UNIVERSITY OF WARWICK

An Integrated Model to Predict M&A Decisions

By

Bing Sun CHUI

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Abstract

Mergers and acquisitions (M&A) are internationally adopted expansion strategies which are imperative to business growth. However, not all M&A are successfully executed nor all post-M&A business expansion have achieved the intended results. Some M&A might have taken place for the wrong reasons. Studies on M&A typically focus on the M&A wave or post-M&A integration. By contrast, this research concentrates on the pre-M&A analysis and planning. Incorporating fuzzy set theory and Monte Carlo simulation, an M&A evaluation and prioritisation model (MAEPM) was established in this study to assist decision makers to implement and execute M&A deals more objectively and effectively, with the aim of maximising the success rate.

Risk analysis, fuzzy critical path analysis, cost-benefit evaluation, as well as decision rule and prioritisation were integrated to support the MAEPM development. The success of M&A is highly uncertain and for that reason four risk factors (i.e., schedule, estimation, process, and external risks) were identified and mapped in every task in the M&A process for assessment and management. Time is one of the critical success factors in M&A. To enhance the accuracy of the MAEPM and to ensure effective M&A project delivery, fuzzy critical path analysis was employed to deal with subjective and vague human judgment in M&A project scheduling. The risk-bearing budget percentage and adjusted rate of return were calculated based on the cost-benefit evaluation of the model, particularly including the cost of manpower, which is regarded as the essential and second largest cost in M&A. All of these which form the MAEPM can provide insight into M&A evaluation and serve as indicators. In order to further facilitate firms to screen and select potential M&A projects in an effective manner, decision rule and prioritisation were created in this study as two decision gates to support M&A decision-making.

Eleven case studies were conducted to verify the MAEPM. The results from the MAEPM were compared with the actual results of M&A deals made by the case company that confirmed the MAEPM is promising and reliable. By applying the MAEPM, firms can gain

insight into the optimistic, normal, and pessimistic scenarios of different M&A deals for better strategic planning, resource allocation, and risk management. This enables firms to select the most ideal M&A deal(s) according to the availability of resources and capital, thus enhancing the success rate of M&A.

The subject company, Sage International Group Limited (SAGE), used this tool to re-evaluate some of its past M&A cases to better understand their post-M&A issues, and also to objectively and effectively evaluate all its possible future M&A. By using the MAEPM, SAGE not only reduced the turnaround time for each M&A deal screening by one third to more effectively compete for favourable M&A deals, which were less uncertain and had higher value in return, but also substantially reduced pre- and post-M&A costs by around HK$5-10 million annually. Another profound impact on the case company should be the improved chances of success of M&A deals because of the expected values generated. The novel MAEPM is confirmed to be reliable and is an important contribution to the field of M&A. The extension of its applicability is warranted to enable a better understanding of this holistic method of analysis and its impact on M&A deals in other sectors.

Acknowledgements

Declaration

I hereby declare that this thesis is my own work and that, to the best of my knowledge and belief, it reproduces no material previously published or written, nor material that has been accepted for the award of any other degree or diploma, except where due acknowledgement has been made in the text.

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Nomenclature

Symbol	Meaning
$S = (O, A, t)$	An activity-on-arrow project network, which consists of a finite set of nodes (O) and a set of arrows (A) with crisp activity time (t).
t_{ij}	The time period of activity, where i and j are elements of the set of arrows (A)
$S_f = (O, A, \tilde{T})$	A project network in the fuzzy environment, where $\tilde{T}$ is the fuzzy activity time $(i, j) \in A$
$\tilde{T}_{ij}$	The fuzzy time period of activity, where i and j are elements of the set of arrows (A)
$S(\tilde{T}_{ij})$	The fuzzy activity function in the support of $\tilde{T}_{ij}$
$\mu_{\tilde{T}_{ij}}(t_{ij})$	The fuzzy membership function of activity
$(T_{ij})_\alpha$	The crisp values at α –cut level
$(T_{ij})_\alpha^L$	The crisp value for the lower bound at α –cut level of the fuzzy sets
$(T_{ij})_\alpha^U$	The crisp value for the upper bound at α –cut level of the fuzzy sets
$\tilde{D}$	The maximal objective value of fuzzy duration
D_α^U	The crisp value for the upper bound at α –cut level of the shortest duration
D_α^L	The crisp value for the lower bound at α –cut level of the shortest duration
$\mu_{\tilde{D}}(d)$	The fuzzy membership function of the shortest duration
max	Maximum of a set
min	Minimum of a set
α	The α –cut level
inf	Infimum of a set
sup	Supremum of a set
L	Lower bound
U	Upper bound
θ	Angle
tan	Tangent function
s.t.	Such that or so that or subject to
$\in$	Set membership, for example, $(i, j) \in A$ means i and j are elements of the set A
$\sum$	Summation
$\int_0^1 d\alpha$	The integral between α=0 and α=1
$\{ \mid \}$	The set of ... such that
$\forall$	For all
y_i	The occurrence time of the node i
y_j	The occurrence time of the node j

$y_n - y_1$	The duration of the project
P_{cg}	The relative degree of criticality from point c (start of project) to point g (end of project)
L_{mcp}^{max}	The longest Yager ranking index
$\geq$	Is greater than or equal to
$\leq$	Is less than or equal to
d	The discount rate
C_t	The net cash flow at time (t)
t	Time

Chapter 1 Introduction

Mergers and acquisitions (M&A) are widespread across the world and have emerged as crucial corporate strategies for rapid business growth and development in the recent decade (Ramakrishnan, 2010). An M&A decision, as an important financial investment decision (Gupta and Gerhask, 2002), plays a vital role in the success of the company in terms of returns. This chapter provides an overview of the study background, explores the trends and advantages of M&A, and discusses the problem statements and research objectives. The overall organisation of this report will also be discussed.

1.1 Background

M&A are the combination of assets and liabilities of two companies to form a single but larger business entity. Mergers are the combination of two companies that are usually portrayed as similar sized, whereas acquisitions occur when a larger or more resourceful firm absorbs a smaller or weaker one. Despite the difference between the two terms – mergers and acquisitions – they are often used interchangeably nowadays. The term M&A is used in general throughout this study to mean the combination of assets and liabilities of two companies to form a single business entity.

Owing to the influence of globalisation and economic integration, businesses nowadays are exposed to a great deal of uncertainty and risk from both internal competition and external threats. In order to survive and expand rapidly, many businesses turn to M&A to obtain resources and gain market share. M&A, as a common corporate strategy, play an important role in corporate finance worldwide and have become a widespread phenomenon

in the business world. In recent decades, M&A deals around the world have increased substantially. There are numerous high-profile M&A cases, such as the acquisition of Jaguar Land Rover by Tata Motors, the Lenovo Group's acquisition of IBM's personal computing division, the acquisition of Volvo Carsby Geely Automobile, and the merger between Yahoo! and Microsoft. M&A examples can be found in different industries.

Companies use M&A to expand businesses with the most favourable opportunities for growth and profit. As Carney (2009) stated, the main strategic motivations for M&A are as follows:

- Synergies: After M&A, the value of the combination is much larger than the sum of the two companies, taking the form of revenue enhancement and cost savings. There are different kinds of synergies brought by M&A, such as administrative synergies, and financial synergies.

- Economies of scale: After bringing two separate companies together to form a larger one, the resulting company has better economies of scale with improved bargaining power due to increased order size and bulk-buying discounts. The company can also reduce costs by eliminating duplicate operations and departments.

- Possession of a leading market share: By absorbing competitors, the resulting company can often gain benefits such as obtaining well-known brand names and patents as marketing advantage to maintain its dominance. The synergic effects in sales growth and expansion of market share will drive companies towards globalisation.

Other than the financial motives, some M&A are initiated because of the chief executive officer's (CEO's) overconfidence, ego, and desire for power. CEOs are rewarded through M&A by an increase in their power over a larger firm. Some CEOs may take over another firm in order to show their ability or eliminate their competitors and opponents.

1.2 Problem Statements

Despite the importance and prevalence of M&A, not all M&A successfully achieve their strategic and financial objectives. The success of M&A is often measured by whether the value of the resulting company is enhanced after the deal. According to Mitchell *et al.*(2001), three out of four M&A deals fail and produce disappointing results. An article (Nic, 2007) indicated that "more than nine out of ten corporate M&A deals fall short of their objectives, with failure often occurring". To date, most studies have pointed out that the overall success rate of M&A deals is about 50% (Robert, 2012). Failure is mainly caused by a lack of attention to the integration process and a lack of rational tools for analysis to manage deals. Overestimating the synergic effect and benefits as well as overlooking the risks involved in M&A are other reasons for M&A failure. This shows that M&A practices are debatable. The following identified problems are the major challenges for many companies that undergo M&A, including SAGE International Group Limited (SAGE), the details of which are discussed in Chapter 1.4.

Limited research attention paid to pre-M&A analysis

Given the importance of M&A and the high failure rate, the literature in the domain of M&A mainly focuses on the following issues: merger wave (Stearns and Allan, 1996; Moellower *et al.*, 2005), M&A in the bank industry (Calomiris 1999; Black, 1999), the role of initial public offerings (IPOs) in M&A (Reuer and Ragozzino, 2008), M&A of private vs. public organisations (Capron and Shen, 2007; Bargeron *et al.*, 2008), determinants of M&A (Rossi and Volpin, 2004; Nina, 2012), and the post-M&A performance and integration/combination of firms (Cloodt*et al.*, 2006; Sherman, 2006; Chen *et al.*, 2010). Little attention has been paid to pre-M&A analysis, such as the basis of which M&A decisions are made, how to involve risk assessment in M&A decisions, and how to prioritise M&A deals.

Pre-M&A analysis is a vital and primary action in the M&A process. It can facilitate companies to deal with M&A in a well-planned manner and its results will influence the decision and even the outcome of M&A deals. It provides companies with an initial foundation to consider whether the M&A deals are worth pursuing, and it prevents companies from making risky and costly M&A deals. With a comprehensive pre-M&A analysis, companies can steer M&A deals towards a more successful path. On the contrary, a lack of effort in the pre-M&A analysis could cause the expected synergy to fall short of expectations and the forecasted benefits of the M&A may not be fully realised.

Inadequate emphasis on risk in M&A

M&A deals usually take a long time to execute, starting from internal discussions, followed by negotiation, and agreement. The process is complex and involves risks. Nonetheless, the literature on M&A is less concentrated on the risk aspect. Most studies have investigated managerial attributes, financial aspects, as well as other determinants of successful and failed M&A cases for the sake of strategic insight. For example, Nina (2012) studied the impacts of stakeholder attributes in M&A on corporate strengths and concerns. Emanuel *et al.* (2007) examined critical factors, such as experience, for M&A success. Mittal and Jain (2012) investigated both financial (e.g., profitability and growth) and non-financial parameters (e.g., managerial capability, technological level, and culture) influencing the outcome of M&A. In the present highly globalised market, financial and strategic measures alone are inadequate for M&A decision-making. M&A incorporate substantial risk, thus leading to M&A failure (Chui, 2011). M&A decisions therefore have to be made from the risk perspective as well.

Critical time of M&A

Critical time and resources in M&A deals are of paramount importance to the completion and success of M&A (Chui, 2011). Firms that are experienced in M&A activities and have a consistent and well-planned strategy are more likely to succeed. One of the main reasons is that they have appropriate resources in terms of skills, knowledge, and people available at the critical time; therefore, they are able to take full advantage of the potential benefits of M&A opportunities. The longer the processing time is for M&A deals, the more uncertainties there are, such as competition, extra resources required, and higher costs.

Thus, critical time and resources in M&A deals are vital and require firms' attention. Completing M&A deals within a critical timeframe is regarded as a critical success factor of M&A. However, such planning, as a part of pre-M&A analysis, is overlooked by academia and the industry.

To seize the opportunity of M&A as well as to execute M&A effectively, firms have to initially evaluate if they could complete the M&A deal with the critical time and resources required. Not completing the M&A within the critical time or missing the right timing for M&A could lead to a loss of value and control over time, and even total failure.

Lack of rational tools for M&A analysis to manage deals

Analysing every M&A opportunity with consideration of risk associated with the M&A cost and critical time, followed by making the M&A decision effectively in a highly uncertain environment, is always a major challenge for managers. One of the main causes of M&A failure is a lack of rational tools for effective and objective M&A analysis. Human subjective and ambiguous judgment and uncertainty associated with M&A deals often influence the outcomes of M&A decisions (Huynh and Nakamori, 2011; Sathish and Ganesan, 2011; Clark *et al.*, 2010; Luban and Hincu, 2010). Previous research has indicated that fuzzy set theory and Monte Carlo simulation can improve decision-making; the former is known for improving the vagueness and subjectivity of human cognition (Tsao, 2009; Kinnunen, 2010) and the latter is known for dealing with risk, uncertainty, and valuation (Clark *et al.*, 2010; Luban and Hincu, 2010; Mellen and Evans, 2010; He *et al.*, 2010). As such, these techniques may provide opportunities to improve pre-M&A

analysis and its subsequent decision-making; their application in the M&A domain with a particular role in risk analysis, M&A task duration estimation, and M&A cost evaluation will be beneficial.

1.3 Research Question and Objectives

In light of the above discussion, the research question "How can fuzzy set theory and Monte Carlo simulation be combined to improve M&A decision-making under consideration of risk, critical time, and valuation?" is formulated for this research.

To answer the research question, an M&A evaluation and prioritisation model (MAEPM) supporting early-stage M&A decision-making is proposed, aiming to improve the success rate of M&A deals. The proposed model not only evaluates the worthiness of M&A deals with risk involvement but also prioritises M&A deals. The objectives of this research are as follows:

- To evaluate the application of fuzzy set theory and Monte Carlo simulation in the M&A domain with particular emphasis on their role in risk analysis, critical path analysis, and M&A valuation. These techniques are incorporated into the development of the proposed model to reduce the noise that arises during pre-M&A analysis, thereby creating the model with precision.
- To recognize any potential risks influencing the final outcome of the M&A. Major risks pertaining to M&A are identified and categorised in this research.

- To identify critical tasks and estimate the critical time required for the completion of M&A. To do so, all the tasks involved in the M&A procedure are identified and their durations for task completion are estimated.

- To link relevant risks to each M&A task upon the identification of risk categories and M&A tasks involved. The level of risk involvement in each task is then assessed.

- To evaluate the cost and benefit of the M&A deal by taking risks into account through Monte Carlo analysis for prioritisation. Decision theory and statistical formulas are studied and adopted to develop the model for indicating the most ideal M&A decision. The cost fluctuation between risk aversion and risk taking in M&A deals is also evaluated. These outcomes can help firms to evaluate the worthiness of each M&A deal. Furthermore, if there are several M&A deals under consideration, prioritisation of the deals can be carried out to support M&A decision-making.

The proposed model can provide firms with supporting evidence when considering undertaking M&A. By managing the foreseeable risks and following the critical path, firms can even increase the efficiency and success rate of M&A.

1.4 Company Studied in This Research

This study focuses on the domain of pre-M&A analysis for strategic planning and management. Data collection in this domain is necessary to support this research. However, this kind of research is usually carried out in-house and the results are seldom published, as data related to any M&A cases are always sensitive and kept highly confidential. This also explains why research in this domain is rare, and further highlights the value of this

research. As the Chairman of SAGE International Group Limited (SAGE), which has undergone M&A, particularly land acquisition, I can gain access to the data set to support this research. Therefore, SAGE is selected for the case study and data from SAGE have been collected to support this research. The introduction to SAGE is given below.

1.4.1 Profile of SAGE International Group Limited

SAGE has been a listed company (stock code: 8082) on the Stock Exchange of Hong Kong since 2001. SAGE principally engages in the development of professional death care services, funeral parlour, and cemetery operations in Greater China. The company has its own professional team of funeral directors to compassionately serve families at difficult times and honour the memory of the deceased. SAGE currently operates one funeral-undertaking shop in Hong Kong, as well as three cemeteries, one funeral parlour, and one crematorium in Mainland China. Its management team has extensive experience in Hong Kong and Mainland China, and its business includes cemetery operations, funeral services, and sales of preneed funeral and memorial products.

Cemetery operations: The land procurement sector of SAGE is involved with the supply of land for cemetery construction to meet the surging demand of the greying population along with the growth of the wealthy population. SAGE currently owns three cemeteries in Mainland China, namely Suzhou Celebrities Cemetery, Guangdong Hauiji Luck Mountain Cemetery and Funeral Parlour, and Guizhou Bijie Reliance Cemetery. The total area of the three cemeteries is 463,200 square meters. Land acquisition is of paramount importance to SAGE's success. Feng Shui, which many Chinese people believe in, is one

of the concerns when choosing land for M&A.

Funeral services: This is a division of SAGE and specialises in providing professional funeral services to customers in Hong Kong and Mainland China. SAGE has been providing high-quality, one-stop funeral-planning services in Hong Kong for years. With emphasis on transparent pricing and innovative ideas, SAGE Funeral Services compassionately assists families in times of difficulty.

Preneed services: This offers customers a prearranged funeral planning option at the most desirable time prior to the time of need. Through a legally binding contract, SAGE Funeral Services delivers funeral services to the customer through predetermined procedures in accordance with the customer's will. Moreover, the customer can fix the price of his or her funeral services through the prepaid contract to avoid any future price increase for the funeral services.

Given that funeral business has traditionally been considered a non-transparent and monopolised industry, SAGE is committed to revolutionising this industry through professional management and setting benchmarks for the industry's best practice, by providing transparency in pricing and operation, and providing affordable quality services. This intrinsic value drives SAGE's corporate philosophy and strategy in achieving growth, developing culture and values, and honouring its social responsibilities.

1.4.2 SAGE's Success in Undertaking M&A Activities and Its Significance in This Research

Originally, SAGE's previous business was in organising exhibitions in Hong Kong and Mainland China. However, due to the financial tsunami in 2008, the business performance declined and the company was losing money. Through actively engaging in M&A activities, such as acquiring Suzhou Celebrities Cemetery on 3 September 2010,Guangdong Hauiji Luck Mountain Cemetery and Funeral Parlour on 2 December 2010, and Guizhou Bijie Reliance Cemetery on 6 July 2011, SAGE successfully transformed into a funeral-focused business with a promising future and disposed its exhibition business.

Aiming to become China's single largest provider of funeral, cremation, and cemetery services, SAGE undertakes on-going M&A activities, particularly land and cemetery acquisitions. These activities facilitate the company to consolidate a fragmented industry and create economies of scale, thereby expanding its market share and reinforcing its business growth. In light of these solid experiences in M&A, SAGE is a suitable case study for this research. In addition, research in this domain, particularly the development of practical models for M&A analysis, often involves confidential and sensitive data from companies; hence, this kind of research is mostly conducted in-house and not made available to the public. It is very difficult for outsiders to gain access to the research findings for further investigation or improvement of the M&A practice. As the Chairman of SAGE, I can collect data from the company to support the proposed model's development and verification, and even generalize the model for the industry.

1.5 Organisation of this Study

This section outlines the structure of this thesis. Chapter 1 initially introduces the study background, problem statements, research objectives, and deliverables. The organisation involved in this research is then described.

Chapter 2 provides the literature review and discussions on theoretical aspects of M&A and relevant methodology. Methodological theories such as fuzzy critical path analysis, cause-and-effect analysis, and Monte Carlo simulation are covered in Chapter 2.

The research design and methodology are described in Chapter 3. The data collection, including interviews and internal information obtained from SAGE, to support the development of the proposed model is explained in this chapter. This chapter also explains the reasons for conducting the case study. The computer applications employed in this research are discussed as well.

Chapter 4 depicts the approach of the proposed model's development. The proposed model includes four components, which are risk analysis, fuzzy critical path, cost-benefit evaluation, as well as decision rule and prioritisation. The construction of these components is discussed in detail.

Subsequently, historical data of an M&A case study from SAGE are used to illustrate the application of the model step by step; detailed explanations are given in Chapter 5. The results generated from the proposed model can be used to support decision-making on

M&A deals by suggesting which deal is worthy of investment and which is not.

To further verify the model and demonstrate its function of prioritisation, ten additional case studies from SAGE are examined in Chapter 6. These case studies can provide strong evidence on the effectiveness of the model.

Key findings and implications of the proposed model in terms of the model feasibility and importance are given in Chapter 7.

The originality and contributions of this research are elucidated in Chapter 8. The MAEPM is novel and original. The contributions of this research to the literature and practical insights from the case studies are explained in this chapter.

Chapter 9 provides a concluding remark and suggests further research directions to polish and extend this research.

Chapter 2 Literature Review

In order to develop an MAEPM for better M&A decision-making and to enhance the success rate of M&A, it is important to identify and understand how the key factors influence the M&A process and decision-making. Relevant literature on motivations for M&A, the M&A process, factors affecting M&A, and M&A decision-making are thus reviewed and discussed in this chapter, so as to ensure that those significant elements are incorporated into the proposed model.

Managing M&A projects is often an integration of project scheduling, risk assessment, and cost estimation. Discussions on the theory and applications of critical path analysis, fuzzy logic, cause-and-effect analysis, and Monte Carlo simulation are therefore provided in this chapter. These theories are used to support the development of the proposed model for making M&A decisions in a more scientific and precise manner.

2.1 Mergers and Acquisitions

M&A have become common strategies in today's business world for companies expanding their business to obtain a wider product range and enter new markets. In some cases, companies undergo M&A with the aim to fight potential competitors or to survive in the market. M&A are one of the most important business strategies. To better understand it, the M&A definition, motivations for M&A, types of M&A, M&A process, and current studies on M&A are discussed in this chapter.

2.1.1 M&A Definition and Motivations

M&A are regarded as aspects of corporate finance, management, and strategy involved with the purchase and combination of companies. A merger is the combination of two companies to form a completely new company. An acquisition is the absorption of a company by another company, where the acquiring company becomes the new owner. In general, a series of informal discussions and formal negotiations, a letter of intent, due diligence, and an M&A agreement are required before the execution of the M&A deal and payment. The M&A process is discussed in more detail in the next section.

In some cases, the M&A move is seen as a strategic action that will lead to a leaner, more profitable company once the transaction is completed – one that is better positioned for growth.

The underlying benefits of M&A drive companies to undergo M&A to expand their businesses and better position themselves for growth and profit.

The strategic motivations can be divided into two categories: financial and non-financial motives. For the financial motives to M&A, Eun and Resnick (2007) stated that the synergistic gains created are the primary factor for companies to undergo M&A. Carney (2009) further indicated two key financial motives, which are economies of scale and possession of a leading market share.

- **Synergies:** After M&A, the value of the combined company is much larger than the sum of the two companies because of revenue enhancement and cost savings. There

are different kinds of synergies brought by M&A, such as administrative synergies and financial synergies.

- **Economies of scale:** After bringing two separate companies together to form a larger one, the resulting company has better economies of scale with improved bargaining power due to increased order size and bulk-buying discounts. The company can also make better use of resources and reduce costs by eliminating duplicate operations and departments. All of these could lead to more sustainable competitive advantage.

- **Possession of a leading market share:** By absorbing competitors, the resulting company can often gain benefits such as obtaining well-known brand names and patents, as well as expanding its current product lines and markets to maintain its dominance. The synergic effects in sales growth and expansion of market share will drive companies towards globalisation.

The non-financial motives include the CEO's over confidence, ego, and desire for power. CEOs are often rewarded through M&A by an increase in their power over a larger firm or elimination of their competitors and opponents.

The motivations for M&A are also classified into the following three major drivers (Kwok, 2000).

- **Resource-driven M&A:** M&A activities bring firms together, combining their knowledge and skills, raw materials, physical plants, technological know-how, patents, and management talents. Combining skills and resources enable firms to boost business growth rapidly.

- **Market-driven M&A:** With effective distribution tactics, the combined entity gains more product distribution channels, a wider market reach, and higher stock turnover. With the benefits of economies of scale, the combined entity can rapidly penetrate the market and foster business growth.

- **Risk-driven M&A:** The combined entity has less research and development (R&D) costs and risks if an innovative firm with substantial technological know-how and strong intellectual property rights is acquired. By improving efficiency and securing competitive advantages with respect to competitors in the market, firms become more capable and powerful through such integration, thereby reducing potential investment and R&D risks.

2.1.2 General M&A Process

The process of M&A is generally initiated when the motivations for M&A or opportunities for business growth are recognized by identifying a target company. Figure 2.1 exhibits the general process of M&A, which consists of eight major steps.
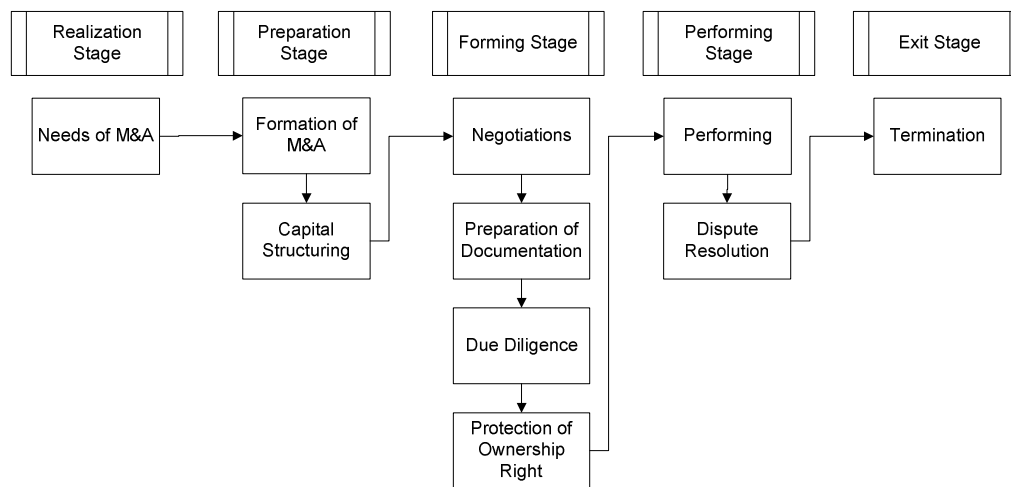
Figure 2.1 General M&A process

Realisation of motivations for M&A: This is often the trigger point of M&A. As mentioned in Chapter 2.1.1, there are several motivations for companies to undergo M&A, such as strengthening the core business, growth in the core geographic markets, diversifying business areas and the risk portfolio, gaining competitive advantage, and reducing financing and shareholder pressure. Due to the advantages of M&A, companies are driven to obtain additional know-how, experience, and capital through M&A for rapid business growth and market penetration within a short timeframe.

Formation of M&A: Choosing a target company is one of the most critical and important decisions for successful M&A. An unsuccessful M&A not only may cause financial damage but also may have a negative impact on intangible assets such as brand image, consumer confidence, and employee commitment towards the M&A (Craig, 2005).

To initiate a possible M&A, the M&A department conducts relevant tasks. A structural

team is formed to monitor and evaluate the worthiness of the M&A. Other than preparing the contract of the M&A, companies face multiple legal barriers such as matters related to the accountability of local administrations, tax laws, employment laws, and anti-corruption laws, particularly for international M&A.

Capital structuring and negotiations: These steps are crucial. They involve internal evaluation on the company's ability to finance for the M&A in both the short and long term. These steps are especially important to international M&A which involve asset distribution (such as in the case of SAGE). Weber *et al.* (2011) indicated that negotiation is essential for a successful M&A as it helps companies to develop a clear plan for immediate M&A action.

In the financial context, capital structure refers to the ways that a company finances its current or potential assets through a combination of equity, hybrid securities, or debt. The composition of liability structuring is measured to ensure that the company is able to meet its expansion needs and also prevent accumulating substantial debt. In order to convince the current shareholders or management team, the threshold requirement and the article of relative company document must be prepared for those shareholders.

With the understanding on the amount of expenditure to invest into the M&A, the M&A department would then be able to obtain the budget range from the finance team before further negotiations with the target company. The M&A team would be able to obtain three

values on the budgeting section: the aspiration point (cost effectiveness and aspirations), settlement range (overlapping area of agreement), and resistance point (cost higher than this would not be considered) (Grande, 2011). The company would also need to prepare for general investment considerations, such as currency restrictions, investment law, local official approvals, repatriation guarantees, and local government constraints (in terms of restrictions, export controls, tax incentives, general local taxation structure, and the nature of the target firms), especially outbound investment to other nations.

Both the merger/acquiring company and the target company need to have a clear understanding of each other's objectives and demand on M&A so that they are able to determine a set of predetermined goals, which are mutually feasible and compatible (Fey, 1995). Many researchers (Geringer, 1991; Harrigan, 1985; Dymsza, 1988; Fey, 1995) have argued that in order for an M&A to be successful, the companies need to possess resource capabilities, management capabilities, and complementary objectives, which in turn provide a strategic fit for bargaining. Whenever the bargaining zone enlarges, the companies are more willing to negotiate.

Documentation including the shareholders' agreement: With the common goals listed and presented on the negotiation table, the objective becomes more realistic and sound. In such a case, a synergic effect would be progressively stimulated for the success of the M&A. Relevant documents need to be prepared, such as the letter of intent (to measure the local market feasibility); formation of terms and conditions; a confidentiality agreement to protect necessary know-how; a formally drafted M&A agreement; agreed due diligence

procedures; a set of management, adherence, and shareholder agreements; and lastly, a confirmation of closing conditions.

Due diligence: This is a common practice involving a series of investigative steps taken by a business or personnel before the signing of the M&A contract. It is a legal obligation for the procurer to perform due diligence before any investment deals, but it is not compulsory across multiple countries. It is often used by a potential acquirer in the evaluation of a target company on its current assets and liability ratio (Hoskisson, 2004). This enables the acquirers to better understand the business and financial information of the target before reaching the definitive M&A agreement.

The basic framework of due diligence would formally include a compatibility audit (measurements that indicate the set of strategic fits), financial audit (liquidation level of the targeted corporation and its current cash flow stability), macro-environment audit (to measure the intensity of the market response), legal audit, marketing audit, production audit (if products are being manufactured), information system audit, and reconciliation audit. Claus (2006) emphasised that due diligence covers not only all human resources aspects but also other issues, in particular culture. Through these audits, the acquirer would be able to measure the value added of the potential M&A (Gillman, 2010).

Protection of ownership rights, including management functions and minority interest: The next critical area in M&A is the possible conflict among decision-making,

managerial styles, and processes. One of the major pitfalls of M&A is related to the strife between the merger/acquiring company and the target company over the control of policies and the majority of business decisions. If mutual agreement cannot be reached, there would be a threat of failure (Ganitsky *et al.*, 1991).

Dispute resolution: Conflicts are unavoidable among parties involved in M&A deals, which tend to cause frustration, unpleasantness, and dissatisfaction (Anderson, 1990). For long-term success, it is important that the newly formed company has a monitoring mechanism to minimise any conflict (Fey, 2000). Integration planning including information exchange and coordination in operations would also be helpful to smooth the transition. Without any clear management definition, excess functions such as shadow functions would appear in the company at the beginning of the M&A, whereby a duplication of work would be produced. In turn, it would increase the complexity, hindering decision-making and limiting the success of the M&A (Hebert, 1994).

2.1.3 Current Studies on M&A

Generally, the domain of M&A has been studied extensively in the literature. These studies have mostly focused on the motives for M&A, factors influencing M&A, success of M&A, merger wave, and impacts of M&A on shareholders.

2.1.3.1 Reasons for and against M&A

As mentioned previously, the reasons and motives for M&A have been frequently discussed in the literature. M&A are a distinctive means for accessing external resources

(Wang and Zajac, 2007). The key motives include economies of scale, synergistic gains, better capacity utilisation, better market positioning, overcoming entry barriers, and achieving a wider market reach (Weston *et al.*, 2004; Bruner, 2004; Hitt *et al.*, 2001; Burkart and Panunzi, 2006). However, reasons against M&A can also be found in the literature. These are using excess cash flows for the transaction costs of M&A deals, managerial entrenchment (by which managers make deals to increase their value and power over shareholders but not to increase shareholder value), and managerial hubris or ego (managers' overconfidence in making decisions on the deals) (Porrini, 2004, Vermeulen and Barkema, 2001, Bruner, 2004).

2.1.3.2 Factors for Successful M&A

M&A activities are becoming prevalent with globalisation. In view of the success rate and returns, influencing factors of M&A have received substantial research attention. Key factors include the prior M&A experience of the merger/acquirer (Nina, 2012; Emanuel *et al.*, 2007), the relation between the businesses of the merger/acquirer and the target company (Bruner, 2002), the time to complete M&A deals, and business valuation. Highly educated managers with rich experience in M&A deals are more capable of evaluating and understanding complex business situations, making decisions, and managing corporate restructuring and integration. Experience also brings execution capabilities, which are critical to the M&A process (Meschi and Metais, 2006). Such managers can help companies choose suitable targets, establish priorities, as well as effectively work out the strategy and plan in terms of resources for the deal and post-M&A. The closeness of the businesses between the merger/acquirer and the target company is positively associated

with the success rate. Offering higher premiums could encourage and induce the target company to make the deal in an effective manner. If M&A negotiations last long without any outcome, this would probably lengthen the time to complete the M&A deal and thus lower the success rate, as disagreement is likely to prevail. Successful deals are commonly found in acquisitions of target companies with a lower market-to-book value (Rhodes-Kropf*et al.*, 2003).

Among the factors influencing M&A, the time to complete M&A deals is critical, yet it has received limited research attention. Deal duration refers to the time from announcing the M&A to the closure of the M&A, either by completion or termination. The more complicated M&A deals are, the longer the time required to complete the deals. However, there are often deals which are abandoned or which take a very long time to be completed. The failure rate of M&A is around 50% (Schoenberg, 2006).

Time is decisive for a thorough M&A evaluation. It is crucial for firms to quickly weigh everything, particularly the strengths and weaknesses of the target company, for a better understanding of the target and then go through the process of due diligence. Poor evaluation with a lack of experience in M&A would probably result in overestimation of the returns or underestimation of the investment requirements. If the evaluation process in M&A lasts for a long time, the companies would probably miss the opportunity of making the M&A deal at the critical time (Emanuel *et al.*, 2007).

2.1.3.3 Failure in M&A

There are many advantages of M&A, but the success and strategic objectives are not always guaranteed and substantial risk exists. M&A activity has been booming but it comes with a high chance of failure (Weber *et al.*, 2012). M&A often lead to major corporate changes, brining two different companies together with uncertainties in terms of managerial compatibility, organisational structure, and cultural differences (Amiot *et al.*, 2006; Lichtenstein and Brush, 2001; Weber and Camerer, 2003; Newbert, 2007; Sirmon *et al.*, 2007; Chambers and Honeycutt, 2009). Incompatibility in thinking and working styles, attitude towards risks, decision-making approach, and communication patterns may increase conflicts and anxiety in the newly combined entity, thereby resulting in dissatisfying and poor post-M&A performance. Some of the important causes for M&A failure include mismatch in the size between the acquirer and the target company, poor strategic fit, poor organisational fit, overpaying, lack of M&A experience, poor cultural fit, incorrect assessment of the target's value, incomplete or inadequate due diligence, poorly managed integration, inadequate attention to people issues, and a lack of proper communication (Chakravorty, 2012; Park *et al.*, 2009).

Companies undergo M&A generally for the purpose of increasing shareholder value; nevertheless, the empirical studies in the literature have revealed that M&A deals consistently benefit the shareholders of the target companies but not those of the mergers/acquirers (Revenscraft and Scherer, 1989; Firth, 1990; Agrawal *et al.*, 1992; Datta *et al.*, 1992). For example, through an empirical study, Datta *et al.* (1992) found that the shareholders of the target companies gained over 20% increase in value or wealth while

the acquiring companies earned nothing or suffered losses after M&A announcement. Firth (1990) further stated that the mergers/acquirers often have to suffer the losses if M&A fail. If an M&A deal is announced but fails, the stock price of the acquiring company is likely to fall. Ghosh (2001) found that the operating performance of the acquiring companies is not enhanced after M&A. Ali and Gupta (1999) specified that the acquiring companies became bigger but with reduced profit after M&A.

2.1.4 Decision-making in M&A

M&A involve a series of decision-making that influences various stages of the M&A process, as well as the M&A outcomes. Jemison and Sitkin (1986) stated from the process perspective that better decision-making could enhance M&A activities and outcomes. M&A decisions primarily affect the degree of M&A success.

In the literature, relatively little research attention has been paid to the decision-making in M&A compared to the motivations and factors for successful M&A. Studies pertaining to the domain of M&A decision-making have focused on post-M&A or integration matters. Very limited work has been done on supporting the decision-making of pre-M&A through investigating how to decide whether the M&A deals are worthy of investment in terms of resources and schedule at the early stage. In order for M&A to be successful, pre-M&A is of paramount importance before deciding what to do and making any commitments. Pre-M&A is a procedure where companies choose the right target and then research to determine if the deals are worthy of investment and if the required capital and resources would be ready at the critical time. A superior pre-M&A procedure could then prevent

risky and costly M&A investment. The pre-M&A procedure plays an important role in the outcome of M&A deals. Due to the importance of pre-M&A decision-making, this study contributes by proposing a model to support such decision-making.

