การประยุกต์ใช้สมการทางคณิตศาสตร์เพื่อหาข้อตกลงในการต่อรองจัดซื้อวัสดุ

นายราฟฟิดดิน บิน โยบ รามลิ

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
สาขาวิชาวิศวกรรมโยธา ภาควิชาวิศวกรรมโยธา
คณะวิศวกรรมศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย
ปีการศึกษา 2555

APPLICATION OF MATHEMATIC FUNCTIONS FOR IDENTIFYING THE JOINT PAY-OFF IN MATERIAL PROCUREMENT NEGOTIATION

Mr. Rafiuddin Bin Yeob Ramli

A Thesis Submitted in Partial Fulfillment of the Requirements
for the Degree of Master of Engineering Program in Civil Engineering
Department of Civil Engineering
Faculty of Engineering
Chulalongkorn University
Academic Year 2012

Thesis Title	APPLICATION OF MATHEMATIC FUNCTIONS FOR IDENTIFYING THE JOINT PAY-OFF IN MATERIAL PROCUREMENT NEGOTIATION
By	Mr. Rafiuddin Bin Yeob Ramli
Field of Study	Civil Engineering
Thesis Advisor	Assistant Professor Vachara Peansupap, Ph.D
Thesis Co-Advisor	Associate Professor Tanit Tongthong, Ph.D

Accepted by the Faculty of Engineering, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

…… Dean of the Faculty of Engineering
(Associate Professor Boonsom Lerdhirunwong, Dr. Ing.)

THESIS COMMITTEE

…….. Chairman
(Assistant Professor Noppadon Jokkaw, Ph. D)

…….……. Thesis Advisor
(Assistant Professor Vachara Peansupap, Ph.D)

…….. Thesis Co-Advisor
(Associate Professor Tanit Tongthong, Ph.D)

…….. External Examiner
(Wasaporn Techapeeraparnich, Ph.D)

ราฟฟิดดิน บิน โยบ รามลิ : การประยุกต์ใช้สมการทางคณิตศาสตร์เพื่อหาข้อตกลงในการต่อรองจัดซื้อวัสดุ. (APPLICATION OF MATHEMATIC FUNCTIONS FOR IDENTIFYING THE JOINT PAY-OFF IN MATERIAL PROCUREMENT NEGOTIATION), อ.ที่ปรึกษาวิทยานิพนธ์หลัก: ผศ.ดร.วัชระ เพียรสุภาพ, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: รศ.ดร.ธนิต ธงทอง, 272 หน้า.

การเจรจาต่อรองเป็นขั้นตอนที่สำคัญในการจัดซื้อวัสดุเพื่อให้บรรลุข้อตกลงระหว่างผู้รับเหมาและผู้จำหน่วยวัสดุ งานวิจัยในอดีตพยายามพัฒนาวิธีการเจรจาต่อรองสำหรับการจัดซื้อวัสดุก่อสร้างเช่น การใช้วิธีเชิงพันธุกรรมเพื่อคำนวณหาจุดสมดุลที่แต่ละฝ่ายยอมรับ อย่างไรก็ตามวิธีการดังกล่าวยังมีข้อจำกัดในการประยุกต์ใช้เนื่องจากกระบวนการคำนวณมีความซับซ้อนและยากต่อความเข้าใจ ในขณะที่สมการทางคณิตศาสตร์มีความง่ายต่อความเข้าใจและสามารถนำมาใช้เป็นวิธีทางเลือกหนึ่งเพื่อหาจุดสมดุลในการเจรจา นอกจากนี้การเจรจาโดยผู้ต่อรองแต่ละฝ่ายอาจมีเป้าหมายและน้ำหนักที่ต่างกันในแต่หัวข้อของการเจรจา ดังนั้นการกำหนดหัวข้อที่ใช้เจรจาและน้ำหนักความสำคัญจึงควรศึกษาและระบุไว้เป็นแนวทาง โดยวัตถุประสงค์ของงานวิจัยคือการประยุกต์ใช้สมการทางคณิตศาสตร์สำหรับคำนวณหาจุดสมดุลที่แต่ละฝ่ายยอมรับ

งานวิจัยเริ่มต้นจากการออกแบบสอบถาม และสัมภาษณ์เกี่ยวกับขั้นตอนการจัดซื้อ วัสดุที่ผู้รับเหมาจัดซื้อเอง และหัวข้อที่ใช้สำหรับการเจรจาต่อรองวัสดุในงานก่อสร้าง ผลการสัมภาษณ์ผู้ที่เกี่ยวข้องจำนวน 35 คน พบหัวข้อที่ใช้เจรจาต่อรองประกอบด้วย ราคา รูปแบบการจ่ายเงิน การจ่ายเงินล่วงหน้า ระยะเวลาการจ่ายเงิน รูปแบบในการส่งวัสดุ การให้บริการขนส่ง จากนั้นผู้วิจัยเลือกวัสดุกรณีศึกษาได้แก่ หิน ซีเมนต์ และคอนกรีตผสมเสร็จ และทำการสัมภาษณ์เชิงลึกจากผู้จำหน่ายวัสดุและผู้รับเหมาสร้าง เพื่อหาค่าถ่วงน้ำหนักของหัวข้อและสร้างสมการความสัมพันธ์ระหว่างระดับการยอมรับกับทางเลือกของแต่ละหัวข้อ เพื่อใช้เป็นสมการพื้นฐานสำหรับการหาจุดสมดุลของการเจรจาต่อรองวัสดุก่อสร้าง โดยผลการวิเคราะห์ด้วยวิธีวิเคราะห์เชิงลำดับชั้นพบว่าราคาเป็นหัวข้อที่มีค่าถ่วงน้ำหนักมากสุด ในขณะที่หัวข้อที่ใช้เจรจาต่อรองอื่น ๆ อาจมีถ่วงค่าน้ำหนักต่างกัน ขึ้นอยู่กับชนิดวัสดุ ศักยภาพของบริษัท ผลการศึกษายังพบว่าสมการทางคณิตศาสตร์สามารถนำมาใช้เพื่อคำนวณหาจุดสมดุลที่แต่ละฝ่ายยอมรับในการเจรจาจัดซื้อวัสดุ

ภาควิชา วิศวกรรมโยธา ลายมือชื่อนิสิต .....

สาขาวิชา วิศวกรรมโยธา ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก .....

ปีการศึกษา 2555 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม .....

547 05180 21: MAJOR CIVIL ENGINEERING

KEYWORDS : MATHEMATIC FUNCTIONS/ MATERIAL PROCUREMENT/ CONSTRUCTION NEGOTIATION.

RAFIUDDIN BIN YEOB RAMLI: APPLICATION OF MATHEMATIC FUNCTIONS FOR IDENTIFYING THE JOINT PAY-OFF IN MATERIAL PROCUREMENT NEGOTIATION. ADVISOR: ASST. PROF. VACHARA PEANSUPAP, Ph.D., CO-ADVISOR: ASSOC. PROF. TANIT TONGTHONG, Ph.D., 272 pp.

Negotiation is an essential process in material procurement to achieve a final agreement between contractor and supplier. Several researches attempt to improve the negotiation process of construction material procurement. For example, the use of genetic algorithm to identifying the joint pay-off that both parties agree. However, this method still has limitations due to the complexity of calculation and the difficulty of understanding. Meanwhile, the mathematical function is easy to understand and can be used as an alternative method to identify the optimum joint pay-off point. In addition, negotiation by each party may have a different target or weight on each issue. Thus, the issues for negotiation and weight of each issue should be studied and define as a guideline. This research aims to apply the mathematical functions for calculating the optimum joint pay-off that is agreed by both parties.

Research started with questionnaire design and interview on the topics related to material procurement process, material buy from contractor and issues that are used for negotiating construction material. The result of interview with 35 experts on material procurement found that six important issues for material negotiation are price, advance payment, credit term, payment period, delivery mode and freight. Then, researcher selected the three materials for conducting case study. There are aggregate stone, cement and ready-mixed concrete. Next, the data is collected from in-depth interview with contractors and suppliers for identifying weight and developing the function between the percent pay-off and options in each issue. These functions were the foundation of identifying joint pay-off for negotiating material. The resulf from analytical hierarchical process (AHP) found that price is perceived as the most important issue whereas other issues are perceived the different weight due to the material type and the ability of contractor. In addition, the result found that the mathematical functions can be used to calculate the optimum joint pay-off for negotiating construction materials.

Department : Civil Engineering Student's Signature : .....

Field of Study : Civil Engineering Advisor's Signature : .....

Academic Year : 2012 Co-advisor's Signature : .....

ACKNOWLEDGEMENTS

This dissertation would not have been possible without the guidance and the help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study. First and foremost, I would like to thank my supervisor, Assistant Professor Dr. Vachara Peansupap for his support, guidance and advice during this project. His supervision, suggestions and comments given throughout the entire project period definitely helped a lot in completing the project. His dedication and effort are much appreciated and valued.

I would like to acknowledge the financial, academic and technical support of the AUN/Seed-Net, particularly in the award of a postgraduate research scholarship that provided the necessary financial support for this research. The library facilities and computer facilities of the University, as well as the Center of Academic Resources (Central Library), have been indispensable. I also thank the Department of Construction Engineering and Management for their support and assistance since the start of my postgraduate research work.

In addition, I also want to express my deepest appreciation to my seniors, Mr. Wuttinan who are always give a lot of opinions and ideas during my research and complete my thesis report. My parents and family who are always give a support and pray for my success in my life and to complete my Master's degree study at Chulalongkorn University.

I also want to express my deepest appreciation to all my friends especially to my classmate who are also together with me doing the research work. With them, I always enjoy my research and got some helped and supported from them to share the knowledge of study. My project would have never been a success without all your continuous support. Thank you.

CONTENTS

Page

Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER I

INTRODUCTION

1.1 Background of Study

Although the construction industry is a major component to develop the Malaysia economy, the industry stills no exception to face with several problems. It is can reduce the efficiency of construction management (Ballard, Tommelein, Koskela and Howell, 2002). The construction projects are widely seen as unpredictable in terms of delivery on time, within budget and to the standards of quality expected. Construction often meets the needs of modern business that must be competitive in international market, and rarely provides best value for clients (Egan, 1998).

As a contractor and supplier in construction projects, both organizations continually examine new methods to improve their business process (Tommelein, 2004). Construction companies that buy and sell products from one another will make up a supply chain. Companies that work in a positive way are seeing the benefits for themselves and their client (Rao, 2007). Thus, supply chain is a formalized process that gives structure to these arrangements. The term of supply chain refers to a series of interdependent steps of processes as well as flows between them. It is supported by infrastructure such as people, equipment, buildings, software and etc (Tommelein, Ballard and Kaminsky, 2008). In addition, the supply chain concept is used to describe the linkage of companies that turns a series of basic materials, products or services into a finished product for the client (Rao, 2007).

In terms of construction management for services and materials supply chain, time consuming is the most common problem that is faced by project managers in material procurement. The procurement of construction material is needed by the main contractor to execute the project (Dzeng and Lin, 2004). Overall, the system involves a variety of steps starting from tender stage, contract awarded until the material has delivered to the construction site. Finally, it needs a documentation of payment (Kong, Li and Love, 2001). The main concern during procurement process is

related with the right material at the right time, and the payment method with an agreed budget. This is important in order to make sure the construction process will flow in a proper ways. The effectiveness of material procurement could affect the overall supply chain management (Sambasivan and Soon, 2007). In other words, material procurement is one of the most important aspects to lead the efficiency of the project. It is related to the negotiation process among main contractor and supplier. Commonly the negation issues related to price, terms of payment and delivery may give the contractor business leverage (Dzeng and Lin, 2004).

The negotiation process is needed in material procurement in order to get the win-win situation among parties involve. However, the process is time consuming that depends on the complexity or value of the contract (Dzeng and Lin, 2004). Thus, only selected item will be taken an apart in the negotiation process. Although time consuming problem has been solved by proceeding only selected items, this kind of solution will give more benefit to the supplier rather than the contractor. Because of the win-win situation does not exist.

1.2 Problem Statement

During the negotiation process, there are several issues that influence on the negotiation such as price, payment term, payment period, delivery, advance payment, freightage, resource provision, extended procurement option, mass procurement option and also future procurement options. Each party may have different targets on each criterion. Their targets can be represented by weight that each party has been perceived or experienced. However, the weight of each key issue in negotiation agent-based is determined by contractor or supplier's opinion without any guideline. It depends on their own benefits (Dzeng and Lin, 2004). Thus, an expert opinion in determining the weight of issues is still lacking and it is needed to be identified for getting a better negotiation result.

Several research attempts to improve the negotiation process. But it still has limitations for negotiation improvement. Most of method in identifying the best result is highly complex. For example in applying the method of Genetic Algorithm, it

involved genetic operator such as mutation and crossover to create a population of offers (Dzeng and Lin, 2004). Without a basic knowledge, it is difficult for the user to accept that method.

