4873	3.5648	3.4474	0.19	0.13	0.19	0.02	0.08	0.01	0.03	0.00
571	3.813	4.0337	3.4547	3.2543	3.0704	3.8142	3.8432	0.24	0.19	0.24	0.11	0.06	0.00	0.20	0.20
572	3.2439	2.9396	2.8697	3.0042	2.5824	2.825	2.676	0.20	0.20	0.12	0.10	0.14	0.00	0.09	0.03
573	3.0384	3.3396	2.5385	2.8682	2.5272	2.4984	2.7276	0.25	0.18	0.25	0.02	0.13	0.01	0.00	0.08
574	3.5574	4.1179	3.5221	3.8368	2.8108	3.6257	3.3639	0.32	0.21	0.32	0.20	0.27	0.00	0.22	0.16
575	3.0147	3.679	3.1642	2.8522	2.8299	3.419	2.6063	0.29	0.14	0.29	0.18	0.09	0.08	0.24	0.00
576	3.8493	4.2698	3.5508	4.3018	3.4896	3.3079	3.226	0.25	0.16	0.24	0.09	0.25	0.08	0.02	0.00
577	2.0864	2.4151	1.5512	2.0116	1.9042	1.4987	1.8184	0.38	0.28	0.38	0.03	0.25	0.21	0.00	0.18
578	2.3159	3.2358	2.0864	2.7447	2.2888	2.3092	2.2797	0.36	0.10	0.36	0.00	0.24	0.09	0.10	0.08
579	2.6868	3.2955	2.5526	3.166	2.3754	2.9532	2.1999	0.33	0.18	0.33	0.14	0.31	0.07	0.26	0.00
580	3.0007	2.9993	2.7408	2.8933	2.6787	2.5908	2.5191	0.16	0.16	0.16	0.08	0.13	0.06	0.03	0.00
581	3.3075	3.8257	2.8965	3.992	2.7222	2.8928	3.0739	0.32	0.18	0.29	0.06	0.32	0.00	0.06	0.11
582	2.1962	3.4558	2.3775	2.1459	2.0648	3.0088	1.9583	0.43	0.11	0.43	0.18	0.09	0.05	0.35	0.00
583	2.5005	2.0263	2.504	2.217	2.5403	2.1257	2.2119	0.20	0.19	0.00	0.19	0.09	0.20	0.05	0.08
584	3.2453	4.2067	2.9864	2.7714	2.7595	2.9132	2.5509	0.39	0.21	0.39	0.15	0.08	0.08	0.12	0.00
585	2.0496	3.2217	2.2857	1.7989	2.085	2.2419	1.8415	0.44	0.12	0.44	0.21	0.00	0.14	0.20	0.02
586	3.2466	3.574	3.0714	3.3579	2.8843	2.9249	2.9309	0.19	0.11	0.19	0.06	0.14	0.00	0.01	0.02
587	4.1847	4.7588	4.1908	4.2207	3.7013	3.648	3.5186	0.26	0.16	0.26	0.16	0.17	0.05	0.04	0.00
588	3.5123	4.132	3.1567	4.128	3.0131	2.9437	3.0187	0.29	0.16	0.29	0.07	0.29	0.02	0.00	0.02

589	2.9169	3.3996	2.5116	2.7157	2.365	2.6453	2.2989	0.32	0.21	0.32	0.08	0.15	0.03	0.13	0.00
590	2.8855	3.6015	3.1538	2.6754	2.3431	3.1724	2.6404	0.35	0.19	0.35	0.26	0.12	0.00	0.26	0.11
591	3.2898	3.3553	3.2594	2.7868	2.7004	3.1004	2.4351	0.27	0.26	0.27	0.25	0.13	0.10	0.21	0.00
592	3.5584	3.4667	3.1101	3.7548	3.1378	3.5892	3.6124	0.17	0.13	0.10	0.00	0.17	0.01	0.13	0.14
593	2.5916	4.4472	2.4234	3.8451	2.4755	3.1561	2.1992	0.51	0.15	0.51	0.09	0.43	0.11	0.30	0.00
594	3.4533	4.2979	3.4274	3.7951	3.0787	3.8197	2.8319	0.34	0.18	0.34	0.17	0.25	0.08	0.26	0.00
595	2.5477	3.4291	2.5165	3.1271	2.4227	2.6737	2.4879	0.29	0.05	0.29	0.04	0.23	0.00	0.09	0.03
596	3.4008	2.969	2.7149	3.1867	2.8552	2.9645	2.7037	0.20	0.20	0.09	0.00	0.15	0.05	0.09	0.00
597	2.4882	3.3293	2.9581	2.934	2.2888	2.8331	2.2991	0.31	0.08	0.31	0.23	0.22	0.00	0.19	0.00
598	3.645	4.1315	3.3903	3.7737	3.2521	3.7559	3.3006	0.21	0.11	0.21	0.04	0.14	0.00	0.13	0.01
599	2.4245	3.233	3.0254	2.3629	2.5349	2.8551	2.5886	0.27	0.03	0.27	0.22	0.00	0.07	0.17	0.09
600	2.8881	3.6605	2.7999	2.6656	2.8199	2.8537	2.6783	0.27	0.08	0.27	0.05	0.00	0.05	0.07	0.00
601	3.449	3.8921	3.5904	4.0134	3.5487	3.5757	3.3382	0.17	0.03	0.14	0.07	0.17	0.06	0.07	0.00
602	3.9132	4.1583	3.8222	3.1221	3.1389	3.0073	2.956	0.29	0.24	0.29	0.23	0.05	0.06	0.02	0.00
603	2.76	3.5303	2.6872	2.4955	2.0656	2.915	2.1978	0.41	0.25	0.41	0.23	0.17	0.00	0.29	0.06
604	2.8335	4.778	3.454	3.7731	2.8138	3.1112	2.9436	0.41	0.01	0.41	0.19	0.25	0.00	0.10	0.04
605	3.6711	4.0867	3.1247	3.6468	3.0852	3.1225	2.9147	0.29	0.21	0.29	0.07	0.20	0.06	0.07	0.00
606	4.8605	5.4376	4.2745	5.1024	4.2933	4.6656	4.4915	0.21	0.12	0.21	0.00	0.16	0.00	0.08	0.05
607	2.0616	2.8168	1.7198	2.3028	1.8369	1.5472	1.6564	0.45	0.25	0.45	0.10	0.33	0.16	0.00	0.07
608	2.9822	4.0314	2.5154	2.9669	2.5986	2.5813	2.4836	0.38	0.17	0.38	0.01	0.16	0.04	0.04	0.00
609	3.0765	3.152	2.6722	3.0149	2.4423	3.1409	2.5658	0.23	0.21	0.23	0.09	0.19	0.00	0.22	0.05
610	3.4273	3.7191	2.9207	3.313	2.7081	2.8892	2.7259	0.27	0.21	0.27	0.07	0.18	0.00	0.06	0.01
611	2.8269	4.0699	3.2712	2.8902	2.7821	3.295	3.1252	0.32	0.02	0.32	0.15	0.04	0.00	0.16	0.11
612	3.0088	3.1408	3.3864	3.0285	2.6146	3.0135	2.6659	0.23	0.13	0.17	0.23	0.14	0.00	0.13	0.02
613	2.5029	2.9301	2.4561	2.3439	2.3592	2.257	2.1929	0.25	0.12	0.25	0.11	0.06	0.07	0.03	0.00
614	3.0563	3.6037	2.9446	3.3131	2.9349	2.9268	2.7873	0.23	0.09	0.23	0.05	0.16	0.05	0.05	0.00
615	2.5443	3.0274	2.4056	2.5287	2.5384	2.5088	1.9722	0.35	0.22	0.35	0.18	0.22	0.22	0.21	0.00
616	1.6862	1.903	1.5824	1.6465	1.4741	1.753	1.5504	0.23	0.13	0.23	0.07	0.10	0.00	0.16	0.05
617	2.7923	2.9543	2.601	2.5296	2.5301	2.4025	2.4668	0.19	0.14	0.19	0.08	0.05	0.05	0.00	0.03
618	2.8532	3.5141	2.9812	2.904	2.6222	3.0913	2.5133	0.28	0.12	0.28	0.16	0.13	0.04	0.19	0.00
619	3.6416	4.1618	3.7663	3.5419	3.0452	3.7078	3.3743	0.27	0.16	0.27	0.19	0.14	0.00	0.18	0.10
620	2.5507	3.3661	2.6682	3.0352	2.4819	3.1277	2.7193	0.26	0.03	0.26	0.07	0.18	0.00	0.21	0.09
621	3.5846	4.2946	4.0953	4.2927	3.4223	3.9452	3.729	0.20	0.05	0.20	0.16	0.20	0.00	0.13	0.08
622	2.739	3.9492	3.2849	3.5416	2.8034	3.0089	2.9254	0.31	0.00	0.31	0.17	0.23	0.02	0.09	0.06
623	3.6211	3.2378	3.2622	3.1711	2.8967	3.357	3.0795	0.20	0.20	0.11	0.11	0.09	0.00	0.14	0.06