2.1.4.1 Timing of M&A

The timing of the M&A decision is vital and is one of the pre-requisites of M&A success. According to the analytical and empirical model developed by Sam and Sabyasachi (2010), acquiring targets in a shorter time period could provide greater opportunities for synergistic fit and cost reduction. As M&A involve financial investment decisions and uncertainties, companies often hesitate to make such decisions until more information concerning the target company and its market is available for more accurate valuation. This however could delay the M&A process and companies may miss the opportunities to take advantage of the full benefits of the M&A deals at the critical time. Early M&A can lower the acquisition cost (Mantecon, 2008) and enable the mergers/acquirers facing uncertainty to gain early control of the target and manage the integration process. Due to its importance, the time needed to complete M&A should be predicted to support pre-M&A decision-making. This study therefore takes this into account. Critical path analysis is useful in this regard and is discussed in subsequent sections.

2.1.4.2 Risk-taking in M&A

The attitudes of managers to risk-taking influence many business decisions on management principles. M&A are complex, multifaceted, and strongly related to business growth and profit. In many cases, information about the target company and its market is limited,

making it difficult for companies to make the right decision at the critical time. Decision-making in M&A with risk-taking is therefore inevitable. However, there are very few studies available with respect to M&A decision-making by considering risk as a variable or with risk analysis. The studies in the domain of M&A in relation to risk have focused only on post-M&A performance (Amy *et al.*, 1996). However, risk is the uncertainty that exists before commitment rather than afterwards (Bowman, 1982). Incorporation of risk is an important variable in providing a strong foundation for M&A decision-making (Amy *et al.*, 1996). Risk as a key variable cannot be omitted in M&A decision-making and is therefore considered in this study. In order to evaluate potential M&A deals, fuzzy set theory and Monte Carlo simulation are employed in this study to cope with uncertainty, thereby increasing the precision of decision-making, particularly when determining the cost and schedule. These techniques are introduced and discussed in subsequent sections.

2.2 Cause-and-effect Analysis and Its Significance in M&A

Cause-and-effect analysis, also called the fishbone diagram or Ishikawa diagram, is a problem-solving tool for quality management. It is commonly used to identify the possible causes of a problem in an organised manner. Researchers have commonly agreed that cause-and-effect analysis is effective and useful in identifying the causes and ensuring comprehensive coverage related to a problem (Karnaukhov, 2006; Hughes *et al.,* 2009; Clary and Wandersee, 2010; Park *et al.*, 2011). This study adopts this technique to map M&A tasks with any potential risks for visualisation. Figure 2.shows a typical fishbone diagram for cause-and-effect analysis. In the fishbone diagram, the head of the fish is denoted as the summative effect while the fish ribs represent causes contributing to the

final effect. The effect is identified, followed by thoroughly recognising the main causes. Park *et al.* (2011) stated that the fishbone diagram is very useful in identifying the causes and ensuring comprehensive coverage related to a problem. In addition, the fishbone diagram is effective and easily implemented (Clary and Wandersee, 2010).
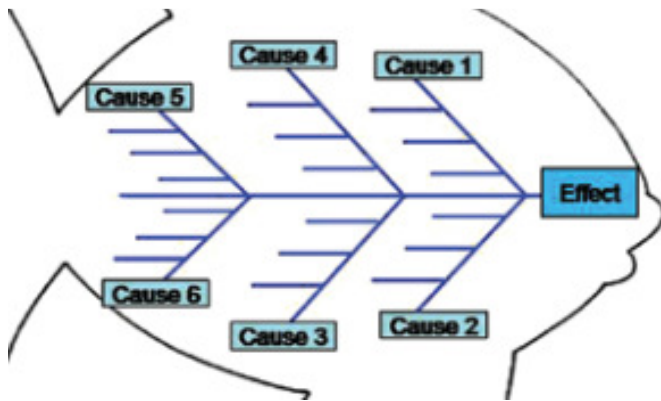
Figure 2. Typical fishbone diagram

The cause-and-effect analysis is useful particularly in studying complex systems. As supported by Karnaukhov (2006), there are many advantages of using the cause-and-effect analysis, such as:

- Providing advisable information at the preliminary stage for subsequent analysis which is more detailed;

- Being easy to be mastered without complex mathematical tools;

- Presenting the interrelations in a complex system in a concise, graphic form by using the standardised denotations in the cause-and-effect diagram; and

- Helping to integrate knowledge and information from different sources on the phenomenon.

2.3 Project Scheduling Techniques for M&A

2.3.1 Critical Path Analysis and Its Suitability for M&A

M&A are always complex activities in which time and resources are critical to success. For successful M&A, completing the deals at the critical time with the required resources is of paramount important. As such, project-scheduling methods would be useful in the M&A practice, and thus are considered in this research.

Among all the methods discussed in the literature, the two most well-known methods for project scheduling, planning, and management are program evaluation and review technique (PERT) and critical path analysis. PERT is applicable to projects of a more probabilistic nature, in which activity times in projects are unknown and likely to be random variables, and several simplifications and assumptions are defined (Shipley *et al.*, 1997). A detailed discussion on the theoretical basis and pitfalls of PERT can be found in Farnum and Stanton (1987),Chanas *et al.*(2002),and Nadas (1979). On the contrary, critical path analysis is often used for projects where time and cost estimates can be projected from past experience more accurately. In this regard, critical path analysis is deemed more suitable and relevant to this study, for the activity times and details of M&A in this research can be estimated without difficulty by referring to past practices and experience.

Critical path analysis is a common, simple, and formal method for scheduling a set of project tasks. Most project managers (PMs) are familiar with this critical path analysis. The main objective of critical path analysis is to identify the critical path (i.e., the longest path) to project completion. PMs can effectively allocate resources as well as control project time

and costs through identifying the critical path. The activities on the critical path that would delay the project completion or shorten the project duration are called critical activities. There is no provision for variability in start and finish times for critical activities. By contrast, non-critical activities have flexible start and finish times and are floats, which mean the activities can be delayed without influencing the project's scheduled completion time. Typically, a critical path diagram shows a list of activities required for project completion, together with the duration of each activity and the dependencies between the activities.

Figure 2.2 shows an illustrative example of a critical path in activity-on-node network form, which indicates a network of activities represented by nodes and connected by arrows. A node is a start or finish point of activities, which are connected by arrows with the associated duration, cost, and resources. Figure 2.3showsanother critical path in activity-on-arrow network form, in which activities are on arrows and connected by nodes with the related duration. The flow of activities and their relationships are indicated in both network forms.
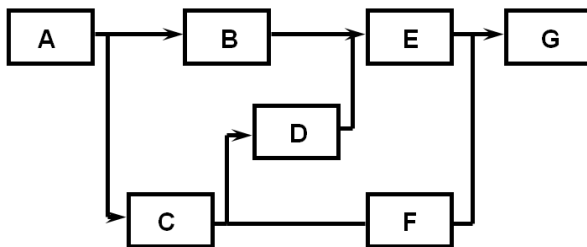
Figure 2.2 Activity-on-node network
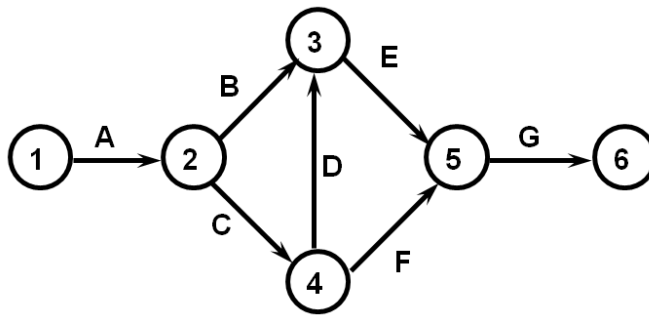
Figure 2.3 Activity-on-arrow network

Critical path analysis has been widely investigated and applied to manage projects with a

practical schedule in many fields, such as construction (Liberatore *et al.*, 2001), software

project scheduling (Ren *et al.*, 2010), production process (Zhao and Huang, 2011), aircraft

maintenance (Omer and Cengiz, 2012), health care (Luttman *et al.*, 1995), and product

design. It consists of key tasks, such as assigning durations of activities, calculating the

earliest and latest occurrence times of all activities, and determining the critical path. By

using this analysis, project planners and managers not only can monitor and control the

progress of a project but also focus efforts on particular activities and better allocate

resources. According to Wong (1964), critical path analysis provides managers with a clear

overview of the project to:

- Determine the probability of meeting deadlines and check progress at intervening
  durations against original plans;

- Compute resource utilisation and compare to availability;

- Manage the optimum project duration and cost levels; and

- Evaluate alternative approaches or re-plan a project with revised data.

Critical path analysis is used to estimate the entire project duration for better project

management in a cost-effective manner. Managers could reduce the project duration by accelerating the critical activities, allocating more resources to critical activities than to floats to expedite the project without adding costs, and re-evaluating the project by simply updating the inputs in terms of duration, cost, and resources of activities when there are changes.

2.3.2 Fuzzy Critical Path Analysis and Its Significance in M&A

Project scheduling is increasingly important in obtaining competitive priorities but in many situations it is challenging and complicated, particularly in this dynamic and cutthroat business environment. In the critical path analysis, human judgments such as estimations of activity times or duration of each task in M&A are sometimes subjective and vague, and thus activity times may not be presented precisely. To deal with imprecise data, the concept of fuzzy set theory is often useful and important.

Fuzzy set theory has been recognised as a powerful technique to tackle fuzziness and uncertainties. It has been commonly used to deal with vague and subjective human judgment, which influences outcomes, for better decision-making (Hsu *et al.*, 2003; Lin and Chen, 2004; Mohanty *et al.*, 2005; Xu*et al.*, 2007; Huynh and Nakamori, 2011). Several studies have investigated the extension of critical path analysis by using fuzzy logic (Dubois *et al.*, 2003a; Sleptsov and Tyshchuk, 2003; Zadeh, 1978; Zielinski, 2005). The application of fuzzy logic to determine the critical path is widely acknowledged, and it has been claimed that the fuzzy logic approach is more accurate compared to purely probabilistic approaches such as PERT (Fargier *et al.*, 2000; Dubois, 2003b; Liberatore, 2008; Bonnal*et al.*, 2004;

Sleptsov and Tyshchuk, 1999). In general, fuzzy sets are used to describe the activity times of each project task to cope with vague duration estimations based on human judgment. The approach of critical path analysis with fuzzy activity times has been well established and validated; examples can be found in the literature (Chanas and Zielinski, 2001; Zammori *et al.*, 2009; Chen, 2007; Liberatore, 2008; Sathish and Ganesan, 2011). Fuzzy set theory is therefore employed in this study to analyse the critical path in a more precise manner.

In a non-fuzzy environment, the activity-on-arrow project network is considered as $S = (O, A, t)$, which consists of a finite set of nodes (O) and a set of arrows (A) with crisp activity time (t). Moreover, t_{ij} is denoted as the time period of activity $(i, j) \in A$.

In order to deal with the imprecise duration time, fuzzy logic is applied to the project scheduling and thus the project network in the fuzzy environment is defined as $S_f = (O, A, \tilde{T})$, where $\tilde{T}$ is the fuzzy activity time $(i, j) \in A$, and its membership function is $\mu_{\tilde{T}_{ij}}(t_{ij})$.

There are two main steps in the fuzzy critical path analysis. One is to find the fuzzy critical paths and the other is to find the length of the most critical path in crisp value. These two main steps are explained in Appendix 1 and the details can be found in the study by Chen (2007). The approach to fuzzy critical path analysis proposed by Chen (2007) is adopted in this study to determine the critical path of a project; in this case, projects represent M&A deals.

2.4 Monte Carlo Simulation and Its Significance for M&A

Monte Carlo simulation is a practical and useful tool in planning, decision-making, and risk analysis. It is commonly used by large companies to produce forecasts of business activity and to examine the effects of all possible combinations of variables and their realisations (Proctor, 2012). It involves the artificial generation of experience or data (Hincu, 2002; Luban, 2005). It helps managers define a list of possible variables for inputs and the relative probability of their occurrence. The Monte Carlo simulation executes the problem many times by performing a large number of simulations with triangular distribution. It then generates the full range of possible outcomes resulting from the inputs. Each solution to the problem is called an iteration. It is greatly recommended in performing simulation with multiple degrees of freedom and high deviation in various uncertainty models.

Better risk management could often improve the probability of project success, including M&A deals, while unacceptable and very high costs and threats often accompany the risks associated with a project. Monte Carlo simulation is useful particularly in decision-making and risk analysis as it is suitable for all kinds of distribution of activities (Liu *et al.*, 2011). Ahmed (2007) stated that "Monte Carlo simulation is a versatile method of risk analysis that can be applied to diverse applications". Carl and James (2012) stated that Monte Carlo simulation is "a fast, flexible, easy and accurate method" for estimation. Lutfi *et al.* (2012) further emphasised that Monte Carlo simulation can deal with a combination of all the special conditions easily without any negative impact on accuracy. It can also achieve a highly accurate result by performing a large number of simulations.

In general, Monte Carlo simulation is commonly applied to quantify and visualise risk and uncertainty associated with project costs (Clark *et al.*, 2010; Luban and Hincu, 2010), to perform risk analysis of critical path method scheduling (Ahmed, 2007), to simulate project networks (Williams, 2004; Liu *et al.*, 2011), and to determine the probability of project completion (Lee, 2005; Simmons, 2002). It is assumed that each activity in a project network is randomly independent in Monte Carlo simulation. The random project duration with the critical path method can be acquired by obtaining the random data of activity durations by using sampling technique. In addition, the use of Monte Carlo simulation can be found in supply chain models (Merrill, 2007), forecasts of hotel arrivals and occupancy (Athanasiu *et al.*, 2011), electricity market models (Duenas *et al.*, 2011), and investment and financial portfolios (Kay *et al.*, 2011; Peng, 2012; Alvehag and Soder, 2011). With regard to its features and wide applications, Monte Carlo simulation is deemed appropriate and important for determining the M&A cost with a consideration of risk analysis. Examples of Monte Carlo simulation and how it works can be found in the articles (Frost, 2017; Palisade Corporation, 2017)

Monte Carlo simulation is a computerised mathematical technique. It is a useful and powerful tool that should be conducted using a software platform, particularly a spreadsheet application (Albright and Winston, 2007; Winston, 2007; Luban, 2005). Winston (1996) demonstrated the application of Monte Carlo simulation by using a spreadsheet that requires no computer programming expertise and further concluded that a software to easily perform Monte Carlo simulation is essential, making its application more

accessible and practical. This is supported by other scholars (Winston, 2007; Luban, 2005; Frost, 2017). Hence, Monte Carlo simulation through spreadsheet analysis tool is adopted in this study.

Summarised by Ahmed (2007), the algorithm of Monte Carlo simulation is described as follows:

1. Generate a random number on the interval [0-1].

2. Transform the random number into a random variate.

3. Substitute the random variate into the appropriate variables in the model.

4. Calculate the desired output parameters within the model.

5. Store the resulting output for further statistical analysis.

6. Perform desired risk analysis based on the collected sample of output after repeating the above steps many times.

With the support of the wide range of literature adopting Monte Carlo simulation in various fields, Monte Carlo simulation is regarded as a practical and valuable tool for cost and schedule estimation; thus, it is applied in this study to simulate a project network with risk analysis. It is assumed that each activity in a project network is randomly independent. The random project duration with the critical path method can be acquired by obtaining the random data of activity durations by using sampling technique. Referring to the literature (Ahmed, 2007; Liu *et al.*, 2011), the key steps involved in project scheduling are outlined as follows:

1. Each activity has a variable duration and is described using a statistical distribution.

Typically, triangular distribution is generated, which is made up of the pessimistic, most likely, and optimistic durations.

2. The possible duration of each activity is a random number acquired from the distribution.

3. The project duration with the critical path method can then be determined and a maximum project duration can be estimated after all the activities are given a duration.

4. By running the simulations repeatedly, a distribution of the maximum project duration is formed, on which a risk analysis can be based.

The above process could also be used for the estimation of the total project cost by using the activity cost instead.

Chapter 3 Methodology

This chapter describes the methodology that solves the problem statements mentioned in Chapter 1. The research framework and approach to develop the MAEPM with three components, namely the fuzzy critical path, risk analysis, and cost-benefit evaluation is discussed. Methods used to develop the proposed model in this research are introduced.

3.1 Research Framework and Approach

The research framework is shown in Figure 3.1.To provide grounds for developing the model, the primary step of this research is to conduct the literature review in the domain of M&A, for instance, the practice of M&A, the reasons of failure in M&A, the key factors to successful M&A, the focus of current M&A studies, how these studies are carried out, techniques used, and possible techniques for the development of the proposed model. By exploring the literature, problem statements are identified (see Chapter 1.2), followed by the research aim and objectives. Aiming to improve the success rate of M&A deals, an MAEPM, which resolves the problems, is proposed.

The approach to developing the proposed model takes an exploratory and problem-solving nature. Supported by the literature review in Chapter 2, this study considered adopting techniques including fuzzy critical path analysis, cause-and-effect analysis, and Monte Carlo simulation to develop the proposed model. Fuzzy critical path analysis is useful to determine the longest path while describing the process of M&A. Cause-and-effect analysis eases the mapping between potential risks and M&A tasks and visualises the results. Monte Carlo simulation is helpful in performing the cost-benefit evaluation of the

proposed model. Practical and user-friendly tools, such as Microsoft Excel with a plug-in @Risk, Microsoft Project, and Microsoft Visio, were employed to construct particular parts of the proposed model. The integration of these techniques is useful in developing the proposed model.

In order to illustrate as well as validate the proposed model, collecting real data from the M&A environment is inevitable. Case study is adopted as a qualitative research approach, and interviews and data collection have been conducted on the case company to support the model development. As stated by researchers (Gerring, 2004; Baxter and Jack, 2008), case study is a tool for researchers to study complex phenomena within their contexts and to intensively study a single unit with an aim to generalise results across a larger set of units. The use of case study in this research can assist the in-depth investigation into the M&A practice in a real-life context and enable the proposed model to be more generalised; case study is thus considered as the most appropriate approach for this research. The details of the data collection are discussed in the next section.

After the construction of the model, case studies are conducted for illustration and verification. Eleven case studies are conducted in this research to test the feasibility of the model determining whether an M&A deal is worth investment. The details of the case studies are discussed in the next section.
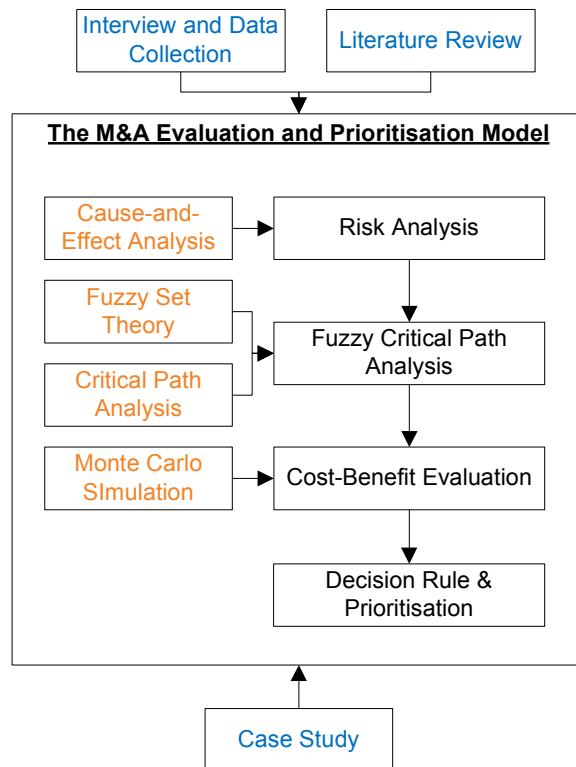
Figure 3.1Research framework

3.2 Case Study

As discussed in Chapter 3.1, case study is the most popular and suitable approach to study the complex M&A practice in a real-life context. In order to illustrate and verify the proposed model, eleven case studies are conducted in this research to develop, illustrate, and test the proposed model. These case studies are helpful in demonstrating how the proposed model works and provides evidence to companies when deciding whether an M&A deal is worthy of investment.

Regarding the literature, it is highly common and creditable to use case study to examine a problem or situation in order to understand it (Sim and Pandian, 2003; Odagiri, 2003;

Prescott and Millower, 2001). Sumi and Tsuruoka (2002) confirmed that case study is a practical and helpful technique to help readers gain a better understanding. This also applies to the research on M&A. Cassiman *et al.* (2005) used information from a case study of individual M&A deals to analyse and reveal the impact of M&A on R&D. Sumi and Tsuruoka (2002) used case study to illustrate the integration of M&A systems. Wernet and Jones (1992) used case study to analyse the M&A process and activity between two organisations. In addition, many scholars have used case study to illustrate and verify their proposed models (Ullrich *et al.*, 2005; Markus, 2003; Tsai and Hsieh, 2006; Wang *et al.*, 2012). In view of the extensive use of case study, this research adopts the case study technique to help demonstrate and validate the feasibility of the proposed model.

As discussed in Chapter 1.4, SAGE is selected as the case study in this research. The information (including internal and confidential data) of the eleven cases has been obtained from SAGE and then used as input into the proposed model for processing. The results generated from the proposed model can help decision makers to decide if the M&A deals should be undertaken. Such decisions derived from the proposed model are then compared to the actual decisions of the cases. The details of the case studies are provided in Chapters 5 and 6.

3.3 Interviews and Data Collection from SAGE

To better understand M&A practices and collect internal data to support this research, three interviews and discussions with a group of three M&A experts from SAGE were conducted on 24 August 2012, 8 October 2012, and 28 February 2013.The M&A experts have a

combined experience in M&A of over 40 years. They provide strategic planning advice and counsel on SAGE's M&A-related business. During the interviews, most of the key M&A issues were discussed; the topics covered are highlighted in Table 3.1. The data on M&A practice and detailed task list with duration obtained from the interviews are compiled and illustrated in Table 3.2 and Table 3.3, respectively. A statement of research ethics is attached in Appendix 2.

Based on the experience of SAGE's M&A experts, the M&A process generally takes about three to nine months to finish, depending on the project scale. Typically, SAGE goes through a series of steps, such as initial due diligence, as part of the M&A filtration process, followed by legitimacy of assessment. Concurrently, SAGE estimates the revenue-generating capacity of the target company, which helps in the negotiation process. Before any contract is signed, SAGE would conduct a site visit to ensure that the facilities and surrounding environment match the assessments.

Table 3.1 Topics discussed in interviews

Topics discussed	Description
Task identification	It is critical to recognise every task in the M&A practice for evaluating the critical path and total duration for M&A completion. It is also necessary to understand the internal process and the reasons behind each task. A list of M&A tasks is obtained from SAGE for reference (Table 3.2 and Table 3.3).
Task arrangement (Predecessors)	To plan for M&A deals, those tasks should be listed out with their predecessors for better scheduling and resource allocation. Predecessors are those tasks that have to be completed before other tasks start.
Duration of each task	Task duration refers to the time taken for each task to be completed before the start of other activities. Normally, the duration is measured in different standard units such as by day, week, or month, depending on the scale of the project. In this case, such measurement is in the unit of a day.
Total duration of the M&A	This is the estimated time required for completing the M&A deal. It is important for project planning and resource allocation.
Personnel/parties' involvement	Human resources play an important role in the M&A practice. Personnel involvement in each task should be considered as it affects the M&A progress, resource allocation, costs, and outcomes.
Problems encountered	Learning from experience and identifying M&A problems encountered can help improve the M&A process through better preparation. According to the interviews, the time to complete the M&A deal and taking risk analysis into account are essential for evaluating whether the M&A deal is worthwhile.
Delays incurred	Comparing the actual and projected duration of M&A is critical for the analytical process to reveal potential obstacles and minimise the distortion level of the final result.

Table 3.2M&A practice in SAGE

Activities involved in the M&A practice	Description
Project selection	This is a form of preliminary assessment of the target company's background check on its board of directors and chairperson, as well as its financial status, market position, business development, and sustainability.
Legitimacy of assessment	Preliminary investigation of valid licenses is conducted to verify the land use permit and business licensing, as well as to ensure that M&A are legally acknowledged and governed by legal entities.
PM assignment	After a series of preliminary investigations, SAGE assigns a PM to keep track of the M&A activities to ensure milestones are setup and achieved on time with quality assurance.
Valuation	SAGE is able to perform an array of fundamental valuations based on the financial sheets obtained from the target company, which would return those basic statistical data on Internal Rate of Return (IRR).
Competitor assessment	It is important to be alert to any potential competitors who could compete to acquire the same target company. This is because M&A opportunities are valuable and firms often have to seize the chances.
Policy assessment	The M&A team is required to understand the foreign policy of the local government towards direct foreign investment, and also the home policy, when M&A involves a huge capital outflow that would affect the cash market's supply in the short term.
Field trips	SAGE arranges a face-to-face meeting with the target company and obtains the feasibility assessment physically, topography, geomancy, and customs, before bringing all those conditions to the final negotiation table with legal documentation.
Capex calculation	This is a term to refer to the amount of free cash flow to spend on purchasing or upgrading fixed assets for future business benefits. It provides a forecast on business sustainability. It usually involves plant, land, or office acquisition and is the most vital part of corporate liquidation assessment. If the growth of potential business after the implementation of this potential investment does not correspond to the required rate of growth, SAGE would need to terminate the M&A deals.

Table 3.3 M&A task list obtained from SAGE

	Task	Man-day Required	Predecessors
A	Initial M&A project evaluation/filtration	5	
B	Legitimacy of assessment	30	A
	Partnership permit	10	
	Land use permit	30	
	Obtain license	15	
C	PM assignment	2	A
D	Initial meeting	3	C
E	Legitimacy confirmation	2	B
F	Signing of memorandum of understanding	1	D, E
G	Valuation	5	
	Corporate financial health	5	A
	Quality of earning	5	A
	Debit in contingency	5	A
H	Competitor assessment	5	G
I	Completion of partner and competitor assessment	3	F, H
J	Policy formulation and evaluation	3	F
K	Feasibility assessment	10	G
L	Capex calculation	5	K
M	Completion of feasibility and Capex assessment	2	L
N	Revenue forecasting model	5	G
O	Negotiation	10	F, I, J, M, N
P	Signing of sales and purchase agreement	5	O
Q	Legal documentation of partnership	15	P

Chapter 4 Model Development

Chapter 2 discusses the extant literature on M&A, fuzzy critical path analysis, cause-and-effect analysis, and Monte Carlo simulation, while Chapter 3 introduces the research framework, research methodology, and data collection. This chapter describes the theoretical framework and development of the proposed model from risk identification to cost-benefit evaluation. For illustration, data collected from SAGE discussed in Chapter 3 are used to develop the model.

4.1 Approach to Model Development

As mentioned in Chapters 1–3, pre-M&A analysis is vital in the early stage of the M&A process. Failing to assess risk associated with M&A deals could cause M&A failure, and making M&A deals at the critical time can reduce uncertainties and take full advantage of the potential benefits of the M&A opportunities. However, previous studies on these aspects are limited. M&A are complicated and the decision-making involved is never easy. Firms are eager to seek rational tools to effectively reduce the fuzziness of human judgment and manage M&A deals, in particular by taking pre-M&A analysis, the critical time, and risk associated with M&A deals into account. However, no such practical tools for M&A analysis exist. To fill the gap and address the need, the proposed model is formulated and used to schedule M&A activities, to identify risks associated with the M&A process, and to judge the returns and risks arising from the M&A deals, so as to maximise the probability of success in M&A.

The proposed model consists of four main components: risk analysis, fuzzy critical path, cost-benefit evaluation, and decision rule and prioritisation. The approach of the model development is shown in Figure 4.1, followed by the construction of these components.
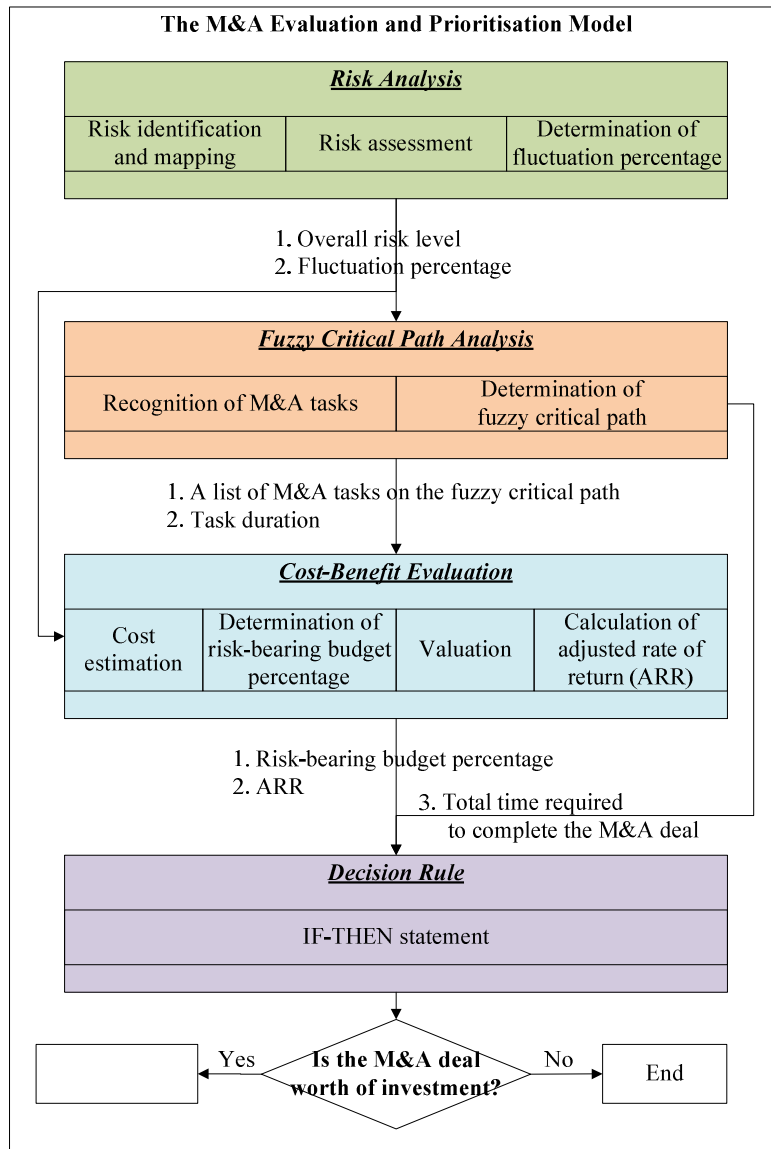
Figure 4.1 M&A evaluation and prioritisation model

- Risk Analysis: The model starts with recognising and listing out necessary M&A tasks which affect the outcome of M&A. These tasks can be identified by companies or

persons with rich experience in M&A deals. After that, a fishbone diagram is used to link up potential risks with relevant M&A tasks after the identification of M&A risks. This mapping process can help visualise what risk factors would affect the M&A tasks. Risk assessment can then be carried out accordingly to determine the overall risk level of the M&A deal. The higher the risk level is, the higher the cost the company has to pay. The estimated overall risk level is thus used to determine the cost fluctuation percentage of the M&A deal, which is subsequently considered in the fuzzy critical path analysis.

- Fuzzy Critical Path Analysis: With the list of M&A tasks, critical tasks in the M&A process can be determined through an analysis of the critical path with fuzzy logic. These tasks highly influence the total duration of M&A deals. Without paying close attention to the tasks on the critical path, the deals are likely to be delayed and companies have to bear extra time, resources, and costs, and even suffer loss or fail to achieve goals. To mitigate the risk of time and reduce the potential of time delay, it is important for the companies to pay close attention to the critical path and allocate sufficient resources to those tasks in a timely manner for their initiation. Identifying the critical path in a precise manner by using fuzzy logic is essential. A list of M&A tasks on the fuzzy critical path and their durations are determined in this component, and are used as input for the cost-benefit evaluation. In addition, the total time required to complete the M&A deal is determined and serves as input for the decision rule.

- Cost-benefit Evaluation: A simulation program is established to estimate the total budget for the M&A deal in a normal circumstance with the risk-bearing budget

percentage at 95% confidence. Such a cost estimation takes into consideration the cost fluctuation percentage determined from the risk analysis. The risk-bearing budget percentage is defined as the percentage change in the total budget for M&A deals, estimated from normal to certain circumstances. A higher risk-bearing budget percentage means the company has to pay more for the deals. The value of the target company in M&A deals is predicted by adopting the discounted cash flow analysis. By using the results of cost estimation and valuation, the adjusted rate of return (ARR) can be determined. The ARR is a new equation, which is created by improving the traditional IRR. The ARR is used to determine the rate of return on M&A investment. The details of the ARR are discussed in Chapter 4.4.3. The risk-bearing budget percentage and ARR calculated in this component are the input of the decision rule.

- Decision Rule and Prioritisation: A decision rule using the IF-THEN statement based on the total time required to complete M&A, the ARR, and the risk-bearing budget percentage is defined to support decision-making on M&A deals. If there is more than one M&A deal at the same time, prioritisation would be undertaken to provide further evidence for decision-making. The output of this component is the ultimate one, which tells the decision maker which M&A deal is worthy of investment and which is not.

4.2 Risk Analysis

4.2.1 Risk Identification with Cause-and-effect Analysis

4.2.1.1 Construction of a Fishbone Diagram

Risk identification is to identify the risk factors that exist in M&A activities. In the risk

identification of the proposed model, the cause-and-effect analysis, also known as the fishbone method, is adopted to identify possible risks. The fishbone diagram can identify many possible causes for an effect or problem. It can be used to structure a brainstorming session, and immediately sort ideas into useful categories. As mentioned in Chapter 2, the fishbone diagram is a tool for analysing process dispersion. The diagram illustrates the main causes and sub-causes leading to an effect. It is a team-brainstorming tool used to identify potential root causes to problems. Because of its function, it may be referred to as a cause-and-effect diagram. In a typical fishbone diagram, the effect is usually a problem which needs to be resolved, and is placed at the "fish head". The causes of the effect are then laid out along the "bones", and classified into different types along the branches. Further causes can be laid out along smaller branches. The general structure of a fishbone diagram is presented in Figure 2. in Chapter 2.

The main goal of the fishbone diagram in this research is not only to link potential risk factors with activities in the M&A process but also illustrate in a graphical way the relationship between a given effect (i.e., completion of the M&A deal) and all the M&A activities and risk factors that influence this effect. It also provides an overall picture of the effect. The steps for constructing and analysing a cause-and-effect diagram are as follows:

1. Define clearly an effect as the fish head, such as completion of the M&A deal, and in this case, with the aim of optimising the M&A process.

2. Extend the spine of the fish to provide sufficient space for the related causes.

3. Identify the main factors that would have an impact on the effect being studied, or the main tasks contributing to the effect. In this case, all the relevant steps to the M&A process are placed in sequence on the spine of the fish from the tail to the

head. Those steps are the M&A activities recognised on the fuzzy critical path. Each task contributes a new bone to the fish spine.

4. Fill in the major or minor causes that would be an influence to the cause of action. Risk factors arising from each task in the M&A process are identified in this regard. Risk factors are denoted as smaller bones connecting to the main tasks, such as M&A activities on the fish spine.

The structure of a fishbone diagram in the case of the completion of an M&A deal is shown in Figure 4.2.
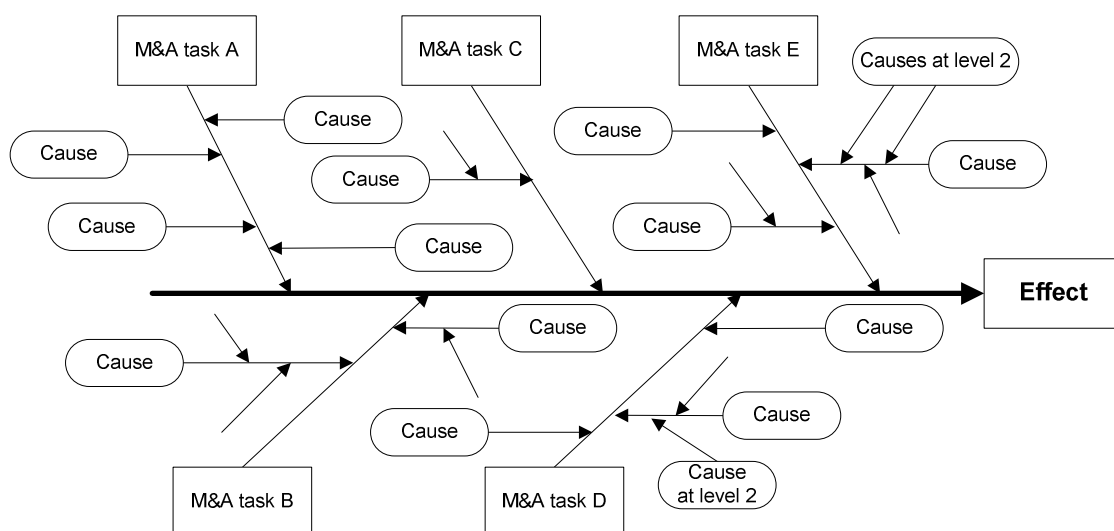
Figure 4.2 Structure of a fishbone diagram for M&A

4.2.1.2 Major Risk Factors

As mentioned in Chapter 2, M&A activities are often risky and costly (Firth, 1990; Weber *et al.*, 2012), and the failure rate is over 50% (Schoenberg, 2006). It is crucial to take risk factors into account. In order to assess and manage potential risks in M&A deals, identifying risk factors and associating them with each M&A activity is required in the

development of the fishbone diagram of the proposed model.