Moreover, the Genetic algorithm method can only easy to use if combined together with agent-based system. The reason is the genetic operators include reproduction, crossover, and mutation. Thus, agent based can help to optimize the result by analyzing all genetic operators. However, the identification of the optimum join pay-off by manual calculation is difficult to use because the current method is complex. Thus, mathematical functions such as linear and step function can be used as an alternative method to identify the optimum joint pay-off.

1.3 Research Objectives

- To understand the material procurement process in Malaysia construction industry.
- To identify the issues and weight that can be applied in material procurement negotiation.
- To apply mathematic functions for identifying joint pay-off in material procurement negotiation.

1.4 Scope of Research

The scope of research focused on the negotiation of material procurement using the mathematical function. This is important towards improvement in the current framework of material purchasing management. In general, the research limit to the construction management in civil engineering. Three main scopes in order to complete the research:

- The building construction project sector is the main area to conduct the interview
- Material procurement in the construction industry is the key design of interview questionnaire
- Negotiation issues and options involved with contractor and supplier

1.5 Research Methodology

The research involved three main tasks including review current framework (issues, option weight) in Malaysia construction industry. The method will use to involve:

- Interview the contractor and the supplier in Malaysia construction company:
  Identify the company experience in order to determine the weight of issues in material procurement negotiation.
- The case study will be the main method for conducting interviews:
  The questionnaire is developed using case study in order to get a clear traditional procurement negotiation result.
- Apply the mathematical function:
  The mathematical function is used to determine the option only benefits the contractor, the option only benefits the supplier and the option that benefit both. Finally the optimum joint pay-off will be identified.

1.6 Structure of Thesis

This thesis documents the work undertaken in the research project. There are eight chapters in this report covering all the information needed in this study. It is structured as follows:

Chapter I is an introduction of the research. The chapter of introduction describes the introduction, definition of study, problem statement, objectives and scope research

Chapter II is the details of the literature review. In this chapter, the scope included to review the previous relevant researches. The important is to explore the research gaps for conduct this research.

Chapter III explains the methodology used in this study. It gives the information on the study area as well as the procedures and methods used for this research. It also described the activities undertaken to meet the goals of each objective.

Chapter IV presents and discusses the results obtained from the experimental as described in chapter 3. This chapter is very important to show the success of the research. Chapter V, VI and VII are also same as chapter IV.

Chapter VIII is the summary of the whole research that had been carried out. Recommendations for future studies are also included.

1.7 Expected Outcome

In order to determine the success of the research, three main expected outcomes are needed to be achieved:

- The material procurement of Malaysian contractors can be understandable.
- The issues weight can be a guideline for contractor and supplier in order to start their negotiation process.
- The method can be used to select the joint pay-off in material procurement negotiation.

CHAPTER II

LITERATURE REVIEW

2.1 Supply Chain Management in Construction Industry

The significance of supply chain in the construction industry could give an impact on management and flow of works in a construction project (Zhang and Huang, 2011). The key point is the one-on-one competition among parties in construction industries are totally does not exist in today's marketplace (Tommelein, 2004). On the other hand, the main component in construction project does not involve only owner, contractor and supplier. But it also included manufacturers, shipping agents and other suppliers of goods and services. It is ranging from commodities to highly specialized made-to-order products (Benton and McHenry, 2010). In other words, the construction industries are seen to be more complex because it follows the world globalization. Without a proper management in a supply chain framework, the project could easily collapse and the effect is an occurring the unsuccessful situation.

To make more understandable on the supply chain framework, the key definition in the supply chain needs to be identified. Tommelein et al., (2008) has explained the flow of construction project resources in the supply chain management. The main project resources include products, services, information and money. In addition, demand and supply could be the key driver to clarify all the resource flows. Figure 2.1 illustrates the resources together with the flow direction.

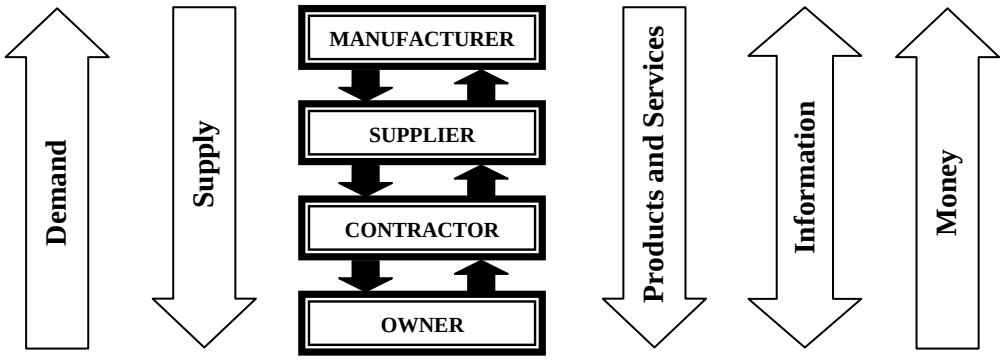


Figure 2.1: Flow of resources in a supply chain

Based on figure 2.1, products and services flow down to the bottom of the supply chain. Meanwhile, money flows opposite from product and services. The illustration means that the products will supply to the buyer after payment has been made. However, the information flows in both directions. The reason is the seller and the buyer need to discuss and negotiate in order to get an agreement from both. Next, in order to fulfill the source demand, the supply needs to go the opposite direction. But they are not always in the opposite direction. As an example, a fabricator may sell their products to a galvanizer. After that, they will make a corporation returned products into a larger assemble manufacturer. As a summary:

i- Products and services:

The products from a manufacturer will be distributed to the supplier. Then, the contractor will make a purchase order to the supplier. All material and equipment related to the construction project has been purchased by the contractor and they will send the materials to the construction site. The purchase order shows all project owner requirements.

ii- Information

To make sure the project flowing smoothly, the distribution of information must be two ways. It involved discussion and meeting among the participants. For example, negotiation is needed in order to get win-win situation. It is important to clarify the term of payment among contractor and supplier.

iii- Money

In general, the owner is the money source in construction project. After all products of material have been delivered by the supplier to the construction site, the payment will be managed by the contractor that complies with the total budget of the owner.

Thus, supply chain could define as management of the resources flows among parties that involve in the activities or processes (Tommelein, Ballard and Kaminsky, 2008). It follows the main goal of customer which is the right product delivered to the right construction site, and at the right time with the payment of the right cost. The complexity of the supply chain could be represented by the engineering expertise and management skill needed in construction project. The flow of resources in figure 2.1

involves with the main actors in construction supply chain. It is included the owner, contractor and supplier. The manufacturer is a secondary component to satisfy the owner demand in designing construction project and it could be combined together with supplier parties.

Benton and McHenry (2010) have clarified the general responsibility of the main actors in supply chain management. The owner needs to determine the purpose of a project, estimate the preliminary cost, prepare final plans together with specifications, and finally prepare notices for bid in selecting the prime contractor. Meanwhile, the role of a contractor is the selection of the material supplier during the material procurement process. Normally, it occurs after the owner awards the contract. The procurement of material should be fulfilled project time schedule. Next, the responsibility of the supplier is to supply the material and equipment to the construction site. This is important to make sure all products supply to the construction site is satisfied by the contractor.

2.1.1 Construction Supply Chain Process and Procedures

After the construction project is awarded to the main contractor, the contractor immediately awarding subcontracts and purchase orders for the various parts of the work (Daniel et al., 1998). The purchase order activities must consider all subjects such as specifications, budgetary and scheduling constraints. As an example, a superintendent wills orders concrete a day before it needed. Normally, the main office is responsible to purchase equipment and materials.

Supply chain process needs a clear communication and project integration in order to reduce adverse project events (Benton and McHenry, 2010). The reason is the project quality, budgets and time completion are needed a proper plan. For example in traditional contract an owner will discuss together with an architect to design a building. After that, the owner will create a contract with a general contractor to build that building (Daniel et al., 1998).

Next, the supply sourcing processes involve assisting the project manager with subcontracting services, bulk materials and also material requirement. The

responsibility to schedule and deliver the required materials to the project site will be done by the project manager (Benton and McHenry, 2010). Because of that, the project manager needs to have experience in management of various project categories such as bridge construction, school buildings, hospitals, etc. Usually the project manager together with the prime contractor will pre-qualify subcontractors. They try to get competitive bids based on the engineering and design specification. The effectiveness of project planning and scheduling are both the key to coordinate the supply in construction project. Figure 2.2 shows the construction transformation process. This process depends on basic criteria which are project completion on time under budget, delivering and acceptable high-quality project to the owner.

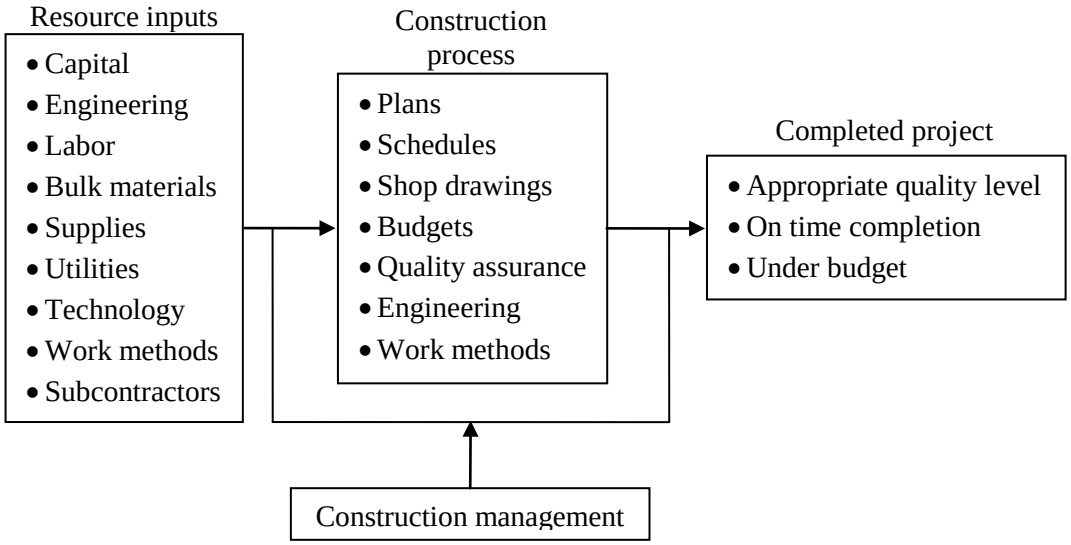


Figure 2.2: Construction transformation process (Benton and McHenry, 2010)

The objective of material procurement in construction projects is to buy material with the right quality, quantity, price from the source and at the right time. Project manager tries to get the highest quality subcontractors and materials at the lowest possible cost for their organizations (Benton and McHenry, 2010). Other than that, they also need to select the supplier by negotiating the lowest price and award a contract after agreed with the price value. This process is to ensure that the correct amount of the material is received at the appropriate time. Project managers must also be experts on the materials that they are purchased. In order to purchase services competitively and wisely, managers need to evaluate suppliers from the basis of quality, price, service support, availability and reliability. The reliability will impact

performance and profits in construction project. This can be explained by considering a supplier's delivery schedule and contractor's work plan.

i- The supplier is asked to deliver materials to meet the contractor's needs.

Figure 2.3 (a): Supplier's delivery schedule and contractor's work plan

ii- When the supplier cannot guarantee required delivery dates, the contractor may have to request earlier delivery to meet the construction schedule.

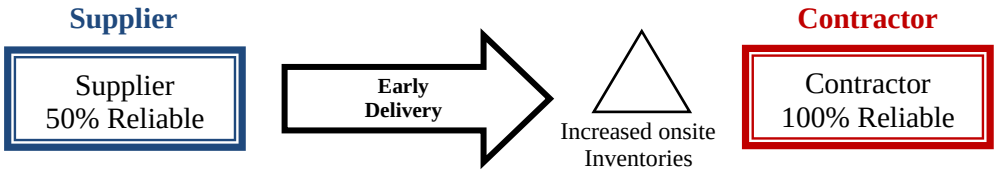


Figure 2.3 (b): Supplier's delivery schedule and contractor's work plan

Result: the on-site materials will increase finally affecting productivity and project scheduling.

iii- When the supplier can guarantee required delivery dates but the contractor does not have a reliable work plan.

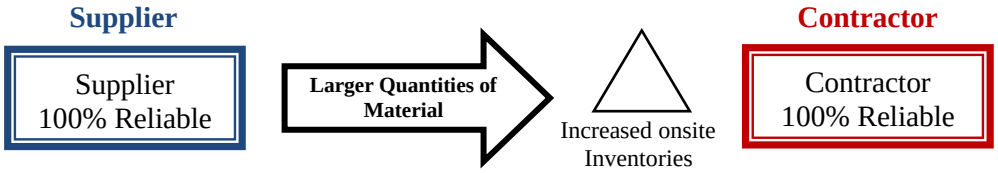


Figure 2.3 (c): Supplier's delivery schedule and contractor's work plan

Result: the contractor often requests larger quantities of materials earlier in the project.

iv- When the materials get delivered just in time and the contractor always has what is needed onsite.