624	3.7113	3.3157	2.8722	3.6379	2.4834	2.9906	2.6633	0.33	0.33	0.25	0.14	0.32	0.00	0.17	0.07
625	3.2173	4.3284	3.1585	3.42	2.828	3.0724	3.0587	0.35	0.12	0.35	0.10	0.17	0.00	0.08	0.08
626	3.1706	3.2319	2.7057	2.6567	2.7457	2.6045	2.6088	0.19	0.18	0.19	0.04	0.02	0.05	0.00	0.00
627	3.8636	5.1264	3.7338	4.7849	3.83	3.5144	3.6117	0.31	0.09	0.31	0.06	0.27	0.08	0.00	0.03
628	3.1941	3.2686	2.8044	2.8752	2.8631	3.0718	2.8737	0.14	0.12	0.14	0.00	0.02	0.02	0.09	0.02
629	2.7691	4.5596	2.4921	2.8706	2.2583	2.1603	2.0892	0.54	0.25	0.54	0.16	0.27	0.07	0.03	0.00
630	3.3575	4.1281	3.5025	3.5958	3.433	3.6896	3.425	0.19	0.00	0.19	0.04	0.07	0.02	0.09	0.02
631	3.4108	3.4283	2.8743	3.1997	2.7487	2.9977	2.6699	0.22	0.22	0.22	0.07	0.17	0.03	0.11	0.00
632	2.8456	3.6475	2.9524	2.8461	2.8019	2.7697	2.7553	0.24	0.03	0.24	0.07	0.03	0.02	0.01	0.00
633	3.3783	3.4039	3.2196	3.2944	3.2278	2.9133	2.927	0.14	0.14	0.14	0.10	0.12	0.10	0.00	0.00
634	2.7402	3.1756	2.408	2.5742	2.1046	2.3588	2.3609	0.34	0.23	0.34	0.13	0.18	0.00	0.11	0.11
635	3.2638	4.324	2.9474	3.6255	2.9351	3.1416	3.0373	0.32	0.10	0.32	0.00	0.19	0.00	0.07	0.03
636	3.4163	3.6786	2.3062	2.8855	2.4223	2.5043	2.3938	0.37	0.32	0.37	0.00	0.20	0.05	0.08	0.04
637	3.2584	3.2346	3.2344	3.3567	3.0897	3.0614	3.0377	0.10	0.07	0.06	0.06	0.10	0.02	0.01	0.00
638	3.8757	3.7441	3.4199	3.1011	3.5507	3.3109	2.9056	0.25	0.25	0.22	0.15	0.06	0.18	0.12	0.00
639	3.862	4.2882	4.3476	3.7183	3.4735	4.0563	3.7493	0.20	0.10	0.19	0.20	0.07	0.00	0.14	0.07
640	2.4986	3.1554	2.2684	2.8799	2.2434	2.2858	2.3115	0.29	0.10	0.29	0.01	0.22	0.00	0.02	0.03
641	3.3609	4.4212	3.2787	3.7639	3.2475	3.3807	3.0581	0.31	0.09	0.31	0.07	0.19	0.06	0.10	0.00
642	2.7639	3.0009	2.9798	2.7505	2.6611	3.0359	2.9023	0.12	0.04	0.11	0.11	0.03	0.00	0.12	0.08
643	2.7027	3.8878	2.9998	2.67	2.6541	3.1263	2.7558	0.32	0.02	0.32	0.12	0.01	0.00	0.15	0.04
644	2.3585	3.3965	2.1663	2.3004	2.1434	2.6417	2.3223	0.37	0.09	0.37	0.01	0.07	0.00	0.19	0.08
645	3.4807	4.136	3.8247	3.8176	3.1723	3.8966	3.6483	0.23	0.09	0.23	0.17	0.17	0.00	0.19	0.13
646	3.665	3.6993	3.8044	4.0402	3.5047	3.6069	3.4003	0.16	0.07	0.08	0.11	0.16	0.03	0.06	0.00
647	2.5388	3.1344	2.6888	2.771	2.2468	2.6554	2.099	0.33	0.17	0.33	0.22	0.24	0.07	0.21	0.00
648	2.3941	2.4668	2.5725	2.256	2.4484	2.5162	2.3723	0.12	0.06	0.09	0.12	0.00	0.08	0.10	0.05
649	1.8912	3.1189	1.9324	2.2623	2.0315	1.8576	1.9529	0.40	0.02	0.40	0.04	0.18	0.09	0.00	0.05
650	3.7035	3.6426	2.9307	3.6623	2.9169	3.4184	3.6322	0.21	0.21	0.20	0.00	0.20	0.00	0.15	0.20
651	4.4981	5.0732	4.301	4.2349	3.613	4.6388	3.6635	0.29	0.20	0.29	0.16	0.15	0.00	0.22	0.01
652	3.7873	3.8529	3.8562	3.8797	3.8064	3.4826	3.6267	0.10	0.08	0.10	0.10	0.10	0.09	0.00	0.04
653	3.4007	4.6413	2.9199	3.5748	3.0055	3.5401	3.0054	0.37	0.14	0.37	0.00	0.18	0.03	0.18	0.03
654	3.4106	3.7335	3.0842	3.4496	2.9043	2.8596	2.9246	0.23	0.16	0.23	0.07	0.17	0.02	0.00	0.02

655	2.835	3.3394	3.2921	3.0945	2.686	3.1691	2.6998	0.20	0.05	0.20	0.18	0.13	0.00	0.15	0.01
656	1.948	2.1332	1.7615	2.3195	1.4988	1.6268	1.4754	0.36	0.24	0.31	0.16	0.36	0.02	0.09	0.00
657	3.9107	4.435	3.1165	4.193	3.4236	2.9775	3.333	0.33	0.24	0.33	0.04	0.29	0.13	0.00	0.11
658	2.9674	3.6833	3.345	3.273	2.7075	2.7803	2.7038	0.27	0.09	0.27	0.19	0.17	0.00	0.03	0.00
659	2.3072	2.8912	1.7713	1.8625	2.0957	1.6888	1.7352	0.42	0.27	0.42	0.05	0.09	0.19	0.00	0.03
660	4.9724	4.1534	4.4416	4.0733	4.4436	4.3276	4.0363	0.19	0.19	0.03	0.09	0.01	0.09	0.07	0.00
661	2.7979	4.3172	2.9082	2.8458	3.1216	3.2501	2.8302	0.35	0.00	0.35	0.04	0.02	0.10	0.14	0.01
662	3.6584	4.0014	4.1148	3.2707	3.4612	4.3111	3.744	0.24	0.11	0.18	0.21	0.00	0.06	0.24	0.13
663	2.4454	4.4078	2.0787	2.435	2.0542	2.1956	2.1002	0.53	0.16	0.53	0.01	0.16	0.00	0.06	0.02
664	4.4925	5.7717	4.2322	4.7791	3.9868	4.1932	4.489	0.31	0.11	0.31	0.06	0.17	0.00	0.05	0.11
665	3.2067	3.1039	2.9152	3.1441	2.8141	2.7355	2.8329	0.15	0.15	0.12	0.06	0.13	0.03	0.00	0.03
666	3.6986	4.1222	3.3491	3.6294	3.2413	3.6797	3.0762	0.25	0.17	0.25	0.08	0.15	0.05	0.16	0.00
667	2.5392	2.7299	2.3322	2.739	2.105	2.5724	2.3882	0.23	0.17	0.23	0.10	0.23	0.00	0.18	0.12
668	3.0661	3.4219	2.9715	3.0457	2.535	2.7443	2.7786	0.26	0.17	0.26	0.15	0.17	0.00	0.08	0.09
669	2.3622	3.6291	2.4199	2.6318	2.3056	2.6228	2.6583	0.36	0.02	0.36	0.05	0.12	0.00	0.12	0.13
670	2.4901	2.1637	2.3206	2.198	2.3063	2.7536	2.1362	0.22	0.14	0.01	0.08	0.03	0.07	0.22	0.00
671	2.7616	3.1119	2.9284	3.0854	2.7239	3.0561	2.4986	0.20	0.10	0.20	0.15	0.19	0.08	0.18	0.00
672	2.0927	2.2212	3.0579	2.2914	2.4452	2.2596	2.4309	0.32	0.00	0.06	0.32	0.09	0.14	0.07	0.14
673	3.3217	4.1124	3.3146	3.1032	3.1142	2.9132	2.9185	0.29	0.12	0.29	0.12	0.06	0.06	0.00	0.00
674	2.8193	3.2465	2.7343	2.6593	2.6745	3.0308	2.5323	0.22	0.10	0.22	0.07	0.05	0.05	0.16	0.00
675	2.3389	3.1515	2.1775	2.5034	2.1237	2.3097	2.2532	0.33	0.09	0.33	0.02	0.15	0.00	0.08	0.06
676	3.9262	3.6271	3.9162	3.5722	3.6312	3.7446	3.3792	0.14	0.14	0.07	0.14	0.05	0.07	0.10	0.00
677	3.0505	3.6285	3.2228	3.1774	2.7135	3.3759	3.138	0.25	0.11	0.25	0.16	0.15	0.00	0.20	0.14