With reference to the interviews of a group of M&A experts (Chapter 3.3) and the typical M&A process shown in Table 3.3in Chapter 3, four kinds of risks associated with the M&A process are identified, namely schedule, estimation, process, and external risks (Figure 4.3).

Figure 4.3 Risk factors associated with M&A

i)   Schedule risk: This refers to any potential delays on each critical task in the M&A deal. The delay would mainly cause unnecessary increment in the project cost and uncertainty in other risks. Without proper project management, scope creep might occur. Such a risk may lead to project failure. Typically, the scope increment includes new tasks or features within the project framework without proper support or corresponding resources, time allocation, or budget. Thus, it would lead to improper allocation of resources to specific planned areas or cause the project team to drift away from the original plan (Shafqat *et al.*, 2011). One possible solution to diminish the risk is to perform a dose-response relationship on each critical task and maintain consistent monitoring.

ii) Estimation risk: This refers to the decision makers' uncertainty about the parameters of the M&A process. It occurs at the time of each task completion and refers to the uncertainty of the outcome of each task, such as whether the task can be completed on time with the expected outcome, and whether the resources allocated are sufficient and used effectively. There would always be a deviation between perceived results and actual results, due to the variance of communication errors or instability of resource supply. This leads to overconfidence in the potential outcome of each task or underestimation of M&A requirements, which eventually causes emotional situations and cognitively affects the short-term M&A arrangement and planning (David *et al.*, 2002).

iii) Process risk: This denotes a series of repercussion effects or butterfly effects (Cooke *et al.*, 2007) on the result of each descendant task in the step-by-step M&A process, because the tasks in the M&A process are closely linked with each other. The better the outcome of the predecessor's task is, the smoother the descendant can be undertaken. Any faulty coordination between tasks would threat the planned M&A duration and resource input. Causing a delay of the subsequent tasks in the M&A process is inevitable in many cases.

iv) External risk: This denotes the external influences on the M&A deals, such as third parties, government intervention, legal barriers, and competitors. Both direct and indirect intervention would influence the amount of input and output of the M&A. One example is Haier's move to the US market; its government imposed a heavy tax on its goods, resulting in Haier's reconsideration in terms of financial returns.

4.2.2 Risk Assessment

To take risk factors into consideration when making M&A decisions, the four aforementioned risk factors are measured in terms of "high", "moderate", and "low" level for each M&A task. Some risk factors may not be applicable to particular M&A tasks, in which case the risk level would be "not applicable". For instance, assigning a PM is regarded as an internal task in the company and is thus not associated with external risk; its external risk level is therefore not applicable. The risk level is assessed by three M&A experts who have over 15years of experience in M&A and risk analysis. The risk assessment sheet is shown in Table 4.1 for calculating the risk level of each M&A task. In the assessment, the risk levels "low", "moderate", and "high" are quantified in terms of the ratings 0.25, 0.5, and 1, respectively. The risk level of each M&A task in quantified value is the ratio of the sum of risk levels for each risk factor to the number of risk factors involved. If the value is less than one third, it is defined as low risk; if it is higher than two thirds, it is considered as high risk; otherwise, it should be moderate. The overall risk level is determined accordingly. The risk measurement results are considered when estimating the costs of the M&A deals afterwards. The cost-benefit evaluation of M&A is discussed in later sections.

Table 4.1 Risk assessment sheet of the proposed model

	Task	Risk Factor				Risk level
		Time	Estimation	Process	External	
Risk Assessment	Initial M&A project evaluation/filtration					
	Legitimacy of assessment					
	PM assignment					
	Initial meeting					
	Legitimacy confirmation					
	Signing of memorandum of understanding					
	Valuation					
	Competitor assessment					
	Completion of partner and competitor assessment					
	Policy formulation and evaluation					
	Feasibility assessment					
	Capex calculation					
	Completion of feasibility and Capex assessments					
	Revenue forecasting models					
	Negotiation					
	Signing of sales and purchase agreement					
	Legal documentation of partnership					
	Overall risk level					

4.2.3 Risk Level and Cost Fluctuation

In estimating resources and costs required for the M&A process, it is assumed that there are three degrees of risk attitudes when making decisions. The three degrees of risk attitudes are risk-averse, risk-neutral, and risk-taking. These risk attitudes are taken into consideration when generating the fluctuation level of cost in relation to the M&A process, based on the overall risk level to be assessed. Table 4.2 shows the percentage of cost fluctuation under the three degrees of risk attitudes towards different risk levels of M&A deals, according to the interviews and discussions with a group of M&A experts from

SAGE. The higher the risk level is, the greater the cost fluctuation is. Furthermore, the potential uncertainties and risks could lengthen the duration of the M&A and require additional resources, which would increase the costs. The cost estimation of the M&A deals thus considers the overall risk level and percentage of cost fluctuation.

Table 4.2 Relationship between cost fluctuation and risk level with different attitudes

Risk Attitude / Risk Level	Cost Fluctuation (%)		
	Risk-averse	Risk-neutral	Risk-taking
Low	95.00%	100.00%	112.50%
Moderate	90.00%	100.00%	125.00%
High	80.00%	100.00%	150.00%

4.3 Fuzzy Critical Path Analysis

To determine the fuzzy critical path of the M&A activities in the deal, the following steps are required, and a case study to illustrate its application is discussed in Chapter 5.2.2.

1. Specify the individual activities in the M&A deal

2. Determine the sequence of those activities

3. Draw an activity-on-arrow network diagram

4. Determine the fuzzy critical path

For steps 1 and 2, the activities involved in the M&A deal and their sequence needs to be identified. Listing all M&A activities is important for the company to estimate the duration of the M&A deal and to arrange resources required for those activities, in order to have effective planning and scheduling. The activities in the M&A deal from initial M&A project evaluation/filtration to legal documentation, together with legitimacy assessment and confirmation, meetings, valuation, competitor assessment, and negotiation, should be

identified. The predecessor(s) of each activity should then be recognised. An input

datasheet for identifying M&A tasks, predecessors, and the man-days required can be

referred to in Table 3.3 in Chapter 3. An activity-on-arrow network diagram can then be

drawn according to the list of activities and sequence (i.e., step 3). The network diagram

visualises the M&A process for better understanding and is helpful in determining the

fuzzy critical path. An example of an activity-on-arrow network diagram is shown in

Figure 2.3 in Chapter 2. The activities with the time required for completion are stated on

arrows and connected by nodes.

For step 4, the approach to determine the fuzzy critical path is as follows and a case study

to illustrate these calculations is discussed in Chapter 5.2.2.

In this research, a set of general equations for the critical path method with n nodes is

implemented. An M&A project network S_f = {O, A, $\tilde{T}$} consists of a set of fuzzy activity

times. O acts as a finite set of nodes and A represents a set of activities on an arrow with

crisp activity time, whereas $\tilde{T}$ is a function of the fuzzy duration of an activity from one

node to another. $\tilde{T}$ is defined by the following equation (1) and its membership function

of $\mu_{\tilde{T}_{ij}}$.

$$\tilde{T}_{ij} = \left\{ \left(t_{ij}, \mu_{\tilde{T}_{ij}}(t_{ij}) \right) \middle| t_{ij} \in S(\tilde{T}_{ij}) \right\}, (i,j) \in A \tag{1}$$

where i and j are elements of the set A, that is, $(i,j) \in A$; $S(\tilde{T}_{ij})$ is the fuzzy activity

function in the support of $\tilde{T}_{ij}$ under the universal set of $(i,j) \in A$ activity time, and $\tilde{T}_{ij}$ is

the fuzzy duration time of activity $(i,j) \in A$ and its membership function is $\mu_{\tilde{T}_{ij}}(t_{ij})$.

The general set of equation (2) is derived from the normal critical path problem with the

consideration of the fuzzy activity function, $S(\tilde{T}_{ij})$.

$$\tilde{D} = \max \sum_{i=1}^{n} \sum_{j=1}^{n} \tilde{T}_{ij} x_{ij}$$

$$s.t. \sum_{j=1}^{n} x_{1j} = 1,$$

$$\sum_{j=1}^{n} x_{ij} = \sum_{k=1}^{n} x_{ki}, \quad i = 2, \dots, n-1,$$

$$\sum_{k=1}^{n} x_{kn} = 1,$$

$$x_{ij} = 0 \text{ or } 1, \ (i,j) \in A \tag{2}$$

Where $\tilde{D}$ is the maximal objective value that is a fuzzy number.

After that, α-cut level should be identified and each α-cut value is set in a separate scenario for analysis. A table of α-cut set duration is derived using formula (3). With the use of the α-cut method, there would be two values per α-cut level unless it is at α-cut level 1.

$$(T_{ij})_\alpha = \left\{ t_{ij} \in S(\tilde{T}_{ij}) \middle| \mu_{\tilde{T}_{ij}}(t_{ij}) \geq \alpha \right\} \tag{3}$$

Therefore, equation (4) which provides the lower and upper boundaries of the crisp values of those fuzzy sets is formed:

$$(T_{ij})_\alpha = \left[\inf_{t_{ij}} \left\{ t_{ij} \in S(\tilde{T}_{ij}) \middle| \mu_{\tilde{T}_{ij}}(t_{ij}) \geq \alpha \right\}, \sup_{t_{ij}} \left\{ t_{ij} \in S(\tilde{T}_{ij}) \middle| \mu_{\tilde{T}_{ij}}(t_{ij}) \geq \alpha \right\} \right] =$$

$$\left[(T_{ij})_\alpha^L, (T_{ij})_\alpha^U \right] \tag{4}$$

Assuming the problem of each fuzzy set is a linear function, the tangent of an angle is calculated for the α-cut calculation. Equations (5) and (6) are used for the calculation of the lower boundary while equations (7) and (8) are for that of the upper boundary.

$$\theta^L = \tan^{-1}\left(\alpha^0 / (T_{ij}{}^M - T_{ij}{}^L)\right) \tag{5}$$

$$(T_{ij})_\alpha^L = T_{ij}^L + \alpha/\tan(\theta^L) \tag{6}$$

$$\theta^U = \tan^{-1}(\alpha^0/(T_{ij}^U - T_{ij}^M)) \tag{7}$$

$$(T_{ij})_\alpha^U = T_{ij}^U - \alpha/\tan(\theta^U) \tag{8}$$

After obtaining the table of fuzzy activity time, the total fuzzy duration is dealt with using Zadeh's extension principle. It is used to denote the shortest duration of the potential fuzzy critical path, of which the membership function can be defined as equation (9):

$$\mu_{\tilde{D}}(d) = \sup_{t_{ij} \in R^+, (i,j) \in A} \min_{(i,j) \in A} \left\{ \mu_{\tilde{T}_{ij}}(t_{ij}) \middle| d = D(t) \right\} \tag{9}$$

Since there are upper and lower boundaries of the crisp sets, two different sets of fuzzy duration at different α-cut values can be obtained. D_α^L is denoted by equation (10) and represents the set for the lower bound, while D_α^U, equation (11), represents the set for the upper bound:

$$D_\alpha^L = \min\left\{ D(t) \middle| (T_{ij})_\alpha^L \le t_{ij} \le (T_{ij})_\alpha^U \forall (i,j) \in A \right\} \tag{10}$$

$$D_\alpha^U = \max\left\{ D(t) \middle| (T_{ij})_\alpha^L \le t_{ij} \le (T_{ij})_\alpha^U \forall (i,j) \in A \right\} \tag{11}$$

Through the dual-level mathematical program, equations (12) and (13) are obtained, where at least one $t_{ij}, (i,j) \in A$ would touch the boundary of each site of the α-cut to satisfy the equation of $\mu_{\tilde{D}}(d) = \alpha$. In other words, the implementation of the dual-level mathematical program increases the reliability of the study through numerous tests.

Dual-level fuzzy mathematical program:

$$D_\alpha^L = \min_{\substack{(T_{ij})_\alpha^L \le t_{ij} \le (T_{ij})_\alpha^U \\ \forall (i,j) \in A}} \begin{cases} \max \sum_{i=1}^n \sum_{j=1}^n t_{ij} x_{ij} \\ s.t. \; \sum_{j=1}^n x_{ij} = 1, \\ \sum_{j=1}^n x_{ij} = \sum_{k=1}^n x_{ki}, \; i = 2, \dots, n-1, \\ \sum_{k=1}^n x_{kn} = 1, \\ x_{ij} \ge 0, \; (i,j) \in A \end{cases} \tag{12}$$

$$D_\alpha^U = \max_{\substack{(T_{ij})_\alpha^L \le t_{ij} \le (T_{ij})_\alpha^U \\ \forall (i,j) \in A}} \begin{cases} \max \sum_{i=1}^n \sum_{j=1}^n t_{ij} x_{ij} \\ s.t. \sum_{j=1}^n x_{ij} = 1, \\ \sum_{j=1}^n x_{ij} = \sum_{k=1}^n x_{ki}, \ i = 2, \dots, n-1, \\ \sum_{k=1}^n x_{kn} = 1, \\ x_{ij} \ge 0, \ (i,j) \in A \end{cases} \tag{13}$$

To solve the dual-level mathematical program formulas, we assume that the predecessors and their corresponding dual problems have the same objective durations. Thus, y_j is denoted as the dual variable that corresponds to the jth general constraint of the second-level problem in equation (12), which would transform the above lower boundary as follows (equation 14), and likewise for the upper boundary (equation 15).

$$D_\alpha^L = \begin{array}{l} min \\ s.t. \\ \ \end{array} \begin{array}{l} y_n - y_1 \\ y_j \ge y_i + (T_{ij})_\alpha^L, \ (i,j) \in A \\ y_i, y_j \ unrestricted \ in \ sign \ \forall (i,j) \in A \end{array} \tag{14}$$

$$D_\alpha^U = \begin{array}{l} max \\ s.t. \\ \ \\ \ \\ \ \end{array} \begin{array}{l} \sum_{i=1}^n \sum_{j=1}^n (T_{ij})_\alpha^U x_{ij} \\ \sum_{j=1}^n x_{ij} = 1, \\ \sum_{j=1}^n x_{ij} = \sum_{k=1}^n x_{ki}, \ i = 2, \dots, n-1, \\ \sum_{k=1}^n x_{kn} = 1, \\ x_{ij} \ge 0, \ (i,j) \in A \end{array} \tag{15}$$

y_j represents the occurrence time of the node j, and the value of y_n-y_1 represents the duration of the project. By solving the problem, a set of total fuzzy duration times and their set of potential fuzzy critical paths are obtained. Some of them might have been duplicated due to different levels of α-cut values under the situation in which a clear route is definite. If a different route appears on that table, the defuzzy step is used, whereby the fuzzy set of numbers are defuzzified into crisp time by using the Yager ranking index, defined by equation (16):

$$I(\tilde{T}) = \int_0^1 \frac{1}{2} (T_\alpha^L + T_\alpha^U) d\alpha \tag{16}$$

where (T_α^L, T_α^U) is the α-cut of $\tilde{T}$. To find out the most critical path in the project network

of $S_f = (O, A, \tilde{T})$, equation (17) is useful for finding the longest Yager ranking index, which is used to find the degree of criticality.

$$L_{mcp}^{max} = \max_k \{\sum_{\forall (i,j) \in FCA_k, k=1,2,\ldots,m} I(\tilde{T}_{ij})\} \tag{17}$$

Let P_{cg} be the relative degree of criticality from point c (start of project) to point g (end of project). The ratio of the Yager ranking index can be derived by using equation (18).

$$Rdeg(P_{cg}) = \frac{\sum_{\forall (i,j) \in P_{cg}} I(\tilde{T}_{ij})}{\max_k \{\sum_{\forall (i,j) \in FCA_k, k=1,2,\ldots,m} I(\tilde{T}_{ij})\}} = \frac{\sum_{\forall (i,j) \in P_{cg}} I(\tilde{T}_{ij})}{L_{mcp}^{max}} \tag{18}$$

The ratio would conclude which critical path is the final fuzzy critical path that we are looking for. The ratio would be from one to zero, whereby L_{mcp}^{max} divided by L_{mcp}^{max} equals one. With the calculations, the fuzzy critical path of the M&A deal can be determined in the expression of an activity-on-arrow diagram.

4.4. Cost-benefit Evaluation

To maximise the probability of M&A success, the prediction of resources to be allocated, costs, and benefits is crucial before making any decisions on the deals. The component of cost-benefit evaluation provides evidence in terms of the costs of managing the deal and the value of the target company, thereby supporting M&A decision-making. Given that M&A are often risky, such cost-benefit evaluation takes the potential risk factors into account.

4.4.1 Cost Estimation with Risk Analysis

In every M&A deal, manpower plays a crucial role and is the most important resource to be allocated. Apart from the fixed amount of acquisition cost, manpower cost is another

essential expenditure in managing M&A deals. Such expenditure is generally the second largest cost following the acquisition cost. In light of this, the manpower cost is influential in determining the final cost of the M&A deal or in making the final M&A decision. In order to evaluate the attractiveness of M&A investments in a more precise manner, the manpower cost should therefore be considered when judging the cost of M&A deals.

Since the manpower cost in M&A deals is closely related to the time needed for the completion of the M&A, risk analysis is taken into account to estimate the manpower cost. Monte Carlo simulation, which is useful and practical for cost estimation with risk analysis, as discussed in Chapter 2.4.2, is used for the cost calculation. The implementation of the cost evaluation with Monte Carlo simulation is illustrated using a case study in Chapter 5.2.3.

The cost evaluation element in this research is not only for manpower cost evaluation but also to help the company with monitoring whether sufficient resources and capital are ready for the completion of the M&A deal. This element also helps determine a risk-bearing budget percentage, which is defined as the relative difference between the optimal budget under complete certainty and the optimal budget in a context of risk.

The cost evaluation element is composed of the input section, simulation section, and output section, which are explained as follows.

Input section (Table 4.3): The percentage of cost fluctuation is defined by the risk

measurement. Parties involved in the M&A process, the number of man-hours per working day, and the manpower costs should be predetermined. These data vary from case to case. A list of M&A tasks with the time required for the deal completion identified earlier should be displayed, and the amount of associated manpower required should be allocated in the input area.

Simulation section (Table 4.4) : This is divided into two main parts for illustration; one is about the man-days required for the M&A tasks, and the other is their operation costs. Before starting the simulation, users can adjust their distribution preference, define the correlation for the Monte Carlo simulation, pre-set the number of iterations, and input the number of simulations. The simulation process begins by simply pressing the "start simulation" button. The main function bar is shown in Figure 4.4.

The number of man-days associated with each of the M&A tasks in the process is estimated, followed by their operation costs, in terms of risk pert distribution with parameters minimum, most likely and maximum. The minimum, most likely, and maximum risk pert parameters can be regarded as optimistic, normal, and pessimistic scenarios, respectively. Risk pert is a function defining the upper, moderate, and lower ranges of the figures. The risk pert expected total number of man-days is calculated by adding the sum of all the risk pert expected durations in the M&A process to Risk output ("total man-days"). Similarly, the risk pert expected total operation costs in the M&A process is calculated by adding the sum of all the risk pert expected costs in the M&A process to Risk output ("total projected costs").
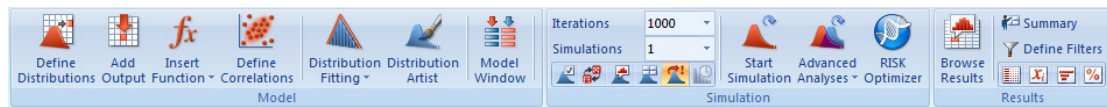
Figure 4.4 Main function bar

Output section (Table 4.5): The estimated budget in a normal situation for the M&A deal and the percentage of additional resources which should be on standby for emergency purpose are estimated and shown in this output area. The underlying formula for the calculation of the percentage of additional resources required is Risk Target (risk pert expected total operation cost, normal operation cost). This output area also illustrates the calculations, at 95% confidence, of the total budget of the M&A deal required and the contingency budget required for the M&A process.

Table 4.3 Input section of the cost estimation sheet

		Risk-averse (Min)		Risk-neutral (Normal)		Risk-taking (Max)
Cost fluctuation (%)						
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert
Man-hours per day		8	8	8	8	8
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450
Task	**Time required (Days)**	**Number of manpower required**				
		Lawyer	Consultant	Project Director	Accountant	Investment Expert
Initial M&A project evaluation/filtration						
Legitimacy of assessment						
PM assignment						
Initial meeting						
Legitimacy confirmation						
Signing of memorandum of understanding						
Valuation						
Competitor assessment						
Completion of target and competitor assessment						
Policy formulation and evaluation						
Feasibility assessment						
Capex calculation						
Completion of feasibility and Capex assessment						
Revenue forecasting models						
Negotiation						
Signing of sales and purchase agreement						
Legal documentation of M&A						

Input Section

Table 4.4 Simulation section of the cost estimation sheet

	Task	Time required (Days)				Operation Cost (HKD)			
		MIN	Most likely	MAX	Risk Pert Expectation	MIN	Most likely	MAX	Risk Pert
Simulation Section	Initial M&A project evaluation/filtration								
	Legitimacy of assessment								
	PM assignment								
	Initial meeting								
	Legitimacy confirmation								
	Signing of memorandum of understanding								
	Valuation								
	Competitor assessment								
	Completion of target and competitor assessment								
	Policy formulation and evaluation								
	Feasibility assessment								
	Capex calculation								
	Completion of feasibility and Capex assessment								
	Revenue forecasting models								
	Negotiation								
	Signing of sales and purchase agreement								
	Legal documentation of M&A								

Table 4.5 Output section of the cost estimation sheet

		HKD	Confidence Level
Output Section	Estimated cost (HKD)		
	Contingency cost required for 95% confidence		
	Total cost required for 95% confidence		
	Risk-bearing budget percentage		

4.4.2 Valuation using Discounted Cash Flow Analysis

Discounted cash flow (DCF) analysis, a popular tool in investment finance and corporate financial management, is used to estimate the value of the target company as a whole in

this research. It determines the amount of money the investor has to pay in the present in order to receive the anticipated earnings in the future. The use of DCF analysis is encouraged in most capital budgeting situations to account for the time value of money (Raiborn *et al.*, 2006). Furthermore, the discount rate is often used to determine the imputed interest of future receipts and expenditures (Raiborn *et al.*, 2006). Due to the opportunity cost of capital and resources over time, all future cash flows must be discounted to give the present value for estimating the potential of the investment (Damodaran, 1996). If the value obtained from the DCF analysis is higher than the estimated investment cost, there is a good opportunity, or in other words, it is acceptable to make the M&A deal.

DCF analysis is adopted in this research to predict the value of the target company in M&A deals by discounting all future cash flows of the target to their present values. Discounted cash flows are then added up to obtain the net present value (NPV) of the target. The equation of the NPV is as follows:

$$NPV(r, N) = \sum_{t=0}^{N} \frac{C_t}{(1 + d)^t}$$

Where t is the time of the cash flow, d is the discount rate, and C_t is the net cash flow at time t. In this research, the discount rate used to determine the NPV is assumed to be 15%.

4.4.3 Adjusted Rate of Return (ARR)

Internal rate of return (IRR) is a well-known method used in capital budgeting and is the interest rate that makes the NPV equal to zero. It is used to evaluate the desirability of a project or investment. The higher the IRR of a project, the more desirable it is to undertake

the project. The calculation of IRR is as follows:

$$NPV = \sum_{t=0}^{N} \frac{C_t}{(1+i)^t} = 0$$

Where t is the time of the cash flow, i is the IRR, and C_t is the net cash flow at time t.

In general, companies only include the acquisition cost in the calculation of IRR but not the manpower cost. As discussed in Chapter 4.4.1, the manpower cost is a vital expenditure in making M&A deals that cannot be ignored. In order to calculate the expected returns on M&A investment in a more precise manner, an ARR which takes into account both the acquisition cost and manpower cost with risk involvement is therefore proposed in this research. ARR is an enhanced method for capital budgeting. It can be used in comparative assessment of potential M&A investments to evaluate their desirability. The calculation is expressed in the following equation:

$$\sum_{t=0}^{N} \frac{C_t}{(1+R)^t} - AC - MC = 0$$

Where t is the time of the cash flow, R is the ARR, and C_t is the net cash flow at time t. AC is the acquisition cost and MC is the manpower cost that is derived from the cost estimation element of the proposed model.

4.5 Decision Rule and prioritisation

To support companies in making M&A decisions in an effective manner, a decision rule is established on the grounds of the estimated ARR, time required for the completion of the M&A, and risk-bearing budget percentage. The decision rule is defined with reference to SAGE's previous M&A cases and the experience of SAGE's M&A experts according to

the interviews and discussions conducted in this study. A consensus on the decision rule is reached that IF the time required for completing an M&A deal is less than 180 days, the risk-bearing budget percentage is smaller than 18%, and the ARR is greater than 25%, THEN the M&A deal is worthy of investment and is thus recommended.

In case there is more than one M&A deal which are worthy of investment but firms have limited resources to process the deals concurrently, prioritisation of the deals is undertaken by calculating a finalised rating of the deals by using the following equation:

$$\text{Priority Rating} = \frac{180 - f}{180} \times 35\% + \frac{18\% - b}{18\%} \times 15\% + \frac{a - 25\%}{25\%} \times 50\%$$

Where f is the result of the fuzzy duration, b is the result of the risk-bearing budget percentage, and a is the result of the ARR of a particular M&A deal. By comparing the ratings, M&A deals can be prioritised. The higher the rating is, the worthier the M&A deal is among those compared. In this case, firms can evaluate their capacity to decide which deals should go forward and which should be passed over for better resource management and strategic planning.

Chapter 5 Case Study for Model Illustration

Chapter 4 discusses the theoretical framework and development of the proposed model. This chapter illustrates the proposed model by using a case study. The case study is a real case of SAGE's previous M&A deal. It is used to demonstrate how the proposed model supports M&A investment decision-making, and is helpful for enhancing decision makers' understanding on the operation of the proposed model.

5.1 Background of Suzhou Universal Chinese Memorial

Due to the financial tsunami in 2008, SAGE's exhibition business faced extreme market pressures and cutthroat competition. In order to diversify SAGE's income sources and to further improve its financial position, SAGE divested the exhibition business and sought opportunities in the death care sector on account of the rapidly aging population in China driving demand for death care services and products. SAGE found that with the existing available land and expected demand increase, burial land capacity in Shanghai would be fully utilised within ten years. With a favourable supply/demand relationship, rising earnings of residents, aging trends, and robust growth, the Shanghai funeral market is expected to thrive in the coming years. In addition, SAGE discovered that the death care industry's largely recession-proof nature and high profit margins makes it a good business to venture into during the global financial downturn. Eventually, SAGE decided to develop its death care services business through M&A.

SAGE acquired Suzhou Universal Chinese Memorial in 2010 in view of the landscape design of the cemetery offering a scenic array of interment options with excellent Fung

Shui. The cemetery situates on Xishan Island, the essence of Tai Hu lake scenic areas in Suzhou, China, and is built alongside hills and is girdled by water. The acquisition process took about three months to complete and its total consideration is HK$110 million. With this 60,000 m²cemetery, SAGE can offer 30,000 burial plots and three columbaria.

5.2 Application of the Proposed Model

To illustrate the proposed model, real data regarding the M&A of the Suzhou Universal Chinese Memorial (Case 1) obtained from SAGE was used. The proposed model described in Chapter 4 is adopted for this purpose and to see if the results generated by the model are consistent with the actual results of this M&A deal.

5.2.1 Cause-and-effect Analysis and Risk Analysis

After SAGE gains insights into the death care industry and decides to acquire Suzhou Universal Chinese Memorial, there are a series of evaluations and considerations for pre-M&A analysis prior to the M&A action. Identifying the M&A activities is the first necessary step, which will assist the subsequent cause-and-effect analysis and risk analysis. The M&A tasks, predecessors, and time required in the case of Suzhou Universal Chinese Memorial are listed in Table 5.1. These M&A tasks are suggested by the experts with reference to the general practice of M&A and the nature of the tasks which are explained in Chapter 3.2.

Table 5.1Tasks, predecessors, and time required for Case 1

	M&A Tasks	Predecessors	Time Required (Days)
A	Initial M&A project evaluation/filtration		5
B	Legitimacy of assessment	A	30
C	PM assignment	A	2
D	Initial meeting	C	3
E	Legitimacy confirmation	B	2
F	Signing of memorandum of understanding	D, E	1
G	Valuation	A	5
H	Competitor assessment	G	5
I	Completion of partner and competitor assessment	F, H	3
J	Policy formulation and evaluation	F	3
K	Feasibility assessment	G	10
L	Capex calculation	K	5
M	Completion of feasibility and Capex assessment	L	2
N	Revenue forecasting models	G	5
O	Negotiation	F, I, J, M, N	10
P	Signing of sales and purchase agreement	O	5
Q	Legal documentation of partnership	P	15

M&A are business investment strategies that are often risky and costly (Firth, 1990; Weber *et al.*, 2012), with a failure rate of over 50% (Schoenberg, 2006). Evaluating the potential risks in the M&A process is critical. To avoid overlooking any potential risks, cause-and-effect analysis as discussed in Chapters 2 and 4 is adopted for risk identification, linking the major risk factors (i.e., schedule, process, estimation, and external risk factors as explained in Chapter 4.2.1.2) to each M&A task in an organised manner.

The initial M&A project evaluation/filtration involves schedule, estimation, and external risks. Since it is the first task in the M&A process, it is expected to be a critical task; any delay on this task would highly affect the commencement of other M&A tasks. Time risk is therefore involved and usually evaluated as being at a high level. Estimation risk also

exists in not only this task but also in all other M&A tasks. This is because the time required and resource allocation for each task is determined by a person. These human judgments may be subjective and inaccurate, and their predication may be made under uncertainty, resulting in a difference between the expected and actual results. In addition, there are plenty of external factors surrounding M&A, such as the flow and availability of information pertaining to the target company and business environment, changes in economic outlook, competitors' reactions, political and legal concerns, as well as government policy in both Hong Kong and Mainland China. Because these external factors could affect SAGE's decisions and the progress of project evaluation/filtration, external risk is therefore considered.

Legitimacy of assessment involves the schedule, process, estimation, and external risks. Time risk is involved as it is a critical task. It is affected by the estimation risk as it has a definite impact on the eligibility of acquiring the target company across the border, and the judgment is likely under uncertainty at an early stage of the M&A process. Furthermore, because the legitimacy of assessment exerts a butterfly impact on subsequent tasks, process risk is therefore linked. There is no doubt that this task is related to external risk because the majority of the assessment relies on the government's approval. The heavy reliance on external approval increases the overall involvement of external risk.

PM assignment is affected by two kinds of risks; one is estimation risk and the other is process risk. Typically, the company selects a PM who should have a wide range of

knowledge and experiences in the specific industry and M&A deals. The company may sometimes select a candidate whose actual performance is out of expectation due to subjective perception and limited resources. This is an estimation risk. The performance of the PM generally affects the outcomes of every task in the M&A process, and this explains why the process risk is associated with this.

During the initial meeting, there are usually different voices from the business partners, such as consultants, accountants, and legal partners, regarding the M&A deal. The involvement of third parties and their opinions on the matter affects the company's attitude towards the deal and the outcome of the meetings. Estimation and external risks are therefore linked.

Since any delay on the legitimacy confirmation would affect the progress of the M&A deal, this is considered as a schedule risk. The potential M&A deal would be terminated if important legal authorities do not grant access to resources; this is closely related to the estimation risk. Since such a confirmation highly depends on the governmental bodies' decision and work progress, it is associated with the external risk, which is uncontrollable.

The signing of the memorandum of understanding by both parties is a critical task and is related to the schedule risk if there is any procrastination. Signing the contract means both parties have the basic understanding on the deal and have the intention to complete it. The exposure of this intention may lead to negative reactions or feedback from third parties such as competitors. External risk is therefore taken into account.

Valuation is related to estimation, process, and external risks. The valuation involves capital analysis and prediction in the IRR. In this fast-paced and dynamic business world, it is difficult to measure the future prosperity of the business. Some current assets which are useful or have value-added may not turn out to be worthwhile after the M&A deal. In addition, a huge amount of data is required for such valuation. The data integrity and availability may be dependent on external media or information providers. Inaccurate data may affect the outcome of the valuation and cannot reflect the potential growth of the target company.

Competitor assessment influences the company's decision. Competition may result in an increase in the M&A costs because the company would have to spend more resources and higher acquisition costs to fight its competitors and ensure that the deal is made successfully. The estimation risk is thus associated with this assessment. The result of the assessment affects the company's strategy and policy for the deal; this is the process risk.

Policy formulation and evaluation is associated with the four risk factors. It is deemed to be a key task and must be completed on time. Some of the terms in the policy are exposed to certain benefit orientation, which may become barriers to access required resources, leading to estimation and process risks. In addition, those terms and conditions defined need to be accepted by both sides after a series of discussions and agreements. Similar to the initial meeting, different parties are involved in the policy formulation and evaluation task to give opinions, and therefore the external risk applies.

Feasibility assessment is associated with estimation and process risks as its results affect the decision on M&A and the whole progress. It can lead to the success of later part of the entire M&A process if the land value increases against inflation and market demand. Information from the media or local land retailing industry would influence the perception on the feasibility assessment.

Capex calculation provides information on excess capital for sustaining the M&A deal. The result could have an immense impact on the final decision-making process. With accurate Capex calculation, the acquirer is able to maintain enough cash flow to protect against external risk, preventing hostile takeover. It is thus related to estimation and external risks.

The revenue forecasting model provides a basic chart on the annual revenue. It is influenced by the market trend; thus, it is closely related to estimation risk during economic instability. Any inaccurate forecasts obtained from the model may lead to overestimation or underestimation of costs and benefits. The external market has immense impact on the calculation of the revenue model, which leads to under-application or over-application of financial forecast.

Negotiation is associated with schedule risk as it is an important task for the company to bargain for more benefits, but an extended negotiation may affect the intention and sincerity of making the deal. Negotiation results may be unexpected and far from the actual return. A time-consuming negotiation would lead to a waste of committed resources.

Because external parties would join the negotiation as a form of consultation or for approval, external risk is involved.

When signing the sales and purchase agreement, the contract is written with explicit terms as well as implied terms according to the local legal framework. Since there may be deviation from cross-border legal terms, a certain level of schedule and estimation risks is involved. This is related to external risk also because governmental bodies have the legal rights to step in and call for the entire agreement to be terminated, such as in the case of Coca Cola and Huiyuan.

Legal documentation of M&A is the last step in the M&A process. Improper implementation of legal documentation might influence the legal eligibility of the M&A deal, increasing the schedule and estimation risks. Process risk is involved in the filing of corrected negotiation terms in the contract.

A fishbone diagram linking risk factors to respective M&A tasks for the case of Suzhou Universal Chinese Memorial is shown in Figure 5.1. It is useful for visualising the relationship between risk factors and M&S tasks and for drawing decision makers' attention to the risks at each step in the M&A process. Risk assessment can then be conducted to evaluate the risk level of the M&A project.