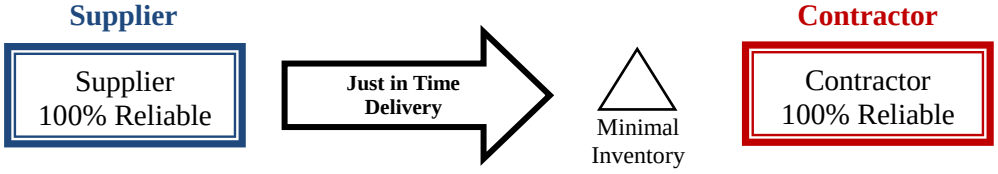


Figure 2.3 (d): Supplier's delivery schedule and contractor's work plan

Result: high reliability by all parties thus improves profits for everyone.

The example shows that the ideal scenario is 100 percent reliability from both contractor and supplier which is in the number iv (Tommelein, 2004):

2.1.2 Supply Chain Problems and Advanced Technology

The sourcing of supplier services is the most neglect element in the construction process (Benton and McHenry, 2010). When the cost of materials and subcontracting services increased, the construction management process investigates alternative methods to the planning and control of the acquisition and transformation functions in the organization. The causes of construction delays as perceived by clients can be contractor's improper planning, labor supply problem and also subcontractors problems (Sambasivan and Soon, 2007). While delays as perceived by a contractor includes contractor's poor site management, inadequate contractor experience and also equipment availability and failures. It is clearly that supply chain needs to have a good management in order to minimize delays in the construction project can be minimized.

Most of the contractors do not have their own equipments and need to rent when they required (Sambasivan and Soon, 2007). When there are many construction projects, the equipments are limited and poorly maintained by the renter. Poor materials management can result in large and avoidable costs during construction (Patel and Vyas, 2011). The main key to make a supply chain becomes more successful in the construction industry, it needed to develop and use a good technology which can help to increase profitability. Benton and McHenry, (2010) also said some construction contractors have embraced new technology and invested in technology which can drive construction systems. The reality is that technology and advanced management systems are rapidly displacing labor works. Therefore, the supply chain management needs an improvement to make sure the construction process becomes smoothly without any barriers in construction projects.

The supply chain management covers the flow of goods from supplier through manufacturing and distribution chains to the end user (Houlihan, 1987). Since there are many parties involved in a project, the communication between the parties is very

crucial for the success of the project (Sambasivan and Soon, 2007). During the planning stage, a proper communication channel between various parties must be established. Figure 2.4 shows the scope of supply chain management in a construction site.

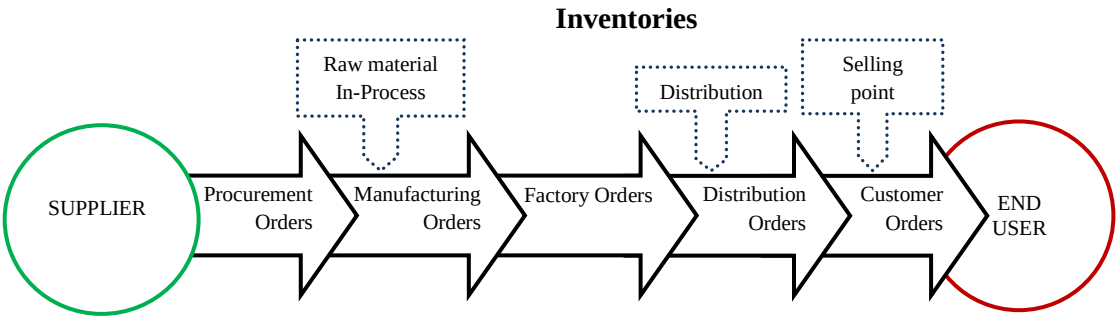


Figure 2.4: The scope of supply chain management (Houlihan, 1987)

Companies who lack of engaging in supply chain management may find themselves falling rapidly behind their supply chain conscious competitors (Benton and McHenry, 2010). To make a supply chain becomes a value chain in the construction industry, all participants must put exceptional care and effort into providing value to their direct and indirect customers and into removing waste from the project delivery system (Tommelein, 2004). In the end, the value delivered in a value chain is reflected in the profitability of all value chain participants. Because of that, barriers and problems need to reduce in order to manage supply chain becoming a value chain.

As a summary, supply chain management is one of the important aspects of the construction project. It is important in order to make sure the flow of works is smooth and reduce adverse project event. Other than that:

i- Owner, contractor and supplier are the main component involved in construction supply chain.

ii- The reliability will impact performance and profits in construction project. This can be explained by considering a supplier's delivery schedule and contractor's work plan.

iii- Supply chain management needs some new technology in order to improve current framework. With a good supply chain management, delay in a construction project can be reduced. Due to the complexity of works, current

management is depended on the engineering expertise and management skill. Therefore, the technology is required to support management in construction project.

2.2 Material Procurement in Construction

The sourcing of supplier services is the most neglect element in the construction process Material procurement is a part of supply chain management and it is needed by the main contractor to execute the project (Dzeng and Lin, 2004). The main concern during procurement process is related with the right material at the right time and the payment method with an agreed budget to make sure the construction process will flow in a proper manner (Tommelein, Ballard and Kaminsky, 2008). The effectiveness of material procurement could impact the overall installation process (Sambasivan and Soon, 2007). Thus, it is could be one of the most important aspect in contractor's resource management (Gaosheng, Ge and Hui, 2010).

The duty of material procurement is to ensure material supply can be performed at satisfied condition. Other than that, it should control the flowing of the budget including direct procurement cost (material price) and indirect procurement cost (delivery of material, storage cost and etc.). In order to manage the material procurement in construction project, the purchase order could be divided into centralize and decentralize (Wisner, Tan and Leong, 2009). The meaning of centralize purchase order is a single purchasing department. It is usually located at the firm corporate office. While decentralize purchase order is an individual purchasing department at the plant or field-office level. Both types of purchase order have their own advantages and could summarize as follow (Wisner, Tan and Leong, 2009):

A) Centralization purchase order:
   - i- *Concentrated volume:* The concentrated volume will create quantity discount and less costly volume shipment.
   - ii- *Avoid duplication:* The buyer can do a research and make a large purchase order to avoid the same material request by all construction projects.
   - iii- *Specialization:* Buyers easy to specialize in a particular group of items rather than being responsible for all purchase material.

iv- *Lower transportation cost:* Because of a large bundle of material purchase order in one delivery, cost of transportation could reduce without delivering the material many times.

v- *No competition within the unit:* Because all units will make purchase order together in a single purchase order.

vi- *Common supply base*: Can making easier to manage and negotiate contracts.

B) Decentralize purchase order

i- *Closer knowledge of requirement:* A manager in a single project is more likely to know its exact need rather than centralize the purchase order.

ii- *Local sourcing:* The local project manager will know more about the local suppliers. Thus, proximity of local suppliers allows material to be delivered more frequently in small lot sizes. Thus, this can reduce the material storage on construction sites.

iii- *Less bureaucracy:* It aloud quicker response by the supplier because of less bureaucracy and closer contact between project manager and the supplier.

2.2.1 Framework of Traditional Procurement

In traditional procurement, the process could be divided into tender stage and post-contract stage (Kong, Li and Love, 2001). Figure 2.5 shows the flow of material process in construction project. In tender stage, once the contractor received tender documents, the community in contractor organization starts on estimating and searching for a suitable supplier. It occurs before sending out inquiries to suppliers. It is important in order to get a relevant quotation before identifying the best supplier and complete the tender documents. After the tender document has been submitted, the contractor needs to wait the tendering result. If the contract is awarded, the procurement process will continue in post-contract stage; which mean the buying department will start to revise the previous supplier quotes to reconfirm the validity of the original quotation.

Normally the contractor will make a phone call to communicate with suppliers to make sure the price is still valid (Kong et al., 2004). Before an agreement is made, both parties will negotiate the price according to the quantity of material, term of

payment and material delivery (Dzeng and Lin, 2004). This kind of interaction is beneficial for both parties in order to get a win-win situation. Normally, the contractor will select based on the lowest prices (Perdomo and Tabet, 2006). However, most of the contractor will try to negotiate the price for major material in construction project. In some situation, the contractor may consider supplier with higher prices if they can provide better service based on project requirements. Typically the contractor request prices of material that was originally estimated. After a suitable supplier has been selected, the purchase order will take place in the next step. A legal contract will be made after the supplier accepts or acknowledges receipt of the order (Kong, Li and Love, 2001). The order becomes a written approval to accept and the payment will follow the terms and conditions agreement. A further step is making progress measurement until the material has delivered and material checked on site.

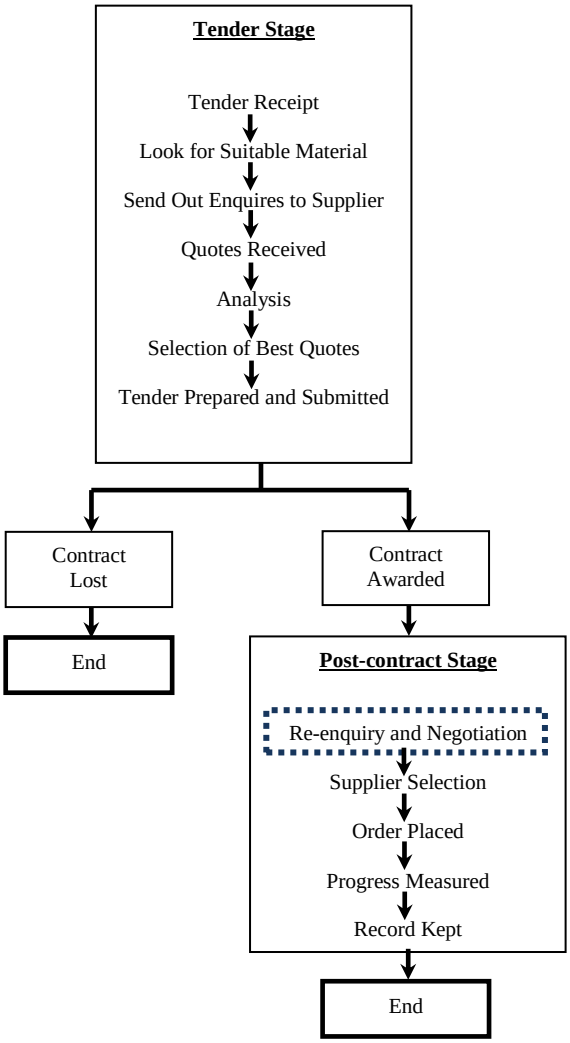


Figure 2.5: Material procurement process (Kong, Li and Love, 2001)

The quantity of material procurement at large scale project is huge. Without a proper management, it will directly affect the contractor's procurement cost control (Gaosheng, Ge and Hui, 2010). The contractor needs to communicate positively with suppliers. This is important to develop material procurement and transportation plans. Because it may reduce the probability of delay in material procurement cycles and optimizes the cost of material transportation.

2.2.2 Delay in Material Procurement

The definition of delay is situated when the act is not finished timely which is more than expected (Trauner Jr, Manginelli, Lowe, Nagata and Furniss, 2009). Delay in construction can be grouped into three types which are excusable delay, non-excusable delay and concurrent delay. It depends on the causes of delay occur.

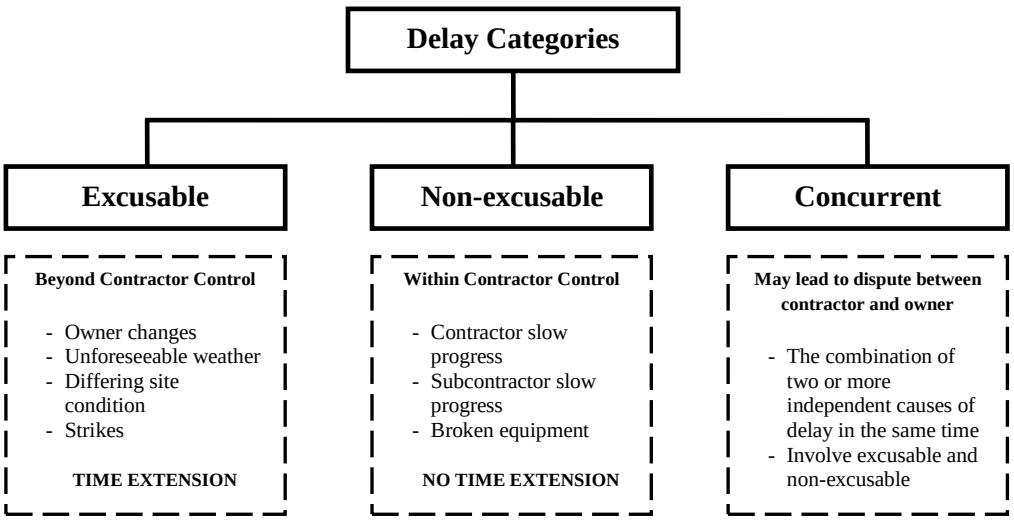


Figure 2.6: Group of delay in construction

Base on figure 2.6, delay in material procurement must be non-excusable because it happens within the contractor control (Abdullah, Rahman and Azis, 2010). If it is occurs, no time extension for the contractor to finish the work on a construction project. Table 2.1 shows the causes of procurement delay with their ranking. The survey is based on 22 highway projects in Nepal.