678	2.361	3.1636	2.2739	2.454	2.4653	2.6265	2.2138	0.30	0.06	0.30	0.03	0.10	0.10	0.16	0.00
679	3.3646	4.0287	3.2987	3.4103	3.258	3.48	3.4727	0.19	0.03	0.19	0.01	0.04	0.00	0.06	0.06
680	3.503	4.8082	3.1741	4.7482	3.1517	4.2028	3.2586	0.34	0.10	0.34	0.01	0.34	0.00	0.25	0.03
681	3.167	2.9121	2.3544	2.4264	2.2926	2.2007	2.2127	0.31	0.31	0.24	0.07	0.09	0.04	0.00	0.01
682	3.6321	4.7246	3.4081	3.7877	3.2252	3.2481	3.2447	0.32	0.11	0.32	0.05	0.15	0.00	0.01	0.01
683	2.7244	4.3774	2.7336	2.99	2.3847	3.2843	2.7821	0.46	0.12	0.46	0.13	0.20	0.00	0.27	0.14
684	2.8732	2.7841	3.0515	2.9057	2.9392	2.8018	2.8397	0.09	0.03	0.00	0.09	0.04	0.05	0.01	0.02
685	2.6596	3.6262	2.9172	2.7919	2.5837	2.4407	2.6102	0.33	0.08	0.33	0.16	0.13	0.06	0.00	0.06
686	3.4077	4.059	3.1991	3.6704	3.3239	3.1931	3.0913	0.24	0.09	0.24	0.03	0.16	0.07	0.03	0.00
687	2.8268	3.8118	2.4973	2.4576	2.3545	2.7358	2.3015	0.40	0.19	0.40	0.08	0.06	0.02	0.16	0.00
688	3.0949	3.5641	2.9262	2.942	2.7898	3.3366	2.968	0.22	0.10	0.22	0.05	0.05	0.00	0.16	0.06
689	4.0749	4.2081	3.2897	4.0518	3.2297	3.7516	3.2056	0.24	0.21	0.24	0.03	0.21	0.01	0.15	0.00
690	2.4469	2.777	2.3004	2.4671	2.1656	2.4458	2.3584	0.22	0.11	0.22	0.06	0.12	0.00	0.11	0.08
691	2.9609	3.8453	2.6368	3.3848	2.6928	2.8064	2.3406	0.39	0.21	0.39	0.11	0.31	0.13	0.17	0.00
692	3.5329	4.0002	2.2386	3.0462	2.7122	2.6217	2.6813	0.44	0.37	0.44	0.00	0.27	0.17	0.15	0.17
693	2.3602	3.1659	2.4324	2.5551	2.2916	2.6451	2.4386	0.28	0.03	0.28	0.06	0.10	0.00	0.13	0.06
694	3.8838	3.8573	4.1061	3.6984	3.5583	3.7022	3.6904	0.13	0.08	0.08	0.13	0.04	0.00	0.04	0.04
695	2.0868	2.2671	2.3385	2.192	1.9797	2.1649	1.7022	0.27	0.18	0.25	0.27	0.22	0.14	0.21	0.00
696	2.8805	4.5905	3.8466	2.5784	3.0306	3.5618	2.7399	0.44	0.10	0.44	0.33	0.00	0.15	0.28	0.06
697	2.7296	3.0276	3.0435	2.5974	2.6707	2.9294	2.3475	0.23	0.14	0.22	0.23	0.10	0.12	0.20	0.00
698	4.0763	4.8292	3.7813	4.6714	3.8199	4.3536	4.1594	0.22	0.07	0.22	0.00	0.19	0.01	0.13	0.09
699	3.3885	3.9814	2.5419	3.7188	2.6035	2.7083	2.6473	0.36	0.25	0.36	0.00	0.32	0.02	0.06	0.04
700	3.0345	4.017	3.4617	3.4153	2.8831	4.0789	2.8237	0.31	0.07	0.30	0.18	0.17	0.02	0.31	0.00
701	2.731	3.4066	2.1642	2.6232	1.9239	2.3257	2.0047	0.44	0.30	0.44	0.11	0.27	0.00	0.17	0.04
702	4.3989	4.9356	3.7892	4.0032	3.7847	3.988	4.0343	0.23	0.14	0.23	0.00	0.05	0.00	0.05	0.06
703	2.9666	2.8568	2.8195	2.6352	2.5038	2.8564	2.6138	0.16	0.16	0.12	0.11	0.05	0.00	0.12	0.04
704	2.8726	3.7756	3.4462	2.6867	2.9084	3.6316	2.9522	0.29	0.06	0.29	0.22	0.00	0.08	0.26	0.09
705	2.5873	3.6641	2.681	3.0625	2.4201	2.804	2.1636	0.41	0.16	0.41	0.19	0.29	0.11	0.23	0.00
706	2.7848	4.1769	2.8054	3.0381	2.7974	3.1641	2.6522	0.37	0.05	0.37	0.05	0.13	0.05	0.16	0.00
707	3.1593	3.3441	2.8665	2.7432	2.5962	3.0462	2.663	0.22	0.18	0.22	0.09	0.05	0.00	0.15	0.03
708	2.8617	3.2525	2.912	2.865	2.4882	2.7318	2.4146	0.26	0.16	0.26	0.17	0.16	0.03	0.12	0.00
709	2.2511	2.9894	2.3552	3.2025	1.8851	2.0322	1.8846	0.41	0.16	0.37	0.20	0.41	0.00	0.07	0.00
710	3.7565	4.7975	4.0152	4.4451	3.9794	4.2802	3.8323	0.22	0.00	0.22	0.06	0.15	0.06	0.12	0.02
711	3.7206	3.551	2.9593	3.9684	2.9332	3.1511	2.7076	0.32	0.27	0.24	0.09	0.32	0.08	0.14	0.00
712	3.0673	3.1283	3.0455	3.098	2.8372	3.0486	3.048	0.09	0.08	0.09	0.07	0.08	0.00	0.07	0.07
713	2.1145	3.2848	2.5202	2.7666	2.3409	2.8535	2.3105	0.36	0.00	0.36	0.16	0.24	0.10	0.26	0.08
714	3.1587	3.5089	2.6986	2.3864	2.4064	2.8806	2.2403	0.36	0.29	0.36	0.17	0.06	0.07	0.22	0.00
715	2.1121	2.2774	1.9734	2.1256	1.5906	1.8847	1.8554	0.30	0.25	0.30	0.19	0.25	0.00	0.16	0.14
716	3.0328	3.1385	2.5369	2.7112	2.0478	2.7859	2.417	0.35	0.32	0.35	0.19	0.24	0.00	0.26	0.15
717	2.6443	3.2957	2.3384	1.7988	2.0769	2.4142	1.7774	0.46	0.33	0.46	0.24	0.01	0.14	0.26	0.00
718	3.395	3.9819	3.254	3.4792	2.9945	3.4874	3.4528	0.25	0.12	0.25	0.08	0.14	0.00	0.14	0.13
719	2.7458	3.4972	3.0481	3.185	2.6298	3.2504	2.8766	0.25	0.04	0.25	0.14	0.17	0.00	0.19	0.09
720	4.0641	3.9804	3.602	4.1616	3.0606	3.5953	3.2062	0.26	0.25	0.23	0.15	0.26	0.00	0.15	0.05

721	3.3584	4.5257	2.5412	3.7147	2.681	2.6708	2.8577	0.44	0.24	0.44	0.00	0.32	0.05	0.05	0.11
722	2.9428	2.8821	2.6772	2.9623	2.3274	2.4267	2.1963	0.26	0.25	0.24	0.18	0.26	0.06	0.09	0.00
723	2.2845	2.7589	2.4592	2.8059	2.2016	2.4308	2.2627	0.22	0.04	0.20	0.10	0.22	0.00	0.09	0.03
724	3.4577	4.5946	3.3077	3.284	2.7986	2.9346	2.6739	0.42	0.23	0.42	0.19	0.19	0.04	0.09	0.00
725	4.2196	3.7619	3.7043	3.7212	3.7734	3.4238	3.5745	0.19	0.19	0.09	0.08	0.08	0.09	0.00	0.04
726	3.6083	5.3935	3.338	3.598	3.1962	3.2429	3.2552	0.41	0.11	0.41	0.04	0.11	0.00	0.01	0.02
727	2.6192	2.9044	2.7509	2.6249	2.6098	2.9428	2.6236	0.11	0.00	0.10	0.05	0.01	0.00	0.11	0.01
728	2.2727	2.4163	1.9714	2.1796	2.0471	1.9186	1.9912	0.21	0.16	0.21	0.03	0.12	0.06	0.00	0.04
729	2.5173	3.7033	2.6382	2.7351	2.7749	3.0332	3.0179	0.32	0.00	0.32	0.05	0.08	0.09	0.17	0.17
730	3.8848	3.5441	3.8321	3.3153	3.3158	3.6087	3.3418	0.15	0.15	0.06	0.13	0.00	0.00	0.08	0.01
731	1.838	2.2196	1.898	1.8524	1.8457	1.6844	1.5528	0.30	0.16	0.30	0.18	0.16	0.16	0.08	0.00