A group of experts with rich experience in M&A were responsible for the risk assessment of every M&A case, as mentioned in Chapter 3.2. The experts evaluated the risk level (i.e.,

low, moderate, or high) of risk factors (i.e., schedule, estimation, process, and external risks) against the list of tasks (17 tasks in total) one by one. The assessment results generated by the group of experts are presented on the risk assessment sheet in Table 5.2. According to the discussion in Chapter 4.2, the overall risk level for this case is determined as moderate, and thus the cost fluctuation percentage is between 90% and 125%, according to Table 4.2. This cost fluctuation percentage is used for the determination of the fuzzy critical path and cost-benefit assessment to take the risk attitude into account.
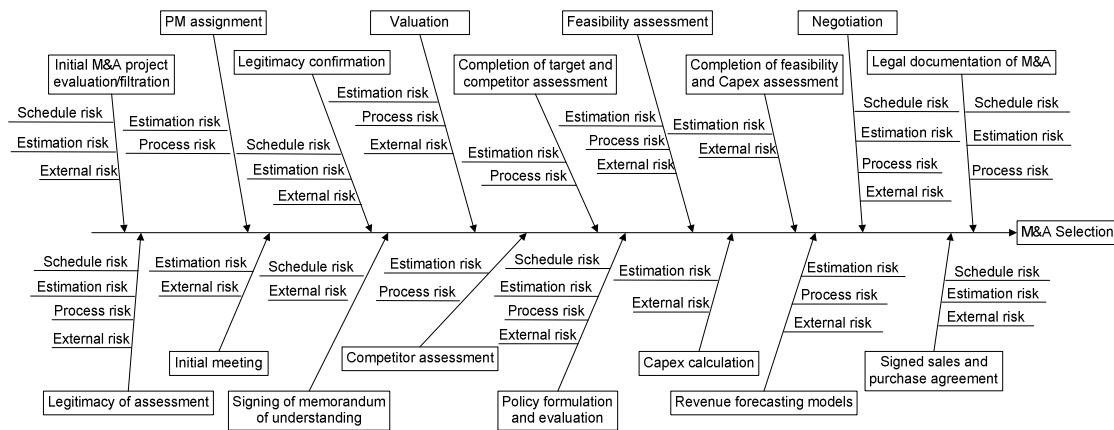
Figure 5.1 Fishbone diagram

Table 5.2Risk assessment results for Case 1

Tasks	Risk factors				Risk level result
	Schedule	Estimation	Process	External	
Initial M&A project evaluation/filtration	High	Moderate		Moderate	High
Legitimacy of assessment	Low	Moderate	High	High	High
PM assignment		Moderate	Moderate		Moderate
Initial meeting		Low		Low	Low
Legitimacy confirmation	High	Moderate		High	High
Signing of memorandum of understanding	Moderate			Moderate	Moderate
Valuation		High	Moderate	High	High
Competitor assessment		Low	Low		Low
Completion of target and competitor assessment		Low	Moderate		Moderate
Policy formulation and evaluation	Moderate	Moderate	High	Low	Moderate
Feasibility assessment		High	High	Moderate	High
Capex calculation		Low		High	Moderate
Completion of feasibility and Capex assessment		Low		High	Moderate
Revenue forecasting model		Moderate	Low	High	Moderate
Negotiation	Low	High	Low	High	Moderate
Signing of sales and purchase agreement	Low	Moderate		High	High
Legal documentation of M&A	Low	Low	Moderate		Moderate
Overall risk level					**Moderate**

Note: shadow cell means the risk factor is not applicable to the task.

5.2.2 Fuzzy Critical Path Analysis

In order to schedule project tasks and manage various milestones in the M&A process, it is necessary to determine the key sequence of tasks that are critical and have to be completed for the M&A deal. As discussed in Chapter 4.3, fuzzy critical path analysis is adopted for this purpose, with consideration of vague and subjective human judgments.

Based on the estimated duration, tasks, and predecessors given in Table 5.1, a Gantt chart (Figure 5.2) is created to schedule the M&A of Suzhou Universal Chinese Memorial, and an activity-on-arrow network diagram(Figure 5.3)is developed to visualise the M&A process. Since the task duration estimations involve human judgments, which are imprecise and fuzzy, fuzzy critical path analysis is adopted.

According to the discussion on the fuzzy critical path in Chapter 4.3, the M&A project network for this case can be defined as S_1 = {O, A, $\tilde{T}$}. With reference to Figure 5.3, O contains 14 nodes and A contains 17 activities/tasks with crisp activity time (t_{ij}). t_{ij} refers to the time required for each activity (Table 5.1), where i and j are elements of the set A. According to equation (1) in Chapter 4.3, the function of fuzzy activity time ($\tilde{T}$) for this case is shown in Table 5.3, where the upper and lower boundaries are calculated using the estimated cost fluctuation percentage (i.e., moderate with reference to the result of the risk analysis as shown in Table 5.2).

With reference to equation (2) in Chapter 4.3 and Figure 5.3, the general set of formula for fuzzy critical path ($\widetilde{D}$) in this case is derived as below:

$x_{1,2} = 1$

$x_{1,2} = x_{2,3} + x_{2,4} + x_{2,7}$

$x_{2,3} = x_{3,5}$

$x_{2,4} = x_{4,5}$

$x_{3,5} + x_{4,5} = x_{5,6}$

$x_{5,6} = x_{6,11}$

$$x_{2,7} = x_{7,9} + x_{7,10} + x_{7,8} + x_{7,11}$$

$$x_{7,8} = x_{8,11}$$

$$x_{7,9} = x_{9,10}$$

$$x_{9,10} + x_{7,10} = x_{10,11}$$

$$x_{10,11} + x_{8,11} + x_{7,11} + x_{6,11} = x_{11,12}$$

$$x_{11,12} = x_{12,13}$$

$$x_{12,13} = x_{13,14}$$

$$x_{13,14} = 1$$

$$x_{1,2}, x_{2,3}, x_{2,4}, x_{2,7}, x_{3,5}, x_{4,5}, x_{5,6}, x_{6,11}, x_{7,9}, x_{7,10}, x_{9,10}, x_{7,8}, x_{7,11}, x_{10,11}, x_{8,11}, x_{11,12}, x_{12,13}, x_{13,14}$$

$$\geq 0$$

Given the predetermined α-cut level ranging from one to zero with 0.1 for each interval, the α-cut of T_{ij}(i.e., $(T_{ij})_\alpha$) with lower and upper boundaries (i.e.,$(T_{ij})_\alpha^L$ and $(T_{ij})_\alpha^U$, respectively)are calculated using equations (3-8), as discussed in Chapter 4.3, and the results are shown in Table 5.4.

Taking $x_{1,2}$ at α-cut level = 0.9as an example to explain the calculations, according to equation (3) in Chapter 4.3,

$$(T_{ij})_\alpha = (T_{1,2})_{\alpha=0.9}$$

according to equation (5) in Chapter 4.3 and referring to Table 5.3,

$$\theta^L = \tan^{-1}(\alpha^0/(T_{ij}{}^M - T_{ij}{}^L)$$

$$= \tan^{-1}(1/(5 - 4.5))$$

$$= 1.11$$

according to equation (6) in Chapter 4.3,

$$(T_{ij})_\alpha^L = T_{ij}{}^L + \alpha/\tan(\theta^L)$$

$$(T_{1,2})_{\alpha=0.9}^L = T_{1,2}{}^L + 0.9/\tan(1.11)$$

$$= 4.5 + 0.9/\tan(1.11)$$

$$= 4.95$$

according to equation (7) in Chapter 4.3 and referring to Table 5.3,

$$\theta^U = \tan^{-1}(\alpha^0/(T_{ij}{}^U - T_{ij}{}^M)$$

$$= \tan^{-1}(1/(6.25 - 5)$$

$$= 0.67$$

according to equation (8) in Chapter 4.3,

$$(T_{ij})_\alpha^U = T_{ij}{}^U - \alpha/\tan(\theta^U)$$

$$(T_{1,2})_{\alpha=0.9}^U = T_{1,2}{}^U - 0.9/\tan(0.67)$$

$$= 6.25 - 0.9/\tan(0.67)$$

$$= 5.125$$

by solving equations (5-8), equation (4) in Chapter 4.3 can be calculated as below,

$$(T_{ij})_\alpha = \left[(T_{ij})_\alpha^L, (T_{ij})_\alpha^U\right]$$

$$(T_{1,2})_{\alpha=0.9} = \left[(T_{1,2})_{\alpha=0.9}^L, (T_{1,2})_{\alpha=0.9}^U\right]$$

$$= (4.95, 5.15)$$

The results in Table 5.4 indicate the upper and lower values of the fuzzy activity time required for each activity at different α-cut levels. For example, if i=2, j=3, and α-cut=0.9, then $(T_{ij})_\alpha$ is $(T_{2,3})_{0.9}$. To calculate its lower and upper boundaries (i.e., $(T_{2,3})_{0.9}^L$ and $(T_{2,3})_{0.9}^U$, respectively), equations (3-8)are used and the results $(T_{2,3})_{0.9}^L$ =29.7 and$(T_{2,3})_{0.9}^U$=30.75 are obtained, such that $(T_{2,3})_{0.9} = (29.7, 30.75)$.
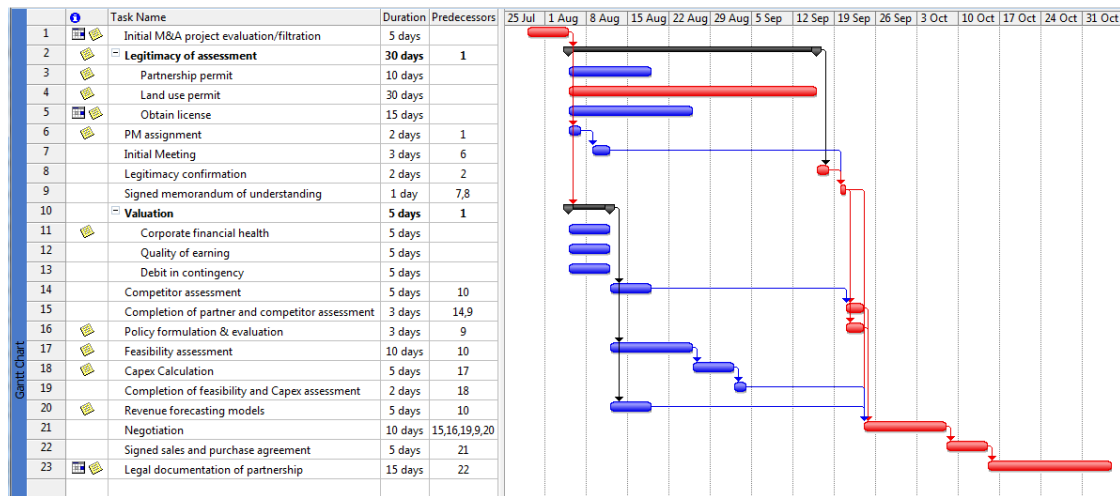
Figure 5.2 Gantt chart for Case 1
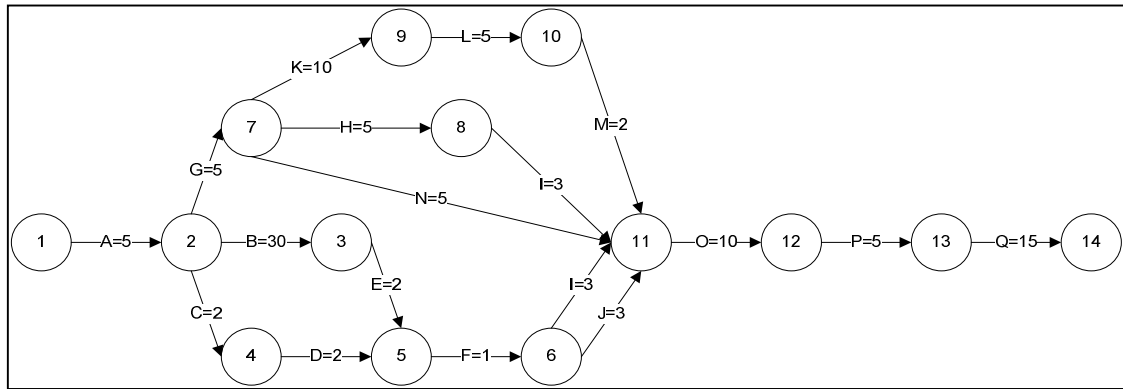
Figure 5.3 Activity-on-arrow network diagram for Case 1

Table 5.3 Crispy activity time and fuzzy activity time for Case 1

Activity	$\widetilde{T}_{ij}$	T_{ij}^{L}	$t_{ij}=T_{ij}^{M}$	T_{ij}^{U}
$X_{1,2}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{2,3}$	(27, 30, 37.5)	27	30	37.5
$X_{2,4}$	(1.8, 2, 2.5)	1.8	2	2.5
$X_{2,7}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{3,5}$	(1.8, 2, 2.5)	1.8	2	2.5
$X_{4,5}$	(2.7, 3, 3.75)	2.7	3	3.75
$X_{5,6}$	(0.9, 1, 1.25)	0.9	1	1.25
$X_{6,11}$	(2.7, 3, 3.75)	2.7	3	3.75
$X_{9,10}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{7,9}$	(9, 10, 12.5)	9	10	12.5
$X_{7,8}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{7,11}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{10,11}$	(1.8, 2, 2.5)	1.8	2	2.5
$X_{8,11}$	(2.7, 3, 3.75)	2.7	3	3.75
$X_{11,12}$	(9, 10, 12.5)	9	10	12.5
$X_{12,13}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{13,14}$	(13.5, 15, 18.75)	13.5	15	18.75

Table 5.4 Upper and lower values of fuzzy activity time required for each activity at different α-cut levels for Case 1

Activity	θ^L	θ^U	$(T_{ij})_{\alpha=1}$	$(T_{ij})_{\alpha=0.9}$	$(T_{ij})_{\alpha=0.8}$	$(T_{ij})_{\alpha=0.7}$	$(T_{ij})_{\alpha=0.6}$	$(T_{ij})_{\alpha=0.5}$	$(T_{ij})_{\alpha=0.4}$	$(T_{ij})_{\alpha=0.3}$	$(T_{ij})_{\alpha=0.2}$	$(T_{ij})_{\alpha=0.1}$	$(T_{ij})_{\alpha=0}$
$X_{1,2}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{2,3}$	0.32	0.13	(30, 30)	(29.7, 30.75)	(29.4, 31.5)	(29.1, 32.25)	(28.8, 33)	(28.5, 33.75)	(28.2, 34.5)	(27.9, 35.25)	(27.6, 36)	(27.3, 36.75)	(27, 37.5)
$X_{2,4}$	1.37	1.11	(2, 2)	(1.98, 2.05)	(1.96, 2.1)	(1.94, 2.15)	(1.92, 2.2)	(1.9, 2.25)	(1.88, 2.3)	(1.86, 2.35)	(1.84, 2.4)	(1.82, 2.45)	(1.8, 2.5)
$X_{2,7}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{3,5}$	1.37	1.11	(2, 2)	(1.98, 2.05)	(1.96, 2.1)	(1.94, 2.15)	(1.92, 2.2)	(1.9, 2.25)	(1.88, 2.3)	(1.86, 2.35)	(1.84, 2.4)	(1.82, 2.45)	(1.8, 2.5)
$X_{4,5}$	1.28	0.93	(3, 3)	(2.97, 3.075)	(2.94, 3.15)	(2.91, 3.225)	(2.88, 3.3)	(2.85, 3.375)	(2.82, 3.45)	(2.79, 3.525)	(2.76, 3.6)	(2.73, 3.675)	(2.7, 3.75)
$X_{5,6}$	1.47	1.33	(1, 1)	(0.99, 1.025)	(0.98, 1.05)	(0.97, 1.075)	(0.96, 1.1)	(0.95, 1.125)	(0.94, 1.15)	(0.93, 1.175)	(0.92, 1.2)	(0.91, 1.225)	(0.9, 1.25)
$X_{6,11}$	1.28	0.93	(3, 3)	(2.97, 3.075)	(2.94, 3.15)	(2.91, 3.225)	(2.88, 3.3)	(2.85, 3.375)	(2.82, 3.45)	(2.79, 3.525)	(2.76, 3.6)	(2.73, 3.675)	(2.7, 3.75)
$X_{9,10}$	1.28	0.93	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{7,9}$	1.11	0.67	(10, 10)	(9.9, 10.25)	(9.8, 10.5)	(9.7, 10.75)	(9.6, 11)	(9.5, 11.25)	(9.4, 11.5)	(9.3, 11.75)	(9.2, 12)	(9.1, 12.25)	(9, 12.5)
$X_{7,8}$	0.79	0.38	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{7,11}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{10,11}$	1.11	0.67	(2, 2)	(1.98, 2.05)	(1.96, 2.1)	(1.94, 2.15)	(1.92, 2.2)	(1.9, 2.25)	(1.88, 2.3)	(1.86, 2.35)	(1.84, 2.4)	(1.82, 2.45)	(1.8, 2.5)
$X_{8,11}$	1.37	1.11	(3, 3)	(2.97, 3.075)	(2.94, 3.15)	(2.91, 3.225)	(2.88, 3.3)	(2.85, 3.375)	(2.82, 3.45)	(2.79, 3.525)	(2.76, 3.6)	(2.73, 3.675)	(2.7, 3.75)
$X_{11,12}$	1.28	0.93	(10, 10)	(9.9, 10.25)	(9.8, 10.5)	(9.7, 10.75)	(9.6, 11)	(9.5, 11.25)	(9.4, 11.5)	(9.3, 11.75)	(9.2, 12)	(9.1, 12.25)	(9, 12.5)
$X_{12,13}$	0.79	0.38	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{13,14}$	1.11	0.67	(15, 15)	(14.85, 15.375)	(14.7, 15.75)	(14.55, 16.125)	(14.4, 16.5)	(14.25, 16.875)	(14.1, 17.25)	(13.95, 17.625)	(13.8, 18)	(13.65, 18.375)	(13.5, 18.75)

To reveal the fuzzy duration for this M&A project, solving equations (14) and (15), as explained in Chapter 4.3, is necessary. In this case, the following eighteen equations are obtained with reference to equation (14) and Figure 5.1. By solving these equations, the set of fuzzy durations for the lower boundary (i.e., D_α^L) can be determined; the results are shown in Table 5.6.

$$
\begin{aligned}
D_\alpha^L = \quad & min \quad y_{14} - y_1 \\
& s.t. \quad y_2 \geq y_1 + (T_{1,2})_\alpha^L \\
& \qquad y_3 \geq y_2 + (T_{2,3})_\alpha^L \\
& \qquad y_4 \geq y_2 + (T_{2,4})_\alpha^L \\
& \qquad y_7 \geq y_2 + (T_{2,7})_\alpha^L \\
& \qquad y_5 \geq y_3 + (T_{3,5})_\alpha^L \\
& \qquad y_5 \geq y_4 + (T_{4,5})_\alpha^L \\
& \qquad y_6 \geq y_5 + (T_{5,6})_\alpha^L \\
& \qquad y_{11} \geq y_6 + (T_{6,11})_\alpha^L \\
& \qquad y_{10} \geq y_9 + (T_{9,10})_\alpha^L \\
& \qquad y_9 \geq y_7 + (T_{7,9})_\alpha^L \\
& \qquad y_8 \geq y_7 + (T_{7,8})_\alpha^L \\
& \qquad y_{11} \geq y_7 + (T_{7,11})_\alpha^L \\
& \qquad y_{11} \geq y_{10} + (T_{10,11})_\alpha^L \\
& \qquad y_{11} \geq y_8 + (T_{8,11})_\alpha^L \\
& \qquad y_{12} \geq y_{11} + (T_{11,12})_\alpha^L \\
& \qquad y_{13} \geq y_{12} + (T_{12,13})_\alpha^L \\
& \qquad y_{14} \geq y_{13} + (T_{13,14})_\alpha^L \\
& \qquad y_i \ unrestricted \ in \ sign, i = 1,2,\dots,14.
\end{aligned}
$$

where y is the occurrence time of the node, such that y_{14} is the occurrence time of the node 14; and $(T_{1,2})_\alpha^L$ refers to the lower value of the fuzzy activity time between node 1 and node 2 at the α-cut level.

Taking $(T_{1,2})_{\alpha=0.9}^L$ as an example to solve equation (14) with reference to Table 5.4,

$$D^L_{\alpha=0.9} = \quad min \quad y_{14} - y_1$$
$$s.t. \quad y_2 \geq y_1 + 4.95$$
$$y_3 \geq y_2 + 29.7$$
$$y_4 \geq y_2 + 1.98$$
$$y_7 \geq y_2 + 4.95$$
$$y_5 \geq y_3 + 1.98$$
$$y_5 \geq y_4 + 2.97$$
$$y_6 \geq y_5 + 0.99$$
$$y_{11} \geq y_6 + 2.97$$
$$y_{10} \geq y_9 + 2.97$$
$$y_9 \geq y_7 + 4.95$$
$$y_8 \geq y_7 + 9.9$$
$$y_{11} \geq y_7 + 4.95$$
$$y_{11} \geq y_{10} + 4.95$$
$$y_{11} \geq y_8 + 1.98$$
$$y_{12} \geq y_{11} + 9.9$$
$$y_{13} \geq y_{12} + 4.95$$
$$y_{14} \geq y_{13} + 14.85$$
$$y_i \ unrestricted \ in \ sign, i = 1,2,\dots,14.$$

$$D^L_{\alpha=0.9} = \quad min \quad y_{14} - y_1$$
$$s.t. \quad y_2 \geq 0 + 4.95$$
$$y_3 \geq 4.95 + 29.7$$
$$y_4 \geq 4.95 + 1.98$$
$$y_7 \geq 4.95 + 4.9$$
$$y_5 \geq 4.95 + 29.7 + 1.98$$
$$y_5 \geq 4.95 + 1.98 + 2.97$$
$$y_6 \geq 4.95 + 29.7 + 1.98 + 0.99$$
$$y_{11} \geq 4.95 + 29.7 + 1.98 + 0.99 + 2.97$$
$$y_{10} \geq 4.95 + 4.9 + 4.95 + 2.97$$
$$y_9 \geq 4.95 + 4.9 + 4.95$$
$$y_8 \geq 4.95 + 4.9 + 9.9$$
$$y_{11} \geq 4.95 + 4.9 + 4.95$$
$$y_{11} \geq 4.95 + 4.9 + 4.95 + 2.97 + 4.95$$
$$y_{11} \geq 4.95 + 4.9 + 9.9 + 1.98$$
$$y_{12} \geq 4.95 + 29.7 + 1.98 + 0.99 + 2.97 + 9.9$$
$$y_{13} \geq 4.95 + 29.7 + 1.98 + 0.99 + 2.97 + 9.9 + 4.95$$
$$y_{14} \geq 4.95 + 29.7 + 1.98 + 0.99 + 2.97 + 9.9 + 4.95 + 14.85$$
$$y_i \ unrestricted \ in \ sign, i = 1,2,\dots,14.$$

$$D^L_{\alpha=0.9} = 70.29$$

According to equation (15), the upper boundary (i.e., D_α^U) of the fuzzy duration can be solved as follows:

$$
\begin{aligned}
D_\alpha^U = \quad max \quad & (T_{1,2})_\alpha^U x_{1,2} + (T_{2,3})_\alpha^U x_{2,3} + (T_{2,4})_\alpha^U x_{2,4} + (T_{2,7})_\alpha^U x_{2,7} + (T_{3,5})_\alpha^U x_{3,5} + (T_{4,5})_\alpha^U x_{4,5} \\
& + (T_{5,6})_\alpha^U x_{5,6} + (T_{6,11})_\alpha^U x_{6,11} + (T_{9,10})_\alpha^U x_{9,10} + (T_{7,9})_\alpha^U x_{7,9} + (T_{7,8})_\alpha^U x_{7,8} + (T_{7,11})_\alpha^U x_{7,11} \\
& + (T_{10,11})_\alpha^U x_{10,11} + (T_{8,11})_\alpha^U x_{8,11} + (T_{11,12})_\alpha^U x_{11,12} + (T_{12,13})_\alpha^U x_{12,13} + (T_{13,14})_\alpha^U x_{13,14}
\end{aligned}
$$

$$
\begin{aligned}
s.t. \quad & x_{1,2} = 1 \\
& x_{1,2} = x_{2,3} + x_{2,4} + x_{2,7} \\
& x_{2,3} = x_{3,5} \\
& x_{2,4} = x_{4,5} \\
& x_{3,5} + x_{4,5} = x_{5,6} \\
& x_{5,6} = x_{6,11} \\
& x_{2,7} = x_{7,9} + x_{7,8} + x_{7,11} \\
& x_{7,8} = x_{8,11} \\
& x_{7,9} = x_{9,10} \\
& x_{9,10} = x_{10,11} \\
& x_{10,11} + x_{8,11} + x_{7,11} + x_{6,11} = x_{11,12} \\
& x_{11,12} = x_{12,13} \\
& x_{12,13} = x_{13,14} \\
& x_{13,14} = 1 \\
& x_{1,2}, x_{2,3}, x_{2,4}, x_{2,7}, x_{3,5}, x_{4,5}, x_{5,6}, x_{6,11}, x_{9,10}, x_{7,9}, x_{7,8}, x_{7,11}, x_{10,11}, x_{8,11}, x_{11,12}, x_{12,13}, x_{13,14} \geq 0
\end{aligned}
$$

Where the optimal decision variable x_{ij} equals one if the corresponding activity from node i to node j is critical and indispensable in the path; this explains why $x_{1,2}$, $x_{11,12}$, $x_{12,13}$ and $x_{13,14}$ are equal to one in this case, with reference to Figure 5.3. Otherwise, x_{ij} equals zero. The results of the values of corresponding activities are shown in Table 5.5. By solving the above maximisation problem, the α-cut of the total duration time and the fuzzy critical paths at eleven distinct α values for the upper bound (i.e., D_α^U) are estimated and the results are shown in Table 5.6.

Taking $(T_{1,2})^L_{\alpha=0.9}$ as an example to solve equation (15) with reference to Tables 5.4 and 5.5,

$$
\begin{aligned}
D^U_\alpha = \quad max \quad & 5.125(1) + 30.75(1) + 2.05(0) + 5.125(0) + 2.05(1) + 3.075(0) \\
& +1.025(1) + 3.075(1) + 10.25(0) + 3.075(0) + 5.125(0) + 5.125(0) \\
& +2.05(0) + 3.075(0) + 10.25(1) + 5.125(1) + 15.375(1) \\
s.t. \quad & x_{1,2}, x_{2,3,}, x_{3,5}, x_{5,6}, x_{6,11}, x_{11,12}, x_{12,13}, x_{13,14} = 1 \\
& x_{2,4}, x_{2,7}, x_{4,5}, x_{7,9}, x_{7,10}, x_{9,10}, x_{7,8}, x_{7,11}, x_{10,11}, x_{8,11}, = 0
\end{aligned}
$$

$$
D^U_\alpha = \quad 72.775
$$

In Table 5.6, it is clear that the fuzzy critical path is 1-2-3-5-6-11-12-13-14.Thepath length is equal to 73.66 days according to equations (16-17);that means the company would take 73.66 days to complete the M&A deal. This result is critical and meaningful as its relative degree of criticality is equal to one, as estimated using equation (18). By identifying the fuzzy critical path, the company is able to define the critical tasks which have high chance to delay and thus the company can pay more attention to ensure the resources for these tasks are allocated early and on time for the commencement of the task, thereby reducing potential delay.

In addition, Table 5.6provides further information for SAGE to reserve and allocate resources for the deal in both optimistic and pessimistic situations. The results suggest that the company may take 67.45 days to complete the deal in optimistic situations and79.88 days in pessimistic situations. The more time the deal requires, the more resources and costs the company has to spend. This can help the company plan the resource allocation. Furthermore, the critical path would not change unless an immense impact occurs on the business environment or unexpected incidents occur during the M&A process. In this fast-

paced and highly competitive business world, it is important for the company to grasp the

time and race against competitors to make the deal.

Table 5.5 Results of decision variables for Case 1

Activity	Value
$x_{1,2}$	1
$x_{2,3}$	1
$x_{2,4}$	0
$x_{2,7}$	0
$x_{3,5}$	1
$x_{4,5}$	0
$x_{5,6}$	1
$x_{6,11}$	1
$x_{9,10}$	0
$x_{7,9}$	0
$x_{7,8}$	0
$x_{7,11}$	0
$x_{10,11}$	0
$x_{8,11}$	0
$x_{11,12}$	1
$x_{12,13}$	1
$x_{13,14}$	1

Table 5.6 α-cuts of the total duration of corresponding critical paths for Case 1

	Lower boundary		Upper boundary	
α	D_{α}^{L}	Critical path	D_{α}^{U}	Critical path
1	71	1-2-3-5-6-11-12-13-14	71	1-2-3-5-6-11-12-13-14
0.9	70.29	1-2-3-5-6-11-12-13-14	72.775	1-2-3-5-6-11-12-13-14
0.8	69.58	1-2-3-5-6-11-12-13-14	74.55	1-2-3-5-6-11-12-13-14
0.7	68.87	1-2-3-5-6-11-12-13-14	76.325	1-2-3-5-6-11-12-13-14
0.6	68.16	1-2-3-5-6-11-12-13-14	78.1	1-2-3-5-6-11-12-13-14
0.5	67.45	1-2-3-5-6-11-12-13-14	79.875	1-2-3-5-6-11-12-13-14
0.4	66.74	1-2-3-5-6-11-12-13-14	81.65	1-2-3-5-6-11-12-13-14
0.3	66.03	1-2-3-5-6-11-12-13-14	83.425	1-2-3-5-6-11-12-13-14
0.2	65.32	1-2-3-5-6-11-12-13-14	85.2	1-2-3-5-6-11-12-13-14
0.1	64.61	1-2-3-5-6-11-12-13-14	86.975	1-2-3-5-6-11-12-13-14
0	63.9	1-2-3-5-6-11-12-13-14	88.75	1-2-3-5-6-11-12-13-14

5.2.3 Cost-benefit Evaluation

Apart from the consideration of time, the company needs to evaluate the costs and benefits

of the M&A deal of Suzhou Universal Chinese Memorial in order to explore its possibility

of success and avoid failure and loss. According to the discussion in Chapter 4.4, the cost-benefit evaluation for this case is described below.

As discussed, acquisition cost and manpower cost are the most essential expenditures in managing M&A deals. To estimate the costs of this M&A deal, the manpower required and relevant costs have been collected from the company and are shown in the input section of Table 5.7.To complete the M&A deal, two lawyers, an external consultant, a project director, three accountants, and an investment expert were involved. After the data input, the constructed spreadsheet for the simulation section discussed in Chapter 4.4 and shown in Table 4.4 can be used for simulation. The number of man-days and operation costs associated with each of the M&A tasks in the process are estimated in terms of risk pert distribution with the parameters minimum, most likely, and maximum. By performing the simulation, the results for this simulation section are obtained and shown in Table 5.8.According to the results, SAGE normally needs 30 days and HKD$1,188,000 as manpower cost for the completion of the task "legitimacy of assessment". In an optimistic situation, the time required could be reduced to 27 days and the manpower cost would be HKD$1,069,200. By contrast, in a pessimistic situation, the time required could be increased to 37.5 days and the manpower cost would beHKD$1,485,000. These figures draw the company's attention to the availability of manpower resources, the time required, and the change in operation costs in optimistic, normal, and pessimistic scenarios. This not only helps the company to plan and prepare for different situations comprehensively but also supports the company in deciding if it would have sufficient resources for the deal.

To further understand the manpower budget required for the deal and the percentage of additional resources which should be on standby for emergency purpose or for a higher confidence level, the output section is generated and shown in Table 5.9. The output section makes use of the data generated from the simulation section to estimate a forecasted budget and contingency budget for the deal, with consideration of the potential risk involved. It is estimated that in a normal situation, HKD$5,220,400 would be required for the deal, with a confidence level of82.8%. There are always obstacles in the process of an M&A deal, such as time delay, manpower shortage, and time-consuming negotiations. For a successful deal with a higher confidence level (i.e., 95% with reference to the simulation result), the company should prepare for contingency with additional operation costs of HKD$342,957 for a normal situation. In other words, it is predicted that the manpower cost required for the deal at 95% confidence level would be HKD$5,563,357. Such a cost estimation with consideration of risk analysis would be useful for the company to predict the operation costs in a more precise manner and to take the contingency budget into account before starting the deal. According to Table 5.9, the risk-bearing budget percentage is determined at 6.57%. The higher the risk-bearing budget is, the riskier the deal is and the higher the opportunity costs are for the company. This risk-bearing budget percentage would be considered under the decision rule, which is discussed in the next section, to assess the worthiness of the M&A deal.

Table 5.7 Manpower required and relevant costs for Case 1

		Risk-averse (Min)		Risk-neutral (Normal)		Risk-taking (Max)
Cost fluctuation (%)		90%		100%		125%
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert
Man-hours per day		8	8	8	8	8
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450

Task	Man-days Required	Number of manpower required				
		Lawyer	Consultant	Project Director	Accountant	Investment Expert
Initial M&A project evaluation/filtration	5		1	1		1
Legitimacy of assessment	30		1	1		1
PM assignment	2			1		1
Initial meeting	3		1	1		1
Legitimacy confirmation	2			1		1
Signing of memorandum of understanding	1	2		1	3	1
Valuation	5			1	3	1
Competitor assessment	5		1	1		1
Completion of target and competitor assessment	3		1	1		1
Policy formulation and evaluation	3	2	1			1
Feasibility assessment	10		1			1
Capex calculation	5				3	1
Completion of feasibility and Capex assessment	2		1	1	3	1
Revenue forecasting models	5				3	1
Negotiation	10	2	1	1		1
Signing of sales and purchase agreement	5	2			3	
Legal documentation of M&A	15	2				

Table 5.8 Simulation section for the manpower cost analysis for Case 1

		Time required (Days)				Operation Cost (HKD)			
	Task	MIN	Most likely	MAX	Risk Pert	MIN	Most likely	MAX	Risk Pert
Simulation Section	Initial M&A project evaluation/filtration	4.5	5	6.25	5.125	$178,200	$198,000	$247,500	$202,950
	Legitimacy of assessment	27	30	37.5	30.75	$1,069,200	$1,188,000	$1,485,000	$1,217,700
	PM assignment	1.8	2	2.5	2.05	$42,480	$47,200	$59,000	$48,380
	Initial meeting	2.7	3	3.75	3.075	$106,920	$118,800	$148,500	$121,770
	Legitimacy confirmation	1.8	2	2.5	2.05	$42,480	$47,200	$59,000	$48,380
	Signing of memorandum of understanding	0.9	1	1.25	1.025	$87,480	$97,200	$121,500	$99,630
	Valuation	4.5	5	6.25	5.125	$149,400	$166,000	$207,500	$170,150
	Competitor assessment	4.5	5	6.25	5.125	$178,200	$198,000	$247,500	$202,950
	Completion of target and competitor assessment	2.7	3	3.75	3.075	$106,920	$118,800	$148,500	$121,770
	Policy formulation and evaluation	2.7	3	3.75	3.075	$225,720	$250,800	$313,500	$257,070
	Feasibility assessment	9	10	12.5	10.25	$176,400	$196,000	$245,000	$200,900
	Capex calculation	4.5	5	6.25	5.125	$59,400	$66,000	$82,500	$67,650
	Completion of feasibility and Capex assessment	1.8	2	2.5	2.05	$88,560	$98,400	$123,000	$100,860
	Revenue forecasting models	4.5	5	6.25	5.125	$59,400	$66,000	$82,500	$67,650
	Negotiation	9	10	12.5	10.25	$932,400	$1,036,000	$1,295,000	$1,061,900
	Signing of sales and purchase agreement	4.5	5	6.25	5.125	$331,200	$368,000	$460,000	$377,200
	Legal documentation of M&A	13.5	15	18.75	15.375	$864,000	$960,000	$1,200,000	$984,000

Table 5.9 Output section of the model for Case 1

		HKD	Confidence Level
Output Section	Estimated cost (HKD)	$5,220,400	82.8%
	Contingency cost required for 95.0% confidence	$342,957	95.0%
	Total cost required for 95.0% confidence	$5,563,357	95.0%
	Risk-bearing budget percentage	6.57%	

After determining the fuzzy critical path, manpower costs with the consideration of risk, and risk-bearing budget percentage, it is necessary to calculate the ARR for capital budgeting before making the final decision on the M&A deal, as discussed in Chapter 4.4.3.

Due to data confidentiality, the calculations of the net cash flow over time (C_t) and acquisition cost (AC) are not shown in this study. The discount rate used for the Suzhou Universal Chinese Memorial case is 15%. By solving the equation of ARR as shown in Chapter 4.4.3, the ARR in this case is calculated to be 38.95%. The ARR results are used to assess the worthiness of the deal under the decision rule.

5.2.4 Decision Rule and Prioritisation

With the results of the fuzzy duration (73.66 days), risk-bearing budget percentage (6.57%), and ARR (38.95%), SAGE can make use of the decision rule as discussed in Chapter 4.5 to support its decision-making on the M&A deal for the case of Suzhou Universal Chinese Memorial. In this case, the results fit the IF-THEN decision rule, that is, the time required to complete the M&A deal is less than 180 days, the risk-bearing budget percentage is smaller than 18%, and the ARR is greater than 25%. It is therefore suggested that the M&A deal is worthy of investment and should be undertaken.

Furthermore, when selecting an M&A deal with the highest potential of financial return among other deals, decision makers can make use of the equation of priority rating as discussed in Chapter 4.5 to rank all cases for assessment. Accordingly, the priority rating for the case of Suzhou Universal Chinese Memorial is 0.64. The discussion on prioritisation is in Chapter 6.

Overall, for the success of the M&A deal, the model developed in this study can (a) help the company ensure that resources are wisely spent, particularly on critical tasks, (b) serve

as a key evaluating tool that takes risk assessment into account for cost evaluation and monitoring of the M&A process, and (c) support the company to assess the worthiness of the potential M&A deal and its potential risk-bearing level for better decision-making.

Chapter 6 Prioritisation of M&A Deals for Model Verification

The previous chapter demonstrate show to apply the proposed model through a case study. In this chapter, ten more case studies are conducted using the same approach, and their results are discussed. The prioritisation of these M&A deals including the one illustrated in the previous chapter is examined in this chapter for model verification. This chapter also provides a discussion on the implications of the proposed model.