Table 2.1: Causes of procurement delay

Causes	Rank	Occurrence (%)
Organizational weakness	1	38.46
Supplier default	2	30.77
Government regulation	3	16.92
Transportation has delayed	4	13.85

Research done by Manavazhi and Adhikari (2002), some of delay causes in material procurement are organizational weakness, supplier default, transportation delay or government regulations. Organizational weakness and supplier default rank as top two in the list. The study revealed that most projects experienced on procurement delays and high turnover of staff in the projects. It was resulted in the loss of continuity, consequent breakdowns in the command structure and communications. Thus, a new method or technology systems is needed to identify in order to improve the communication system in both participants.

Basically, information flow in material procurement is mostly manual and numerous paper copies of documents are dominant in practice (Wang, Yang and Shen, 2007). In transferring the information from supplier to the contractor, the technology such as e-mail and fax are often used to make the negotiation process is successful. But these kind of discussion process is very time consuming and tedious. It also may reduce the production process.

Obviously, the traditional material procurement has some limitation and need a new system to improve the process (Kong et al., 2004). It is important to make sure the construction industry moves forward followed the modern business. Delay problems in construction project are a global phenomenon and difficult to avoid. However, it can be reduced by using a suitable method (Kong et al., 2004;Sambasivan and Soon, 2007). Some relevant problem in traditional material procurement can be:

i- Limitation of geographical region

The traditional procurement process can only work with suppliers within a defined geographical region to avoid delay in the purchase order process (Ruikar, Anumba and Carrillo, 2003). Only the material does not exist in the selected

region will purchase from another region. It is important to avoid delays in delivering construction material.

ii- Barriers in traditional technology

Normally, contractors use the phone to make a negotiation process and confirm the purchase order (Kong et al., 2004). This type of technology only could make one-to-one communication. Once a deal has made between both parties, the contractor will difficult to change another supplier.

iii- Time consuming

The negotiation of construction material only takes place for the complex or valuable contract (Dzeng and Lin, 2004). In order to avoid time consuming, only limited material will make a deal to negotiate. Thus, this situation could make the supplier can get more benefit than a contractor.

2.3 Negotiation in Material Procurement

Negotiation is commonly required in material procurement in order to achieve a final decision for contractual agreement between contractor and supplier (Dzeng and Lin, 2004). It is normally conducted by physical communication and sometime involved technology such as telephone, fax, and emails to reduce wasting time in the procurement process. According to certain optimizing strategies especially in the negotiation process, material procurement can be organized effectively (Zhang, 2009). Thus, the strategies must be timely and fully controled of information among parties and their real time responses. The objective of negotiation in most procurement process is to obtain the quality of product specified with a reasonable price, and also to get the supplier to perform the contract on time (Burt, Dobler and Starling, 2003). It involved some control over the manner in which contract is performed. It is also important to make a maximum cooperation between both parties. In other words, both sides must win something in order to generate a successful negotiation.

According to Bazerman (1990), the type of negotiation can be classified into two categories based on the attitude of negotiator. These are an integration (enlarging the available pie) and distribution (claiming a share of the pie). The integration negotiation creates a corporation among both organizations involved and getting

higher satisfaction level. This is because of each negotiator has different preferences according to each negotiable issue and option, the key strategy does not aim to win on all issues, but try to identify the most issues the negotiator care and make tradeoff accordingly. In practice, negotiated issues are determined during the beginning of organizations such as price. But sometimes new issues arise during the negotiation process (Dzeng and Lin, 2004). Normally, the contractor will propose an option related to the issues (example payment term and payment period) and the supplier proposes a price according the option (payment term option such as 60-day check, 45-day check or cash). For example in material procurement, the contractor and supplier collaborated with each other to maintain a reliable relationship and to achieve win-win situation. Differences with distributive negotiation, both parties will identify the bottom line of another party and finally will create lost-win situation (Bazerman, 1990). Only one of negotiator will win and give final results in a low satisfaction level. It was found that only the price issue is used during the bargaining process.

2.3.1 Negotiation Framework

To explain the negotiation framework in material procurement, Dzeng and Lin (2004) has done a research in modeling negotiation preferences.

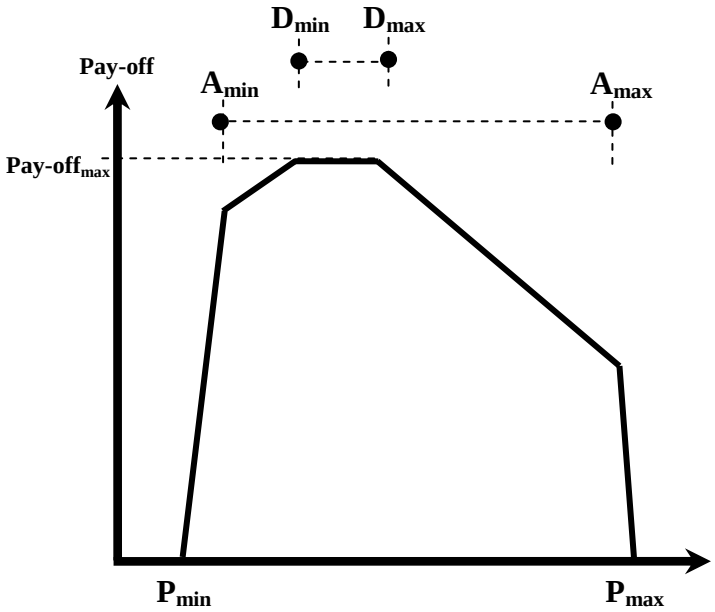


Figure 2.7: Contractor's pay-off function of price (Dzeng and Lin, 2004)

In terms of material price negotiation, contractor and supplier has their own price preference. Figure 2.7 describes the contractor preference and figure 2.8 presents the supplier preference. Contractor acceptable price range, [A_{min}, A_{max}] is considered as reasonable and willing to accept. Contractor desired price range, [D_{min}, D_{max}] falls inside the acceptable price range. To determine the suitable pay-off in the negotiation process, the contractor's pay-off level will be increased when the negotiation price for maximum value is decreased. At D_{max} (the highest desired price), contractor's pay-off is located at the highest percentage. A further decrease in negotiation price, the pay-off function will little increase until the price reaches D_{min} (the lowest desired price).

During the negotiation process, the contractor initially asks the price from suppliers within the desired range. The result of negotiation pay-off and price could be affected by various conditions such as familiarity with negotiating supplier and competition among prospective supplier. Price below D_{min} decreases the pay-off rather than increases it because the contractor starts to see the price as unreasonable and thus doubts supplier credibility. The pay-off continuously decreases with price until the price reaches the lowest acceptable price, A_{min}. Any price below than A_{min} considered as unacceptable by the contractor.

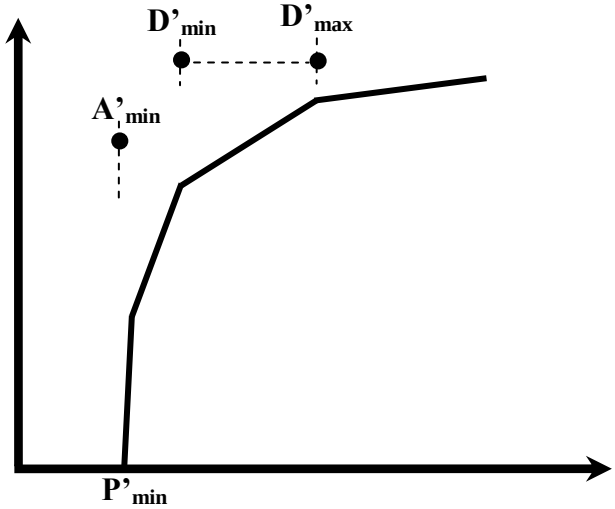


Figure 2.8: Supplier's pay-off function of price (Dzeng and Lin, 2004)

In figure 2.7, supplier also has acceptable [A'_{min}, A'_{max}] and desired [D'_{min}, D'_{max}] price range. The supplier pay-off increases with increasing price which is contrary from contractor pay-off. The highest acceptable price from a supplier is

infinity ($A'_{max} = \infty$) which is excluding the possibility of fraud on the contractor's side. Same as contractor, the range of desired price for supplier falls within the range of acceptable price.

From both graphs in figure 2.7 and 2.8, the maximum acceptable price, A'_{max} by the supplier is ranged inside the range of acceptable price by contractor, $[A_{min}, A_{max}]$. Thus, both groups can be combined together such in figure 2.9.

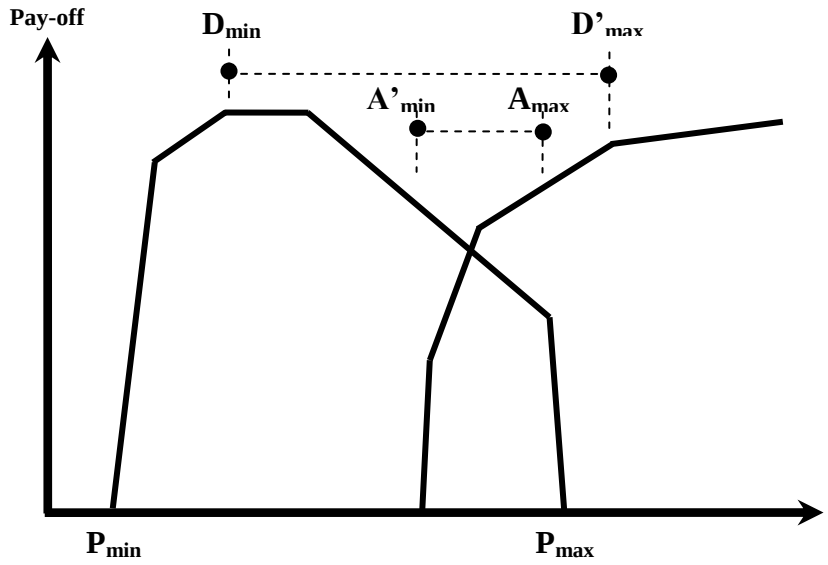


Figure 2.9: Price negotiation space (Dzeng and Lin, 2004)

$\Delta D = [D_{min}, D'_{max}]$ is the maximum possible difference between the initial asking price of the contractor and the initial offering price of the supplier. In other word, the range in ΔD is a space of starting negotiation of price. $\Delta D = [A'_{min}, A_{max}]$ is the range of acceptable price in the negotiation.

Negotiation of material also involves with other issues. The others key issues including payment term, payment period, advance payment, resource provision, freightage and delivery, the pay-off function can be explained in figure 2.10. It depends on external reason such as issue options, size of project and total period to complete the project.

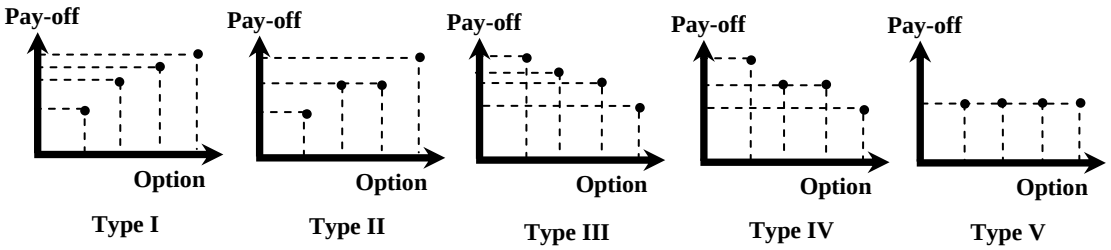


Figure 2.10: Typical pay-off function (Dzeng and Lin, 2004)

Based on figure 2.10, the pay-off function of the type I is positively correlated with options. This type of graph is normally for a longer payment term preferred by a contractor or to make sure the payment can be delayed as long as possible. Thus, pay-off for '60-day check' greater than 'cash'.

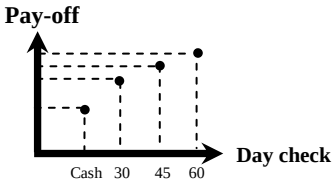


Figure 2.10 (a): Typical pay-off type I

Compared with type II, it is approximately similar with type I and shows that the pay-off function positively correlates with issue options. Only some intermediate options are remained constant. In payment term, some contractors perceive indifferent between '30-day check' and '45-day check'.

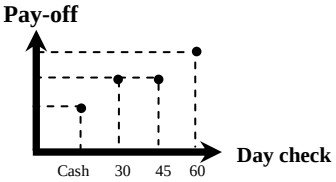


Figure 2.10 (b): Typical pay-off type II

For type III, the pay-off is oppositely correlated with type I, where the slope of type III is negative. As an example, a supplier may prefer the shorter payment term. Thus, pay-off at '60-day check' has lower than pay-off at 'cash'.