732	2.6045	3.4583	2.5812	2.253	2.4041	3.1797	2.3712	0.35	0.13	0.35	0.13	0.00	0.06	0.29	0.05
733	3.8121	4.612	3.7919	4.1035	3.8665	3.616	3.6855	0.22	0.05	0.22	0.05	0.12	0.06	0.00	0.02
734	2.8572	4.1584	2.91	2.8602	2.6421	2.9422	2.5875	0.38	0.09	0.38	0.11	0.10	0.02	0.12	0.00
735	4.0687	4.3113	4.1171	4.3717	4.0144	3.954	4.1828	0.10	0.03	0.08	0.04	0.10	0.02	0.00	0.05
736	3.6226	4.1076	3.5588	4.1502	3.5566	3.2833	3.3344	0.21	0.09	0.20	0.08	0.21	0.08	0.00	0.02
737	3.4436	3.427	3.485	3.5988	3.2808	3.7913	3.4076	0.13	0.05	0.04	0.06	0.09	0.00	0.13	0.04
738	2.9959	3.8333	3.149	3.6394	2.8744	3.453	2.8436	0.26	0.05	0.26	0.10	0.22	0.01	0.18	0.00
739	3.2315	2.9313	2.9128	2.7655	3.0087	2.7769	2.5629	0.21	0.21	0.13	0.12	0.07	0.15	0.08	0.00
740	3.8152	4.4102	3.9091	3.7994	3.691	3.9027	3.7697	0.16	0.03	0.16	0.06	0.03	0.00	0.05	0.02
741	2.3801	2.6663	2.3912	1.8927	2.2304	2.5721	1.8767	0.30	0.21	0.30	0.22	0.01	0.16	0.27	0.00
742	2.9302	3.2488	3.13	2.6319	2.6019	2.5278	2.4898	0.23	0.15	0.23	0.20	0.05	0.04	0.02	0.00
743	3.2507	4.1046	2.9172	3.1884	2.3368	2.7542	2.7398	0.43	0.28	0.43	0.20	0.27	0.00	0.15	0.15
744	3.5073	4.2939	3.2308	3.7373	2.559	3.5443	3.0386	0.40	0.27	0.40	0.21	0.32	0.00	0.28	0.16
745	2.5771	2.4851	2.7299	2.342	2.3997	2.4054	2.2618	0.17	0.12	0.09	0.17	0.03	0.06	0.06	0.00
746	3.1552	3.9759	2.9097	3.3315	2.5539	2.5998	2.6732	0.36	0.19	0.36	0.12	0.23	0.00	0.02	0.04
747	3.2145	4.5122	3.0371	3.6594	3.1099	2.7157	2.8448	0.40	0.16	0.40	0.11	0.26	0.13	0.00	0.05
748	3.9844	4.574	2.9757	4.2295	3.1802	3.5139	3.2319	0.35	0.25	0.35	0.00	0.30	0.06	0.15	0.08
749	2.0407	2.6977	2.1422	2.199	1.7761	2.344	1.8258	0.34	0.13	0.34	0.17	0.19	0.00	0.24	0.03
750	3.7114	3.3581	3.46	3.4648	3.1241	3.5618	3.46	0.16	0.16	0.07	0.10	0.10	0.00	0.12	0.10
751	4.3535	4.4126	3.903	4.7093	3.8318	3.9525	3.835	0.19	0.12	0.13	0.02	0.19	0.00	0.03	0.00
752	1.7975	3.7742	2.3296	2.3398	1.7608	2.5428	2.0223	0.53	0.02	0.53	0.24	0.25	0.00	0.31	0.13
753	1.3751	2.2474	1.7318	1.6586	1.4984	1.3665	1.2292	0.45	0.11	0.45	0.29	0.26	0.18	0.10	0.00
754	2.612	2.8468	2.4124	2.3906	2.4748	2.5301	2.3392	0.18	0.10	0.18	0.03	0.02	0.05	0.08	0.00
755	2.4295	2.751	1.999	2.5243	1.9919	2.4351	1.9941	0.28	0.18	0.28	0.00	0.21	0.00	0.18	0.00
756	3.7052	4.4802	3.3964	3.1194	3.3416	3.5332	3.3368	0.30	0.16	0.30	0.08	0.00	0.07	0.12	0.07
757	2.0965	2.7904	1.7645	2.0853	1.778	2.3405	1.8236	0.37	0.16	0.37	0.00	0.15	0.01	0.25	0.03
758	3.2562	3.8971	3.2408	3.6281	3.1815	3.4737	3.9707	0.20	0.02	0.18	0.02	0.12	0.00	0.08	0.20
759	1.8929	3.1596	2.1293	2.2403	1.9377	2.2925	1.6647	0.47	0.12	0.47	0.22	0.26	0.14	0.27	0.00
760	3.6513	3.6872	3.5437	4.1503	2.8945	3.4361	3.1955	0.30	0.21	0.21	0.18	0.30	0.00	0.16	0.09
761	2.4772	2.9993	2.5443	2.7951	2.4738	2.5648	2.4318	0.19	0.02	0.19	0.04	0.13	0.02	0.05	0.00
762	4.3514	4.9592	3.8367	4.1723	3.909	4.1201	3.7401	0.25	0.14	0.25	0.03	0.10	0.04	0.09	0.00
763	2.518	3.5021	2.3815	3.2622	2.2735	2.649	2.5903	0.35	0.10	0.35	0.05	0.30	0.00	0.14	0.12
764	2.7888	3.4294	3.1066	3.0556	2.7194	2.951	2.511	0.27	0.10	0.27	0.19	0.18	0.08	0.15	0.00
765	3.1932	4.3783	3.28	3.9811	3.0257	3.9762	3.4921	0.31	0.05	0.31	0.08	0.24	0.00	0.24	0.13
766	2.5826	2.9323	2.6509	2.5911	2.5615	2.6503	2.5657	0.13	0.01	0.13	0.03	0.01	0.00	0.03	0.00
767	3.1174	3.8279	2.8846	3.2788	2.4677	2.7448	2.6183	0.36	0.21	0.36	0.14	0.25	0.00	0.10	0.06
768	2.2928	3.8928	2.7236	2.3684	2.4742	2.7948	2.1245	0.45	0.07	0.45	0.22	0.10	0.14	0.24	0.00
769	4.0825	4.2252	4.2312	4.3774	3.9122	4.3935	4.2132	0.11	0.04	0.07	0.08	0.11	0.00	0.11	0.07
770	2.5292	3.2347	2.0326	2.8685	1.9383	2.4435	2.1641	0.40	0.23	0.40	0.05	0.32	0.00	0.21	0.10
771	4.4818	5.1005	3.4391	4.1005	3.4359	4.2509	3.3405	0.35	0.25	0.35	0.03	0.19	0.03	0.21	0.00
772	3.7561	4.1622	4.2427	3.5808	3.594	4.0271	3.8948	0.16	0.05	0.14	0.16	0.00	0.00	0.11	0.08
773	2.3221	3.3287	2.3142	2.0748	1.9845	2.1896	1.759	0.47	0.24	0.47	0.24	0.15	0.11	0.20	0.00
774	1.9787	2.462	2.1872	1.7633	2.0425	2.0428	1.5995	0.35	0.19	0.35	0.27	0.09	0.22	0.22	0.00
775	3.3341	3.7513	3.3528	3.4399	3.3034	3.4731	3.4155	0.12	0.01	0.12	0.01	0.04	0.00	0.05	0.03
776	3.5428	3.8297	3.4636	4.1256	3.2792	3.225	3.3784	0.22	0.09	0.16	0.07	0.22	0.02	0.00	0.05
777	3.1229	4.4167	3.8278	3.0268	2.6199	3.2085	2.7221	0.41	0.16	0.41	0.32	0.13	0.00	0.18	0.04
778	1.8516	2.8138	1.9824	1.893	1.6293	2.62	1.6193	0.42	0.13	0.42	0.18	0.14	0.01	0.38	0.00
779	1.8168	2.8236	1.8135	2.0485	1.8901	1.6201	1.6784	0.43	0.11	0.43	0.11	0.21	0.14	0.00	0.03
780	3.1257	3.7502	2.7506	3.2455	2.6119	2.7569	2.5527	0.32	0.18	0.32	0.07	0.21	0.02	0.07	0.00
781	3.2432	3.618	3.6712	3.5554	3.3677	3.5242	3.4197	0.12	0.00	0.10	0.12	0.09	0.04	0.08	0.05
782	2.5277	3.3216	2.0795	1.9248	1.6961	1.8785	1.6967	0.49	0.33	0.49	0.18	0.12	0.00	0.10	0.00
783	3.9787	4.1488	3.1581	3.5659	2.9744	3.0248	3.0885	0.28	0.25	0.28	0.06	0.17	0.00	0.02	0.04
784	2.3477	3.7176	2.4364	3.1249	2.3048	3.009	2.1687	0.42	0.08	0.42	0.11	0.31	0.06	0.28	0.00
785	1.8964	2.4808	1.9999	1.7275	1.9489	1.5908	1.5486	0.38	0.18	0.38	0.23	0.10	0.21	0.03	0.00