6.1 Background of Case Studies

In order to expand its cemetery and funeral service portfolio, SAGE has explored many M&A opportunities, including the case of Suzhou Universal Chinese Memorial (Case 1) discussed in Chapter 5 and the following ten cases (Cases 2-11) studied in this chapter. Considering the definite advantages and potential returns of each of the following companies, SAGE considered these cases for M&A:

a. Case 2: Jiugongshan cemetery is located in the greater Beijing economic region. It is the largest cemetery in China, occupying 8 million square meters of land and serving a market of over 20 million people with annual deaths of 115,000 people.

b. Case 3: Bijie cemetery is a new cemetery in the Guizhou province of China. It occupies 133,000 square meters of land and is the only cemetery in Bijie. It serves a market of over 500,000 people with annual deaths of 5,000 people.

c. Case 4: Chongqing cemetery is in Chongqing, China. It occupies 333,000 square meters of land and serves a market of over 18 million people with annual deaths of 110,000 people.

d. Case 5: Fangchenggang cemetery is in the Guangxi province of China. It occupies 185,000 square meters of land and serves a market of over 400,000 people with annual deaths of 2,000 people.

e. Case 6: Huaiji Luck Mountain Funeral Parlour Limited was established in July 2000 to provide one-stop funeral services in Hauiji, China. Being the only cemetery in Huaiji, this property comprises approximately 133,000square meters of land and has a monopoly over the 1.1 million-population county with annual deaths of 7,000–8,000 people.

f. Case 7: Panzhihua cemetery is in the Sichuan province of China. It occupies133,000 square meters of land and serves a market of over 1.2 million people with annual deaths of 5,500 people.

g. Case 8: Qinzhou cemetery is in the Guangxi province of China. It occupies 45,000 square meters of land and serves a market of over 1.4 million people with annual deaths of 8,000 people.

h. Case 9: Sai Sing Funeral Parlour is one of the seven funeral parlours in Hong Kong. It has 24 rooms and serves the city's population of 7.2 million people with annual deaths of 40,000 people.

i. Case 10: Tung chung is a columbarium in Hong Kong. It offers 10,000 niches and serves the population of 7.2 million people with annual deaths of 40,000 people.

j. Case 11: Yinchuan cemetery is in Ningxia Hui Autonomous Region of China.   It occupies 400,000 square meters of land and serves a market of over 2 million people with annual deaths of 8,500 people.

6.2 Results and Analysis of the Case Studies

According to the model development approach discussed in Chapter 4 and the model illustration in Chapter 5, the additional ten case studies are conducted and their results are explained in this section.

6.2.1 Cause-and-effect Analysis and Risk Analysis

As mentioned in Chapter 5.2.1, identifying M&A activities is the first necessary step for cause-and-effect analysis and risk analysis. The M&A tasks, predecessors, and time required in Cases 2-11are listed in Table 6.1.

Table 6.1 Tasks, predecessors, and time required for Cases 2-11

	M&A Task	Predecessor	Case									
			2	3	4	5	6	7	8	9	10	11
			Time Required (Days)									
A	Initial M&A project evaluation/filtration		30	20	20	15	3	8	10	5	5	8
B	Legitimacy of assessment	A	30	15	10	20	10	10	20	1	30	10
C	PM assignment	A	1	1	1	1	0.5	1	1	1	1	1
D	Initial meeting	C	30	3	30	10	1.5	15	3	5	5	15
E	Legitimacy confirmation	B	10	2	10	15	2	10	15	2	10	10
F	Signing of memorandum of understanding	D, E	10	5	20	15	1	15	20	2	2	15
G	Valuation	A	5	3	5	6	2	5	5	5	5	5
H	Competitor assessment	G	5	3	7	7	1	5	7	7	7	5
I	Completion of partner and competitor assessment	F, H	2	1	5	5	1	5	3	5	5	5
J	Policy formulation and evaluation	F	10	4	12	15	1	10	10	12	20	10
K	Feasibility assessment	G	15	3	5	15	2	5	15	5	10	5
L	Capex calculation	K	5	3	5	7	2	5	5	5	10	5
M	Completion of feasibility and Capex assessment	L	3	1	3	5	1	3	3	3	3	3
N	Revenue forecasting models	G	3	3	5	5	1	5	3	5	5	5
O	Negotiation	F, I, J, M, N	30	14	40	20	3	30	20	40	5	20
P	Signing of sales and purchase agreement	O	7	7	15	10	3	10	10	15	15	10
Q	Legal documentation of partnership	P	14	20	15	15	10	15	15	15	15	15

Similar to the M&A of Suzhou Universal Chinese Memorial (i.e., Case 1), Cases 2-11 follow the same fishbone diagram shown in Figure 5.1 but have different risk assessment results. Taking Table 6.1 into consideration, the overall risk assessment results were generated by M&A experts and summarised in Table 6.2, while the detailed results of risk factors for each M&A task are shown in Appendix 3(Table A.1-Table A.10). With reference to Table 4.2, the cost fluctuation percentage for Cases 4, 7, 9, and 10 at the moderate risk level is between 90% and 125%, while Cases 2, 3, 5, 6, 8, and 11 at the high risk level is between 80% and 150%.

With reference to the risk assessment results shown in Appendix 3, it is observed that there

is usually more than one risk factor involved in every task of the M&A process. This explains the necessity of constructing the fishbone diagram and the importance of the four risk factors identified (Chapters 4.2.1 and 5.2.1). From Table 6.2, it is obvious that M&A deals seldom involve a low level of risk, resulting in a high possibility of M&A failure. Identifying and assessing the risks in the M&A process is therefore the primary step when evaluating M&A deals and is of paramount importance.

Table 6.2 Overall risk assessment results for Cases 2-11

M&A Task	Case									
	2	3	4	5	6	7	8	9	10	11
Initial M&A project evaluation/filtration	H	M	H	H	M	M	H	H	L	H
Legitimacy of assessment	H	H	M	H	H	M	H	L	H	H
PM assignment	H	M	H	H	M	H	H	H	H	H
Initial meeting	L	M	M	M	L	M	M	L	L	M
Legitimacy confirmation	H	H	M	H	H	M	H	M	H	H
Signing of memorandum of understanding	H	H	M	L	H	L	L	L	L	M
Valuation	H	H	L	H	H	L	H	H	H	M
Competitor assessment	H	H	L	M	H	L	M	L	L	M
Completion of target and competitor assessment	H	H	M	H	H	M	H	L	L	H
Policy formulation and evaluation	M	M	L	H	M	L	M	L	H	M
Feasibility assessment	H	H	L	H	H	L	H	L	H	L
Capex calculation	H	H	M	H	H	M	H	M	M	M
Completion of feasibility and Capex assessment	M	M	M	H	M	M	H	M	M	M
Revenue forecasting model	H	H	M	H	H	M	H	M	M	M
Negotiation	H	H	M	H	H	M	H	L	L	M
Signing of sales and purchase agreement	H	M	H	H	M	H	H	M	M	H
Legal documentation of M&A	H	M	H	H	M	H	H	M	M	H
Overall risk level	**H**	**H**	**M**	**H**	**H**	**M**	**H**	**M**	**M**	**H**

Note: High (H), Moderate (M) and Low (L)

6.2.2 Fuzzy Critical Path Analysis

Based on the data shown in Table 6.1, the activity-on-arrow network diagrams for Cases 2–10 can be created (Figure A.2-Figure A.3 in Appendix 3). By adopting the proposed approach and equations (1-18) explained in earlier chapters (Chapter 4.3 and Chapter 5.2.2), the corresponding fuzzy critical paths and path lengths of completing Cases 2–10aredetermined; their calculations are shown in Appendix 3 (Table A.11-Table A.30) and summarised in Table 6.3.Their corresponding relative degrees of criticality equivalent to one confirmed that the fuzzy critical paths and path lengths determined are critical and meaningful.

The results in Table 6.3 show that the fuzzy critical paths for Cases 2–10 are the same even though the time required to complete each task varies from case to case. This is mainly because M&A deals often involve complex and diverse legal and accounting issues. Table 6.3 further shows that fuzzy critical path analysis not only indicates the fuzzy critical path and calculates the path length for each case under normal condition, but also generates the path length in both optimistic and pessimistic conditions. For example, the normal path length for Case 2 is 151.58 days provided that the resources allocated and time used to complete each M&A task are sufficient as projected. However, unexpected issues, such as due diligence issues, financial and accounting issues, and legal and compliance issues, always occur in M&A deals, hindering the entire M&A process. Case 2 is shown in the pessimistic situation with the tasks of "feasibility assessment", "negotiation", "Signing of sales and purchase agreement", as well as "legal documentation of M&A" affected; the projected pessimistic path length is 176.25 days. These figures can provide concrete

evidence to support decision-making in terms of resource allocation and risk management. This makes the fuzzy critical path distinct from the normal critical path analysis.

Table 6.3 Results of fuzzy critical path analysis for Cases 2–11

Case	Fuzzy critical path	Path length (days)			Relative path degree of criticality
		Normal	Optimistic	Pessimistic	
2	1-2-3-5-6-11-12-13-14	151.58	126.9	176.25	1
3	1-2-3-5-6-11-12-13-14	93.53	78.3	108.75	1
4	1-2-3-5-6-11-12-13-14	158.74	145.35	172.13	1
5	1-2-3-5-6-11-12-13-14	134.38	112.5	156.25	1
6	1-2-3-5-6-11-12-13-14	35.475	29.7	41.25	1
7	1-2-3-5-6-11-12-13-14	112.05	102.6	121.5	1
8	1-2-3-5-6-11-12-13-14	129	108	150	1
9	1-2-3-5-6-11-12-13-14	100.64	92.15	109.12	1
10	1-2-3-5-6-11-12-13-14	105.83	96.9	114.75	1
11	1-2-3-5-6-11-12-13-14	105.35	88.2	122.5	1

6.2.3 Cost-benefit Evaluation

Based on the discussion in Chapters 4.4 and 5.2.2, the cost-benefit evaluations for Cases 2–10 are described in this section. The input and simulation sections are compiled in Appendix 3 (Table A.31-Table A.50). By simulating the input data in terms of time, risk, and resources for Cases 2–11 individually, the estimated operation cost, contingency cost required at 95% confidence, total cost required at 95% confidence, and risk-bearing budget percentage for each case can be determined; the results are shown in the output sections in Table 6.4-Table 6.13. Referring to those tables, the risk-bearing budget percentage in Case 4 is the lowest while that in Case 6 is the highest among Cases 2-11. This indicates that the company has to pay a higher opportunity cost to complete the M&A process for Case 6 compared to Case 4. The risk-bearing budget percentage can serve as one of the indicators in M&A assessment.

Table 6.4 Output section of the model for Case 2

Output Section		HKD	Confidence Level
	Estimated cost	$19,035,200	83.4%
	Contingency cost required for 95% confidence	$2,610,252	
	Total cost required for 95% confidence	$21,645,452	95.0%
	Risk-bearing budget percentage	13.71%	

Table 6.5 Output section of the model for Case 3

Output Section		HKD	Confidence Level
	Estimated cost	$7,418,400	80.9%
	Contingency cost required for 95% confidence	$1,012,967	
	Total cost required for 95% confidence	$8,431,367	95.0%
	Risk-bearing budget percentage	13.65%	

Table 6.6 Output section of the model for Case 4

Output Section		HKD	Confidence Level
	Estimated cost	$11,141,200	87.1%
	Contingency cost required for 95% confidence	$663,131	
	Total cost required for 95% confidence	$11,804,331	95.0%
	Risk-bearing budget percentage	5.95%	

Table 6.7 Output section of the model for Case 5

Output Section		HKD	Confidence Level
	Estimated cost	$8,698,000	89.9%
	Contingency cost required for 95% confidence	$967,960	
	Total cost required for 95% confidence	$9,665,960	95.0%
	Risk-bearing budget percentage	11.13%	

Table 6.8 Output section of the model for Case 6

Output Section		HKD	Confidence Level
	Estimated cost	$2,875,000	78.2%
	Contingency cost required for 95% confidence	$460,353	
	Total cost required for 95% confidence	$3,335,353	95.0%
	Risk-bearing budget percentage	16.01%	

Table 6.9 Output section of the model for Case 7

Output Section		HKD	Confidence Level
	Estimated cost (HKD)	$7,001,600	89.0%
	Contingency cost required for 95% confidence	$425,907	
	Total cost required for 95% confidence	$7,427,507	95.0%
	Risk-bearing budget percentage	6.08%	

Table 6.10 Output section of the model for Case 8

Output Section		HKD	Confidence Level
	Estimated cost	$8,504,400	88.8%
	Contingency cost required for 95% confidence	$1,003,383	
	Total cost required for 95% confidence	$9,507,783	95.0%
	Risk-bearing budget percentage	11.80%	

Table 6.11 Output section of the model for Case 9

Output Section		HKD	Confidence Level
	Estimated cost	$9,919,600	84.0%
	Contingency cost required for 95% confidence	$654,927	
	Total cost required for 95% confidence	$10,574,527	95.0%
	Risk-bearing budget percentage	6.60%	

Table 6.12 Output section of the model for Case 10

Output Section		HKD	Confidence Level
	Estimated cost	$14,733,200	85.2%
	Contingency cost required for 95% confidence	$942,797	
	Total cost required for 95% confidence	$15,675,997	95.0%
	Risk-bearing budget percentage	6.40%	

Table 6.13 Output section of the model for Case 11

Output Section		HKD	Confidence Level
	Estimated cost	$5,477,600	88.9%
	Contingency cost required for 95% confidence	$656,374	
	Total cost required for 95% confidence	$6,133,974	95.0%
	Risk-bearing budget percentage	11.98%	

Monetary return is always the ultimate goal of making M&A deals from the company perspective. Calculating the ARR of each M&A is therefore necessary to assess the worthiness of the deal. Based on the equation of ARR discussed in Chapter 4.4.3, the ARR of each case can be calculated; their results are shown in Table 6.14.

Table 6.14 Results of ARR for Cases 2–11

Case	ARR
2	29.79%
3	22.25%
4	41.77%
5	23.91%
6	42.00%
7	21.71%
8	28.99%
9	29.13%
10	25.54%
11	39.84%

6.2.4 Decision Rule and Prioritisation

The results for Cases 2–11 obtained from the risk analysis, fuzzy critical path analysis, and cost-benefit analysis are independent indicators to evaluate the particular M&A deals. However, it is still difficult for the company to evaluate all possible deals and identify the most favourable and profitable one. In this proposed model, there are two gates of M&A decision-making; one is the IF-THEN decision rule and the other is prioritisation.

Following the IF-THEN decision rule, IF the time required for completing an M&A deal is less than 180 days, the risk-bearing budget percentage is smaller than 18%, and the ARR is greater than 25%, THEN the M&A deal is worthy of investment and is thus recommended to be undertaken, as discussed in Chapter 4.5. Those M&A cases worthy of investment (Cases 1,2, 4, 6, and 8-11) goes through gate 1 under the decision rule (i.e.,

pass) to gate 2. Those that fail to go through gate 1 are considered not worthy of investment and thus are not taken into account at gate 2 (Cases 3, 5, and 7).

Due to limited resources, the company sometimes has to select the most promising M&A deal for investment; gate 2 is highly valuable for this purpose. Based on the M&A experts' experience and SAGE's previous M&A deals (Chapters 4.5 and 5.2.4), the equation of prioritisation with weightings is formulated. By manipulating the equation of prioritisation, the priority rating can be calculated, followed by the ranking of each case. The results are shown in Table 6.15.

$$\text{Priority Rating} = \frac{180 - f}{180} \times 35\% + \frac{18\% - b}{18\%} \times 15\% + \frac{a - 25\%}{25\%} \times 50\%$$

The proposed model suggests that Case 6 is the most profitable M&A deal while Case 2 is the least. This model supports the company to select the most favourable M&A deals for investment among all potential deals, thereby facilitating the decision-making process and maximising the success rate of M&A.

Table 6.15 Results of decision rule and prioritisation for Cases 1–11

Case	Fuzzy duration (day)	Risk-bearing budget % (at 95% confidence)	Adjusted rate of return (ARR)	Gate 1 Decision Rule	Gate 2 Priority Rating	Ranking
1	73.66	6.57%	38.95%	Pass	0.59	2
2	151.58	13.71%	29.79%	Pass	0.19	8
3	93.53	13.65%	22.25%	Fail	N/A	N/A
4	158.74	5.95%	41.77%	Pass	0.48	4
5	134.38	11.13%	23.91%	Fail	N/A	N/A
6	35.48	16.01%	42.00%	Pass	0.64	1
7	112.05	6.08%	21.71%	Fail	N/A	N/A
8	129	11.80%	28.99%	Pass	0.23	7
9	100.64	6.60%	29.13%	Pass	0.33	5
10	105.83	6.40%	25.54%	Pass	0.25	6
11	105.35	11.98%	39.84%	Pass	0.49	3

6.3 Verification of the Proposed Model

To ensure that the proposed model's results are realistic and meaningful, a comparison with the actual M&A results is conducted (Table 6.16). Further details in terms of the average returns of the M&A deals made by SAGE are shown in Table 6.17. The proposed model's results match the actual results.

In reality, with reference to Table 6.16, SAGE made two profitable M&A deals, Cases 1 and 6, which are ranked 2 and 1, respectively, in the proposal model and which are considered successful. According to the actual returns of Cases 1 and 6 (Table 6.17), the return of Case 6 is 54%, which is higher than that of Case 1 (46%); this supports the ranking results and ARRs suggested by the proposed model. The proposed model's results for Cases 1 and 6 are consistent with the actual results of these M&A deals made by SAGE.

By contrast, Cases 2 and 3which were ranked 8[th]and failure to pass gate 1 respectively, are

considered unsuccessful due to unsatisfactory return on investment (Table 6.16).The proposed model suggests that SAGE can engage with Case 2 which has a 29.79% estimated ARR and a lower ranking, whereas it should not engage with Case 3 due to its failure to pass gate 1. In reality, SAGE made the M&A deal for Case 2 and obtained a return of 25%(Table 6.17), which was less than SAGE's expectation. During the M&A process for Case 2, SAGE experienced substantial hassle and a huge amount of time and effort was spent on integration issues. SAGE considers this deal unfavourable and unsatisfactory. In addition, SAGE completed the M&A deal for Case 3, which is not supported by the proposed model, and suffered 17% loss for the deal (Table 6.17). SAGE considers this a bad investment. The proposed model's results for Cases 2 and 3 match the actual results of these M&A deals made by SAGE. The senior management admitted that they made a wrong decision to proceed with the M&A deals (i.e., Cases 2 and 3). This indicates that the decisions suggested by the proposed model are reliable.

Overall, it is evident that the proposed model is feasible and valuable. A detailed discussion on the successful and unsuccessful cases is provided in Chapter 7.

Table 6.16 Comparison of the model's results with actual results for Cases 1–11

| Case | Gate 2 | Facts from SAGE | | |
	Ranking	M&A decision: Go/No-go	Profitable or not	Considered as successful or not
1	2	Go	Yes	Yes
2	8	Go	Yes but with a lot of hassles	No
3	N/A	Go	No and with a lot of hassles	No
4	4	No-go	N/A	N/A
5	N/A	No-go	N/A	N/A
6	1	Go	Yes	Yes
7	N/A	No-go	N/A	N/A
8	7	No-go	N/A	N/A
9	5	No-go	N/A	N/A
10	6	No-go	N/A	N/A
11	3	No-go	N/A	N/A

Table 6.17 Actual returns of M&A deals made by SAGE

| Case | Gain/Loss percentage | | | | Average return (%) | Remark |
	Year 1	Year 2	Year 3	Year 4		
1	18%	47%	70%	49%	46%	Without a final sale, the actual ARR cannot be calculated, but the revaluation return is reasonable and more than SAGE's expectation.
2	0%	50%	NA	NA	25%	This is the only one which was sold after two years. The ARR is a little less than SAGE's expectation.
3	-10%	-15%	-25%	NA	-17%	SAGE considers this a bad investment.
6	38%	45%	80%	NA	54%	Without a final sale, the actual ARR cannot be calculated, but the revaluation return exceeds SAGE's expectation the most.

Chapter 7 Success Validation and Innovation

After the development and simulation of the MAEPM, this chapter provides a discussion on its implications. Referring to the eleven case studies discussed in Chapters 5 and 6, as well as the comparison in Table 6.16, four of the eleven cases (i.e., two successful and two failure cases) are explained in detail in this chapter, followed by the importance of the proposed model.

7.1 Feasibility of the M&A Evaluation and Prioritisation Model

Based on the discussion in Chapter 6, the MAEPM is confirmed to be reliable for supporting M&A decision-making, as the results of the simulations are consistent with the actual ones. In reality, SAGE did achieve success in Cases 1 and 6 (which are recommended by the proposed model) and admit failure in Cases 2 and 3 (which are not recommended by the proposed model). Details are as follows:

For Case 1, the proposed model indicates that this M&A project is worthy of investment and ranks it second among the eleven projects. It is also projected that this project could be undertaken with less uncertainty due to its moderate risk level and relatively low risk-bearing budget percentage (6.57%); it could be completed within four months according to the suggested fuzzy duration in the normal circumstance (73.66 days); and it would be profitable with an ARR of 38.95%. In reality, SAGE initially thought this project was a "good and profitable" project. This M&A deal turned out to be successful, with everything

on the right track; around three months was taken for its completion (which matches with the optimistic fuzzy duration of 62.9 days), and the project has brought profits to SAGE (46%, with reference to Table 6.17). These facts match the results projected using the proposed model, indicating that the model is reliable.

For Case 6, the MAEPM indicate that this project is worthy of investment and rank it first among the eleven projects. The model further shows that this case should be more profitable than Case 1 due to its higher ARR (42%). It projects that this project should be more challenging and uncertain than Case 1 due to its high risk level and higher risk-bearing budget percentage (16.01%); it could be completed within two months according to the suggested fuzzy duration in the normal circumstance (35.48 days); and it would be profitable with an ARR of 42%. In reality, SAGE considers this project an "okay and profitable" one. Although it was tough at the beginning and had some delay, the project duration was still shorter than 41.25 days (i.e., the expected pessimistic fuzzy duration). Furthermore, this project turned out to be very favourable and profitable (i.e., 54%, with reference to Table 6.17); this explains why it is ranked the first among the eleven cases by the proposed model, even with a higher risk level and risk-bearing budget percentage than Case 6. This further implies that the proposed model's projection is more accurate than SAGE's initial projection.

For Case 2, the proposed model indicates that this project is worthy of investment but not highly recommended, as it is ranked eighth among the eleven projects. This project takes a relatively long fuzzy duration (151.58 days in a normal situation) and has a high risk-

bearing budget percentage (13.71%) but has a relatively low ARR (29.79%). It is inferred that this project should be challenging and unpredictable due to its high risk level and risk-bearing budget percentage (13.71%), and that it would not be very profitable due to the relatively low ARR. In reality, SAGE did make the deal but finally considers this case unsuccessful and admits that the deal was made for the wrong reasons and should have been avoided. At the beginning, SAGE thought this project was favourable but it turned out to involve substantial hassle and integration issues. SAGE then decided to sell it two years after the deal was made, and thus gained some financial return (25%, according to Table 6.16). SAGE stated that this deal was a waste of time and that the company should have chosen other more favourable M&A projects. This case study confirms the importance of the prioritisation of the proposed model, which can facilitate the company to arrange all potential M&A projects in order of the success rate (with consideration of time, risk, and financial return), and then select the most ideal ones.

For Case 3, the proposed model indicates that this project is not worthy of investment and would be unsuccessful (i.e., it does not pass the decision rule at gate 1); therefore, the company should not undertake this M&A deal. In reality, SAGE made the deal as it thought this project was favourable and promising. However, this project was complicated and demanding and caused substantial trouble to SAGE throughout the M&A process. Extra capital and time was invested in this project but no profit was generated in return. SAGE suffered 17% loss for this M&A deal, as shown in Table 6.17. SAGE regrets making this M&A deal and admits that the projection and decision made regarding this case were totally wrong. It is agreed that this M&A project should have been avoided as suggested

by the proposed model. This case study shows the importance of the decision rule (i.e., gate 1) in the proposed model.

7.2 Implications of the M&A Evaluation and Prioritisation Model

The MAEPM comprises cause-and-effect analysis, risk analysis, fuzzy critical path analysis, cost-benefit evaluation, and decision rule and prioritisation. These constituents can individually provide support to the company for evaluating potential M&A deals. For example, the cause-and effect analysis and risk analysis can help the company to better understand the risk level of each M&A task in the process, so as to monitor and control the operation of each task and prevent unexpected issues, minimise negative effects, or react to problems faster. As risk is often unpredictable but is involved in every decision, the risk level determined by the proposed model is therefore taken into account throughout the entire M&A evaluation to achieve precise results. The fuzzy critical path analysis is more comprehensive compared to the traditional critical path analysis. The traditional analysis only provides the critical path with one corresponding path length. However, the novel fuzzy critical path analysis in this proposed model provides the critical path with three corresponding path lengths; this is important evidence for the company to formulate better strategic planning. Based on the results of the fuzzy critical path analysis, the company not only can prepare for the best-case scenario according to the projected resource allocation but also can prepare for the worst-case scenario by reserving some resources or assigning standby resources for support in case of a pessimistic situation. As mentioned in Chapter 4, manpower is the most essential resource to be allocated and its expenditure accounts for

a large portion of M&A investment. The cost-benefit evaluation developed in this study specifically includes the manpower cost with a consideration of risk. The results enable the company to estimate how much manpower cost is required for each M&A deal. More importantly, the cost-benefit evaluation provides the company with projected manpower costs required at 95% confidence level and according to a risk-bearing budget percentage and ARR, enabling the company to assess if its working capital or liquidity is sufficient for the M&A deal, if it can afford to bear the risk, and if the return on investment would be satisfactory, respectively.

The power of the proposed model is attributed to the operation of its gates, that is, the decision rule and prioritisation. The gates make the constituents closely integrated so that the outcomes of one constituent serve as the inputs of other constituents. This ensures that the proposed model is comprehensive and precise, as the time, risk, and monetary terms involved in M&A deals are evaluated as a whole. The decision rule helps the company to eliminate unfavourable M&A deals and the prioritisation can further facilitate the company to prioritise the deals that pass gate 1, thereby enabling the selection of the most favourable deals. For example, the company would face difficulties in selecting one deal out of Cases 7, 9, and 10 for investment due to the similar results in terms of fuzzy duration (i.e., 112.05, 100.64, and 105.83 days, respectively), risk-bearing budget percentage (i.e., 6.08%, 6.6%, and 6.4%, respectively), and ARR (i.e., 21.71%, 29.13%, and 25.54%, respectively). In this case, the decision rule and prioritisation can effectively support the company's decision-making by eliminating Case 7 at gate 1 and then prioritise Case 9, followed by Case 10. In this fast-paced and dynamic global economy, companies have to seize M&A

opportunities as well as compete and respond within a very short time; this proposed model could effectively support M&A decision-making with accuracy.

7.3 Innovation of this Study

Many M&A deals are undertaken worldwide and the number has been increasing in recent years. This trend is gaining momentum, with companies using M&A to drive growth and expand their regional and international footprint. M&A are the most cost-efficient strategies for venturing into new markets and expanding internationally. Based on previous research in the field of M&A, very few studies have concentrated on pre-M&A analysis. How to take risk, critical time, and valuation into account for M&A considerations, how to evaluate if a potential M&A deal is worthy of investment, and how analytics tools such as fuzzy set theory and Monte Carlo simulation can be incorporated to support objective and efficient M&A decision-making are not evident in the literature. In light of this gap in the literature and the needs of the industry, including those of the case company, this study's development of the MAEPM to improve M&A success is of great value.

The MAEPM designed to be a holistic methodology for use by companies to manage M&A deals at the early stage is derived and tested, providing a stronger focus on the drivers of M&A success and combining essential elements from fuzzy set theory and Monte Carlo simulation for M&A decision-making.It pays attention to details such as the time and resources required, the risk-taking level, and the realistic estimation of the effort needed to complete an M&A deal, as well as its value. Unlike previous studies, the MAEPM emphasizes the pre-M&A analysis rather than the post-M&A analysis. Because pre-M&A

analysis is the starting point to a long M&A journey, it is of paramount importance for companies to become agile at evaluating and executing an M&A transaction within the legal and time constraints, and further achieve all transaction objectives and maximise the transaction value. The MAEPM developed in this study is original, and this study fills the aforementioned literature gap.

Chapter 8 Conclusion

M&A as strategies to gain competitive advantage have been essential for the expansion and growth of numerous companies. To answer the research question stated in Chapter 1, the MAEPM is developed in Chapter 4 and verified in Chapters 5 and 6, while its findings and importance are explained in Chapter 7. This chapter concludes the objectives achieved and the major findings. Contributions to knowledge are discussed, followed by the difficulties encountered in this research and suggested future research directions.

8.1 Objectives Achieved and Major Findings

To resolve the key problems leading to M&A failure identified in Chapter 1.2, this research developed and verified the MAEPM, which incorporates fuzzy set theory and Monte Carlo simulation, to support M&A decision-making, thereby achieving the research objectives mentioned in Chapter 1.3. The model consists of four parts, namely risk analysis, fuzzy critical path analysis, cost-benefit evaluation, as well as decision rule and prioritisation. For the risk analysis, four risk factors involved in M&A including schedule, estimation, process, and external risks are recognised and incorporated; these risk factors can be linked to M&A tasks for subsequent risk assessment. The risk level identified is taken into consideration when determining the fuzzy critical time and manpower cost required for M&A deals. This fills the literature gap on the risk aspect in M&A and further enhances the model's integrity by taking risk into consideration. For the fuzzy critical path analysis, the fuzzy critical time required to complete M&A deals in optimistic, normal, and pessimistic situations can be calculated. This facilitates firms to complete the deals at the critical time, thereby increasing the chance of success and reducing uncertainties. The

fuzzy set theory adopted helps eliminate subjective and vague human judgment, thereby resulting in a more accurate model. The remaining components of the model are helpful for firms to evaluate whether the deals are a "go" (i.e., worthy of investment) or "no-go" (i.e., unworthy of investment) through Monte Carlo simulation, and to prioritise the deals according to the fuzzy duration, risk-bearing budget percentage, and ARR. Serving as a comprehensive pre-M&A analysis, the model provides firms with substantial evidence to rapidly respond to M&A opportunities by pursuing favourable deals and avoiding risky and costly ones, thus maximising M&A success and achieving the research aim and objectives.

With reference to the eleven case studies for model development and verification, the key findings in this research are summarised as follows:

- Four kinds of risks associated with the M&A process are identified, namely schedule, estimation, process, and external risks,. These risks involve the potential delays, uncertainty related to human judgment, butterfly effects in each step of the M&A process, and external influences such as competitors and legal barriers. They can be mapped with the necessary tasks involved in the M&A process through cause-and-effect analysis and the fishbone diagram to support the subsequent comprehensive risk assessment. This mapping also helps firms to visualise the potential risks in each task in the M&A process, enabling better monitoring and management to ensure the effective completion of each M&A task.

- The risk assessment sheet of the model facilitates firms to evaluate every risk factor in the M&A process. The overall risk level determined is one indicator to support

M&A decision-making. It is also used in the proposed model to indicate the percentage of cost fluctuation in M&A deals.

- The adoption of the fuzzy critical path analysis is helpful in dealing with vague and subjective human judgment involved in the estimation of M&A scheduling. This enables firms to more precisely determine the critical path and relative total duration for M&A deals in a normal situation. Firms can then pay more attention to the tasks on the critical path and allocate sufficient resources to avoid time delay and extra costs.

- The fuzzy critical path analysis used in the proposed model provides more information for M&A decision-making, including the time required to complete the M&A deals in both optimistic and pessimistic situations. As indicated by Sam and Sabyasachi (2010), acquiring target companies in shorter time could provide greater opportunities for synergistic fit and lower prices. Firms can make use of the total duration estimated for strategic planning to complete the deals effectively and ensure the expected synergies.

- The cost evaluation of the model consists of input, simulation, and output sections, as well as the equation of ARR. It takes manpower cost into account, which is regarded as essential and the second-largest cost in M&A, and is also closely related to the time required for M&A completion. The cost evaluation enhances the M&A decision-making process by calculating the budget required for the M&A deals in a normal situation, as well as by giving decision makers insight on the total cost required at 95% confidence, the contingency cost required, and the risk-bearing budget percentage. In addition, the ARR as an enhanced method for capital budgeting helps calculate the expected returns on M&A investment.

- The results generated from the above elements can serve as individual indicators for M&A evaluation. However, firms often have difficulties in leveraging the individual results generated for effective decision-making. The decision rule and prioritisation in the model resolve this problem. They provide two decision gates to suggest whether the M&A deals are a "go" (i.e., should be undertaken) or "no-go" (i.e., should not be undertaken due to unworthiness of investment), and to prioritise all the potential deals for selection to maximise the probability of success in M&A.

To conclude, the achieved objectives and major findings discussed above provide an answer to the research question "How can fuzzy set theory and Monte Carlo simulation be combined to improve M&A decision-making under consideration of risk, critical time, and valuation?" The established MAEPM combining fuzzy theory and Monte Carlo simulation provides a scientific and structured approach to assess and prioritise M&A deals in a more precise manner as well as to gain insights into the management of risks, project schedules, and costs involved in M&A deals. This can enable better strategic planning and enhance the effectiveness and precision of M&A decision-making.

8.2 Contributions to the Literature

Based on the interviews with experts and the literature review conducted, four kinds of risk factors closely related to the M&A process are identified (Chapter 4.2), which can be connected to respective tasks involved in the M&A procedure for risk assessment. As discussed in Chapter 2, risk-taking is unavoidable in the M&A practice and risk is a crucial variable in providing a strong foundation for M&A decision-making (Amy *et al.*,

1996).The identification of the four risk factors and their interrelationship with M&A tasks through cause-and-effect analysis are thus critical to this research. The risk assessment sheet created is original and important for effective risk evaluation and pre-M&A analysis. Both deliverables contribute to the literature.

The fuzzy critical path analysis applied to M&A in this research is innovative and adds value to the literature of pre-M&A analysis. The time requirement of M&A plays a major role in M&A practice. Many scholars have indicated that acquiring target companies in a short time, that is, at the critical time, could achieve greater opportunities for synergistic effects and a higher success rate (Rhodes-Kropf *et al.*, 2003; Sam and Sabyasachi, 2010). However, M&A project scheduling always involves vague and subjective human judgment that influences the accuracy of its projection. The fuzzy critical path analysis adopted in this research not only enables decision makers to determine the critical path of M&A more precisely but also provides the critical time in normal, optimistic, and pessimistic situations. This is constructive and new to this area of research and provides more evidence for strategic planning.

The proposed cost-benefit evaluation with consideration of risk and manpower costs and its incorporation of the risk-bearing budget percentage and ARR makes this research comprehensive, thereby contributing to the literature and filling the aforementioned literature gap. As discussed in Chapter 1.2, existing studies have mainly focused on the post-M&A analysis including the integration process (Cloodt *et al.*, 2006; Sherman, 2006; Chen *et al.*, 2010) rather than the pre-M&A analysis regarding the worthiness and priority

of M&A deals. The cost-benefit evaluation and decision rule and prioritisation developed in this research serve as a rational mechanism to manage M&A deals by taking all key elements of M&A, namely time, risk, and monetary terms, into account. This comprehensive and effective mechanism provides new insights into pre-M&A analysis for better M&A decision-making, thereby improving M&A success.

8.3 Contributions to Industries

With the support of the discussion in Chapters 6 and 7on the model verification and its implications, the model developed in this research is confirmed to be reliable and important for making effective and accurate decisions on M&A. Based on the results and estimations generated by the model, SAGE can formulate its strategic planning to manage risks associated with each M&A task, better allocate its capacity for M&A investment, and facilitate business growth by maximising M&A success. With the help of this model, SAGE can reduce the turnaround time for each M&A deal screening by one third, and also reduce pre- and post-M&A costs substantially. SAGE realised that some of the previous M&A deals took place for the wrong motives; with the help of the model as objective decision-making guidance, SAGE can avoid troublesome M&A deals and many post-M&A issues. The savings in time and costs related to M&A integration are substantial, amounting to around HK$5-10 million annually.

The MAEPM serves as a generalised pre-M&A analysis framework. It provides insights to decision makers on the key risk factors, fuzzy critical path analysis, and cost-benefit evaluation in M&A. The model developed in this research not only benefits SAGE but also

is applicable to other firms in various industries for M&A decision-making. M&A deals vary from case to case but the M&A practice does not differ to a large extent among industries. Taking SAGE as an example, its M&A procedures are the same in various M&A deals, but this does not mean the fuzzy critical paths are the same as well. The developed model is flexible for the analysis of different M&A deals. In different M&A procedures, firms can still adopt the generalised framework by adding or removing particular M&A tasks, followed by linking these tasks to the key risk factors, if necessary, through the cause-and-effect analysis and the construction of the fishbone diagram. They can also make appropriate changes in the parameters of the decision rule and the prioritisation equation according to their own company weightings, so as to devise their own custom-made pre-M&A model.