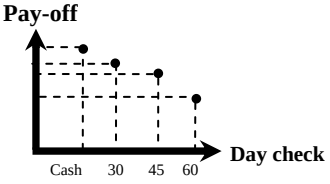


Figure 2.10 (c): Typical pay-off type III

Similarly, type IV is approximately similar with type III and shows that the pay-off function is negatively correlated with issue options. Example, some suppliers perceive indifferent between ‘30-day check’ and ‘45-day check’.

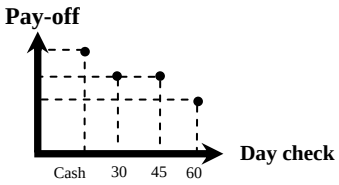


Figure 2.10 (d): Typical pay-off type IV

Type V shows that the pay-off is same between each option.

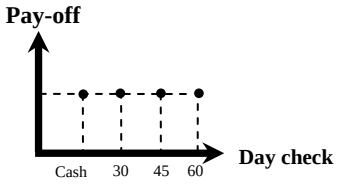


Figure 2.10 (e): Typical pay-off type V

In terms of negotiation issues for the supplier, the typical pay-off for type III or type IV has similar characteristics to the issues of payment period and delivery. Payment term, advance payment and freightage have similar characteristics to typical pay-off of type I or II. In addition typical pay-off of type IV has similar characteristics to resource provision issue. But, most of contractor pay-off with issues option is generally opposite from supplier pay-off.

Other factors may affect the pay-off function for contractor and supplier such as in payment period options. This can be ‘on delivery’, ‘on completion of milestones’, ‘on completion’, ‘monthly’ and ‘bi-weekly’. However, he function is depended on the size of the project, and period to complete the project. For payment period option, a contractor has a pay-off in type III which is preferred to have ‘on completion’ rather than other options. Because the contractor prefers to delay the payment as long as possible and make sure the level of reserved cash is maintain high, and get the high quality of work received from supplier. However, the contractor pay-off may change to type IV or V if payment is small or duration of work is short.

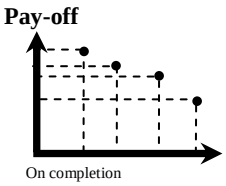


Figure 2.10 (f): Typical pay-off type III

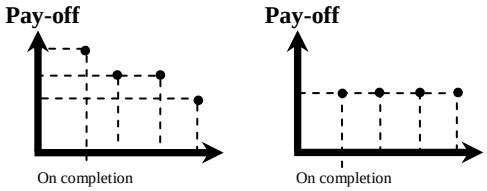


Figure 2.10 (g): Typical pay-off type IV and V

Compared to supplier pay-off, the function is oppositely correlated with a contractor pay-off. Because the contractor pay-off is type III, thus supplier pay-off normally will be type I. It means that the supplier needs to receive payment as soon as possible in order to maintain high cash reserves, and try to reduce the risk of completing the job without any payment. However, the supplier pay-off will change to type II if payment is small or duration of work is short.

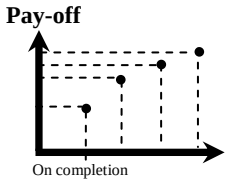


Figure 2.10 (h): Typical pay-off type I

.

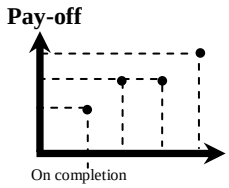


Figure 2.10 (I): Typical pay-off type II

If a supplier involves lengthy and complicated paper work, normally type III or IV will be selected as payment term. Although issues in negotiation can be opportunities such as extended, mass and future procurement, but these issues are not

considered negotiable because they mainly arise in a negotiation out of capacity leeway of a contractor and are wholly determined by the contractor.

2.3.2 The Concept of Using the Maximum Joint Pay-off in Material Negotiation

The basic concept in material negotiation is based on Bazerman (1990) in chapter 2.3. The idea is the price of material needs to negotiate between contractor and supplier in order to achieve an agreement from both parties. Basically contractor and supplier have their own desired price, (D) and acceptable price, (A). This can be shown in figure 2.11.

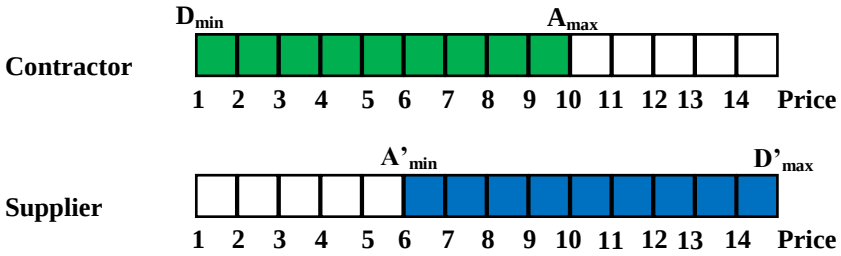


Figure 2.11: Price negotiation between contractor and supplier (Bazerman, 1990)

Desired minimum, (D_{min}) and acceptable maximum, (A_{max}) is the range of the price agreed by the contractor during the negotiation process. While acceptable minimum, (A'_{min}) and desired maximum, (D'_{max}) represent the range of the price agreed by the supplier which is contrary from the contractor. The range from [D_{min}, D'_{max}] represents the negotiation price range between both parties. If the price is higher than A_{max} or lower than A'_{min}, it is will only benefit for one side party either contractor or supplier. Thus, the price must be in the range [A'_{min}, A_{max}] to make sure the purchasing process will benefit both the contractor and the supplier. In other words, both easily to accept with that kind of price if it occurs in that range. The contractor can easier to purchase the construction material from supplier if the price issue by the contractor inside the supplier price ranges [A'_{min}, D'_{max}].

Contractor and supplier have their own percentage agreement for each option. It is placed inside the range of issues that needs to negotiate. As an example for the issue of the price (main issue needs to negotiate), both parties have few price options

could be used during the negotiation process. All options have their own percentage agreed. It depends on their perception of benefits. This can be represented by percentage pay-off based on researched by Dzeng and Lin (2004) which has been reviewed in chapter 2.3.1. High percentage pay-off means the agreed or benefit level with that option issue is high. Figure 2.12 shows the summary of the review.

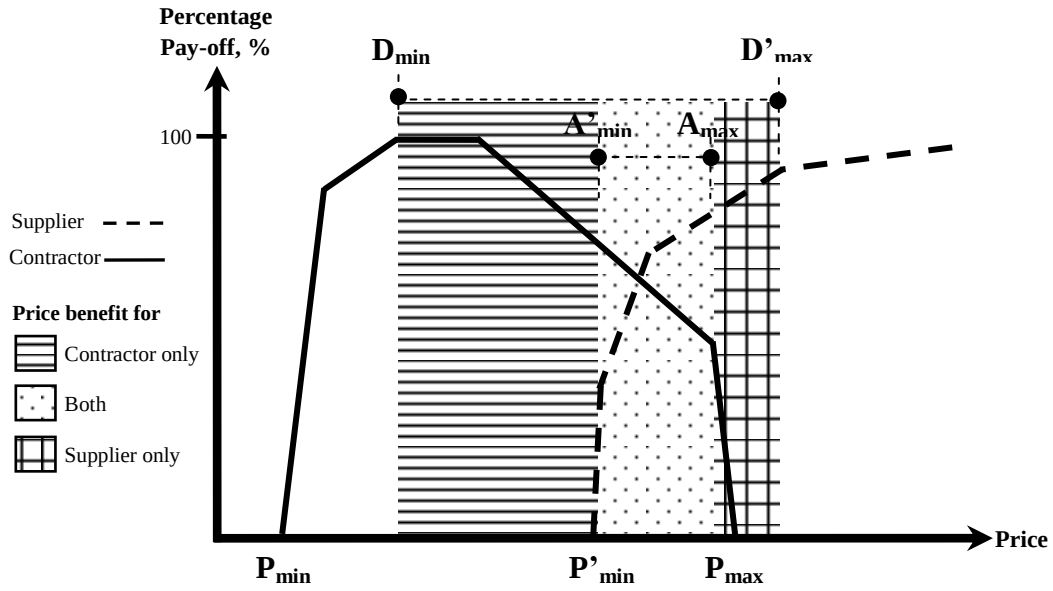


Figure 2.12: Percentage pay-off for contractor and supplier (Dzeng and Lin, 2004)

The 'dash' line represents percentage pay-off from contractor perception, while the 'straight' line is the supplier percentage pay-off. By combining both graphs together, the range of price negotiation will be inside [D_{min}, D'_{max}]. Same as figure 2.11, contractor and supplier have their own range of desired and acceptable price. However, figure 2.12 illustrates the price range details together with level of agreed price options. It is represented by percentage pay-off at y-axis.

Based on the figure 2.12, the area below combination graph can be separated into three areas. The 'line' area between [D_{min}, A'_{min}] is the price range only benefits the contractor. Next, inside [A'_{min}, A_{max}] range or 'dotted' area is the price benefit for both the contractor and the supplier. In other words, A'_{min} and A_{max} points are the started and final price that both benefits may occur. The contractor will be eased to purchase the construction material from the supplier if negotiation issues can be

benefited for both parties. If the price options take place at interception point, the level of pay-off will be same for the contractor and the supplier. Finally, the price more than A_{max} is only benefits for the supplier. It is represented by 'square' area inside [A_{max}, D'_{max}] range. The pay-off function below A'_{min} price is considered as unreasonable for the supplier. While, the pay-off function above A_{max} price is considered as an unreasonable price for contractors.

Summation of both pay-off could be used as a reference to measure the level of agreed for contractor and supplier at each option of price. The term joint pay-off is used to show the summation of both pay-off (single pay-off from contractor and supplier). In the summation of joint pay-off function, the maximum joint pay-off will represent the maximum agreed for both parties. To identify the maximum joint pay-off, normal straight line function theory can be used to explain the concept as illustrated in figure 2.12.

2.3.3 Formulating Other Issues Joint Pay-off Function

Price is not the only issue need to consider during the negotiation process. Table 2.2 is related issue need to be considered by contractor and supplier for the case study in Malaysia building construction. The issue of negotiation is based on pilot survey that has been conducted before.

Table 2.2: Issue and option involve in material procurement negotiation

Issue	Option
Advance payment	10%, 15%, 20%, 25% and 30%
Delivery	Single, multiple and on-call
Freightage	Included, excluded
Warranty	2-year, 3-year, 5-year, 7-year, 10-year and 15-year
Payment period	On delivery, on completion of milestone, on completion, monthly and bi-weekly
Payment term	60-day check, 45-day check, 30-day check and cash

For all issues in table 2.2, the percentage pay-off for each option is not a linear function. Because each option pay-off inside the issue will not linearly change from one to another option such in figure 2.13. The percentage pay-off for step function does not linearly change with the changes of each option. Each single pay-off represents each single option. As an example in figure 2.13, four options are used in

the issue of ‘term of payment’. The cash, 30-day check, 45-day check, and 60-day check options have their own value of percentage pay-off. It doesn't mean the value of 30 to 44-day checks have a percentage pay-off ‘60%-contractor, 80%-supplier’, or 45 to 59-day checks have a percentage pay-off ‘80%-contractor, 60%-supplier’.

In mathematical symbol:

Circle with white color inside ○ : Excluded

Circle with black color inside ● : Included

Based on that figure 2.13, all step functions do not include the value of other options or adjoin of single option.

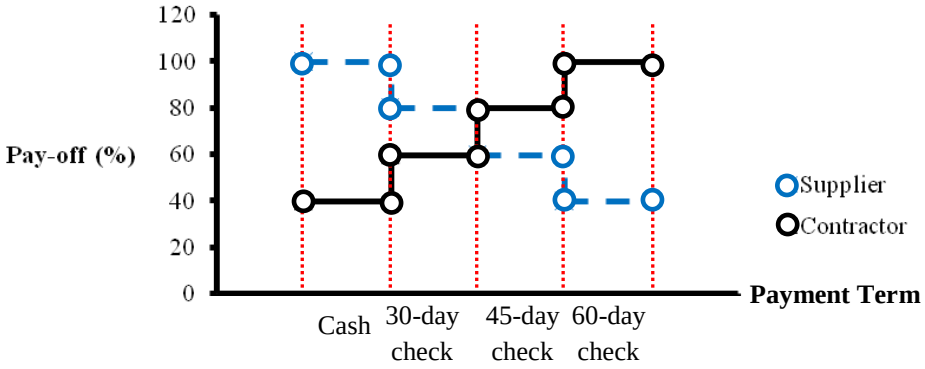


Figure 2.13: Single pay-off value reversible from each other

Table 2.3: All joint pay-off are same

Option	Cash	30-day check	45-day check	60-day check
Contractor Pay-off, %	40	60	80	100
Supplier Pay-off, %	100	80	60	40
Joint Pay-off, %	**140**	**140**	**140**	**140**

Only two shapes of graphs are possible to occur in analysis of the step function either up or down steps graph. Other than that, both single pay-off functions for all issues in table 2.3 are always contrary among each other. It depends on the type of issues and size of construction project. For the case study in Malaysia building construction, the type of project can be classified according to grade 1 until grade 7 (G1 until G7) based on the cost of projects on contractor capability.