786	2.0804	2.8953	2.0057	2.1141	1.8888	2.3514	1.7633	0.39	0.15	0.39	0.12	0.17	0.07	0.25	0.00

787	3.7049	3.3886	3.04	4.1454	2.9107	2.3618	2.7319	0.43	0.36	0.30	0.22	0.43	0.19	0.00	0.14
788	2.3439	3.9276	2.3162	2.0435	2.0979	2.4634	1.9795	0.50	0.16	0.50	0.15	0.03	0.06	0.20	0.00
789	2.9289	3.1299	3.0686	2.9279	2.68	2.9427	2.6933	0.14	0.08	0.14	0.13	0.08	0.00	0.09	0.00
790	3.2908	4.1527	2.6499	3.2451	2.5788	2.982	2.6488	0.38	0.22	0.38	0.03	0.21	0.00	0.14	0.03
791	3.627	4.7686	3.8126	4.2195	3.5977	3.5439	3.5001	0.27	0.03	0.27	0.08	0.17	0.03	0.01	0.00
792	2.9589	3.8594	3.6671	3.2715	3.2813	3.5405	3.354	0.23	0.00	0.23	0.19	0.10	0.10	0.16	0.12
793	4.0855	3.5436	3.4195	3.4105	3.6812	3.4846	3.2139	0.21	0.21	0.09	0.06	0.06	0.13	0.08	0.00
794	2.821	3.0266	2.4227	2.9337	2.4285	2.5222	2.4695	0.20	0.14	0.20	0.00	0.17	0.00	0.04	0.02
795	3.0265	2.4077	2.7487	2.683	2.4999	2.4753	2.4922	0.20	0.20	0.00	0.12	0.10	0.04	0.03	0.03
796	2.8294	3.9227	2.7407	3.5911	2.7465	2.9386	2.7487	0.30	0.03	0.30	0.00	0.24	0.00	0.07	0.00
797	3.8113	4.9386	2.9445	3.588	3.4758	2.6967	3.3636	0.45	0.29	0.45	0.08	0.25	0.22	0.00	0.20
798	4.4545	5.4308	4.4175	4.6045	3.7962	4.697	4.169	0.30	0.15	0.30	0.14	0.18	0.00	0.19	0.09
799	3.4408	3.9744	2.9643	4.0704	3.0792	3.0954	3.127	0.27	0.14	0.25	0.00	0.27	0.04	0.04	0.05
800	3.2281	3.7578	2.7577	2.9311	2.7294	2.6095	2.8454	0.31	0.19	0.31	0.05	0.11	0.04	0.00	0.08
801	3.6189	3.8633	3.4515	4.0424	3.4607	3.5526	3.8863	0.15	0.05	0.11	0.00	0.15	0.00	0.03	0.11
802	2.1382	3.7776	2.511	3.0675	1.8064	2.017	2.174	0.52	0.16	0.52	0.28	0.41	0.00	0.10	0.17
803	2.1121	2.6798	2.3701	2.3492	1.9534	2.3658	2.2705	0.27	0.08	0.27	0.18	0.17	0.00	0.17	0.14
804	2.5579	3.2169	2.2537	2.4295	2.2029	2.2833	2.0848	0.35	0.18	0.35	0.07	0.14	0.05	0.09	0.00
805	3.5783	3.7956	3.035	3.1314	2.9595	3.3499	2.9135	0.23	0.19	0.23	0.04	0.07	0.02	0.13	0.00
806	3.1813	4.6914	3.4287	3.7171	2.8539	3.5168	3.3682	0.39	0.10	0.39	0.17	0.23	0.00	0.19	0.15
807	2.2994	2.6513	2.6428	1.9505	2.6748	2.3738	2.0523	0.27	0.15	0.26	0.26	0.00	0.27	0.18	0.05
808	4.1911	4.0811	3.5791	4.2787	3.4527	3.4098	3.4374	0.20	0.19	0.16	0.05	0.20	0.01	0.00	0.01
809	2.6809	3.4516	2.8372	2.8199	2.8757	2.9717	2.8761	0.22	0.00	0.22	0.06	0.05	0.07	0.10	0.07
810	2.5273	3.479	3.0186	3.0314	2.7629	3.1107	2.6166	0.27	0.00	0.27	0.16	0.17	0.09	0.19	0.03
811	3.0895	4.0278	3.4637	3.8718	2.6652	3.1188	3.1105	0.34	0.14	0.34	0.23	0.31	0.00	0.15	0.14
812	2.6522	3.9233	2.2732	2.9162	2.3805	2.3533	2.651	0.42	0.14	0.42	0.00	0.22	0.05	0.03	0.14
813	2.7832	3.1718	2.5502	3.3491	2.6814	2.7324	2.3892	0.29	0.14	0.25	0.06	0.29	0.11	0.13	0.00
814	3.0485	3.8154	3.7189	3.3877	3.2171	4.005	3.2136	0.24	0.00	0.20	0.18	0.10	0.05	0.24	0.05
815	2.0164	2.9002	1.7597	1.945	1.8868	2.1948	1.7587	0.39	0.13	0.39	0.00	0.10	0.07	0.20	0.00
816	2.5976	2.3346	2.3261	2.195	2.1098	2.2384	2.2813	0.19	0.19	0.10	0.09	0.04	0.00	0.06	0.08
817	1.513	2.4447	2.0933	1.6086	1.6209	2.2253	1.301	0.47	0.14	0.47	0.38	0.19	0.20	0.42	0.00
818	2.6007	2.7346	2.701	2.6482	2.0357	2.4092	2.2926	0.26	0.22	0.26	0.25	0.23	0.00	0.16	0.11
819	2.6875	3.4605	2.5151	3.1616	2.3524	2.6953	2.3324	0.33	0.13	0.33	0.07	0.26	0.01	0.13	0.00
820	3.0438	2.9009	3.2809	2.6723	2.772	2.8314	2.548	0.22	0.16	0.12	0.22	0.05	0.08	0.10	0.00
821	3.1493	3.9933	3.1118	3.5038	2.8798	3.338	3.074	0.28	0.09	0.28	0.07	0.18	0.00	0.14	0.06
822	2.9166	2.5727	2.4063	2.8748	2.4049	2.4031	2.2774	0.22	0.22	0.11	0.05	0.21	0.05	0.05	0.00
823	3.5494	3.2606	3.038	3.5216	2.6479	2.8981	2.4535	0.31	0.31	0.25	0.19	0.30	0.07	0.15	0.00
824	1.84	3.6217	1.8645	2.47	1.8565	1.8546	1.8907	0.49	0.00	0.49	0.01	0.26	0.01	0.01	0.03
825	2.1651	2.306	1.8731	2.0212	1.7566	1.6737	1.5717	0.32	0.27	0.32	0.16	0.22	0.11	0.06	0.00
826	3.3433	3.0994	3.0632	3.0691	2.5641	3.0348	2.8212	0.23	0.23	0.17	0.16	0.16	0.00	0.16	0.09
827	2.8285	4.1722	2.9848	2.8147	2.6416	2.7552	2.665	0.37	0.07	0.37	0.11	0.06	0.00	0.04	0.01
828	3.4833	3.9445	3.8305	3.598	3.569	3.6471	3.2463	0.18	0.07	0.18	0.15	0.10	0.09	0.11	0.00
829	3.1203	4.3125	3.2261	3.2892	2.7266	3.6915	3.2604	0.37	0.13	0.37	0.15	0.17	0.00	0.26	0.16
830	2.7567	3.8258	3.1706	3.212	3.05	3.304	2.9031	0.28	0.00	0.28	0.13	0.14	0.10	0.17	0.05
831	3.0262	3.6888	3.0534	3.1767	2.4761	2.9569	2.7386	0.33	0.18	0.33	0.19	0.22	0.00	0.16	0.10
832	3.2387	3.8975	2.8989	3.6296	3.0738	3.7575	2.864	0.27	0.12	0.27	0.01	0.21	0.07	0.24	0.00
833	3.7877	4.1476	3.6918	3.5244	3.4727	3.9605	3.5076	0.16	0.08	0.16	0.06	0.01	0.00	0.12	0.01
834	2.2546	3.4211	2.4139	2.5777	1.8558	2.8429	2.0653	0.46	0.18	0.46	0.23	0.28	0.00	0.35	0.10
835	3.5406	4.9725	4.1323	3.8212	3.6353	4.0521	3.6346	0.29	0.00	0.29	0.14	0.07	0.03	0.13	0.03
836	3.303	4.1591	3.7185	3.5778	3.7393	3.9055	3.48	0.21	0.00	0.21	0.11	0.08	0.12	0.15	0.05
837	2.3852	3.0188	2.5113	2.8518	2.1	2.4856	2.4497	0.30	0.12	0.30	0.16	0.26	0.00	0.16	0.14
838	3.9698	4.9114	3.7938	4.5578	3.3763	3.8617	3.9867	0.31	0.15	0.31	0.11	0.26	0.00	0.13	0.15
839	2.8406	4.5979	2.9067	3.206	2.7101	3.5625	2.8105	0.41	0.05	0.41	0.07	0.15	0.00	0.24	0.04
840	2.2087	2.436	2.1063	2.2827	2.0336	2.1837	2.1002	0.17	0.08	0.17	0.03	0.11	0.00	0.07	0.03