8.4 Limitations and Future Research

In order to develop and verify the model, genuine data are essential to this research. However, the collection of genuine data is difficult, particularly when financial data are involved. Firms usually keep M&A data and results, especially those of unfinished deals and failed deals, highly confidential. They are reluctant to disclose sensitive information to outsiders for research. This limits the number of case studies conducted in this study. Furthermore, due to the difficulty in data collection, the case studies conducted in this research all pertain to land acquisitions.

To improve and extend this research, data of M&A deals other than land acquisitions from other industries and countries could be used to test the applicability and capability of the

MAEPM. Comparative study could be further undertaken to investigate the differences in pre-M&A analysis so as to extend the applicability of this model. This can also enrich the literature on the evaluation of M&A deals and pre-M&A planning.

Further research could also test the sensitivity of the proposed model to changes in the input variables such as the risk assessments, in order to increase understanding of the relationships between the risk level associated with particular M&A tasks and the M&A decision in the proposed model. In addition, considering the growing attention on the success factors of M&A and post-M&A integration, future studies connecting these with pre-M&A analysis would enhance the value of the study and would be meaningful for theoretical and practical purposes. Future studies could also develop a more integrated M&A model comprising both pre-M&A analysis and post-M&A integration. This may yield valuable insights to support M&A decision-making.

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Appendix 1

The fuzzy critical path analysis integrates the concept of α-cut, Zadeh's extension principle (Zadeh, 1978), the Yager ranking method (Yager, 1981), and linear programming. The two main steps in the fuzzy critical path analysis (Chen, 2007) adopted in this study are as follows:

Step 1: Find the fuzzy critical paths at each possibility level α

    1a. It is necessary to determine fuzzy activity times by using triangular fuzzy numbers. For example, if the activity time is 6 hours, the fuzzy activity time of the activity will be defined as $\tilde{T}_{12} = \{[t_{12}, \mu_{\tilde{T}_{12}}(t_{12})]|t_{12} \in [5,7]\}$ or $\tilde{T}_{12} = (5,6,7)$ .The membership function of $\tilde{T}_{12}$ is shown in Figure A.1as an example.

    1b. By applying the α-cut concept, the α-cut of $\tilde{T}_{ij}$ is defined as $(T_{ij})_\alpha = \{t_{ij} \in S(\tilde{T}_{ij})|\mu_{\tilde{T}_{ij}}(t_{ij}) \geq \alpha\}$. By using α-cut, $\tilde{T}_{ij}$ can be represented by different levels of confidence intervals (Zimmermann, 2001), which are crisp. The α-cut of $\tilde{T}_{ij}$ can then be expressed as:

$$(T_{ij})_\alpha = \left[\underset{t_{ij}}{\overset{inf}{}}\left\{t_{ij} \in S(\tilde{T}_{ij})\middle|\mu_{\tilde{T}_{ij}}(t_{ij}) \geq \alpha\right\}, \underset{t_{ij}}{\overset{sup}{}}\left\{t_{ij} \in S(\tilde{T}_{ij})\middle|\mu_{\tilde{T}_{ij}}(t_{ij}) \geq \alpha\right\} \right]$$

$$= \left[(T_{ij})_\alpha^L, (T_{ij})_\alpha^U\right]$$

where the values of t_{ij} lie at possibility α, $(T_{ij})_\alpha^L$ is the lower bound of the α-cut of $\tilde{T}_{ij}$, and $(T_{ij})_\alpha^U$ is the upper bound of the α-cut of $\tilde{T}_{ij}$. Figure A.1showsan example of α-cut=0.6, such that $(T_{12})_{0.6} = [5.6, 6.4]$
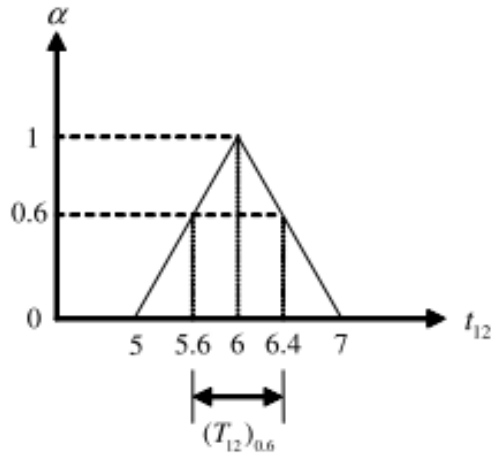
Figure A.1 Example of a membership function with α-cut (Source: Chen, 2007)

1c. A minimisation operation is developed to find the lower bound of the total duration time of the project network at possibility level α. Such minimisation operation is expressed in the following form:

$$D_\alpha^L = \min\ y_n - y_1$$

$$s.t.\ y_j \geq y_i + (T_{ij})_\alpha^L, \qquad (i,j) \in A,$$

$$y_i, y_j\ unrestricted\ in\ sign\ \forall(i,j) \in A$$

1d. A maximisation operation is constructed to find the upper bound of the total duration time of the project network at possibility level α. Such maximisation operation is expressed as:

$$D_\alpha^U = \max \sum_{i=1}^{n} \sum_{j=1}^{n} (T_{ij})_\alpha^U x_{ij}$$

$$s.t. \sum_{j=1}^{n} x_{1j} = 1,$$

$$\sum_{j=1}^{n} x_{ij} = \sum_{k=1}^{n} x_{ki}, \qquad i = 2, \ldots, n-1,$$

$$\sum_{k=1}^{n} x_{kn} = 1$$

$$x_{ij} \geq 0, \qquad (i,j) \in A$$

Step 2: Transform the fuzzy critical paths into crisp ones

2a. The Yager ranking index is employed to identify the critical level of each suggested

critical path. The Yager ranking index is defined as $I(\tilde{t}) = \int_0^1 \frac{1}{2}(t_\alpha^L + t_\alpha^U)d\alpha$

where (t_α^L, t_α^U) is the α-cut of $\tilde{t}$. The fuzziest critical path has the largest Yager

ranking index.

2b. A defuzzification process is required to convert the fuzzy value into crisp value.

The length of the most critical path in crisp value can be calculated using this

equation:

$$L_{mcp}^{max} = \max_k \left\{ \sum_{\forall(i,j)\in FCA_k, k=1,2,\dots,m} I(\tilde{T}_{ij}) \right\}$$

2c. Given that the path degree of criticality of its most critical path is 1, the relative

path degree of criticality can be determined using this equation:

$$Rdeg(P_{fg}) = \frac{\sum_{\forall(i,j)\in P_{fg}} I(\tilde{T}_{ij})}{\max_k \sum_{\forall(i,j)\in FCA_k, k=1,2,\dots,m} I(\tilde{T}_{ij})} = \frac{\sum_{\forall(i,j)\in P_{fg}} I(\tilde{T}_{ij})}{L_{mcp}^{max}}$$

where the relative degree of criticality of a path is $p_{fg} \in P_{fg}, g \in \{1,2,\dots,G\}$.

Appendix 2

<u>Statement of Research Ethics</u>

While acknowledging the rights of all the research participants, I also retain the right to report the results and findings accurately and truthfully, providing that I have complied with all the ethical protocols outlined here.

Informed consent of those studied is given. I provided a script, which is read in appropriate detail and in terms meaningful to the participants prior to proceeding with the interviews. I explained that this research is undertaking by myself for Ph.D. study at the University of Warwick. The research is about the development of an M&A evaluation and prioritisation model in which SAGE International Group Limited (SAGE) will be used as a case study. Data from SAGE will be collected and the participants' contribution through interviews and discussions on M&A will also be used to support the completion of this research, and they are aware of the following:

Research participants understand that their participation in this research is entirely voluntary and that they have the right to withdraw from this research at any time without having to give any reason.

Identities concerning research participants and any information provided by them will be kept strictly confidential and anonymous. Research participants will not be named in any write-ups and material submitted for publication. All information collected will be erased on completion of the research.

All the results from the research process will be used solely for this research purpose. It is ensured that the physical, social, and psychological well-being of research participants is not adversely affected by the research. There is no harm to any of the research participants and no consequences for their work.

It is my promise that, while carrying out this research, I will maintain the highest integrity at all times regarding data gathering and only report information that is relevant to this research.

Appendix 3

Table A.1 Risk assessment results for Case 2

	Tasks	Risk factors				Risk level result
		Schedule	Estimation	Process	External	
Risk Assessment	Initial M&A project evaluation/filtration	Low	High		High	High
	Legitimacy of assessment	High	High	High	High	High
	PM assignment		Moderate	High		High
	Initial meeting		Low		Low	Low
	Legitimacy confirmation	High	High		Moderate	High
	Signing of memorandum of understanding	High			Moderate	High
	Valuation		High	High	High	High
	Competitor assessment		High	Moderate		High
	Completion of target and competitor assessment		High	Moderate		High
	Policy formulation and evaluation	Moderate	Moderate	Moderate	Low	Moderate
	Feasibility assessment		High	Moderate	Moderate	High
	Capex calculation		High		Moderate	High
	Completion of feasibility and Capex assessment		High		Low	Moderate
	Revenue forecasting model		High	Moderate	Moderate	High
	Negotiation	High	Moderate	High	Moderate	High
	Signing of sales and purchase agreement	High	Moderate		High	High
	Legal documentation of M&A	Moderate	Moderate	Moderate		High
	Overall risk level					**High**

Table A.2 Risk assessment results for Case 3

	Tasks	Risk factors				Risk level result
		Schedule	Estimation	Process	External	
Risk Assessment	Initial M&A project evaluation/filtration	Low	High		Moderate	Moderate
	Legitimacy of assessment	High	High	High	High	High
	PM assignment		Moderate	Moderate		Moderate
	Initial meeting		Moderate		Low	Moderate
	Legitimacy confirmation	High	High		High	High
	Signing of memorandum of understanding	High			Moderate	High
	Valuation		High	High	High	High
	Competitor assessment		High	Moderate		High
	Completion of target and competitor assessment		High	Moderate		High
	Policy formulation and evaluation	Moderate	High	Moderate	Low	Moderate
	Feasibility assessment		High	Moderate	Moderate	High
	Capex calculation		High		Moderate	High
	Completion of feasibility and Capex assessment		High		Low	Moderate
	Revenue forecasting model		High	Moderate	Moderate	High
	Negotiation	High	Moderate	High	Moderate	High
	Signing of sales and purchase agreement	Moderate	Low		Moderate	Moderate
	Legal documentation of M&A	Moderate	Low	Low		Moderate
	Overall risk level					**High**

Table A.3 Risk assessment results for Case 4

	Tasks	Risk factors				Risk level result
		Schedule	**Estimation**	**Process**	**External**	
Risk Assessment	Initial M&A project evaluation/filtration	Moderate	High		High	High
	Legitimacy of assessment	Low	Moderate	Moderate	Moderate	Moderate
	PM assignment		High	High		High
	Initial meeting		Moderate		Low	Moderate
	Legitimacy confirmation	Low	Low		Low	Moderate
	Signing of memorandum of understanding	Moderate			Moderate	Moderate
	Valuation		Low	Low	Low	Low
	Competitor assessment		Low	Low		Low
	Completion of target and competitor assessment		Moderate	Moderate		Moderate
	Policy formulation and evaluation	Low	Low	Low	Moderate	Low
	Feasibility assessment		Low	Low	Low	Low
	Capex calculation		Moderate		Moderate	Moderate
	Completion of feasibility and Capex assessment		Moderate		Low	Moderate
	Revenue forecasting model		Moderate	Moderate	Moderate	Moderate
	Negotiation	Moderate	Moderate	Moderate	Moderate	Moderate
	Signing of sales and purchase agreement	High	Moderate		Moderate	High
	Legal documentation of M&A	Moderate	Moderate	Moderate		High
Overall risk level						**Moderate**

Table A.4 Risk assessment results for Case 5

Tasks	Risk Factors				Risk Level Result
	Schedule	Estimation	Process	External	
Initial M&A project evaluation/filtration	Moderate	High		High	High
Legitimacy of assessment	High	High	High	High	High
PM assignment		High	High		High
Initial meeting		Moderate		Low	Moderate
Legitimacy confirmation	High	High		Moderate	High
Signing of memorandum of understanding	Low			Low	Low
Valuation		High	High	High	High
Competitor assessment		Moderate	Moderate		Moderate
Completion of target and competitor assessment		High	Moderate		High
Policy formulation & evaluation	Moderate	High	High	High	High
Feasibility assessment		High	Moderate	Moderate	High
Capex calculation		High		High	High
Completion of feasibility and Capex assessment		High		High	High
Revenue forecasting model		High	Moderate	Moderate	High
Negotiation	High	Moderate	High	Moderate	High
Signing of sales and purchase agreement	High	Moderate		Moderate	High
Legal documentation of M&A	Moderate	Moderate	Moderate		High
Overall risk level					**High**

Table A.5 Risk assessment results for Case 6

	Tasks	Risk factors				Risk level result
		Schedule	Estimation	Process	External	
Risk Assessment	Initial M&A project evaluation/filtration	Low	High		Moderate	Moderate
	Legitimacy of assessment	High	High	High	High	High
	PM assignment		Moderate	Moderate		Moderate
	Initial meeting		Low		Low	Low
	Legitimacy confirmation	High	High		Moderate	High
	Signing of memorandum of understanding	High			Moderate	High
	Valuation		High	High	High	High
	Competitor assessment		High	Moderate		High
	Completion of target and competitor assessment		High	Moderate		High
	Policy formulation and evaluation	Moderate	Moderate	Moderate	Low	Moderate
	Feasibility assessment		High	Moderate	Moderate	High
	Capex calculation		High		Moderate	High
	Completion of feasibility and Capex assessment		High		Low	Moderate
	Revenue forecasting model		High	Moderate	Moderate	High
	Negotiation	High	Moderate	High	Moderate	High
	Signing of sales and purchase agreement	Moderate	Low		Moderate	Moderate
	Legal documentation of M&A	Moderate	Low	Low		Moderate
	Overall risk level					**High**

Table A.6 Risk assessment results for Case 7

	Tasks	Risk factors				Risk level result
		Schedule	Estimation	Process	External	
Risk Assessment	Initial M&A project evaluation/filtration	Moderate	Moderate		Moderate	Moderate
	Legitimacy of assessment	Low	Moderate	Moderate	Moderate	Moderate
	PM assignment		High	High		High
	Initial meeting		Moderate		Low	Moderate
	Legitimacy confirmation	Low	Low		Low	Moderate
	Signing of memorandum of understanding	Low			Low	Low
	Valuation		Low	Low	Low	Low
	Competitor assessment		Low	Low		Low
	Completion of target and competitor assessment		Moderate	Moderate		Moderate
	Policy formulation and evaluation	Low	Low	Low	Moderate	Low
	Feasibility assessment		Low	Low	Low	Low
	Capex calculation		Moderate		Moderate	Moderate
	Completion of feasibility and Capex assessment		Moderate		Low	Moderate
	Revenue forecasting model		Moderate	Moderate	Moderate	Moderate
	Negotiation	Moderate	Moderate	Moderate	Moderate	Moderate
	Signing of sales and purchase agreement	High	Moderate		Moderate	High
	Legal documentation of M&A	Moderate	Moderate	Moderate		High
	Overall risk level					**Moderate**

Table A.7 Risk assessment results for Case 8

	Tasks	Risk factors				Risk level result
		Schedule	Estimation	Process	External	
Risk Assessment	Initial M&A project evaluation/filtration	Low	High		High	High
	Legitimacy of assessment	High	High	High	High	High
	PM assignment		High	High		High
	Initial meeting		Moderate		Low	Moderate
	Legitimacy confirmation	High	High		Moderate	High
	Signing of memorandum of understanding	Low			Low	Low
	Valuation		High	High	High	High
	Competitor assessment		Moderate	Moderate		Moderate
	Completion of target and competitor assessment		High	Moderate		High
	Policy formulation and evaluation	Moderate	Moderate	Moderate	Low	Moderate
	Feasibility assessment		High	Moderate	Moderate	High
	Capex calculation		High		High	High
	Completion of feasibility and Capex assessment		High		High	High
	Revenue forecasting model		High	Moderate	Moderate	High
	Negotiation	High	Moderate	High	Moderate	High
	Signing of sales and purchase agreement	High	Moderate		Moderate	High
	Legal documentation of M&A	Moderate	Moderate	Moderate		High
	Overall risk level					**High**

Table A.8 Risk assessment results for Case 9

Tasks	Risk factors				Risk level result
	Schedule	Estimation	Process	External	
Initial M&A project evaluation/filtration	High	High		High	High
Legitimacy of assessment	Low	Low	Low	Low	Low
PM assignment		High	High		High
Initial meeting		Low		Low	Low
Legitimacy confirmation	Low	Low		Low	Moderate
Signing of memorandum of understanding	Low			Low	Low
Valuation		High	High	Moderate	High
Competitor assessment		Low	Low		Low
Completion of target and competitor assessment		Low	Low		Low
Policy formulation and evaluation	Low	Low	Low	Moderate	Low
Feasibility assessment		Low	Low	Low	Low
Capex calculation		Moderate		Moderate	Moderate
Completion of feasibility and Capex assessment		Moderate		Low	Moderate
Revenue forecasting model		Moderate	Moderate	Moderate	Moderate
Negotiation	Low	Low	Low	Low	Low
Signing of sales and purchase agreement	Low	Low		Low	Moderate
Legal documentation of M&A	Low	Low	Low		Moderate
Overall risk level					**Moderate**

Table A.9 Risk assessment results for Case 10

	Tasks	Risk factors				Risk level result
		Schedule	Estimation	Process	External	
Risk Assessment	Initial M&A project evaluation/filtration	Low	Low		Low	Low
	Legitimacy of assessment	High	High	High	High	High
	PM assignment		High	High		High
	Initial meeting		Low		Low	Low
	Legitimacy confirmation	High	High		High	High
	Signing of memorandum of understanding	Low			Low	Low
	Valuation		High	High	Moderate	High
	Competitor assessment		Low	Low		Low
	Completion of target and competitor assessment		Low	Low		Low
	Policy formulation and evaluation	Low	High	High	Moderate	High
	Feasibility assessment		High	High	High	High
	Capex calculation		Moderate		Moderate	Moderate
	Completion of feasibility and Capex assessment		Moderate		Low	Moderate
	Revenue forecasting model		Moderate	Moderate	Moderate	Moderate
	Negotiation	Low	Low	Low	Low	Low
	Signing of sales and purchase agreement	Low	Low		Low	Moderate
	Legal documentation of M&A	Low	Low	Low		Moderate
	Overall risk level					**Moderate**

Table A.10 Risk assessment results for Case 11

	Tasks	Risk factors				Risk level result
		Schedule	Estimation	Process	External	
Risk Assessment	Initial M&A project evaluation/filtration	High	High		High	High
	Legitimacy of assessment	High	Moderate	Moderate	High	High
	PM assignment		High	High		High
	Initial meeting		Moderate		Low	Moderate
	Legitimacy confirmation	Moderate	Moderate		Moderate	High
	Signing of memorandum of understanding	Moderate			Low	Moderate
	Valuation		Moderate	Moderate	Moderate	Moderate
	Competitor assessment		Moderate	Moderate		Moderate
	Completion of target and competitor assessment		High	Moderate		High
	Policy formulation and evaluation	Low	Moderate	Moderate	Moderate	Moderate
	Feasibility assessment		Low	Low	Low	Low
	Capex calculation		Moderate		Moderate	Moderate
	Completion of feasibility and Capex assessment		Moderate		Low	Moderate
	Revenue forecasting model		Moderate	Moderate	Moderate	Moderate
	Negotiation	Moderate	Moderate	Moderate	Moderate	Moderate
	Signing of sales and purchase agreement	High	Moderate		Moderate	High
	Legal documentation of M&A	Moderate	Moderate	Moderate		High
Overall risk level						**High**

Figure A.2 Activity-on-arrow network diagram for Case 2
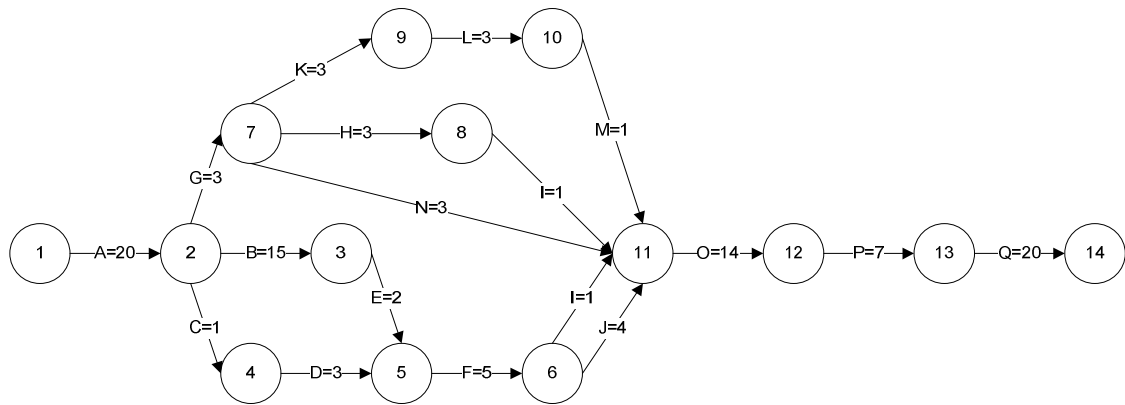
Figure A.3 Activity-on-arrow network diagram for Case 3
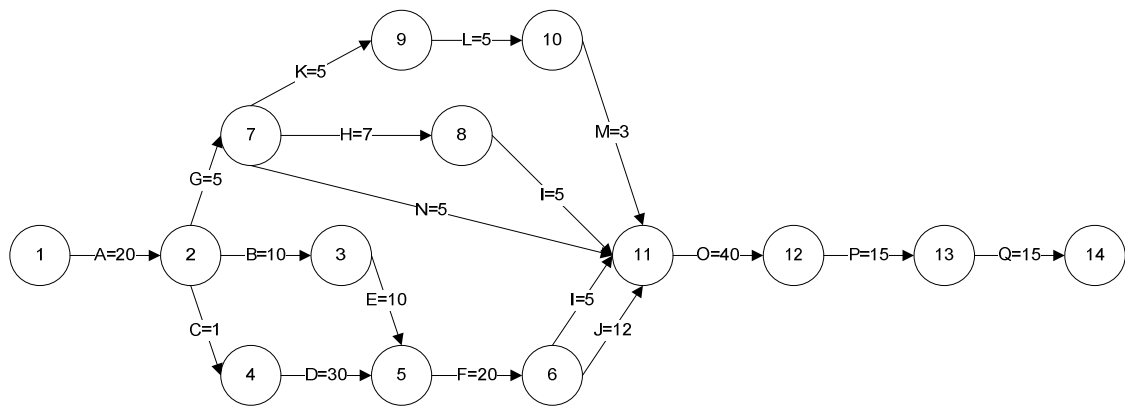
Figure A.4 Activity-on-arrow network diagram for Case 4
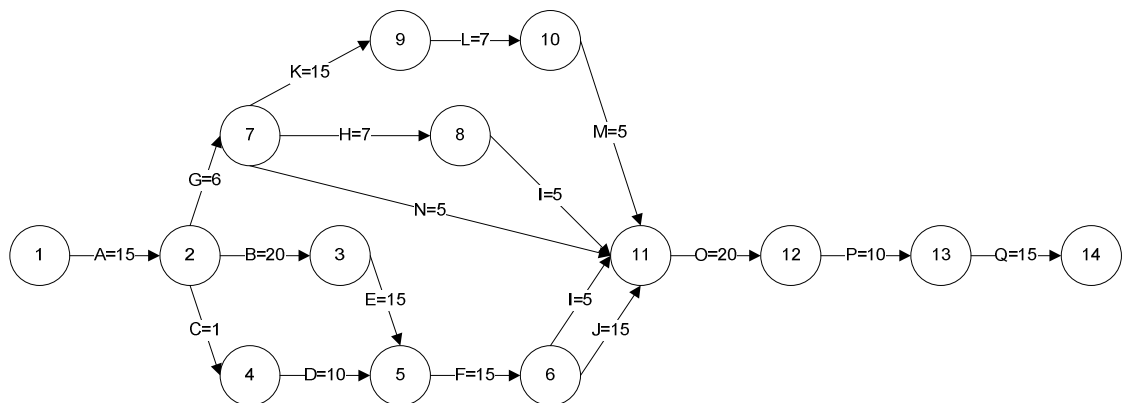
Figure A.5 Activity-on-arrow network diagram for Case 5
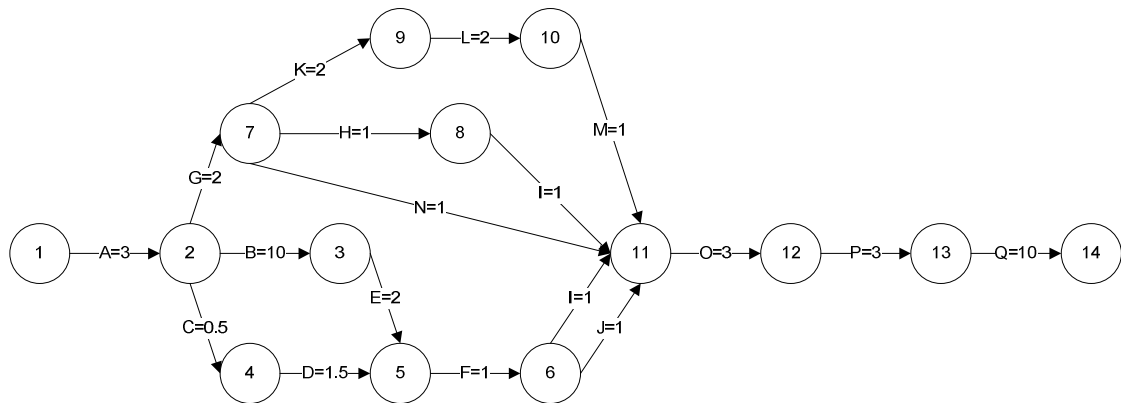
Figure A.6 Activity-on-arrow network diagram for Case 6
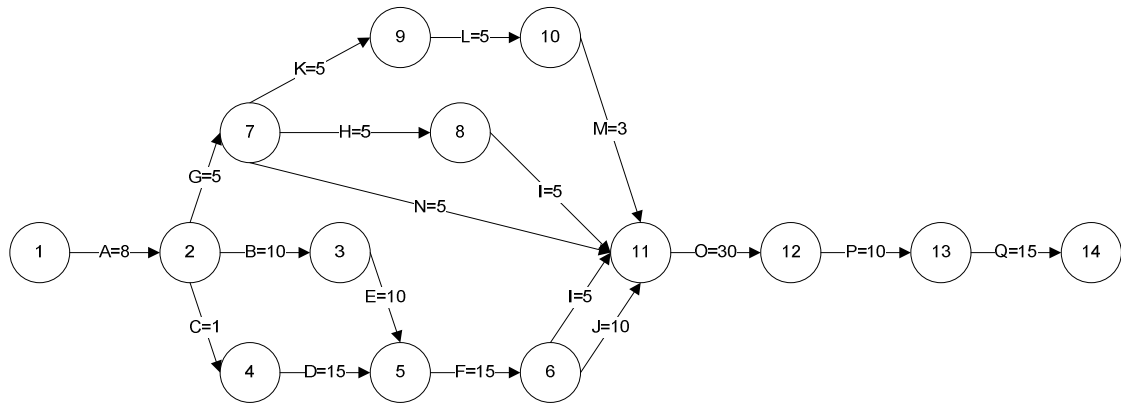
Figure A.7 Activity-on-arrow network diagram for Case 7
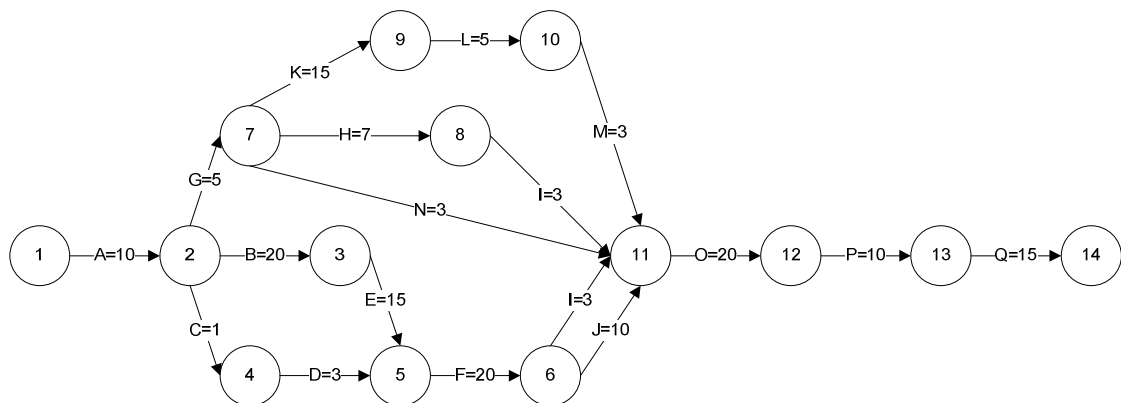
Figure A.8 Activity-on-arrow network diagram for Case 8
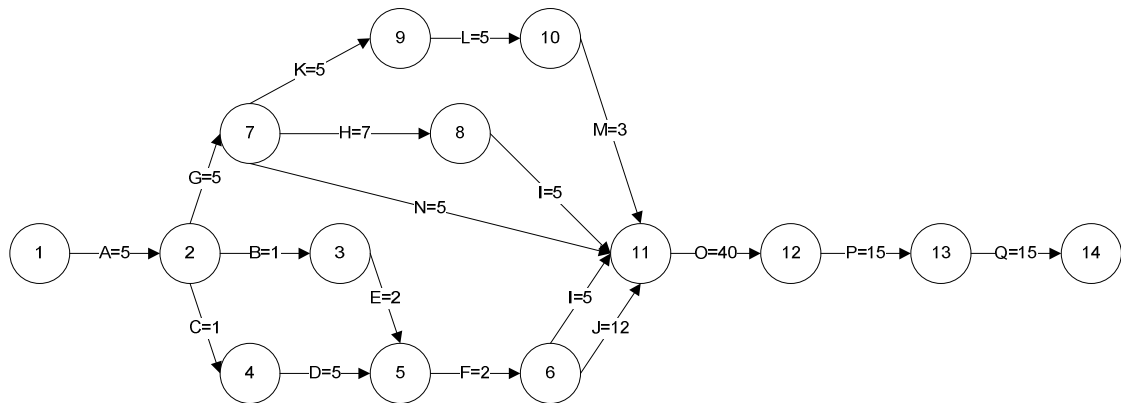
Figure A.9 Activity-on-arrow network diagram for Case 9
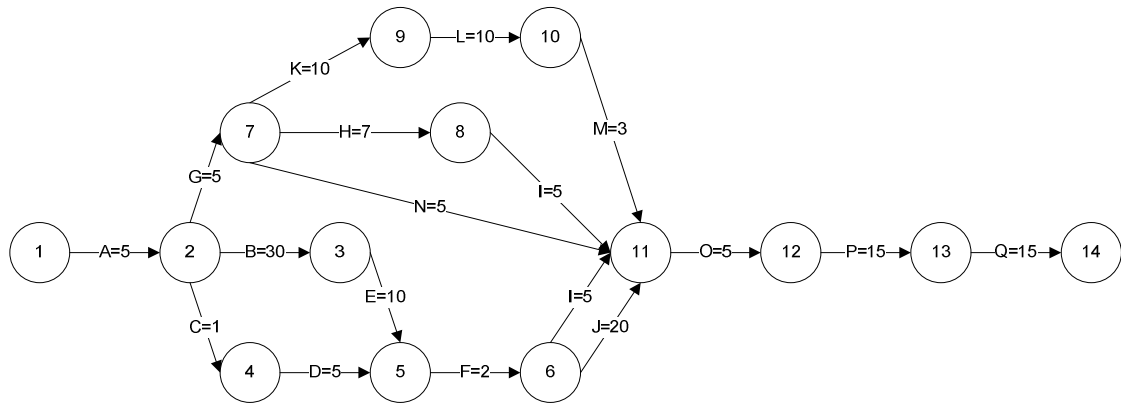
Figure A.2 Activity-on-arrow network diagram for Case 10
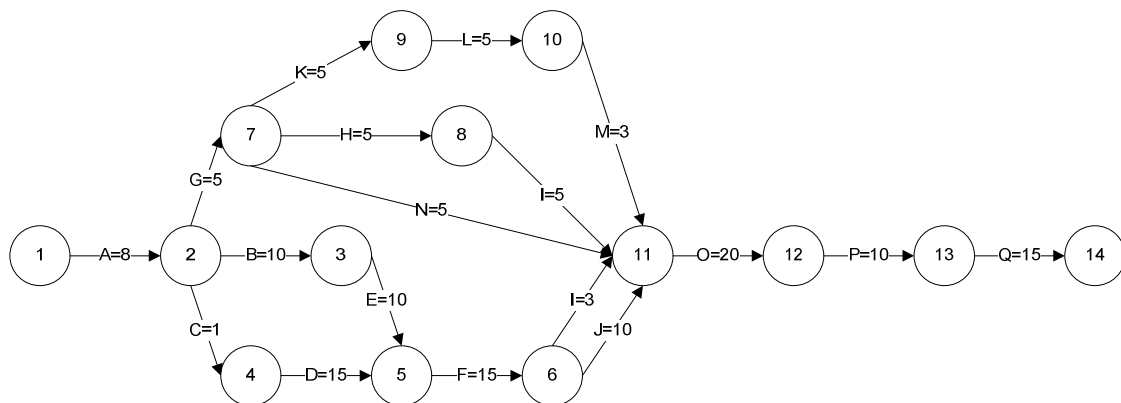
Figure A.3 Activity-on-arrow network diagram for Case 11

Table A.11 Crispy activity time and fuzzy activity time for Case 2

Activity	$\widetilde{T}_{ij}$	T_{ij}^L	t_{ij}	T_{ij}^U
$X_{1,2}$	(24, 30, 45)	24	30	45
$X_{2,3}$	(24, 30, 45)	24	30	45
$X_{2,4}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{2,7}$	(4, 5, 7.5)	4	5	7.5
$X_{3,5}$	(8, 10, 15)	8	10	15
$X_{4,5}$	(24, 30, 45)	24	30	45
$X_{5,6}$	(8, 10, 15)	8	10	15
$X_{6,11}$	(8, 10, 15)	8	10	15
$X_{9,10}$	(4, 5, 7.5)	4	5	7.5
$X_{7,9}$	(12, 15, 22.5)	12	15	22.5
$X_{7,8}$	(4, 5, 7.5)	4	5	7.5
$X_{7,11}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{10,11}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{8,11}$	(1.6, 2, 3)	1.6	2	3
$X_{11,12}$	(24, 30, 45)	24	30	45
$X_{12,13}$	(5.6, 7, 10.5)	5.6	7	10.5
$X_{13,14}$	(11.2, 14, 21)	11.2	14	21

Table A.12 Crispy activity time and fuzzy activity time for Case 3

Activity	$\widetilde{T}_{ij}$	T_{ij}^L	t_{ij}	T_{ij}^U
$X_{1,2}$	(16, 20, 30)	16	20	30
$X_{2,3}$	(12, 15, 22.5)	12	15	22.5
$X_{2,4}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{2,7}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{3,5}$	(1.6, 2, 3)	1.6	2	3
$X_{4,5}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{5,6}$	(4, 5, 7.5)	4	5	7.5
$X_{6,11}$	(3.2, 4, 6)	3.2	4	6
$X_{9,10}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{7,9}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{7,8}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{7,11}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{10,11}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{8,11}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{11,12}$	(11.2, 14, 21)	11.2	14	21
$X_{12,13}$	(5.6, 7, 10.5)	5.6	7	10.5
$X_{13,14}$	(16, 20, 30)	16	20	30

Table A.13 Crispy activity time and fuzzy activity time for Case 4

Activity	$\widetilde{T}_{ij}$	T_{ij}^L	t_{ij}	T_{ij}^U
$X_{1,2}$	(18, 20, 25)	18	20	25
$X_{2,3}$	(9, 10, 12.5)	9	10	12.5
$X_{2,4}$	(0.9, 1, 1.25)	0.9	1	1.25
$X_{2,7}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{3,5}$	(9, 10, 12.5)	9	10	12.5
$X_{4,5}$	(27, 30, 37.5)	27	30	37.5
$X_{5,6}$	(18, 20, 25)	18	20	25
$X_{6,11}$	(10.8, 12, 15)	10.8	12	15
$X_{9,10}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{7,9}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{7,8}$	(6.3, 7, 8.75)	6.3	7	8.75
$X_{7,11}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{10,11}$	(2.7, 3, 3.75)	2.7	3	3.75
$X_{8,11}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{11,12}$	(36, 40, 50)	36	40	50
$X_{12,13}$	(13.5, 15, 18.75)	13.5	15	18.75
$X_{13,14}$	(13.5, 15, 18.75)	13.5	15	18.75