In the case study of Malaysia construction industry, there are six issues need to consider as shown in table 2.2. However, not all issues can be benefited for single party only. The reason is the negotiation needs an agreement from both the contractor

and the supplier at the end of the process. Thus, contractor and supplier need to discuss until both will agree with all options selected in negotiation issue. The weight of single pay-off represents the significance of each negotiation issue for the parties during material procurement negotiation process.

2.4 Summary of Chapter

In summary, the negotiation process in material procurement involves a variety of issues and the issues consist of negotiation options which need to be identified by the contractor. The supplier will give their own quotation according to propose negotiation issues by the contractor. Most pay-off functions of issues from contractor and supplier perception are opposite among each other. The value depends on the proposed price by both parties. Generally, the negotiation pay-off function consists of six basic graphs. For example, the function of unit price can be separated according to contractor and supplier pay-off level. Only contractor has the maximum price while the supplier maximum price is undefined. The function and slope of the graph are depended on the external factors such as the size of the project and the total period of complete project. In selection of the best pay-off among both parties involvement, a point with the possible joint pay-off needs to identified.

CHAPTER III

METHODOLOGY

This chapter explains the methodology used in this research. It gives the information on the study area as well as the procedures and methods used. It also described the activities undertaken to meet the goals of each objective. The research can be divided into two parts including part I as pilot studies and part I apply the mathematic functions.

3.1 Research Design

In order to collect and analyze the data, the research design was divided into Part I and Part II. It is based on the research objectives in section 1.3. Figure 3.1 illustrates the flow chart of research design.

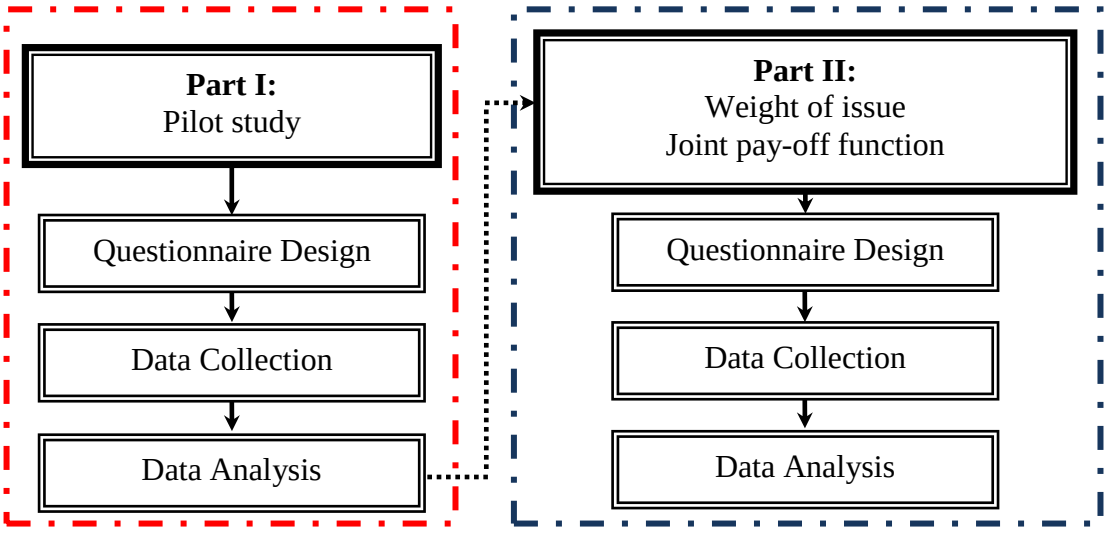


Figure 3.1: Flow chart of research design

In Part I, it involves questionnaire design, data collection and data analysis. The main objective in Part I is to identify the materials and the relevant negotiation issues involved in Malaysia construction industry. The analysis results from Part I will be used to continue the research in Part II. Same as Part I, questionnaire design, data collection and data analysis are needed in Part II. The objective is to analyze the negotiation issues by applying mathematical function. It includes linear and step function.

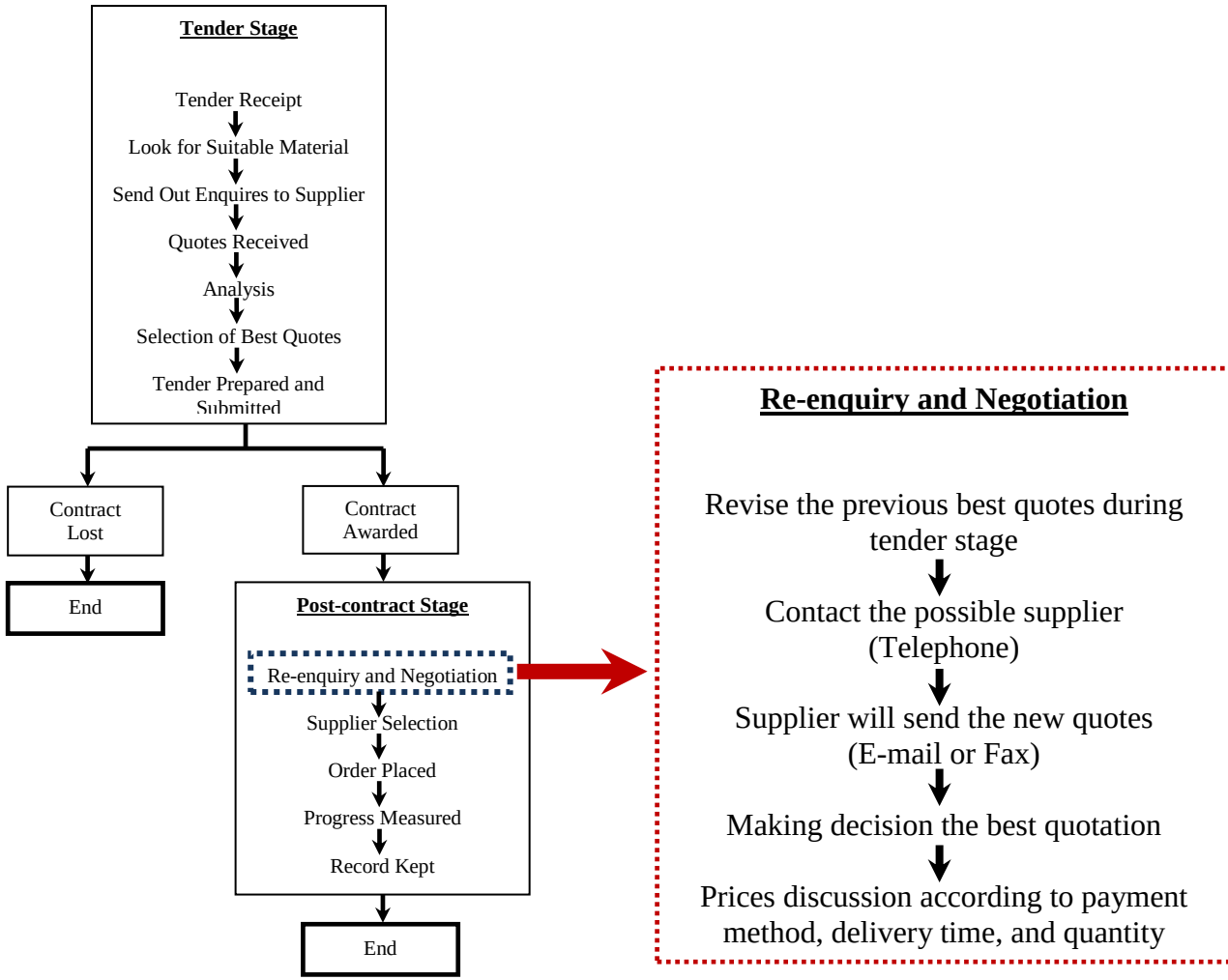


Figure 3.2: Flowchart traditional procurement and negotiation process

Figure 3.2 shows the material procurement process in construction industry. Basically, post-contract stage is only occurs if the project owner awarded the project to the main contractor. Based on figure 3.2, negotiation is a part in material procurement to get an agreement for contractor to purchase the material from a supplier. However, the most relevant option can be selected in each issue is difficult to identify. Thus, analysis by mathematical function can help the contractor and the supplier to get the most suitable option for conducting material negotiation.

3.1.1 Data Collection in Part I

Based on figure 3.1, the research in Part I is focused on identifying the current practice of negotiation process. The management of material procurement is used as a case study to analyze the traditional negotiation system. The research method used in this analysis is a case study. The data collection is applied interviewed the respondent based on the survey questionnaire. The objective of the interview is to explore and get a clear process of material procurement negotiation.

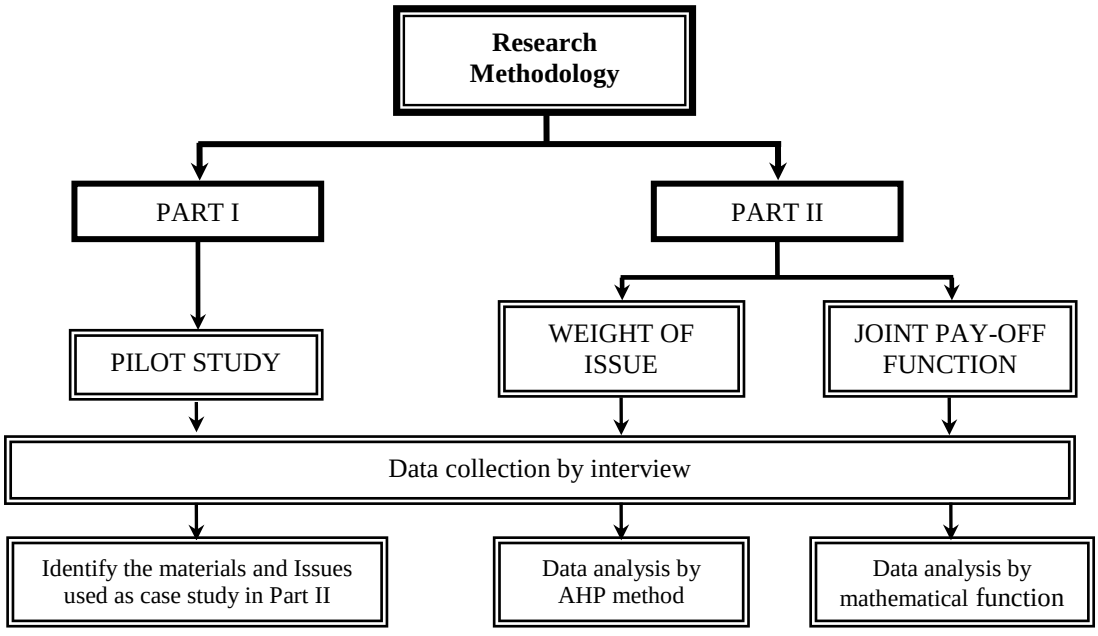


Figure 3.3: Steps and process flow chart

As a summarized in figure 3.3, the questionnaire design involves a basic review and pilot survey. It is important in order to identify the negotiation issues and options needed in procurement of material. Thus, five contractors have been interviewed as a

pilot study to get a clear framework in Malaysia construction. Next, a pilot study was conducted in order to define a relevant question. From literature review by Dzeng and Lin (2004), the options and issues have been adapted to follow the Malaysia negotiation environment. After that, the questionnaire has been developed and thirty five contractors have been interviewed to classify the type of material will be used as a case study. Based on pilot survey in Part I, only seven issues have been selected in this research. It includes the advance payment, delivery, freightage, payment period, payment term, price and warranty period. Meanwhile, three types of materials have selected based on that interview.

3.1.2 Data Collection in Part II

After the issues and the types of material involved in this case study has been determined, the Part II will be continued to identify the weight of each issue and the option of percentage pay-off. The method of Analytical Hierarchy Process, (AHP) is used to identify the weight of negotiation issue. The nine expert persons in a Malaysia procurement negotiation have been interviewed. Three types of materials are used as a focus group to analyze the joint pay-off function. It includes aggregate stone, cement and ready mix concrete. The selection of materials is based on the materials that are directly purchased by the main contractor. It is got from the pilot study in Part I. Each material has their own specification. The table 3.1 shows the details of the materials.

Table 3.1: Material specification

Material	Description	Unit
Aggregate	Granite ¾”	MT
Cement	Ordinary Portland Cement, Bulk	MT
Ready mix concrete	Normal mix, grade 35, granite	m^3

The description and unit in table 3.1 will be affected the overall selected option especially the price issue. In normal negotiation practice, price is the main issue needs to negotiate between the main contractor and the supplier. The data collection for the aggregate and the cement is based on price per metric ton, (MT) because both materials are purchased in bulk. Meanwhile, the ready mix concrete is based on price

per meter cubic, (m^3). This is to make sure that the data does not affected by the quantity of materials. But it only based on a normal quantity practice.

3.2 Analytical Hierarchical Process

Analytical hierarchical process, (AHP) is a method to determine the weight of negotiation issues. Each weight of the issue needs to identify by the contractor and the supplier before a negotiation process can be started. Method of interview among expert person (contractor and supplier) is used as a sampling data. The questionnaire is designed based on the issues in material negotiation. It includes the advance payment, delivery, freightage, payment period, payment term, and price. Although seven issues are needed to consider, however only six issues are selected. The reason is the warranty period does not a related issue during the negotiation process for aggregate stone, cement and ready mix concrete.