841	2.6992	3.5297	2.8071	3.2835	2.6205	2.5272	2.5952	0.28	0.06	0.28	0.10	0.23	0.04	0.00	0.03
842	2.8801	3.7035	3.3584	3.3243	3.0116	3.2884	3.0559	0.22	0.00	0.22	0.14	0.13	0.04	0.12	0.06
843	2.3856	3.1579	2.8595	2.7151	2.2691	2.8362	2.3404	0.28	0.05	0.28	0.21	0.16	0.00	0.20	0.03
844	3.5264	4.285	2.7129	3.3115	3.0678	2.7565	2.8545	0.37	0.23	0.37	0.00	0.18	0.12	0.02	0.05
845	2.9475	5.1375	3.4321	3.0068	3.0979	3.6388	3.2356	0.43	0.00	0.43	0.14	0.02	0.05	0.19	0.09
846	2.4491	3.3406	2.2363	2.0849	1.8506	2.1098	1.8332	0.45	0.25	0.45	0.18	0.12	0.01	0.13	0.00
847	2.2391	2.0587	1.8843	2.0403	2.2317	1.9085	1.8438	0.18	0.18	0.10	0.02	0.10	0.17	0.03	0.00
848	4.2181	5.0956	3.3056	3.9485	3.2428	3.804	3.304	0.36	0.23	0.36	0.02	0.18	0.00	0.15	0.02
849	3.2733	3.6499	3.2373	3.2932	3.1133	3.1812	3.1325	0.15	0.05	0.15	0.04	0.05	0.00	0.02	0.01
850	3.1796	3.0973	2.9232	2.5953	3.0278	2.7102	2.7336	0.18	0.18	0.16	0.11	0.00	0.14	0.04	0.05
851	2.4974	2.9929	2.5481	2.4571	2.3158	2.5447	2.474	0.23	0.07	0.23	0.09	0.06	0.00	0.09	0.06
852	3.1219	3.9451	3.3836	3.5425	2.9911	3.9154	3.2042	0.24	0.04	0.24	0.12	0.16	0.00	0.24	0.07

853	3.2597	3.3442	2.1198	3.4306	2.3569	2.092	2.7732	0.39	0.36	0.37	0.01	0.39	0.11	0.00	0.25
854	2.3869	3.6061	2.2937	2.5467	2.3755	2.5809	2.5506	0.36	0.04	0.36	0.00	0.10	0.03	0.11	0.10
855	3.2135	3.2134	3.1772	2.7782	2.7562	2.9381	2.8282	0.14	0.14	0.14	0.13	0.01	0.00	0.06	0.03
856	2.5253	2.8224	2.5181	2.4797	2.3799	2.4135	2.3479	0.17	0.07	0.17	0.07	0.05	0.01	0.03	0.00
857	3.1065	3.2203	2.8248	2.8952	2.5732	2.6307	2.4752	0.23	0.20	0.23	0.12	0.15	0.04	0.06	0.00
858	2.8701	3.7152	2.8166	2.6247	2.619	3.0275	2.7897	0.30	0.09	0.30	0.07	0.00	0.00	0.13	0.06
859	2.2845	3.4329	2.5498	2.2726	2.2099	2.3889	2.0183	0.41	0.12	0.41	0.21	0.11	0.09	0.16	0.00
860	3.2829	4.1923	3.2848	2.6396	2.5487	3.2009	2.663	0.39	0.22	0.39	0.22	0.03	0.00	0.20	0.04
861	2.404	2.7956	2.063	2.4371	2.1065	1.9904	2.1926	0.29	0.17	0.29	0.04	0.18	0.06	0.00	0.09
862	2.8843	3.5604	2.9824	3.3663	2.6736	3.0974	3.1536	0.25	0.07	0.25	0.10	0.21	0.00	0.14	0.15
863	3.0321	3.9107	3.0559	3.339	2.6283	3.6309	2.8412	0.33	0.13	0.33	0.14	0.21	0.00	0.28	0.07
864	3.1088	4.6014	3.0436	3.7282	3.15	3.6698	3.1257	0.34	0.02	0.34	0.00	0.18	0.03	0.17	0.03
865	2.4453	3.0416	2.224	2.7218	1.9344	2.3991	2.1638	0.36	0.21	0.36	0.13	0.29	0.00	0.19	0.11
866	2.5767	2.628	2.6536	2.2078	2.6182	2.5072	2.5974	0.17	0.14	0.16	0.17	0.00	0.16	0.12	0.15
867	3.7708	3.7719	3.528	3.6823	3.3124	3.3125	3.32	0.12	0.12	0.12	0.06	0.10	0.00	0.00	0.00
868	2.6331	2.5799	2.7374	2.4004	2.2625	2.3612	2.1146	0.23	0.20	0.18	0.23	0.12	0.07	0.10	0.00
869	3.8138	4.2098	3.6366	4.6273	3.1788	3.8304	3.8136	0.31	0.17	0.24	0.13	0.31	0.00	0.17	0.17
870	1.6607	2.7596	1.8773	2.0589	1.3634	2.1005	1.4939	0.51	0.18	0.51	0.27	0.34	0.00	0.35	0.09
871	3.473	4.1172	2.9677	2.9257	2.8812	2.7507	2.7017	0.34	0.22	0.34	0.09	0.08	0.06	0.02	0.00
872	3.2301	3.4214	2.74	2.6259	2.6947	2.9776	2.4981	0.27	0.23	0.27	0.09	0.05	0.07	0.16	0.00
873	2.5481	4.7619	2.5078	3.4717	2.2551	2.5854	2.5464	0.53	0.11	0.53	0.10	0.35	0.00	0.13	0.11
874	4.1461	5.4362	4.3444	4.952	3.8766	4.8215	4.4514	0.29	0.07	0.29	0.11	0.22	0.00	0.20	0.13
875	3.0995	3.9827	3.3865	3.232	3.0104	3.4358	2.9611	0.26	0.04	0.26	0.13	0.08	0.02	0.14	0.00
876	2.7219	3.5434	2.6772	3.0232	2.2105	2.6945	2.5808	0.38	0.19	0.38	0.17	0.27	0.00	0.18	0.14
877	3.4665	3.7093	3.3985	3.6396	3.4778	3.4653	3.4353	0.08	0.02	0.08	0.00	0.07	0.02	0.02	0.01
878	4.0804	4.4977	3.9317	4.4283	4.1184	4.4443	4.1014	0.13	0.04	0.13	0.00	0.11	0.05	0.12	0.04
879	3.1048	4.475	3.1901	3.7926	2.5025	3.2074	2.962	0.44	0.19	0.44	0.22	0.34	0.00	0.22	0.16
880	3.4501	3.3799	2.4739	2.674	2.3589	2.9845	1.9206	0.44	0.44	0.43	0.22	0.28	0.19	0.36	0.00
881	4.1318	4.3907	4.4698	4.0433	3.6773	4.3546	4.05	0.18	0.11	0.16	0.18	0.09	0.00	0.16	0.09
882	3.8383	4.2914	3.4481	3.5678	3.2483	3.4196	3.5822	0.24	0.15	0.24	0.06	0.09	0.00	0.05	0.09
883	3.0338	3.7894	2.955	3.3601	2.7669	3.2113	3.2262	0.27	0.09	0.27	0.06	0.18	0.00	0.14	0.14
884	2.9357	3.8727	2.9941	3.1554	2.6544	3.1968	2.9855	0.31	0.10	0.31	0.11	0.16	0.00	0.17	0.11
885	2.7606	3.8536	2.534	3.569	2.5134	2.6414	2.3838	0.38	0.14	0.38	0.06	0.33	0.05	0.10	0.00
886	3.763	5.0399	3.9824	4.3393	3.9585	4.3615	4.4063	0.25	0.00	0.25	0.06	0.13	0.05	0.14	0.15
887	4.0863	4.5424	4.3901	4.1615	3.8821	4.2028	4.1226	0.15	0.05	0.15	0.12	0.07	0.00	0.08	0.06
888	3.6035	4.2759	3.5546	3.879	3.2769	3.734	3.3708	0.23	0.09	0.23	0.08	0.16	0.00	0.12	0.03
889	3.0119	4.4327	3.2854	2.6573	2.6546	3.3444	2.0748	0.53	0.31	0.53	0.37	0.22	0.22	0.38	0.00
890	2.4616	3.5028	2.1917	3.1355	2.1454	2.5583	1.9637	0.44	0.20	0.44	0.10	0.37	0.08	0.23	0.00
891	3.3955	4.4412	3.3573	3.4206	2.9903	3.7112	3.4698	0.33	0.12	0.33	0.11	0.13	0.00	0.19	0.14
892	2.7503	3.6702	2.9485	2.2818	2.5681	2.31	2.1324	0.42	0.22	0.42	0.28	0.07	0.17	0.08	0.00
893	4.4886	4.8918	3.7641	4.749	3.7379	4.3209	3.764	0.24	0.17	0.24	0.01	0.21	0.00	0.13	0.01
894	2.6425	4.1852	3.0365	2.1743	2.0647	2.8559	2.0994	0.51	0.22	0.51	0.32	0.05	0.00	0.28	0.02