Table A.14 Crispy activity time and fuzzy activity time for Case 5

Activity	$\widetilde{T}_{ij}$	T_{ij}^L	t_{ij}	T_{ij}^U
$X_{1,2}$	(12, 15, 22.5)	12	15	22.5
$X_{2,3}$	(16, 20, 30)	16	20	30
$X_{2,4}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{2,7}$	(4.8, 6, 9)	4.8	6	9
$X_{3,5}$	(12, 15, 22.5)	12	15	22.5
$X_{4,5}$	(8, 10, 15)	8	10	15
$X_{5,6}$	(12, 15, 22.5)	12	15	22.5
$X_{6,11}$	(12, 15, 22.5)	12	15	22.5
$X_{9,10}$	(5.6, 7, 10.5)	5.6	7	10.5
$X_{7,9}$	(12, 15, 22.5)	12	15	22.5
$X_{7,8}$	(5.6, 7, 10.5)	5.6	7	10.5
$X_{7,11}$	(4, 5, 7.5)	4	5	7.5
$X_{10,11}$	(4, 5, 7.5)	4	5	7.5
$X_{8,11}$	(4, 5, 7.5)	4	5	7.5
$X_{11,12}$	(16, 20, 30)	16	20	30
$X_{12,13}$	(8, 10, 15)	8	10	15
$X_{13,14}$	(12, 15, 22.5)	12	15	22.5

Table A.15 Crispy activity time and fuzzy activity time for Case 6

Activity	$\widetilde{T}_{ij}$	T_{ij}^{L}	t_{ij}	T_{ij}^{U}
$X_{1,2}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{2,3}$	(8, 10, 15)	8	10	15
$X_{2,4}$	(0.4, 0.5, 0.75)	0.4	0.5	0.75
$X_{2,7}$	(1.6, 2, 3)	1.6	2	3
$X_{3,5}$	(1.6, 2, 3)	1.6	2	3
$X_{4,5}$	(1.2, 1.5, 2.25)	1.2	1.5	2.25
$X_{5,6}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{6,11}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{9,10}$	(1.6, 2, 3)	1.6	2	3
$X_{7,9}$	(1.6, 2, 3)	1.6	2	3
$X_{7,8}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{7,11}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{10,11}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{8,11}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{11,12}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{12,13}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{13,14}$	(8, 10, 15)	8	10	15

Table A.16 Crispy activity time and fuzzy activity time for Case 7

Activity	$\widetilde{T}_{ij}$	T_{ij}^{L}	t_{ij}	T_{ij}^{U}
$X_{1,2}$	(7.2, 8, 10)	7.2	8	10
$X_{2,3}$	(9, 10, 12.5)	9	10	12.5
$X_{2,4}$	(0.9, 1, 1.25)	0.9	1	1.25
$X_{2,7}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{3,5}$	(9, 10, 12.5)	9	10	12.5
$X_{4,5}$	(13.5, 15, 18.75)	13.5	15	18.75
$X_{5,6}$	(13.5, 15, 18.75)	13.5	15	18.75
$X_{6,11}$	(9, 10, 12.5)	9	10	12.5
$X_{9,10}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{7,9}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{7,8}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{7,11}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{10,11}$	(2.7, 3, 3.75)	2.7	3	3.75
$X_{8,11}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{11,12}$	(27, 30, 37.5)	27	30	37.5
$X_{12,13}$	(9, 10, 12.5)	9	10	12.5
$X_{13,14}$	(13.5, 15, 18.75)	13.5	15	18.75

Table A.17 Crispy activity time and fuzzy activity time for Case 8

Activity	$\widetilde{T}_{ij}$	T_{ij}^L	t_{ij}	T_{ij}^U
$X_{1,2}$	(8, 10, 15)	8	10	15
$X_{2,3}$	(16, 20, 30)	16	20	30
$X_{2,4}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{2,7}$	(4, 5, 7.5)	4	5	7.5
$X_{3,5}$	(12, 15, 22.5)	12	15	22.5
$X_{4,5}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{5,6}$	(16, 20, 30)	16	20	30
$X_{6,11}$	(8, 10, 15)	8	10	15
$X_{9,10}$	(4, 5, 7.5)	4	5	7.5
$X_{7,9}$	(12, 15, 22.5)	12	15	22.5
$X_{7,8}$	(5.6, 7, 10.5)	5.6	7	10.5
$X_{7,11}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{10,11}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{8,11}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{11,12}$	(16, 20, 30)	16	20	30
$X_{12,13}$	(8, 10, 15)	8	10	15
$X_{13,14}$	(12, 15, 22.5)	12	15	22.5

Table A.18 Crispy activity time and fuzzy activity time for Case 9

Activity	$\widetilde{T}_{ij}$	T_{ij}^L	t_{ij}	T_{ij}^U
$X_{1,2}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{2,3}$	(0.9, 1, 1.25)	0.9	1	1.25
$X_{2,4}$	(0.9, 1, 1.25)	0.9	1	1.25
$X_{2,7}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{3,5}$	(1.8, 2, 2.5)	1.8	2	2.5
$X_{4,5}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{5,6}$	(1.8, 2, 2.5)	1.8	2	2.5
$X_{6,11}$	(10.8, 12, 15)	10.8	12	15
$X_{9,10}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{7,9}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{7,8}$	(6.3, 7, 8.75)	6.3	7	8.75
$X_{7,11}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{10,11}$	(2.7, 3, 3.75)	2.7	3	3.75
$X_{8,11}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{11,12}$	(36, 40, 50)	36	40	50
$X_{12,13}$	(13.5, 15, 18.75)	13.5	15	18.75
$X_{13,14}$	(13.5, 15, 18.75)	13.5	15	18.75

Table A.19 Crispy activity time and fuzzy activity time for Case 10

Activity	$\widetilde{T}_{ij}$	T_{ij}^L	t_{ij}	T_{ij}^U
$X_{1,2}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{2,3}$	(27, 30, 37.5)	27	30	37.5
$X_{2,4}$	(0.9, 1, 1.25)	0.9	1	1.25
$X_{2,7}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{3,5}$	(9, 10, 12.5)	9	10	12.5
$X_{4,5}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{5,6}$	(1.8, 2, 2.5)	1.8	2	2.5
$X_{6,11}$	(18, 20, 25)	18	20	25
$X_{9,10}$	(9, 10, 12.5)	9	10	12.5
$X_{7,9}$	(9, 10, 12.5)	9	10	12.5
$X_{7,8}$	(6.3, 7, 8.75)	6.3	7	8.75
$X_{7,11}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{10,11}$	(2.7, 3, 3.75)	2.7	3	3.75
$X_{8,11}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{11,12}$	(4.5, 5, 6.25)	4.5	5	6.25
$X_{12,13}$	(13.5, 15, 18.75)	13.5	15	18.75
$X_{13,14}$	(13.5, 15, 18.75)	13.5	15	18.75

Table A.20 Crispy activity time and fuzzy activity time for Case 11

Activity	$\widetilde{T}_{ij}$	T_{ij}^L	t_{ij}	T_{ij}^U
$X_{1,2}$	(6.4, 8, 12)	6.4	8	12
$X_{2,3}$	(8, 10, 15)	8	10	15
$X_{2,4}$	(0.8, 1, 1.5)	0.8	1	1.5
$X_{2,7}$	(4, 5, 7.5)	4	5	7.5
$X_{3,5}$	(8, 10, 15)	8	10	15
$X_{4,5}$	(12, 15, 22.5)	12	15	22.5
$X_{5,6}$	(12, 15, 22.5)	12	15	22.5
$X_{6,11}$	(8, 10, 15)	8	10	15
$X_{9,10}$	(4, 5, 7.5)	4	5	7.5
$X_{7,9}$	(4, 5, 7.5)	4	5	7.5
$X_{7,8}$	(4, 5, 7.5)	4	5	7.5
$X_{7,11}$	(4, 5, 7.5)	4	5	7.5
$X_{10,11}$	(2.4, 3, 4.5)	2.4	3	4.5
$X_{8,11}$	(4, 5, 7.5)	4	5	7.5
$X_{11,12}$	(16, 20, 30)	16	20	30
$X_{12,13}$	(8, 10, 15)	8	10	15
$X_{13,14}$	(12, 15, 22.5)	12	15	22.5

Table A.21 Upper and lower values of fuzzy activity time required for each activity at different α-cut levels

for Case 2

Activity	θ^L	θ^U	$(T_{ij})_{\alpha=1}$	$(T_{ij})_{\alpha=0.9}$	$(T_{ij})_{\alpha=0.8}$	$(T_{ij})_{\alpha=0.7}$	$(T_{ij})_{\alpha=0.6}$	$(T_{ij})_{\alpha=0.5}$	$(T_{ij})_{\alpha=0.4}$	$(T_{ij})_{\alpha=0.3}$	$(T_{ij})_{\alpha=0.2}$	$(T_{ij})_{\alpha=0.1}$	$(T_{ij})_{\alpha=0}$
$X_{1,2}$	0.17	0.07	(30, 30)	(29.4, 31.5)	(28.8, 33)	(28.2, 34.5)	(27.6, 36)	(27, 37.5)	(26.4, 39)	(25.8, 40.5)	(25.2, 42)	(24.6, 43.5)	(24, 45)
$X_{2,3}$	0.17	0.07	(30, 30)	(29.4, 31.5)	(28.8, 33)	(28.2, 34.5)	(27.6, 36)	(27, 37.5)	(26.4, 39)	(25.8, 40.5)	(25.2, 42)	(24.6, 43.5)	(24, 45)
$X_{2,4}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{2,7}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{3,5}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{4,5}$	0.17	0.07	(30, 30)	(29.4, 31.5)	(28.8, 33)	(28.2, 34.5)	(27.6, 36)	(27, 37.5)	(26.4, 39)	(25.8, 40.5)	(25.2, 42)	(24.6, 43.5)	(24, 45)
$X_{5,6}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{6,11}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{9,10}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{7,9}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)
$X_{7,8}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{7,11}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{10,11}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{8,11}$	1.19	0.79	(2, 2)	(1.96, 2.1)	(1.92, 2.2)	(1.88, 2.3)	(1.84, 2.4)	(1.8, 2.5)	(1.76, 2.6)	(1.72, 2.7)	(1.68, 2.8)	(1.64, 2.9)	(1.6, 3)
$X_{11,12}$	0.17	0.07	(30, 30)	(29.4, 31.5)	(28.8, 33)	(28.2, 34.5)	(27.6, 36)	(27, 37.5)	(26.4, 39)	(25.8, 40.5)	(25.2, 42)	(24.6, 43.5)	(24, 45)
$X_{12,13}$	0.62	0.28	(7, 7)	(6.86, 7.35)	(6.72, 7.7)	(6.58, 8.05)	(6.44, 8.4)	(6.3, 8.75)	(6.16, 9.1)	(6.02, 9.45)	(5.88, 9.8)	(5.74, 10.15)	(5.6, 10.5)
$X_{13,14}$	0.34	0.14	(14, 14)	(13.72, 14.7)	(13.44, 15.4)	(13.16, 16.1)	(12.88, 16.8)	(12.6, 17.5)	(12.32, 18.2)	(12.04, 18.9)	(11.76, 19.6)	(11.48, 20.3)	(11.2, 21)

Table A.22 Upper and lower values of fuzzy activity time required for each activity at different α-cut levels

for Case 3

Activity	θ^L	θ^U	$(T_{ij})_{\alpha=1}$	$(T_{ij})_{\alpha=0.9}$	$(T_{ij})_{\alpha=0.8}$	$(T_{ij})_{\alpha=0.7}$	$(T_{ij})_{\alpha=0.6}$	$(T_{ij})_{\alpha=0.5}$	$(T_{ij})_{\alpha=0.4}$	$(T_{ij})_{\alpha=0.3}$	$(T_{ij})_{\alpha=0.2}$	$(T_{ij})_{\alpha=0.1}$	$(T_{ij})_{\alpha=0}$
$X_{1,2}$	0.24	0.10	(20, 20)	(19.6, 21)	(19.2, 22)	(18.8, 23)	(18.4, 24)	(18, 25)	(17.6, 26)	(17.2, 27)	(16.8, 28)	(16.4, 29)	(16, 30)
$X_{2,3}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)
$X_{2,4}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{2,7}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{3,5}$	1.19	0.79	(2, 2)	(1.96, 2.1)	(1.92, 2.2)	(1.88, 2.3)	(1.84, 2.4)	(1.8, 2.5)	(1.76, 2.6)	(1.72, 2.7)	(1.68, 2.8)	(1.64, 2.9)	(1.6, 3)
$X_{4,5}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{5,6}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{6,11}$	0.90	0.46	(4, 4)	(3.92, 4.2)	(3.84, 4.4)	(3.76, 4.6)	(3.68, 4.8)	(3.6, 5)	(3.52, 5.2)	(3.44, 5.4)	(3.36, 5.6)	(3.28, 5.8)	(3.2, 6)
$X_{9,10}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{7,9}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{7,8}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{7,11}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{10,11}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{8,11}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{11,12}$	0.34	0.14	(14, 14)	(13.72, 14.7)	(13.44, 15.4)	(13.16, 16.1)	(12.88, 16.8)	(12.6, 17.5)	(12.32, 18.2)	(12.04, 18.9)	(11.76, 19.6)	(11.48, 20.3)	(11.2, 21)
$X_{12,13}$	0.62	0.28	(7, 7)	(6.86, 7.35)	(6.72, 7.7)	(6.58, 8.05)	(6.44, 8.4)	(6.3, 8.75)	(6.16, 9.1)	(6.02, 9.45)	(5.88, 9.8)	(5.74, 10.15)	(5.6, 10.5)
$X_{13,14}$	0.24	0.10	(20, 20)	(19.6, 21)	(19.2, 22)	(18.8, 23)	(18.4, 24)	(18, 25)	(17.6, 26)	(17.2, 27)	(16.8, 28)	(16.4, 29)	(16, 30)

Table A.23 Upper and lower values of fuzzy activity time required for each activity at different α-cut levels

for Case 4

Activity	θ^L	θ^U	$(T_{ij})_{\alpha=1}$	$(T_{ij})_{\alpha=0.9}$	$(T_{ij})_{\alpha=0.8}$	$(T_{ij})_{\alpha=0.7}$	$(T_{ij})_{\alpha=0.6}$	$(T_{ij})_{\alpha=0.5}$	$(T_{ij})_{\alpha=0.4}$	$(T_{ij})_{\alpha=0.3}$	$(T_{ij})_{\alpha=0.2}$	$(T_{ij})_{\alpha=0.1}$	$(T_{ij})_{\alpha=0}$
$X_{1,2}$	0.46	0.20	(20, 20)	(19.8, 20.5)	(19.6, 21)	(19.4, 21.5)	(19.2, 22)	(19, 22.5)	(18.8, 23)	(18.6, 23.5)	(18.4, 24)	(18.2, 24.5)	(18, 25)
$X_{2,3}$	0.79	0.38	(10, 10)	(9.9, 10.25)	(9.8, 10.5)	(9.7, 10.75)	(9.6, 11)	(9.5, 11.25)	(9.4, 11.5)	(9.3, 11.75)	(9.2, 12)	(9.1, 12.25)	(9, 12.5)
$X_{2,4}$	1.47	1.33	(1, 1)	(0.99, 1.025)	(0.98, 1.05)	(0.97, 1.075)	(0.96, 1.1)	(0.95, 1.125)	(0.94, 1.15)	(0.93, 1.175)	(0.92, 1.2)	(0.91, 1.225)	(0.9, 1.25)
$X_{2,7}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{3,5}$	0.79	0.38	(10, 10)	(9.9, 10.25)	(9.8, 10.5)	(9.7, 10.75)	(9.6, 11)	(9.5, 11.25)	(9.4, 11.5)	(9.3, 11.75)	(9.2, 12)	(9.1, 12.25)	(9, 12.5)
$X_{4,5}$	0.32	0.13	(30, 30)	(29.7, 30.75)	(29.4, 31.5)	(29.1, 32.25)	(28.8, 33)	(28.5, 33.75)	(28.2, 34.5)	(27.9, 35.25)	(27.6, 36)	(27.3, 36.75)	(27, 37.5)
$X_{5,6}$	0.46	0.20	(20, 20)	(19.8, 20.5)	(19.6, 21)	(19.4, 21.5)	(19.2, 22)	(19, 22.5)	(18.8, 23)	(18.6, 23.5)	(18.4, 24)	(18.2, 24.5)	(18, 25)
$X_{6,11}$	0.69	0.32	(12, 12)	(11.88, 12.3)	(11.76, 12.6)	(11.64, 12.9)	(11.52, 13.2)	(11.4, 13.5)	(11.28, 13.8)	(11.16, 14.1)	(11.04, 14.4)	(10.92, 14.7)	(10.8, 15)
$X_{9,10}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{7,9}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{7,8}$	0.96	0.52	(7, 7)	(6.93, 7.175)	(6.86, 7.35)	(6.79, 7.525)	(6.72, 7.7)	(6.65, 7.875)	(6.58, 8.05)	(6.51, 8.225)	(6.44, 8.4)	(6.37, 8.575)	(6.3, 8.75)
$X_{7,11}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{10,11}$	1.28	0.93	(3, 3)	(2.97, 3.075)	(2.94, 3.15)	(2.91, 3.225)	(2.88, 3.3)	(2.85, 3.375)	(2.82, 3.45)	(2.79, 3.525)	(2.76, 3.6)	(2.73, 3.675)	(2.7, 3.75)
$X_{8,11}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{11,12}$	0.24	0.10	(40, 40)	(39.6, 41)	(39.2, 42)	(38.8, 43)	(38.4, 44)	(38, 45)	(37.6, 46)	(37.2, 47)	(36.8, 48)	(36.4, 49)	(36, 50)
$X_{12,13}$	0.59	0.26	(15, 15)	(14.85, 15.375)	(14.7, 15.75)	(14.55, 16.125)	(14.4, 16.5)	(14.25, 16.875)	(14.1, 17.25)	(13.95, 17.625)	(13.8, 18)	(13.65, 18.375)	(13.5, 18.75)
$X_{13,14}$	0.59	0.26	(15, 15)	(14.85, 15.375)	(14.7, 15.75)	(14.55, 16.125)	(14.4, 16.5)	(14.25, 16.875)	(14.1, 17.25)	(13.95, 17.625)	(13.8, 18)	(13.65, 18.375)	(13.5, 18.75)

Table A.24 Upper and lower values of fuzzy activity time required for each activity at different α-cut levels

for Case 5

Activity	θ^L	θ^U	$(T_{ij})_{\alpha=1}$	$(T_{ij})_{\alpha=0.9}$	$(T_{ij})_{\alpha=0.8}$	$(T_{ij})_{\alpha=0.7}$	$(T_{ij})_{\alpha=0.6}$	$(T_{ij})_{\alpha=0.5}$	$(T_{ij})_{\alpha=0.4}$	$(T_{ij})_{\alpha=0.3}$	$(T_{ij})_{\alpha=0.2}$	$(T_{ij})_{\alpha=0.1}$	$(T_{ij})_{\alpha=0}$
$X_{1,2}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)
$X_{2,3}$	0.24	0.10	(20, 20)	(19.6, 21)	(19.2, 22)	(18.8, 23)	(18.4, 24)	(18, 25)	(17.6, 26)	(17.2, 27)	(16.8, 28)	(16.4, 29)	(16, 30)
$X_{2,4}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{2,7}$	0.69	0.32	(6, 6)	(5.88, 6.3)	(5.76, 6.6)	(5.64, 6.9)	(5.52, 7.2)	(5.4, 7.5)	(5.28, 7.8)	(5.16, 8.1)	(5.04, 8.4)	(4.92, 8.7)	(4.8, 9)
$X_{3,5}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)
$X_{4,5}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{5,6}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)
$X_{6,11}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)
$X_{9,10}$	0.62	0.28	(7, 7)	(6.86, 7.35)	(6.72, 7.7)	(6.58, 8.05)	(6.44, 8.4)	(6.3, 8.75)	(6.16, 9.1)	(6.02, 9.45)	(5.88, 9.8)	(5.74, 10.15)	(5.6, 10.5)
$X_{7,9}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)
$X_{7,8}$	0.62	0.28	(7, 7)	(6.86, 7.35)	(6.72, 7.7)	(6.58, 8.05)	(6.44, 8.4)	(6.3, 8.75)	(6.16, 9.1)	(6.02, 9.45)	(5.88, 9.8)	(5.74, 10.15)	(5.6, 10.5)
$X_{7,11}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{10,11}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{8,11}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{11,12}$	0.24	0.10	(20, 20)	(19.6, 21)	(19.2, 22)	(18.8, 23)	(18.4, 24)	(18, 25)	(17.6, 26)	(17.2, 27)	(16.8, 28)	(16.4, 29)	(16, 30)
$X_{12,13}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{13,14}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)

Table A.25 Upper and lower values of fuzzy activity time required for each activity at different α-cut levels

for Case 6

Activity	θ^L	θ^U	$(T_{ij})_{\alpha=1}$	$(T_{ij})_{\alpha=0.9}$	$(T_{ij})_{\alpha=0.8}$	$(T_{ij})_{\alpha=0.7}$	$(T_{ij})_{\alpha=0.6}$	$(T_{ij})_{\alpha=0.5}$	$(T_{ij})_{\alpha=0.4}$	$(T_{ij})_{\alpha=0.3}$	$(T_{ij})_{\alpha=0.2}$	$(T_{ij})_{\alpha=0.1}$	$(T_{ij})_{\alpha=0}$
$X_{1,2}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{2,3}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{2,4}$	1.47	1.33	(0.5, 0.5)	(0.49, 0.525)	(0.48, 0.55)	(0.47, 0.575)	(0.46, 0.6)	(0.45, 0.625)	(0.44, 0.65)	(0.43, 0.675)	(0.42, 0.7)	(0.41, 0.725)	(0.4, 0.75)
$X_{2,7}$	1.19	0.79	(2, 2)	(1.96, 2.1)	(1.92, 2.2)	(1.88, 2.3)	(1.84, 2.4)	(1.8, 2.5)	(1.76, 2.6)	(1.72, 2.7)	(1.68, 2.8)	(1.64, 2.9)	(1.6, 3)
$X_{3,5}$	1.19	0.79	(2, 2)	(1.96, 2.1)	(1.92, 2.2)	(1.88, 2.3)	(1.84, 2.4)	(1.8, 2.5)	(1.76, 2.6)	(1.72, 2.7)	(1.68, 2.8)	(1.64, 2.9)	(1.6, 3)
$X_{4,5}$	1.28	0.93	(1.5, 1.5)	(1.47, 1.575)	(1.44, 1.65)	(1.41, 1.725)	(1.38, 1.8)	(1.35, 1.875)	(1.32, 1.95)	(1.29, 2.025)	(1.26, 2.1)	(1.23, 2.175)	(1.2, 2.25)
$X_{5,6}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{6,11}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{9,10}$	1.19	0.79	(2, 2)	(1.96, 2.1)	(1.92, 2.2)	(1.88, 2.3)	(1.84, 2.4)	(1.8, 2.5)	(1.76, 2.6)	(1.72, 2.7)	(1.68, 2.8)	(1.64, 2.9)	(1.6, 3)
$X_{7,9}$	1.19	0.79	(2, 2)	(1.96, 2.1)	(1.92, 2.2)	(1.88, 2.3)	(1.84, 2.4)	(1.8, 2.5)	(1.76, 2.6)	(1.72, 2.7)	(1.68, 2.8)	(1.64, 2.9)	(1.6, 3)
$X_{7,8}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{7,11}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{10,11}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{8,11}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{11,12}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{12,13}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{13,14}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)

Table A.26 Upper and lower values of fuzzy activity time required for each activity at different α-cut levels

for Case 7

Activity	θ^L	θ^U	$(T_{ij})_{\alpha=1}$	$(T_{ij})_{\alpha=0.9}$	$(T_{ij})_{\alpha=0.8}$	$(T_{ij})_{\alpha=0.7}$	$(T_{ij})_{\alpha=0.6}$	$(T_{ij})_{\alpha=0.5}$	$(T_{ij})_{\alpha=0.4}$	$(T_{ij})_{\alpha=0.3}$	$(T_{ij})_{\alpha=0.2}$	$(T_{ij})_{\alpha=0.1}$	$(T_{ij})_{\alpha=0}$
$X_{1,2}$	0.90	0.46	(8, 8)	(10, 10)	(1, 1)	(5, 5)	(10, 10)	(15, 15)	(15, 15)	(10, 10)	(5, 5)	(5, 5)	(5, 5)
$X_{2,3}$	0.79	0.38	(7.92, 8.2)	(9.9, 10.25)	(0.99, 1.025)	(4.95, 5.125)	(9.9, 10.25)	(14.85, 15.375)	(14.85, 15.375)	(9.9, 10.25)	(4.95, 5.125)	(4.95, 5.125)	(4.95, 5.125)
$X_{2,4}$	1.47	1.33	(7.84, 8.4)	(9.8, 10.5)	(0.98, 1.05)	(4.9, 5.25)	(9.8, 10.5)	(14.7, 15.75)	(14.7, 15.75)	(9.8, 10.5)	(4.9, 5.25)	(4.9, 5.25)	(4.9, 5.25)
$X_{2,7}$	1.11	0.67	(7.76, 8.6)	(9.7, 10.75)	(0.97, 1.075)	(4.85, 5.375)	(9.7, 10.75)	(14.55, 16.125)	(14.55, 16.125)	(9.7, 10.75)	(4.85, 5.375)	(4.85, 5.375)	(4.85, 5.375)
$X_{3,5}$	0.79	0.38	(7.68, 8.8)	(9.6, 11)	(0.96, 1.1)	(4.8, 5.5)	(9.6, 11)	(14.4, 16.5)	(14.4, 16.5)	(9.6, 11)	(4.8, 5.5)	(4.8, 5.5)	(4.8, 5.5)
$X_{4,5}$	0.59	0.26	(7.6, 9)	(9.5, 11.25)	(0.95, 1.125)	(4.75, 5.625)	(9.5, 11.25)	(14.25, 16.875)	(14.25, 16.875)	(9.5, 11.25)	(4.75, 5.625)	(4.75, 5.625)	(4.75, 5.625)
$X_{5,6}$	0.59	0.26	(7.52, 9.2)	(9.4, 11.5)	(0.94, 1.15)	(4.7, 5.75)	(9.4, 11.5)	(14.1, 17.25)	(14.1, 17.25)	(9.4, 11.5)	(4.7, 5.75)	(4.7, 5.75)	(4.7, 5.75)
$X_{6,11}$	0.79	0.38	(7.44, 9.4)	(9.3, 11.75)	(0.93, 1.175)	(4.65, 5.875)	(9.3, 11.75)	(13.95, 17.625)	(13.95, 17.625)	(9.3, 11.75)	(4.65, 5.875)	(4.65, 5.875)	(4.65, 5.875)
$X_{9,10}$	1.11	0.67	(7.36, 9.6)	(9.2, 12)	(0.92, 1.2)	(4.6, 6)	(9.2, 12)	(13.8, 18)	(13.8, 18)	(9.2, 12)	(4.6, 6)	(4.6, 6)	(4.6, 6)
$X_{7,9}$	1.11	0.67	(7.28, 9.8)	(9.1, 12.25)	(0.91, 1.225)	(4.55, 6.125)	(9.1, 12.25)	(13.65, 18.375)	(13.65, 18.375)	(9.1, 12.25)	(4.55, 6.125)	(4.55, 6.125)	(4.55, 6.125)
$X_{7,8}$	1.11	0.67	(7.2, 10)	(9, 12.5)	(0.9, 1.25)	(4.5, 6.25)	(9, 12.5)	(13.5, 18.75)	(13.5, 18.75)	(9, 12.5)	(4.5, 6.25)	(4.5, 6.25)	(4.5, 6.25)
$X_{7,11}$	1.11	0.67	(8, 8)	(10, 10)	(1, 1)	(5, 5)	(10, 10)	(15, 15)	(15, 15)	(10, 10)	(5, 5)	(5, 5)	(5, 5)
$X_{10,11}$	1.28	0.93	(7.92, 8.2)	(9.9, 10.25)	(0.99, 1.025)	(4.95, 5.125)	(9.9, 10.25)	(14.85, 15.375)	(14.85, 15.375)	(9.9, 10.25)	(4.95, 5.125)	(4.95, 5.125)	(4.95, 5.125)
$X_{8,11}$	1.11	0.67	(7.84, 8.4)	(9.8, 10.5)	(0.98, 1.05)	(4.9, 5.25)	(9.8, 10.5)	(14.7, 15.75)	(14.7, 15.75)	(9.8, 10.5)	(4.9, 5.25)	(4.9, 5.25)	(4.9, 5.25)
$X_{11,12}$	0.32	0.13	(7.76, 8.6)	(9.7, 10.75)	(0.97, 1.075)	(4.85, 5.375)	(9.7, 10.75)	(14.55, 16.125)	(14.55, 16.125)	(9.7, 10.75)	(4.85, 5.375)	(4.85, 5.375)	(4.85, 5.375)
$X_{12,13}$	0.79	0.38	(7.68, 8.8)	(9.6, 11)	(0.96, 1.1)	(4.8, 5.5)	(9.6, 11)	(14.4, 16.5)	(14.4, 16.5)	(9.6, 11)	(4.8, 5.5)	(4.8, 5.5)	(4.8, 5.5)
$X_{13,14}$	0.59	0.26	(7.6, 9)	(9.5, 11.25)	(0.95, 1.125)	(4.75, 5.625)	(9.5, 11.25)	(14.25, 16.875)	(14.25, 16.875)	(9.5, 11.25)	(4.75, 5.625)	(4.75, 5.625)	(4.75, 5.625)

Table A.27 Upper and lower values of fuzzy activity time required for each activity at different α-cut levels

for Case 8

Activity	θ^L	θ^U	$(T_{ij})_{\alpha=1}$	$(T_{ij})_{\alpha=0.9}$	$(T_{ij})_{\alpha=0.8}$	$(T_{ij})_{\alpha=0.7}$	$(T_{ij})_{\alpha=0.6}$	$(T_{ij})_{\alpha=0.5}$	$(T_{ij})_{\alpha=0.4}$	$(T_{ij})_{\alpha=0.3}$	$(T_{ij})_{\alpha=0.2}$	$(T_{ij})_{\alpha=0.1}$	$(T_{ij})_{\alpha=0}$
$X_{1,2}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{2,3}$	0.24	0.10	(20, 20)	(19.6, 21)	(19.2, 22)	(18.8, 23)	(18.4, 24)	(18, 25)	(17.6, 26)	(17.2, 27)	(16.8, 28)	(16.4, 29)	(16, 30)
$X_{2,4}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{2,7}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{3,5}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)
$X_{4,5}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{5,6}$	0.24	0.10	(20, 20)	(19.6, 21)	(19.2, 22)	(18.8, 23)	(18.4, 24)	(18, 25)	(17.6, 26)	(17.2, 27)	(16.8, 28)	(16.4, 29)	(16, 30)
$X_{6,11}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{9,10}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{7,9}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)
$X_{7,8}$	0.62	0.28	(7, 7)	(6.86, 7.35)	(6.72, 7.7)	(6.58, 8.05)	(6.44, 8.4)	(6.3, 8.75)	(6.16, 9.1)	(6.02, 9.45)	(5.88, 9.8)	(5.74, 10.15)	(5.6, 10.5)
$X_{7,11}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{10,11}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{8,11}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{11,12}$	0.24	0.10	(20, 20)	(19.6, 21)	(19.2, 22)	(18.8, 23)	(18.4, 24)	(18, 25)	(17.6, 26)	(17.2, 27)	(16.8, 28)	(16.4, 29)	(16, 30)
$X_{12,13}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{13,14}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)

Table A.28 Upper and lower values of fuzzy activity time required for each activity at different α-cut levels

for Case 9

Activity	θ^L	θ^U	$(T_{ij})_{\alpha=1}$	$(T_{ij})_{\alpha=0.9}$	$(T_{ij})_{\alpha=0.8}$	$(T_{ij})_{\alpha=0.7}$	$(T_{ij})_{\alpha=0.6}$	$(T_{ij})_{\alpha=0.5}$	$(T_{ij})_{\alpha=0.4}$	$(T_{ij})_{\alpha=0.3}$	$(T_{ij})_{\alpha=0.2}$	$(T_{ij})_{\alpha=0.1}$	$(T_{ij})_{\alpha=0}$
$X_{1,2}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{2,3}$	1.47	1.33	(1, 1)	(0.99, 1.025)	(0.98, 1.05)	(0.97, 1.075)	(0.96, 1.1)	(0.95, 1.125)	(0.94, 1.15)	(0.93, 1.175)	(0.92, 1.2)	(0.91, 1.225)	(0.9, 1.25)
$X_{2,4}$	1.47	1.33	(1, 1)	(0.99, 1.025)	(0.98, 1.05)	(0.97, 1.075)	(0.96, 1.1)	(0.95, 1.125)	(0.94, 1.15)	(0.93, 1.175)	(0.92, 1.2)	(0.91, 1.225)	(0.9, 1.25)
$X_{2,7}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{3,5}$	1.37	1.11	(2, 2)	(1.98, 2.05)	(1.96, 2.1)	(1.94, 2.15)	(1.92, 2.2)	(1.9, 2.25)	(1.88, 2.3)	(1.86, 2.35)	(1.84, 2.4)	(1.82, 2.45)	(1.8, 2.5)
$X_{4,5}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{5,6}$	1.37	1.11	(2, 2)	(1.98, 2.05)	(1.96, 2.1)	(1.94, 2.15)	(1.92, 2.2)	(1.9, 2.25)	(1.88, 2.3)	(1.86, 2.35)	(1.84, 2.4)	(1.82, 2.45)	(1.8, 2.5)
$X_{6,11}$	0.69	0.32	(12, 12)	(11.88, 12.3)	(11.76, 12.6)	(11.64, 12.9)	(11.52, 13.2)	(11.4, 13.5)	(11.28, 13.8)	(11.16, 14.1)	(11.04, 14.4)	(10.92, 14.7)	(10.8, 15)
$X_{9,10}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{7,9}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{7,8}$	0.96	0.52	(7, 7)	(6.93, 7.175)	(6.86, 7.35)	(6.79, 7.525)	(6.72, 7.7)	(6.65, 7.875)	(6.58, 8.05)	(6.51, 8.225)	(6.44, 8.4)	(6.37, 8.575)	(6.3, 8.75)
$X_{7,11}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{10,11}$	1.28	0.93	(3, 3)	(2.97, 3.075)	(2.94, 3.15)	(2.91, 3.225)	(2.88, 3.3)	(2.85, 3.375)	(2.82, 3.45)	(2.79, 3.525)	(2.76, 3.6)	(2.73, 3.675)	(2.7, 3.75)
$X_{8,11}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{11,12}$	0.24	0.10	(40, 40)	(39.6, 41)	(39.2, 42)	(38.8, 43)	(38.4, 44)	(38, 45)	(37.6, 46)	(37.2, 47)	(36.8, 48)	(36.4, 49)	(36, 50)
$X_{12,13}$	0.59	0.26	(15, 15)	(14.85, 15.375)	(14.7, 15.75)	(14.55, 16.125)	(14.4, 16.5)	(14.25, 16.875)	(14.1, 17.25)	(13.95, 17.625)	(13.8, 18)	(13.65, 18.375)	(13.5, 18.75)
$X_{13,14}$	0.59	0.26	(15, 15)	(14.85, 15.375)	(14.7, 15.75)	(14.55, 16.125)	(14.4, 16.5)	(14.25, 16.875)	(14.1, 17.25)	(13.95, 17.625)	(13.8, 18)	(13.65, 18.375)	(13.5, 18.75)