Table 3.2: Meaning of scale

Scale range	Importance level	Explanation
1	Equal	Two criteria contribute equally to the objective
2, 3	Moderate	Experience and judgment slightly favor one criteria over another
4, 5	Strong	Experience and judgment slightly favor one criteria over another
6, 7	Very strong	The criteria are favored very strongly over another, it's dominance demonstrated in practice

Table 3.3: Questionnaire scale

Issue	Very strong		Strong		Moderate		Equal	Moderate		Strong		Very strong		Issue
	7	6	5	4	3	2	1	2	3	4	5	6	7	
Unit price														Payment term
Unit price														Payment period
Unit price														Delivery
Unit price														Advance payment
Unit price														Freightage

In order to analyze the data, the process can be referred from Saaty (1980). The first step is state a relevant problem to be solved. Thus, the problem is to identify the level of weight for each issue in material procurement negotiation. Next, qualitative factors are determined to evaluate the result. This is important as design criteria for questionnaire interview. All factors are key issues in the negotiation process. Method of scale is used in designing questionnaires. The table 3.2 shows the meaning of each scale. While, the table 3.3 is the example of questionnaire scale will be used.

After design the questionnaire, it is distributed to the expert group to identify the issues that influence the negotiation. They need to enter pairwise comparison judgments of issues with respect to their impact on the overall objective. Then, they need to enter pairwise comparison judgment of objective with respect to all criteria.

The next step is to analyze the survey questionnaire data by setup the matrix questionnaire. The number of decision makers that judge and develop the matrix is $n(n\text{-}1)/2$, where n is the elements of $n \times n$ matrix. For matrix development, C_1, C_2, C_3, ... C_n are the set of criteria. The quantified judgments on pairs of criteria C_i, C_j are represented by a $n \times n$ matrix. $A = (a_{ij})$, $(i,j = 1, 2, 3, \ldots, n)$. The entries a_{ij} is defined by the following entry rules.

Rule 1. If $a_{ij} = a$, *then* $a_{ij} = 1/a$, $a \neq 0$.

Rule 2. If C_i is judge to set of equal relative importance as C_j, then $a_{ij} = 1$, $a_{ij} = 1$; in particular, $a_{ij} = 1$ for all i. Thus matrix A will be:

$$A = \begin{pmatrix} 1 & a_{12} & a_{13} & \ldots & a_{1n} \\ 1/a_{12} & 1 & a_{23} & \ldots & a_{2n} \\ \vdots & \vdots & \vdots & & \vdots \\ 1/a_{1n} & 1/_{2n} & a_{3n} & \ldots & 1 \end{pmatrix}$$

In order to compute the vector of priorities from the given matrix, Saaty (1980) propose four ways of calculation. In this research, Good Multiply method is used. Where, multiply the n elements in each row and take the nth root. It is used to normalize the resulting number. Finally, the weight of each issue can be identified.

3.2.1 Weight of Issue

The sum of each weight issue must be equal to 1. It reflects the percentage important of a single issue of the single party (contractor or supplier). Each party has their own weight of issue configuration. It depends on the benefit of a single issue to their company. It relies on the size, strength, facilities and even age of the company.

As an example, consider only the issue of freightage and payment term during material procurement negotiation. Some companies have high strength of cash flow and need an airplane to transport the construction material from East Malaysia to Peninsular. This kind of condition may make the weight of payment term lower than freightage issue. The detail analysis will be described in chapter 4.

3.3 Formulating Price Joint Pay-off Function

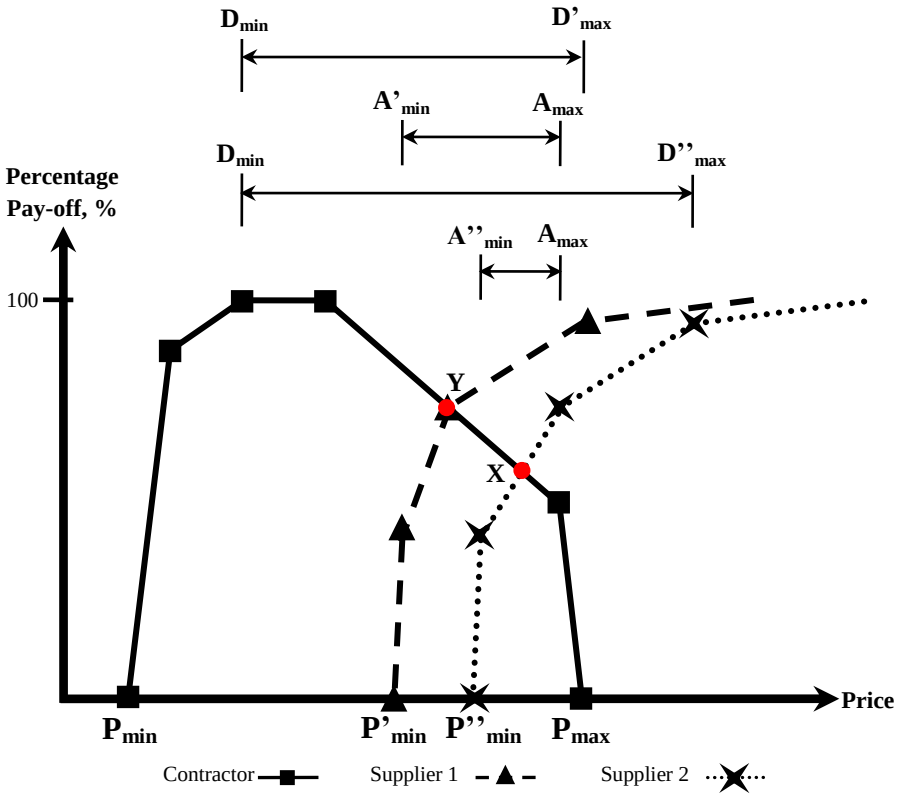


Figure 3.4: Two types of intersection cases from both pay-off

Normal straight line function $y(x) = mx + c$ is used to identify maximum price joint pay-off among contractor and supplier. The summarize cases of both single pay-

off functions can be shown in figure 3.4 which depends on the slope of the graphs. The first case is ‘two lines intersect at a same point which is point X’. The second is ‘more than three lines intersect at a same point which is point Y’.

3.3.1 Two Lines Intersect at a Same Point (Point X)

In general, the maximum joint pay-off for both parties will be determined by referred the two points at left or right joint pay-off function. The maximum joint pay-off among these two points (at most left or right hand side of the graph) depends on the value of the slope, *m* from a single pay-off function. It means that the intercept-y, *c* is not the only factor can change the coordinate of maximum joint pay-off. It is either from ‘the left change to the right’ or from ‘the right change to the left’ of the graph. However, the maximum joint pay-off does not occur at the intersection point in the case of ‘two lines intersect at the same point’.

Figure 3.5 is used as a reference graph for comparison with another figure. Figure 3.6 illustrates the effect of slope from both single pay-off functions. While, figure 3.7 shows the intercept-y that affected the joint pay-off value. Next, figure 3.8 is an example of both lines that have the same slope. In all examples, the contractor pay-off function is used as reference line and all option values (1 to 6) are constant. The intersection point will be only occurred if the slope sign (positive or negative) is different between both lines. Thus, the sign of the slope is neglected in order to identify the higher slope between both lines. There are four cases of linear intersection, which can be explained by the following graphs.

Case 1.1: Contractor slope is higher than supplier slope

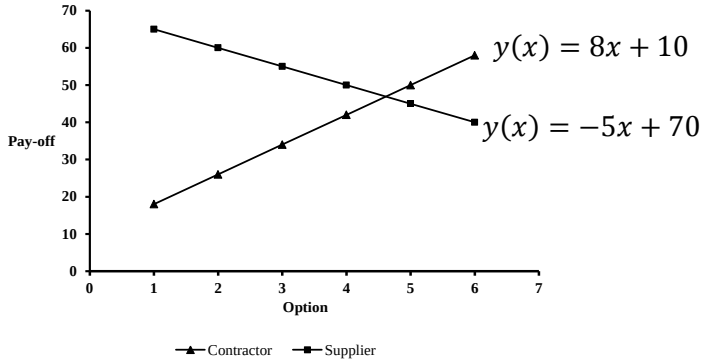


Figure 3.5: Supplier slope lower than contractor slope

Table 3.4: Supplier and contractor joint pay-off table 1

Option	1	2	3	4	5	6
Contractor Pay-off, %	18	26	34	42	50	58
Supplier Pay-off, %	65	60	55	50	45	40
Joint Pay-off, %	83	86	89	92	95	**98**

The table 3.4 show, 98% is maximum joint pay-off which occurs at the point (6, 58) and (6, 40). The maximum joint pay-off generate at the right hand side of the graph.

Case 1.2: Supplier slope higher than contractor

Comparing with case 1.1, the value of supplier slope, *m* is changed from 5 to 11. Meanwhile, the interception y-axis, *c* is constant.

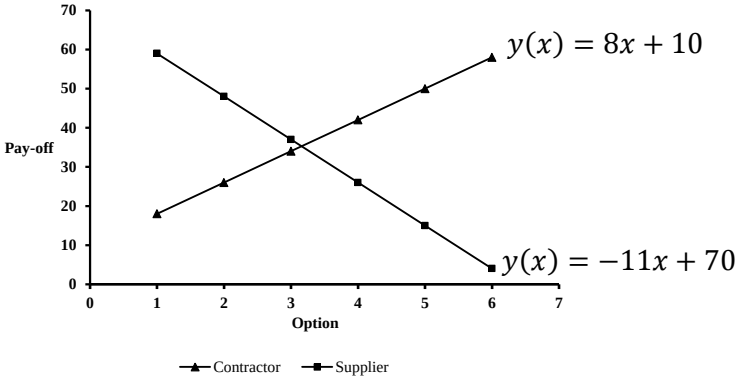


Figure 3.6: Supplier slope higher than contractor slope

Table 3.5: Supplier and contractor joint pay-off table 2

Option	1	2	3	4	5	6
Contractor Pay-off, %	18	26	34	42	50	58
Supplier Pay-off, %	59	48	37	26	15	4
Joint Pay-off, %	**77**	74	71	68	65	62

The result in table 3.5 shows the highest joint pay-off occurs at the point (1, 18) and (1, 59). Compared with figure 3.5, the maximum joint pay-off has changed to the left hand side of the graph which is 77%. Thus, the value of the slope is the main factor to change the coordinate of maximum joint pay-off from the right of the graph to the left.

As a conclusion, the maximum joint pay-off may occur at the right of the graph if contractor slope is higher than supplier slope. But if supplier slope is higher than a contractor, the maximum joint pay-off will be on the left.

Case 1.3: Supplier slope and intercept y-axis higher than contractor

Comparing with case 1.1, the value of supplier slope, *m* is changed from 5 to 11. While the interception y-axis, *c* is changed from 70 to 90.

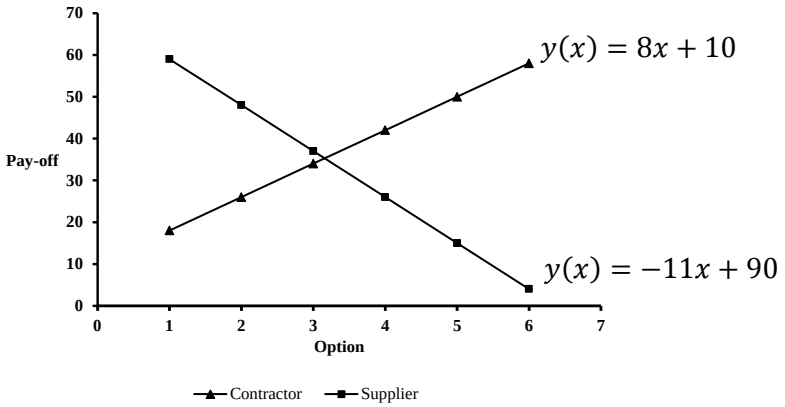


Figure 3.7: Supplier slope and intercept y-axis higher than contractor slope

Table 3.6: Supplier and contractor joint pay-off table 3

Option	1	2	3	4	5	6
Contractor Pay-off, %	18	26	34	42	50	58
Supplier Pay-off, %	79	68	57	46	35	24
Joint Pay-off, %	**97**	94	91	88	85	82

The result in table 3.6 shows maximum joint pay-off generate at the left hand side of the graph which is 97%. The highest joint pay-off occurs at the point (1, 18) and (1, 79). Although the value of intercept-y for the supplier is higher than a contractor, the maximum joint pay-off generates at the left hand side of graph same as case 1.2. The main reason is the supplier slope is higher than contractor based on explanation in case 1.2.

Case 1.4: Both slopes are same

Comparing with case 1.1, the value of supplier slope, *m* is same as contractor slope. While, interception y-axis, *c* is constant.