895	3.1871	3.7782	3.4488	3.2597	2.794	3.2392	2.6613	0.30	0.16	0.30	0.23	0.18	0.05	0.18	0.00
896	2.3122	3.2089	2.8235	2.0731	1.9546	2.4463	2.3567	0.39	0.15	0.39	0.31	0.06	0.00	0.20	0.17
897	2.2132	3.5629	2.2101	3.143	1.9223	2.6814	2.3009	0.46	0.13	0.46	0.13	0.39	0.00	0.28	0.16
898	3.0482	3.0184	2.4673	3.4091	2.4367	2.799	2.851	0.29	0.20	0.19	0.01	0.29	0.00	0.13	0.15
899	4.3693	4.468	3.9279	4.339	3.893	4.0497	4.0132	0.13	0.11	0.13	0.01	0.10	0.00	0.04	0.03
900	3.2054	3.7921	3.4058	2.8246	2.7162	3.0238	2.6583	0.30	0.17	0.30	0.22	0.06	0.02	0.12	0.00
901	3.3395	4.8816	3.0395	2.8449	2.8232	2.9953	2.77	0.43	0.17	0.43	0.09	0.03	0.02	0.08	0.00
902	3.3652	3.9755	3.2303	3.4758	3.2399	3.9111	3.1652	0.20	0.06	0.20	0.02	0.09	0.02	0.19	0.00
903	3.1672	3.3539	2.8206	2.8373	2.5243	2.7657	2.7129	0.25	0.20	0.25	0.11	0.11	0.00	0.09	0.07
904	3.1154	4.7537	3.0596	3.7105	2.4631	2.7518	2.5219	0.48	0.21	0.48	0.19	0.34	0.00	0.10	0.02
905	4.4794	4.9897	4.3507	4.7716	4.1979	4.4499	4.2771	0.16	0.06	0.16	0.04	0.12	0.00	0.06	0.02
906	4.0789	4.8519	4.199	4.2189	3.6961	4.2646	3.7102	0.24	0.09	0.24	0.12	0.12	0.00	0.13	0.00
907	3.2343	4.487	3.8946	3.5193	3.125	3.7856	3.3444	0.30	0.03	0.30	0.20	0.11	0.00	0.17	0.07
908	3.7747	4.3189	4.0077	4.267	3.7169	3.9936	3.8363	0.14	0.02	0.14	0.07	0.13	0.00	0.07	0.03
909	3.1187	4.4149	3.1606	3.8805	3.083	3.3985	2.6694	0.40	0.14	0.40	0.16	0.31	0.13	0.21	0.00
910	2.8993	3.0108	2.6323	2.7955	2.7453	2.5236	2.5724	0.16	0.13	0.16	0.04	0.10	0.08	0.00	0.02
911	3.2824	4.1907	3.255	2.9215	2.8455	3.6904	2.7151	0.35	0.17	0.35	0.17	0.07	0.05	0.26	0.00
912	3.1762	4.9017	3.3642	3.6064	3.0945	4.0784	3.2041	0.37	0.03	0.37	0.08	0.14	0.00	0.24	0.03
913	3.1153	3.4885	2.5321	3.1505	2.0175	3.1446	2.3404	0.42	0.35	0.42	0.20	0.36	0.00	0.36	0.14
914	3.4641	4.3994	2.8342	3.7825	2.4555	2.5222	2.9848	0.44	0.29	0.44	0.13	0.35	0.00	0.03	0.18
915	3.2134	3.8255	2.8379	3.3616	2.6093	2.7449	2.8303	0.32	0.19	0.32	0.08	0.22	0.00	0.05	0.08
916	2.5713	2.7873	2.4798	2.9008	2.5423	2.7382	2.382	0.18	0.07	0.15	0.04	0.18	0.06	0.13	0.00
917	2.8465	3.9188	3.2787	3.4212	2.9901	3.9141	2.8139	0.28	0.01	0.28	0.14	0.18	0.06	0.28	0.00
918	3.3017	3.7243	3.2231	3.3131	3.0752	3.2124	3.2927	0.17	0.07	0.17	0.05	0.07	0.00	0.04	0.07

919	2.7969	3.13	3.0134	2.9604	2.6925	2.7224	2.7327	0.14	0.04	0.14	0.11	0.09	0.00	0.01	0.01
920	3.6809	4.5118	3.6928	4.4735	3.1413	3.6291	3.2966	0.30	0.15	0.30	0.15	0.30	0.00	0.13	0.05
921	3.0568	3.7571	3.256	3.8486	2.8536	2.9984	2.9916	0.26	0.07	0.24	0.12	0.26	0.00	0.05	0.05
922	2.0951	3.199	2.5414	2.356	2.1123	2.6985	2.3379	0.35	0.00	0.35	0.18	0.11	0.01	0.22	0.10
923	2.2121	3.0643	2.3649	2.9556	1.9823	2.3845	2.3638	0.35	0.10	0.35	0.16	0.33	0.00	0.17	0.16
924	3.7456	4.4902	3.5214	3.8945	3.6226	3.7726	3.6412	0.22	0.06	0.22	0.00	0.10	0.03	0.07	0.03
925	3.3169	4.711	3.1454	3.7488	3.2057	3.4071	3.1379	0.33	0.05	0.33	0.00	0.16	0.02	0.08	0.00
926	3.0764	2.8731	2.7999	2.5352	2.669	2.9428	2.5218	0.18	0.18	0.12	0.10	0.01	0.06	0.14	0.00
927	3.7344	4.4818	3.8168	3.9892	3.1432	3.8038	3.2862	0.30	0.16	0.30	0.18	0.21	0.00	0.17	0.04
928	2.029	2.605	2.4042	2.283	2.1774	2.1083	2.158	0.22	0.00	0.22	0.16	0.11	0.07	0.04	0.06
929	3.4209	3.8823	3.3798	3.7958	2.8367	3.1148	2.9198	0.27	0.17	0.27	0.16	0.25	0.00	0.09	0.03
930	3.7387	3.8146	3.4445	4.0352	3.5427	4.0542	3.3236	0.18	0.11	0.13	0.04	0.18	0.06	0.18	0.00
931	2.9125	3.3108	2.7571	3.3198	2.2309	2.7387	2.4842	0.33	0.23	0.33	0.19	0.33	0.00	0.19	0.10
932	3.4294	4.2309	3.3954	3.5454	3.2396	3.3649	3.3146	0.23	0.06	0.23	0.05	0.09	0.00	0.04	0.02
933	3.0891	3.2877	2.8602	3.106	2.8298	3.2911	2.9305	0.14	0.08	0.14	0.01	0.09	0.00	0.14	0.03
934	3.7504	3.85	3.7139	2.934	2.9194	3.5121	2.9232	0.24	0.22	0.24	0.21	0.00	0.00	0.17	0.00
935	4.1519	5.2239	4.446	4.2598	3.7756	4.7063	3.7838	0.28	0.09	0.28	0.15	0.11	0.00	0.20	0.00
936	2.1525	3.166	2.1474	1.8634	2.1138	2.0488	1.8251	0.42	0.15	0.42	0.15	0.02	0.14	0.11	0.00
937	2.638	3.1324	2.5713	2.2473	2.5867	2.3455	2.1271	0.32	0.19	0.32	0.17	0.05	0.18	0.09	0.00
938	4.0758	3.8934	3.8408	3.8017	3.1254	3.6574	3.2616	0.23	0.23	0.20	0.19	0.18	0.00	0.15	0.04
939	2.8934	3.0896	2.5993	2.6519	2.4999	2.6614	2.4375	0.21	0.16	0.21	0.06	0.08	0.02	0.08	0.00
940	3.0702	3.9454	2.6378	3.3766	2.5277	3.1114	2.5464	0.36	0.18	0.36	0.04	0.25	0.00	0.19	0.01
941	2.6587	3.3862	2.611	2.3709	1.8636	2.6215	2.255	0.45	0.30	0.45	0.29	0.21	0.00	0.29	0.17
942	2.9079	3.1666	2.9588	3.079	2.6799	3.1092	2.4532	0.23	0.16	0.23	0.17	0.20	0.08	0.21	0.00
943	3.392	3.5806	3.4998	3.4591	2.9343	3.7121	3.4507	0.21	0.13	0.18	0.16	0.15	0.00	0.21	0.15
944	3.2984	3.8306	3.4081	3.604	2.979	3.6434	3.1975	0.22	0.10	0.22	0.13	0.17	0.00	0.18	0.07
945	2.6044	2.8247	2.6829	2.688	2.5802	2.7458	2.2533	0.20	0.13	0.20	0.16	0.16	0.13	0.18	0.00
946	3.7971	3.5774	3.4727	3.3448	3.1572	3.3208	3.3908	0.17	0.17	0.12	0.09	0.06	0.00	0.05	0.07
947	2.872	3.2901	2.0972	2.4938	2.4464	2.1399	2.2717	0.36	0.27	0.36	0.00	0.16	0.14	0.02	0.08
948	2.3904	2.7488	2.0748	2.1871	2.1396	1.9377	2.1384	0.30	0.19	0.30	0.07	0.11	0.09	0.00	0.09