Table A.29 Upper and lower values of fuzzy activity time required for each activity at different α-cut levels

for Case 10

Activity	θ^L	θ^U	$(T_{ij})_{\alpha=1}$	$(T_{ij})_{\alpha=0.9}$	$(T_{ij})_{\alpha=0.8}$	$(T_{ij})_{\alpha=0.7}$	$(T_{ij})_{\alpha=0.6}$	$(T_{ij})_{\alpha=0.5}$	$(T_{ij})_{\alpha=0.4}$	$(T_{ij})_{\alpha=0.3}$	$(T_{ij})_{\alpha=0.2}$	$(T_{ij})_{\alpha=0.1}$	$(T_{ij})_{\alpha=0}$
$X_{1,2}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{2,3}$	0.32	0.13	(30, 30)	(29.7, 30.75)	(29.4, 31.5)	(29.1, 32.25)	(28.8, 33)	(28.5, 33.75)	(28.2, 34.5)	(27.9, 35.25)	(27.6, 36)	(27.3, 36.75)	(27, 37.5)
$X_{2,4}$	1.47	1.33	(1, 1)	(0.99, 1.025)	(0.98, 1.05)	(0.97, 1.075)	(0.96, 1.1)	(0.95, 1.125)	(0.94, 1.15)	(0.93, 1.175)	(0.92, 1.2)	(0.91, 1.225)	(0.9, 1.25)
$X_{2,7}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{3,5}$	0.79	0.38	(10, 10)	(9.9, 10.25)	(9.8, 10.5)	(9.7, 10.75)	(9.6, 11)	(9.5, 11.25)	(9.4, 11.5)	(9.3, 11.75)	(9.2, 12)	(9.1, 12.25)	(9, 12.5)
$X_{4,5}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{5,6}$	1.37	1.11	(2, 2)	(1.98, 2.05)	(1.96, 2.1)	(1.94, 2.15)	(1.92, 2.2)	(1.9, 2.25)	(1.88, 2.3)	(1.86, 2.35)	(1.84, 2.4)	(1.82, 2.45)	(1.8, 2.5)
$X_{6,11}$	0.46	0.20	(20, 20)	(19.8, 20.5)	(19.6, 21)	(19.4, 21.5)	(19.2, 22)	(19, 22.5)	(18.8, 23)	(18.6, 23.5)	(18.4, 24)	(18.2, 24.5)	(18, 25)
$X_{9,10}$	0.79	0.38	(10, 10)	(9.9, 10.25)	(9.8, 10.5)	(9.7, 10.75)	(9.6, 11)	(9.5, 11.25)	(9.4, 11.5)	(9.3, 11.75)	(9.2, 12)	(9.1, 12.25)	(9, 12.5)
$X_{7,9}$	0.79	0.38	(10, 10)	(9.9, 10.25)	(9.8, 10.5)	(9.7, 10.75)	(9.6, 11)	(9.5, 11.25)	(9.4, 11.5)	(9.3, 11.75)	(9.2, 12)	(9.1, 12.25)	(9, 12.5)
$X_{7,8}$	0.96	0.52	(7, 7)	(6.93, 7.175)	(6.86, 7.35)	(6.79, 7.525)	(6.72, 7.7)	(6.65, 7.875)	(6.58, 8.05)	(6.51, 8.225)	(6.44, 8.4)	(6.37, 8.575)	(6.3, 8.75)
$X_{7,11}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{10,11}$	1.28	0.93	(3, 3)	(2.97, 3.075)	(2.94, 3.15)	(2.91, 3.225)	(2.88, 3.3)	(2.85, 3.375)	(2.82, 3.45)	(2.79, 3.525)	(2.76, 3.6)	(2.73, 3.675)	(2.7, 3.75)
$X_{8,11}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{11,12}$	1.11	0.67	(5, 5)	(4.95, 5.125)	(4.9, 5.25)	(4.85, 5.375)	(4.8, 5.5)	(4.75, 5.625)	(4.7, 5.75)	(4.65, 5.875)	(4.6, 6)	(4.55, 6.125)	(4.5, 6.25)
$X_{12,13}$	0.59	0.26	(15, 15)	(14.85, 15.375)	(14.7, 15.75)	(14.55, 16.125)	(14.4, 16.5)	(14.25, 16.875)	(14.1, 17.25)	(13.95, 17.625)	(13.8, 18)	(13.65, 18.375)	(13.5, 18.75)
$X_{13,14}$	0.59	0.26	(15, 15)	(14.85, 15.375)	(14.7, 15.75)	(14.55, 16.125)	(14.4, 16.5)	(14.25, 16.875)	(14.1, 17.25)	(13.95, 17.625)	(13.8, 18)	(13.65, 18.375)	(13.5, 18.75)

Table A.30 Upper and lower values of fuzzy activity time required for each activity at different α-cut levels

for Case 11

Activity	θ^L	θ^U	$(T_{ij})_{\alpha=1}$	$(T_{ij})_{\alpha=0.9}$	$(T_{ij})_{\alpha=0.8}$	$(T_{ij})_{\alpha=0.7}$	$(T_{ij})_{\alpha=0.6}$	$(T_{ij})_{\alpha=0.5}$	$(T_{ij})_{\alpha=0.4}$	$(T_{ij})_{\alpha=0.3}$	$(T_{ij})_{\alpha=0.2}$	$(T_{ij})_{\alpha=0.1}$	$(T_{ij})_{\alpha=0}$
$X_{1,2}$	0.56	0.24	(8, 8)	(7.84, 8.4)	(7.68, 8.8)	(7.52, 9.2)	(7.36, 9.6)	(7.2, 10)	(7.04, 10.4)	(6.88, 10.8)	(6.72, 11.2)	(6.56, 11.6)	(6.4, 12)
$X_{2,3}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{2,4}$	1.37	1.11	(1, 1)	(0.98, 1.05)	(0.96, 1.1)	(0.94, 1.15)	(0.92, 1.2)	(0.9, 1.25)	(0.88, 1.3)	(0.86, 1.35)	(0.84, 1.4)	(0.82, 1.45)	(0.8, 1.5)
$X_{2,7}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{3,5}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{4,5}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)
$X_{5,6}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)
$X_{6,11}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{9,10}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{7,9}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{7,8}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{7,11}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{10,11}$	1.03	0.59	(3, 3)	(2.94, 3.15)	(2.88, 3.3)	(2.82, 3.45)	(2.76, 3.6)	(2.7, 3.75)	(2.64, 3.9)	(2.58, 4.05)	(2.52, 4.2)	(2.46, 4.35)	(2.4, 4.5)
$X_{8,11}$	0.79	0.38	(5, 5)	(4.9, 5.25)	(4.8, 5.5)	(4.7, 5.75)	(4.6, 6)	(4.5, 6.25)	(4.4, 6.5)	(4.3, 6.75)	(4.2, 7)	(4.1, 7.25)	(4, 7.5)
$X_{11,12}$	0.24	0.10	(20, 20)	(19.6, 21)	(19.2, 22)	(18.8, 23)	(18.4, 24)	(18, 25)	(17.6, 26)	(17.2, 27)	(16.8, 28)	(16.4, 29)	(16, 30)
$X_{12,13}$	0.46	0.20	(10, 10)	(9.8, 10.5)	(9.6, 11)	(9.4, 11.5)	(9.2, 12)	(9, 12.5)	(8.8, 13)	(8.6, 13.5)	(8.4, 14)	(8.2, 14.5)	(8, 15)
$X_{13,14}$	0.32	0.13	(15, 15)	(14.7, 15.75)	(14.4, 16.5)	(14.1, 17.25)	(13.8, 18)	(13.5, 18.75)	(13.2, 19.5)	(12.9, 20.25)	(12.6, 21)	(12.3, 21.75)	(12, 22.5)

Table A.31 Manpower required and relevant costs for Case 2

		Risk-averse (Min)		Risk-neutral (Normal)		Risk-taking (Max)	
Cost fluctuation (%)		80%		100%		150%	
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Man-hours per day		8	8	8	8	8	
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450	
Task	**Man-days Required**	**Number of manpower required**					
		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Initial M&A project evaluation/filtration	30		4	1		1	
Legitimacy of assessment	30	2	4	1	1	1	
PM assignment	1			1			
Initial meeting	30	2	4	1	1	1	
Legitimacy confirmation	10	2		1	1		
Signing of memorandum of understanding	10	2		1		1	
Valuation	5			1	1	1	
Competitor assessment	5			1		1	
Completion of target and competitor assessment	2			1		1	
Policy formulation and evaluation	10		2	2		1	
Feasibility assessment	15		1	1		1	
Capex calculation	5			1	1	1	
Completion of feasibility and Capex assessment	3			1		1	
Revenue forecasting models	3			1	1	1	
Negotiation	30			1			
Signing of sales and purchase agreement	7	2	1	1			
Legal documentation of M&A	14	2	4	1	1		

Input Section (row label on left spanning the task rows)

Table A.32 Manpower required and relevant costs for Case 3

		Risk-averse (Min)		Risk-neutral(Normal)		Risk-taking (Max)	
Cost fluctuation (%)		80%		100%		150%	
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Man-hours per day		8	8	8	8	8	
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450	
Task	**Man-days Required**	**Number of manpower required**					
		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Initial M&A project evaluation/filtration	20		1	1		1	
Legitimacy of assessment	15	3	1	1	1	1	
PM assignment	1			1			
Initial meeting	3	2	1	1	1	1	
Legitimacy confirmation	2	2		1	1		
Signing of memorandum of understanding	5	2		1		1	
Valuation	3			1	1	1	
Competitor assessment	3					1	
Completion of target and competitor assessment	1			1		1	
Policy formulation and evaluation	4		2	2		1	
Feasibility assessment	3		1	1		1	
Capex calculation	3			1	1	1	
Completion of feasibility and Capex assessment	1			1	1	1	
Revenue forecasting models	3			1	1	1	
Negotiation	14		1	1			
Signing of sales and purchase agreement	7	2	1	1			
Legal documentation of M&A	20	2	1		1		

(Left margin label: **Input Section**)

Table A.33 Manpower required and relevant costs for Case 4

		Risk-averse (Min)		Risk-neutral(Normal)		Risk-taking (Max)	
Cost fluctuation (%)		80%		100%		150%	
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Man-hours per day		8	8	8	8	8	
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450	
Task	**Man-days Required**	**Number of manpower required**					
		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Initial M&A project evaluation/filtration	20		2	1		1	
Legitimacy of assessment	10	1	2	1		1	
PM assignment	1			1			
Initial meeting	30		2	1		1	
Legitimacy confirmation	10	1	2	1			
Signing of memorandum of understanding	20	1		1		1	
Valuation	5			1	1	1	
Competitor assessment	7			1		1	
Completion of target and competitor assessment	5			1		1	
Policy formulation and evaluation	12		2	2		1	
Feasibility assessment	5			1		1	
Capex calculation	5			1		1	
Completion of feasibility and Capex assessment	3			1		1	
Revenue forecasting models	5			1	1	1	
Negotiation	40		2	1			
Signing of sales and purchase agreement	15	1		1		1	
Legal documentation of M&A	15	1		1		1	

(Input Section)

Table A.34 Manpower required and relevant costs for Case 5

		Risk-averse (Min)		Risk-neutral(Normal)		Risk-taking (Max)	
Cost fluctuation (%)		80%		100%		150%	
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Man-hours per day		8	8	8	8	8	
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450	
Task	**Man-days Required**	**Number of manpower required**					
		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Initial M&A project evaluation/filtration	15		1	1		1	
Legitimacy of assessment	20	1	1	1		1	
PM assignment	1			1			
Initial meeting	10		1	1		1	
Legitimacy confirmation	15	1		1			
Signing of memorandum of understanding	15	1		1		1	
Valuation	6			1		1	
Competitor assessment	7			1		1	
Completion of target and competitor assessment	5			1		1	
Policy formulation and evaluation	15		1	2			
Feasibility assessment	15		1	1		1	
Capex calculation	7		1	1		1	
Completion of feasibility and Capex assessment	5			1		1	
Revenue forecasting models	5			1		1	
Negotiation	20		1	1			
Signing of sales and purchase agreement	10	1	1	1		1	
Legal documentation of M&A	15	1		1		1	

(Input Section)

Table A.35 Manpower required and relevant costs for Case 6

		Risk-averse (Min)		Risk-neutral (Normal)		Risk-taking (Max)
Cost fluctuation (%)		80%		100%		150%
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert
Man-hours per day		8	8	8	8	8
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450
Task	**Man-days Required**	**Number of manpower required**				
		Lawyer	Consultant	Project Director	Accountant	Investment Expert
Initial M&A project evaluation/filtration	3		1	1		1
Legitimacy of assessment	10	2	1	1	1	1
PM assignment	0.5			1		
Initial meeting	1.5	1	1	1	1	1
Legitimacy confirmation	2	1		1	1	
Signing of memorandum of understanding	1	1.5		1		1
Valuation	2			1	1	1
Competitor assessment	1					1
Completion of target and competitor assessment	1			1		1
Policy formulation and evaluation	1		1	1		
Feasibility assessment	2		1	1		1
Capex calculation	2				1	1
Completion of feasibility and Capex assessment	1			1		1
Revenue forecasting models	1				1	1
Negotiation	3			1		
Signing of sales and purchase agreement	3	2		1		
Legal documentation of M&A	10	2	1		1	

Input Section

Table A.36 Manpower required and relevant costs for Case 7

		Risk-averse (Min)		Risk-neutral(Normal)		Risk-taking (Max)
Cost fluctuation (%)		80%		100%		150%
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert
Man-hours per day		8	8	8	8	8
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450

		Number of manpower required				
Task	**Man-days Required**	Lawyer	Consultant	Project Director	Accountant	Investment Expert
Initial M&A project evaluation/filtration	10	1	1	1		1
Legitimacy of assessment	1			1		
PM assignment	15		1	1		1
Initial meeting	10	1	1	1		
Legitimacy confirmation	15	1		1		1
Signing of memorandum of understanding	5			1	1	1
Valuation	5			1		1
Competitor assessment	5			1		1
Completion of target and competitor assessment	10		1	2		
Policy formulation and evaluation	5			1		1
Feasibility assessment	5			1		1
Capex calculation	3			1		1
Completion of feasibility and Capex assessment	5			1	1	1
Revenue forecasting models	30		1	1		
Negotiation	10	1		1		1
Signing of sales and purchase agreement	15	1		1		1
Legal documentation of M&A	10	1	1	1		1

Input Section

Table A.37 Manpower required and relevant costs for Case 8

		Risk-averse (Min)		Risk-neutral (Normal)		Risk-taking (Max)	
Cost fluctuation (%)		80%		100%		150%	
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Man-hours per day		8	8	8	8	8	
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450	
Task	**Man-days Required**	**Number of manpower required**					
		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Initial M&A project evaluation/filtration	10		2	1		1	
Legitimacy of assessment	20	1	2	1		1	
PM assignment	1			1			
Initial meeting	3		2	1		1	
Legitimacy confirmation	15	1		1			
Signing of memorandum of understanding	20	1		1		1	
Valuation	5			1		1	
Competitor assessment	7			1		1	
Completion of target and competitor assessment	3			1		1	
Policy formulation and evaluation	10		1	2			
Feasibility assessment	15		1	1		1	
Capex calculation	5		1	1		1	
Completion of feasibility and Capex assessment	3			1		1	
Revenue forecasting models	3			1		1	
Negotiation	20		1	1			
Signing of sales and purchase agreement	10	1	1	1		1	
Legal documentation of M&A	15	1		1		1	

Input Section

Table A.38 Manpower required and relevant costs for Case 9

		Risk-averse (Min)		Risk-neutral (Normal)		Risk-taking (Max)
Cost fluctuation (%)		80%		100%		150%
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert
Man-hours per day		8	8	8	8	8
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450
Task	**Man-days Required**	**Number of manpower required**				
		Lawyer	Consultant	Project Director	Accountant	Investment Expert
Initial M&A project evaluation/filtration	5		5	1	1	1
Legitimacy of assessment	1			1		
PM assignment	1			1		
Initial meeting	5		5	1		1
Legitimacy confirmation	2	1	5	1		
Signing of memorandum of understanding	2	1		1		1
Valuation	5		3	1	1	1
Competitor assessment	7		2	1		1
Completion of target and competitor assessment	5		1	1		1
Policy formulation and evaluation	12		8	2		2
Feasibility assessment	5		3	1		1
Capex calculation	5		2	1		1
Completion of feasibility and Capex assessment	3			1		1
Revenue forecasting models	5		2	1	1	1
Negotiation	40		3	1		
Signing of sales and purchase agreement	15	1		1		1
Legal documentation of M&A	15	1		1		1

Input Section (vertical label on left of task rows)

Table A.39 Manpower required and relevant costs for Case 10

		Risk-averse (Min)		Risk-neutral(Normal)		Risk-taking (Max)	
Cost fluctuation (%)		80%		100%		150%	
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Man-hours per day		8	8	8	8	8	
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450	
Task	**Man-days Required**	**Number of manpower required**					
		Lawyer	Consultant	Project Director	Accountant	Investment Expert	
Initial M&A project evaluation/filtration	5		5	1	1	1	
Legitimacy of assessment	30	3		1			
PM assignment	1			1			
Initial meeting	5		5	1		1	
Legitimacy confirmation	10	2	5	1			
Signing of memorandum of understanding	2	1		1		1	
Valuation	5		3	1	1	1	
Competitor assessment	7		2	1		1	
Completion of target and competitor assessment	5		1	1		1	
Policy formulation and evaluation	20		8	2		2	
Feasibility assessment	10	1	3	1		1	
Capex calculation	10		2	1		1	
Completion of feasibility and Capex assessment	3			1		1	
Revenue forecasting models	5		2	1	1	1	
Negotiation	5		3	1			
Signing of sales and purchase agreement	15	1		1		1	
Legal documentation of M&A	15	1		1		1	

Input Section

Table A.40 Manpower required and relevant costs for Case 11

		Risk-averse (Min)		Risk-neutral (Normal)		Risk-taking (Max)
Cost fluctuation (%)		80%		100%		150%
Parties involved in M&A		Lawyer	Consultant	Project Director	Accountant	Investment Expert
Man-hours per day		8	8	8	8	8
Manpower cost (HKD/hour)		$4,000	$2,000	$2,500	$400	$450
Task	**Man-days Required**	**Number of manpower required**				
		Lawyer	Consultant	Project Director	Accountant	Investment Expert
Initial M&A project evaluation/filtration	8			1		1
Legitimacy of assessment	10	1		1		1
PM assignment	1			1		
Initial meeting	15			1		1
Legitimacy confirmation	10	1		1		
Signing of memorandum of understanding	15	1		1		1
Valuation	5			1		1
Competitor assessment	5			1		1
Completion of target and competitor assessment	5			1		1
Policy formulation and evaluation	10			2		1
Feasibility assessment	5			1		1
Capex calculation	5			1		1
Completion of feasibility and Capex assessment	3			1		1
Revenue forecasting models	5			1		1
Negotiation	20			1		
Signing of sales and purchase agreement	10	1		1		1
Legal documentation of M&A	15	1		1		1

Input Section

Table A.41 Simulation section for the manpower cost analysis for Case 2

	Task	Time required (Days)				Operation Cost (HKD)			
		MIN	Most likely	MAX	Risk Pert	MIN	Most likely	MAX	Risk Pert
	Initial M&A project evaluation/filtration	24	30	45	31.5	2,102,400	2,628,000	3,942,000	2,759,400
	Legitimacy of assessment	24	30	45	31.5	3,715,200	4,644,000	6,966,000	4,876,200
	PM assignment	0.8	1	1.5	1.05	16,000	20,000	30,000	21,000
	Initial meeting	24	30	45	31.5	3,715,200	4,644,000	6,966,000	4,876,200
	Legitimacy confirmation	8	10	15	10.5	697,600	872,000	1,308,000	915,600
	Signing of memorandum of understanding	8	10	15	10.5	700,800	876,000	1,314,000	919,800
	Valuation	4	5	7.5	5.25	107,200	134,000	201,000	140,700
	Competitor assessment	4	5	7.5	5.25	94,400	118,000	177,000	123,900
	Completion of target and competitor assessment	1.6	2	3	2.1	37,760	47,200	70,800	49,560
	Policy formulation and evaluation	8	10	15	10.5	604,800	756,000	1,134,000	793,800
	Feasibility assessment	12	15	22.5	15.75	475,200	594,000	891,000	623,700
	Capex calculation	4	5	7.5	5.25	107,200	134,000	201,000	140,700
Simulation Section	Completion of feasibility and Capex assessment	2.4	3	4.5	3.15	56,640	70,800	106,200	74,340
	Revenue forecasting models	2.4	3	4.5	3.15	64,320	80,400	120,600	84,420
	Negotiation	24	30	45	31.5	480,000	600,000	900,000	630,000
	Signing of sales and purchase agreement	5.6	7	10.5	7.35	560,000	700,000	1,050,000	735,000
	Legal documentation of M&A	11.2	14	21	14.7	1,693,440	2,116,800	3,175,200	2,222,640

Table A.42 Simulation section for the manpower cost analysis for Case 3

	Task	Time required (Days)				Operation Cost (HKD)			
		MIN	Most likely	MAX	Risk Pert	MIN	Most likely	MAX	Risk Pert
	Initial M&A project evaluation/filtration	16	20	30	21	633,600	792,000	1,188,000	831,600
	Legitimacy of assessment	12	15	22.5	15.75	1,665,600	2,082,000	3,123,000	2,186,100
	PM assignment	0.8	1	1.5	1.05	16,000	20,000	30,000	21,000
	Initial meeting	2.4	3	4.5	3.15	256,320	320,400	480,600	336,420
	Legitimacy confirmation	1.6	2	3	2.1	139,520	174,400	261,600	183,120
	Signing of memorandum of understanding	4	5	7.5	5.25	350,400	438,000	657,000	459,900
	Valuation	2.4	3	4.5	3.15	64,320	80,400	120,600	84,420
	Competitor assessment	2.4	3	4.5	3.15	8,640	10,800	16,200	11,340
	Completion of target and competitor assessment	0.8	1	1.5	1.05	18,880	23,600	35,400	24,780
	Policy formulation and evaluation	3.2	4	6	4.2	241,920	302,400	453,600	317,520
	Feasibility assessment	2.4	3	4.5	3.15	95,040	118,800	178,200	124,740
	Capex calculation	2.4	3	4.5	3.15	64,320	80,400	120,600	84,420
	Completion of feasibility and Capex assessment	0.8	1	1.5	1.05	21,440	26,800	40,200	28,140
Simulation Section	Revenue forecasting models	2.4	3	4.5	3.15	64,320	80,400	120,600	84,420
	Negotiation	11.2	14	21	14.7	403,200	504,000	756,000	529,200
	Signing of sales and purchase agreement	5.6	7	10.5	7.35	560,000	700,000	1,050,000	735,000
	Legal documentation of M&A	16	20	30	21	1,331,200	1,664,000	2,496,000	1,747,200

Table A.43 Simulation section for the manpower cost analysis for Case 4

		Time required (Days)				Operation Cost (HKD)			
	Task	MIN	Most likely	MAX	Risk Pert	MIN	Most likely	MAX	Risk Pert
	Initial M&A project evaluation/filtration	18	20	25	20.5	1,000,800	1,112,000	1,390,000	1,139,800
	Legitimacy of assessment	9	10	12.5	10.25	788,400	876,000	1,095,000	897,900
	PM assignment	0.9	1	1.25	1.025	18,000	20,000	25,000	20,500
	Initial meeting	27	30	37.5	30.75	1,501,200	1,668,000	2,085,000	1,709,700
	Legitimacy confirmation	9	10	12.5	10.25	756,000	840,000	1,050,000	861,000
	Signing of memorandum of understanding	18	20	25	20.5	1,000,800	1,112,000	1,390,000	1,139,800
	Valuation	4.5	5	6.25	5.125	120,600	134,000	167,500	137,350
	Competitor assessment	6.3	7	8.75	7.175	148,680	165,200	206,500	169,330
	Completion of target and competitor assessment	4.5	5	6.25	5.125	106,200	118,000	147,500	120,950
	Policy formulation and evaluation	10.8	12	15	12.3	816,480	907,200	1,134,000	929,880
	Feasibility assessment	4.5	5	6.25	5.125	106,200	118,000	147,500	120,950
	Capex calculation	4.5	5	6.25	5.125	106,200	118,000	147,500	120,950
Simulation Section	Completion of feasibility and Capex assessment	2.7	3	3.75	3.075	63,720	70,800	88,500	72,570
	Revenue forecasting models	4.5	5	6.25	5.125	120,600	134,000	167,500	137,350
	Negotiation	36	40	50	41	1,872,000	2,080,000	2,600,000	2,132,000
	Signing of sales and purchase agreement	13.5	15	18.75	15.375	750,600	834,000	1,042,500	854,850
	Legal documentation of M&A	13.5	15	18.75	15.375	750,600	834,000	1,042,500	854,850

Table A.44 Simulation section for the manpower cost analysis for Case 5

	Task	Time required (Days)				Operation Cost (HKD)			
		MIN	Most likely	MAX	Risk Pert	MIN	Most likely	MAX	Risk Pert
	Initial M&A project evaluation/filtration	12	15	22.5	15.75	475,200	594,000	891,000	623,700
	Legitimacy of assessment	16	20	30	21	1,145,600	1,432,000	2,148,000	1,503,600
	PM assignment	0.8	1	1.5	1.05	16,000	20,000	30,000	21,000
	Initial meeting	8	10	15	10.5	316,800	396,000	594,000	415,800
	Legitimacy confirmation	12	15	22.5	15.75	624,000	780,000	1,170,000	819,000
	Signing of memorandum of understanding	12	15	22.5	15.75	667,200	834,000	1,251,000	875,700
	Valuation	4.8	6	9	6.3	113,280	141,600	212,400	148,680
	Competitor assessment	5.6	7	10.5	7.35	132,160	165,200	247,800	173,460
	Completion of target and competitor assessment	4	5	7.5	5.25	94,400	118,000	177,000	123,900
	Policy formulation and evaluation	12	15	22.5	15.75	672,000	840,000	1,260,000	882,000
	Feasibility assessment	12	15	22.5	15.75	475,200	594,000	891,000	623,700
	Capex calculation	5.6	7	10.5	7.35	221,760	277,200	415,800	291,060
Simulation Section	Completion of feasibility and Capex assessment	4	5	7.5	5.25	94,400	118,000	177,000	123,900
	Revenue forecasting models	4	5	7.5	5.25	94,400	118,000	177,000	123,900
	Negotiation	16	20	30	21	576,000	720,000	1,080,000	756,000
	Signing of sales and purchase agreement	8	10	15	10.5	572,800	716,000	1,074,000	751,800
	Legal documentation of M&A	12	15	22.5	15.75	667,200	834,000	1,251,000	875,700

Table A.45 Simulation section for the manpower cost analysis for Case 6

		Time required (Days)				Operation Cost (HKD)			
	Task	MIN	Most likely	MAX	Risk Pert	MIN	Most likely	MAX	Risk Pert
Simulation Section	Initial M&A project evaluation/filtration	2.4	3	4.5	3.15	95,040	118,800	178,200	124,740
	Legitimacy of assessment	8	10	15	10.5	854,400	1,068,000	1,602,000	1,121,400
	PM assignment	0.4	0.5	0.75	0.525	8,000	10,000	15,000	10,500
	Initial meeting	1.2	1.5	2.25	1.575	89,760	112,200	168,300	117,810
	Legitimacy confirmation	1.6	2	3	2.1	88,320	110,400	165,600	115,920
	Signing of memorandum of understanding	0.8	1	1.5	1.05	57,280	71,600	107,400	75,180
	Valuation	1.6	2	3	2.1	42,880	53,600	80,400	56,280
	Competitor assessment	0.8	1	1.5	1.05	2,880	3,600	5,400	3,780
	Completion of target and competitor assessment	0.8	1	1.5	1.05	18,880	23,600	35,400	24,780
	Policy formulation and evaluation	0.8	1	1.5	1.05	28,800	36,000	54,000	37,800
	Feasibility assessment	1.6	2	3	2.1	63,360	79,200	118,800	83,160
	Capex calculation	1.6	2	3	2.1	10,880	13,600	20,400	14,280
	Completion of feasibility and Capex assessment	0.8	1	1.5	1.05	18,880	23,600	35,400	24,780
	Revenue forecasting models	0.8	1	1.5	1.05	5,440	6,800	10,200	7,140
	Negotiation	2.4	3	4.5	3.15	48,000	60,000	90,000	63,000
	Signing of sales and purchase agreement	2.4	3	4.5	3.15	201,600	252,000	378,000	264,600
	Legal documentation of M&A	8	10	15	10.5	665,600	832,000	1,248,000	873,600

Table A.46 Simulation section for the manpower cost analysis for Case 7

		Time required (Days)				Operation Cost (HKD)			
	Task	MIN	Most likely	MAX	Risk Pert	MIN	Most likely	MAX	Risk Pert
	Initial M&A project evaluation/filtration	7.2	8	10	8.2	285,120	316,800	396,000	324,720
	Legitimacy of assessment	9	10	12.5	10.25	644,400	716,000	895,000	733,900
	PM assignment	0.9	1	1.25	1.025	18,000	20,000	25,000	20,500
	Initial meeting	13.5	15	18.75	15.375	534,600	594,000	742,500	608,850
	Legitimacy confirmation	9	10	12.5	10.25	612,000	680,000	850,000	697,000
	Signing of memorandum of understanding	13.5	15	18.75	15.375	750,600	834,000	1,042,500	854,850
	Valuation	4.5	5	6.25	5.125	120,600	134,000	167,500	137,350
	Competitor assessment	4.5	5	6.25	5.125	106,200	118,000	147,500	120,950
	Completion of target and competitor assessment	4.5	5	6.25	5.125	106,200	118,000	147,500	120,950
	Policy formulation and evaluation	9	10	12.5	10.25	504,000	560,000	700,000	574,000
	Feasibility assessment	4.5	5	6.25	5.125	106,200	118,000	147,500	120,950
	Capex calculation	4.5	5	6.25	5.125	106,200	118,000	147,500	120,950
Simulation Section	Completion of feasibility and Capex assessment	2.7	3	3.75	3.075	63,720	70,800	88,500	72,570
	Revenue forecasting models	4.5	5	6.25	5.125	120,600	134,000	167,500	137,350
	Negotiation	27	30	37.5	30.75	972,000	1,080,000	1,350,000	1,107,000
	Signing of sales and purchase agreement	9	10	12.5	10.25	500,400	556,000	695,000	569,900
	Legal documentation of M&A	13.5	15	18.75	15.375	750,600	834,000	1,042,500	854,850

Table A.47 Simulation section for the manpower cost analysis for Case 8

	Task	Time required (Days)				Operation Cost (HKD)			
		MIN	Most likely	MAX	Risk Pert	MIN	Most likely	MAX	Risk Pert
	Initial M&A project evaluation/filtration	8	10	15	10.5	444,800	556,000	834,000	583,800
	Legitimacy of assessment	16	20	30	21	1,401,600	1,752,000	2,628,000	1,839,600
	PM assignment	0.8	1	1.5	1.05	16,000	20,000	30,000	21,000
	Initial meeting	2.4	3	4.5	3.15	133,440	166,800	250,200	175,140
	Legitimacy confirmation	12	15	22.5	15.75	624,000	780,000	1,170,000	819,000
	Signing of memorandum of understanding	16	20	30	21	889,600	1,112,000	1,668,000	1,167,600
	Valuation	4	5	7.5	5.25	94,400	118,000	177,000	123,900
	Competitor assessment	5.6	7	10.5	7.35	132,160	165,200	247,800	173,460
	Completion of target and competitor assessment	2.4	3	4.5	3.15	56,640	70,800	106,200	74,340
	Policy formulation and evaluation	8	10	15	10.5	448,000	560,000	840,000	588,000
	Feasibility assessment	12	15	22.5	15.75	475,200	594,000	891,000	623,700
	Capex calculation	4	5	7.5	5.25	158,400	198,000	297,000	207,900
Simulation Section	Completion of feasibility and Capex assessment	2.4	3	4.5	3.15	56,640	70,800	106,200	74,340
	Revenue forecasting models	2.4	3	4.5	3.15	56,640	70,800	106,200	74,340
	Negotiation	16	20	30	21	576,000	720,000	1,080,000	756,000
	Signing of sales and purchase agreement	8	10	15	10.5	572,800	716,000	1,074,000	751,800
	Legal documentation of M&A	12	15	22.5	15.75	667,200	834,000	1,251,000	875,700

Table A.48 Simulation section for the manpower cost analysis for Case 9

		Time required (Days)				Operation Cost (HKD)			
	Task	MIN	Most likely	MAX	Risk Pert	MIN	Most likely	MAX	Risk Pert
Simulation Section	Initial M&A project evaluation/filtration	4.5	5	6.25	5.125	480,600	534,000	667,500	547,350
	Legitimacy of assessment	0.9	1	1.25	1.025	18,000	20,000	25,000	20,500
	PM assignment	0.9	1	1.25	1.025	18,000	20,000	25,000	20,500
	Initial meeting	4.5	5	6.25	5.125	466,200	518,000	647,500	530,950
	Legitimacy confirmation	1.8	2	2.5	2.05	237,600	264,000	330,000	270,600
	Signing of memorandum of understanding	1.8	2	2.5	2.05	100,080	111,200	139,000	113,980
	Valuation	4.5	5	6.25	5.125	336,600	374,000	467,500	383,350
	Competitor assessment	6.3	7	8.75	7.175	350,280	389,200	486,500	398,930
	Completion of target and competitor assessment	4.5	5	6.25	5.125	178,200	198,000	247,500	202,950
	Policy formulation and evaluation	10.8	12	15	12.3	1,892,160	2,102,400	2,628,000	2,154,960
	Feasibility assessment	4.5	5	6.25	5.125	322,200	358,000	447,500	366,950
	Capex calculation	4.5	5	6.25	5.125	250,200	278,000	347,500	284,950
	Completion of feasibility and Capex assessment	2.7	3	3.75	3.075	63,720	70,800	88,500	72,570
	Revenue forecasting models	4.5	5	6.25	5.125	264,600	294,000	367,500	301,350
	Negotiation	36	40	50	41	2,448,000	2,720,000	3,400,000	2,788,000
	Signing of sales and purchase agreement	13.5	15	18.75	15.375	750,600	834,000	1,042,500	854,850
	Legal documentation of M&A	13.5	15	18.75	15.375	750,600	834,000	1,042,500	854,850

Table A.49 Simulation section for the manpower cost analysis for Case 10

Task	Time required (Days)				Operation Cost (HKD)			
	MIN	Most likely	MAX	Risk Pert	MIN	Most likely	MAX	Risk Pert
Initial M&A project evaluation/filtration	4.5	5	6.25	5.125	480,600	534,000	667,500	547,350
Legitimacy of assessment	27	30	37.5	30.75	3,132,000	3,480,000	4,350,000	3,567,000
PM assignment	0.9	1	1.25	1.025	18,000	20,000	25,000	20,500
Initial meeting	4.5	5	6.25	5.125	466,200	518,000	647,500	530,950
Legitimacy confirmation	9	10	12.5	10.25	1,476,000	1,640,000	2,050,000	1,681,000
Signing of memorandum of understanding	1.8	2	2.5	2.05	100,080	111,200	139,000	113,980
Valuation	4.5	5	6.25	5.125	336,600	374,000	467,500	383,350
Competitor assessment	6.3	7	8.75	7.175	350,280	389,200	486,500	398,930
Completion of target and competitor assessment	4.5	5	6.25	5.125	178,200	198,000	247,500	202,950
Policy formulation and evaluation	18	20	25	20.5	3,153,600	3,504,000	4,380,000	3,591,600
Feasibility assessment	9	10	12.5	10.25	932,400	1,036,000	1,295,000	1,061,900
Capex calculation	9	10	12.5	10.25	500,400	556,000	695,000	569,900
Completion of feasibility and Capex assessment	2.7	3	3.75	3.075	63,720	70,800	88,500	72,570
Revenue forecasting models	4.5	5	6.25	5.125	264,600	294,000	367,500	301,350
Negotiation	4.5	5	6.25	5.125	306,000	340,000	425,000	348,500
Signing of sales and purchase agreement	13.5	15	18.75	15.375	750,600	834,000	1,042,500	854,850
Legal documentation of M&A	13.5	15	18.75	15.375	750,600	834,000	1,042,500	854,850

(Note: The leftmost vertical label reads "Simulation Section")

Table A.50 Simulation section for the manpower cost analysis for Case 11

	Task	Time required (Days)				Operation Cost (HKD)			
		MIN	Most likely	MAX	Risk Pert	MIN	Most likely	MAX	Risk Pert
Simulation Section	Initial M&A project evaluation/filtration	6.4	8	12	8.4	151,040	188,800	283,200	198,240
	Legitimacy of assessment	8	10	15	10.5	444,800	556,000	834,000	583,800
	PM assignment	0.8	1	1.5	1.05	16,000	20,000	30,000	21,000
	Initial meeting	12	15	22.5	15.75	283,200	354,000	531,000	371,700
	Legitimacy confirmation	8	10	15	10.5	416,000	520,000	780,000	546,000
	Signing of memorandum of understanding	12	15	22.5	15.75	667,200	834,000	1,251,000	875,700
	Valuation	4	5	7.5	5.25	94,400	118,000	177,000	123,900
	Competitor assessment	4	5	7.5	5.25	94,400	118,000	177,000	123,900
	Completion of target and competitor assessment	4	5	7.5	5.25	94,400	118,000	177,000	123,900
	Policy formulation and evaluation	8	10	15	10.5	348,800	436,000	654,000	457,800
	Feasibility assessment	4	5	7.5	5.25	94,400	118,000	177,000	123,900
	Capex calculation	4	5	7.5	5.25	94,400	118,000	177,000	123,900
	Completion of feasibility and Capex assessment	2.4	3	4.5	3.15	56,640	70,800	106,200	74,340
	Revenue forecasting models	4	5	7.5	5.25	94,400	118,000	177,000	123,900
	Negotiation	16	20	30	21	320,000	400,000	600,000	420,000
	Signing of sales and purchase agreement	8	10	15	10.5	444,800	556,000	834,000	583,800
	Legal documentation of M&A	12	15	22.5	15.75	667,200	834,000	1,251,000	875,700