949	3.1383	3.8135	2.929	3.5902	2.9085	3.2682	3.046	0.24	0.07	0.24	0.01	0.19	0.00	0.11	0.05
950	3.0976	4.0937	3.0113	3.5337	2.7472	3.2065	2.8432	0.33	0.11	0.33	0.09	0.22	0.00	0.14	0.03
951	4.1787	3.9954	3.2784	3.9234	3.658	3.1888	3.6512	0.24	0.24	0.20	0.03	0.19	0.13	0.00	0.13
952	3.5343	4.348	3.4291	3.8774	3.2346	3.5686	3.5664	0.26	0.08	0.26	0.06	0.17	0.00	0.09	0.09
953	2.0336	2.63	2.3593	2.4886	2.0451	2.1826	2.0845	0.23	0.00	0.23	0.14	0.18	0.01	0.07	0.02
954	3.2606	4.6099	3.4983	4.3335	2.8421	3.8402	3.8829	0.38	0.13	0.38	0.19	0.34	0.00	0.26	0.27
955	2.456	2.5781	2.3177	2.4227	2.54	2.8305	2.3577	0.18	0.06	0.10	0.00	0.04	0.09	0.18	0.02
956	2.7204	2.9753	2.7294	2.6817	2.4882	2.7994	2.6067	0.16	0.09	0.16	0.09	0.07	0.00	0.11	0.05
957	4.1283	5.4396	3.677	4.1128	3.9565	4.4602	3.9099	0.32	0.11	0.32	0.00	0.11	0.07	0.18	0.06
958	2.6622	3.0785	2.9993	3.1473	2.7353	2.8126	2.8542	0.15	0.00	0.14	0.11	0.15	0.03	0.05	0.07
959	2.4772	3.5384	2.9535	2.5361	2.6361	2.4922	2.3297	0.34	0.06	0.34	0.21	0.08	0.12	0.07	0.00
960	3.1209	2.4213	2.2732	2.4413	2.407	2.3379	2.3671	0.27	0.27	0.06	0.00	0.07	0.06	0.03	0.04
961	2.1009	3.087	1.5875	2.3248	1.5592	1.7486	1.7087	0.49	0.26	0.49	0.02	0.33	0.00	0.11	0.09
962	2.5087	3.5111	2.4564	2.9255	2.4063	2.5264	2.5872	0.31	0.04	0.31	0.02	0.18	0.00	0.05	0.07
963	3.699	4.7527	3.3871	3.8497	3.094	3.4143	2.9485	0.38	0.20	0.38	0.13	0.23	0.05	0.14	0.00
964	3.1751	4.182	2.9235	3.0724	2.8257	2.8552	2.9145	0.32	0.11	0.32	0.03	0.08	0.00	0.01	0.03
965	2.8121	3.0761	2.9298	2.7436	2.416	2.7419	2.539	0.21	0.14	0.21	0.18	0.12	0.00	0.12	0.05
966	3.263	3.838	3.1705	2.4504	2.6388	2.9421	2.2586	0.41	0.31	0.41	0.29	0.08	0.14	0.23	0.00
967	3.4213	3.7166	2.8634	3.4103	2.6829	3.0149	2.6107	0.30	0.24	0.30	0.09	0.23	0.03	0.13	0.00
968	3.1696	3.9851	3.1609	3.6677	2.976	3.9788	3.3728	0.25	0.06	0.25	0.06	0.19	0.00	0.25	0.12
969	4.1387	3.0914	3.2679	4.1137	3.0796	3.0633	3.0093	0.27	0.27	0.03	0.08	0.27	0.02	0.02	0.00
970	3.0433	3.7685	3.8846	3.5664	3.5229	3.7306	3.7694	0.22	0.00	0.19	0.22	0.15	0.14	0.18	0.19
971	2.0664	2.4737	1.9355	2.0392	2.1035	1.9809	1.9243	0.22	0.07	0.22	0.01	0.06	0.09	0.03	0.00
972	2.3629	2.5171	2.6942	1.9474	2.1696	2.1859	2.0347	0.28	0.18	0.23	0.28	0.00	0.10	0.11	0.04
973	4.018	4.893	4.0201	4.2241	4.0958	4.5249	3.9933	0.18	0.01	0.18	0.01	0.05	0.03	0.12	0.00
974	3.0851	3.204	3.2258	3.0995	2.1932	2.9658	2.6845	0.32	0.29	0.32	0.32	0.29	0.00	0.26	0.18
975	3.2227	3.5149	2.858	3.1942	2.6349	2.731	2.7873	0.25	0.18	0.25	0.08	0.18	0.00	0.04	0.05
976	3.9792	3.7032	3.4836	3.2867	3.0749	3.7187	3.2376	0.23	0.23	0.17	0.12	0.06	0.00	0.17	0.05
977	2.5834	3.189	2.0863	2.6712	2.3649	2.6319	2.6651	0.35	0.19	0.35	0.00	0.22	0.12	0.21	0.22
978	2.1403	3.6133	2.0823	3.0112	1.9952	2.3993	2.0086	0.45	0.07	0.45	0.04	0.34	0.00	0.17	0.01
979	3.3545	4.4378	3.1805	4.2698	2.8137	3.1154	3.0619	0.37	0.16	0.37	0.12	0.34	0.00	0.10	0.08
980	2.9416	3.4968	3.2667	3.116	2.6349	3.0946	3.0915	0.25	0.10	0.25	0.19	0.15	0.00	0.15	0.15
981	1.937	2.4706	1.9044	2.2872	1.7303	2.0795	1.8026	0.30	0.11	0.30	0.09	0.24	0.00	0.17	0.04
982	3.051	3.9417	3.2687	3.2008	2.7039	3.2513	3.2617	0.31	0.11	0.31	0.17	0.16	0.00	0.17	0.17
983	2.5132	2.9104	2.3261	2.758	2.3647	2.6474	2.4253	0.20	0.07	0.20	0.00	0.16	0.02	0.12	0.04
984	3.4797	4.0716	3.4112	2.9393	2.7224	3.5709	3.3015	0.33	0.22	0.33	0.20	0.07	0.00	0.24	0.18

985	3.3595	2.9972	3.5082	3.0169	2.6554	3.3308	2.9044	0.24	0.21	0.11	0.24	0.12	0.00	0.20	0.09
986	3.2019	3.2875	3.3182	3.5642	3.0093	3.4186	2.7823	0.22	0.13	0.15	0.16	0.22	0.08	0.19	0.00
987	3.9352	4.5182	3.9524	4.1101	3.7993	4.0758	3.7862	0.16	0.04	0.16	0.04	0.08	0.00	0.07	0.00
988	3.8951	3.3299	3.2584	3.2278	3.4715	3.1147	3.1909	0.20	0.20	0.06	0.04	0.04	0.10	0.00	0.02
989	2.9009	3.2559	2.8079	2.7976	2.6106	2.6387	2.7249	0.20	0.10	0.20	0.07	0.07	0.00	0.01	0.04
990	3.4909	4.8028	3.0557	3.1394	2.8259	2.8836	2.5916	0.46	0.26	0.46	0.15	0.17	0.08	0.10	0.00
991	3.2764	3.6612	3.0527	3.0009	2.6774	2.856	2.6547	0.27	0.19	0.27	0.13	0.12	0.01	0.07	0.00
992	3.3863	3.6103	3.4495	2.9161	3.1278	3.5252	3.4445	0.19	0.14	0.19	0.15	0.00	0.07	0.17	0.15
993	2.7182	4.1661	3.3	3.1033	2.4363	3.4089	2.9262	0.42	0.10	0.42	0.26	0.21	0.00	0.29	0.17
994	3.9434	4.6526	3.7917	4.4713	3.6343	4.2977	3.7373	0.22	0.08	0.22	0.04	0.19	0.00	0.15	0.03
995	3.5298	4.6396	2.9935	3.1967	2.7819	2.9727	2.545	0.45	0.28	0.45	0.15	0.20	0.09	0.14	0.00
996	3.2243	3.6507	3.0729	3.2167	3.051	2.928	3.0728	0.20	0.09	0.20	0.05	0.09	0.04	0.00	0.05
997	2.8934	3.4995	2.899	2.7698	2.8328	2.955	2.8581	0.21	0.04	0.21	0.04	0.00	0.02	0.06	0.03
998	2.7219	3.7483	2.9287	3.0201	2.4551	3.2134	2.533	0.35	0.10	0.35	0.16	0.19	0.00	0.24	0.03
999	2.6049	3.2111	2.2908	2.2362	2.3409	2.4007	2.2464	0.30	0.14	0.30	0.02	0.00	0.04	0.07	0.00
1000	3.0458	3.391	2.6398	3.3669	2.5227	2.997	2.8065	0.26	0.17	0.26	0.04	0.25	0.00	0.16	0.10
AVE	3.0763	3.6941	2.9838	3.1618	2.7561	3.0433	2.7924	0.29	0.14	0.28	0.11	0.16	0.04	0.13	0.05

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