The results in table 3.7 show maximum joint pay-off that give the same value for all options which equal to 80%. The main reason is that difference between two points among both pay-off functions are changed at the same option linearly. For example for option 1, 2 and 3, the range difference between '62 and 18' is equal to 44, '54 and 26' equal to 28 and '46 and 34' equal to 12. Thus, figure 3.9 is obtained.

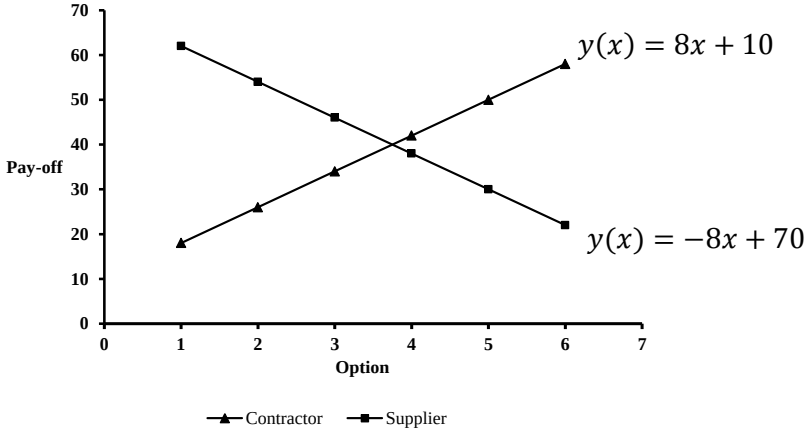


Figure 3.8: Both slopes are same

Table 3.7: Supplier and contractor joint pay-off table 4

Option	1	2	3	4	5	6
Contractor Pay-off, %	18	26	34	42	50	58
Supplier Pay-off, %	62	54	46	38	30	22
Joint Pay-off, %	**80**	**80**	**80**	**80**	**80**	**80**

In order to analyze this joint pay-off function, the interception point is taken as maximum joint pay-off. This to make sure the differences between both single pay-off is highly significant.

As a summary for the 'two lines intersect at a same point' case; two points which are located at left or right hand side of graph need to consider in order to identify maximum joint pay-off. All joint pay-off will be the same if slope for both lines are similar. Thus, the interception joint pay-off can be considered as maximum joint pay-off, if slope for both single pay-off functions are the same.

As a conclusion, the value of the slope, *m* for both pay-off functions is a major factor to determine the point of maximum joint pay-off.

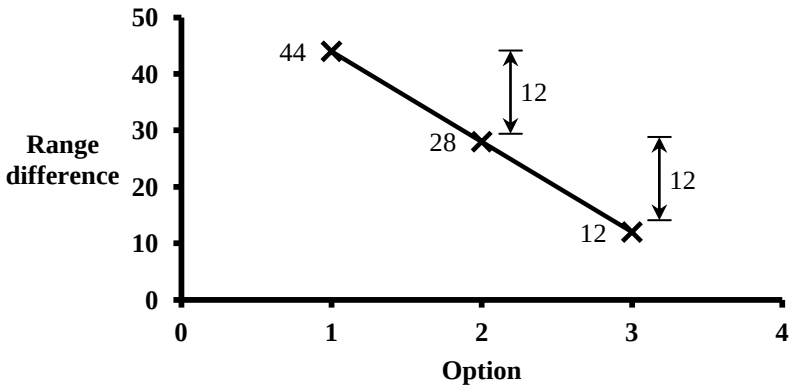


Figure 3.9: Both pay-off functions at the same option is linearly change

3.3.2 More than Two Lines Intersect at a Same Point (Point Y)

In the case of 'more than two lines intersect at a same point', three joint pay-off coordinate needs to consider in order identifying maximum joint pay-off. It can be at left, right or at intersect point. It still depends on the slope and intercept-y value for all three pay-off functions.

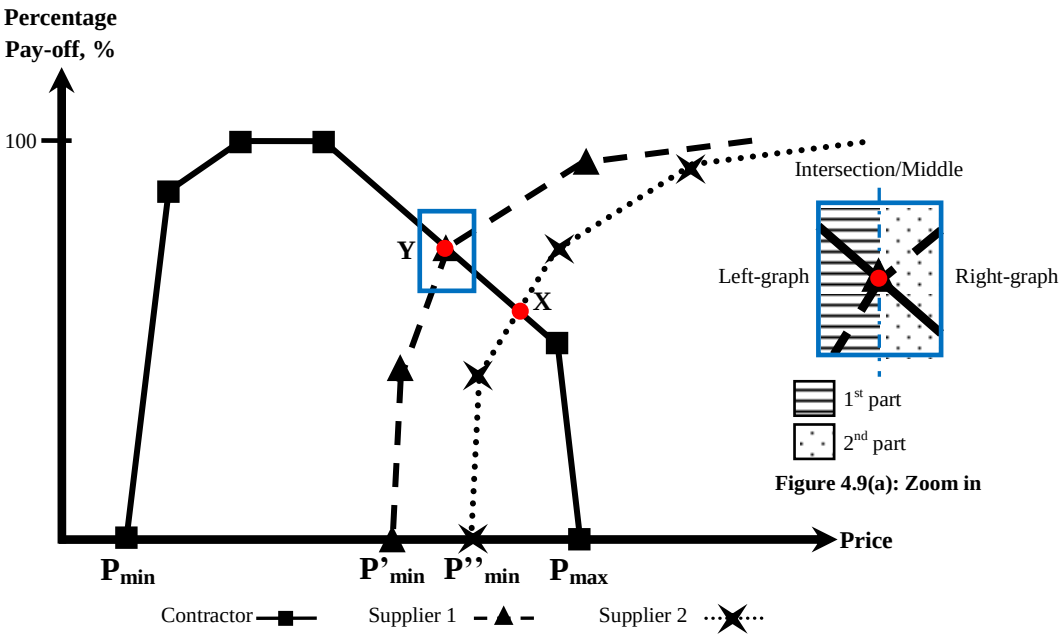


Figure 3.10: Three lines intersect at the same point

This can be explained by referring to the basic cases in 'two lines intersect at a same point'. Figure 3.10 shows the example of explanation based on basic concept in part A to identify maximum joint pay-off for 'more than two lines intersect at a same

point'. To make easy understand, the graph for the contractor and the supplier pay-off function is separate into two parts, 1st and 2nd. By referring to basic cases in 'two lines intersect at a same point', maximum joint pay-off occur either on the right or the left of the join pay-off function. Differently with 'more than two lines intersect at a same point', three coordinates of the joint pay-off need to consider. Based on figure 3.10 and table 3.8, the maximum joint pay-off may occur either on the right or left of the graph. If 'maximum joint pay-off at 1st part' occurs at right-graph and 'maximum joint pay-off at 2nd part' occurs at the left - graph at the same time, the maximum joint pay-off will occur at the intersection point.

Table 3.8: Basic concept from 'two lines intersect at a same point' case

Case	Both Graph at	Higher Slope	Lower Slope	Maximum Joint Pay-off Occur at
2.1	**1st part**	Bottom line (Contractor)	Upper line (Supplier)	Right-graph
2.2	**1st part**	Upper line (Supplier)	Bottom line (Contractor)	Left-graph
2.3	**2nd part**	Bottom line (Supplier)	Upper line (Contractor)	Left-graph
2.4	**2nd part**	Upper line (Contractor)	Bottom line (Supplier)	Right-graph

3.3.3 Algorithm of Mathematical Functions to Identify the Maximum Point of Joint Pay-off

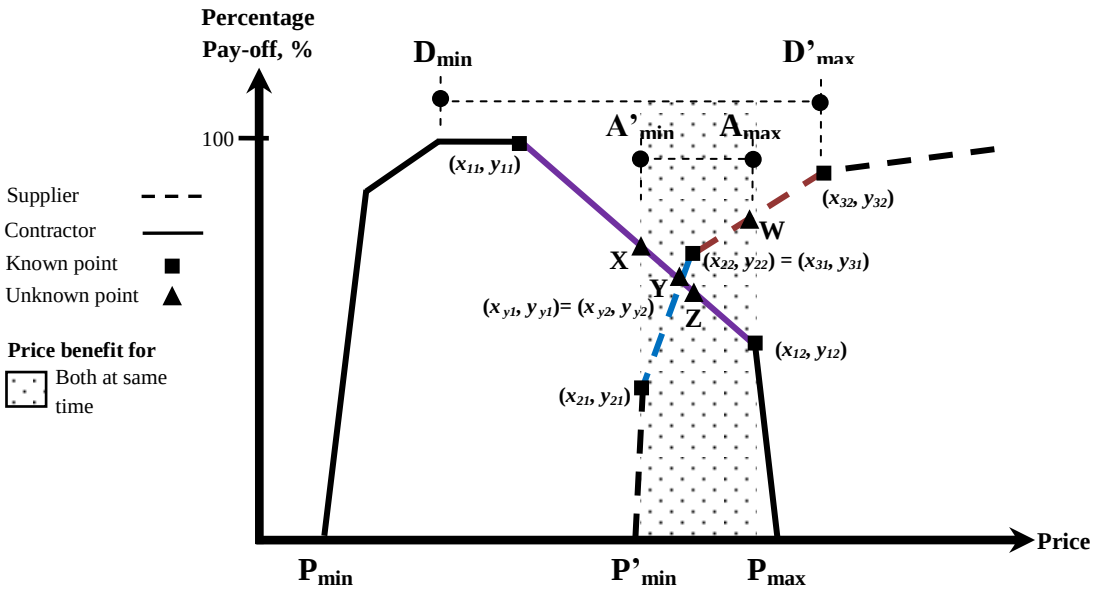


Figure 3.11 (a): Case 2.1- Two lines intersect at one point

Table 3.9 (a): Coordinate and point name for case 2.1

Coordinate	Point
(x_{11}, y_{11})	Contractor desired maximum, D_{max}
(x_{12}, y_{12})	Contractor acceptable maximum, A_{max}
(x_{21}, y_{21})	Supplier acceptable minimum, A'_{min}
(x_{22}, y_{22})	Supplier desired minimum, D'_{min}

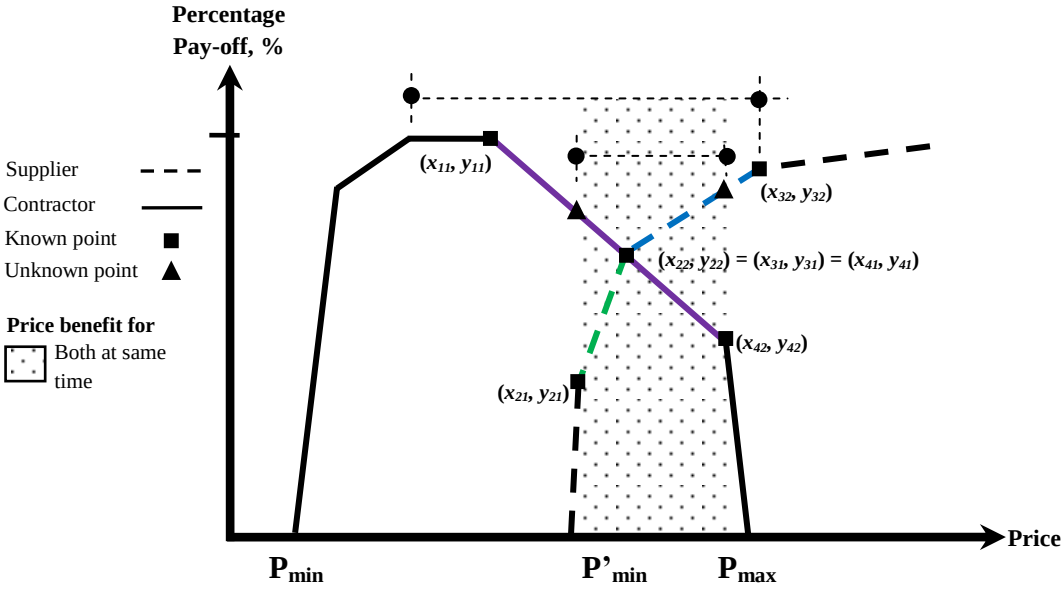


Figure 3.11 (b): Case 2.2- Three lines intersect at one point

Table 3.9 (b): Coordinate and point name for case 2.2

Coordinate	Point
(x_{11}, y_{11})	Contractor desired maximum, D_{max}
(x_{42}, y_{42})	Contractor acceptable maximum, A_{max}
(x_{21}, y_{21})	Supplier acceptable minimum, A'_{min}
(x_{32}, y_{32})	Supplier desired minimum, D'_{min}

Point (x_{ij}, y_{ij}) = Coordinate of a point in case i at point j
Line, i = $1, 2, 3, \ldots, n^{th}$
Point j = 1^{st} or 2^{nd}

The major difference between case 2.1 and 2.2 is the properties of intersect point. The intersection point coordinates in case 2.1 is unknown, while case 2.2 intersect point coordinate is known. Figure 3.11 (b) illustrates two single lines intersected at a known point. To determine maximum joint pay-off in the area of price benefit for both parties, algorithm in figure 3.12 shows the summary of process framework.

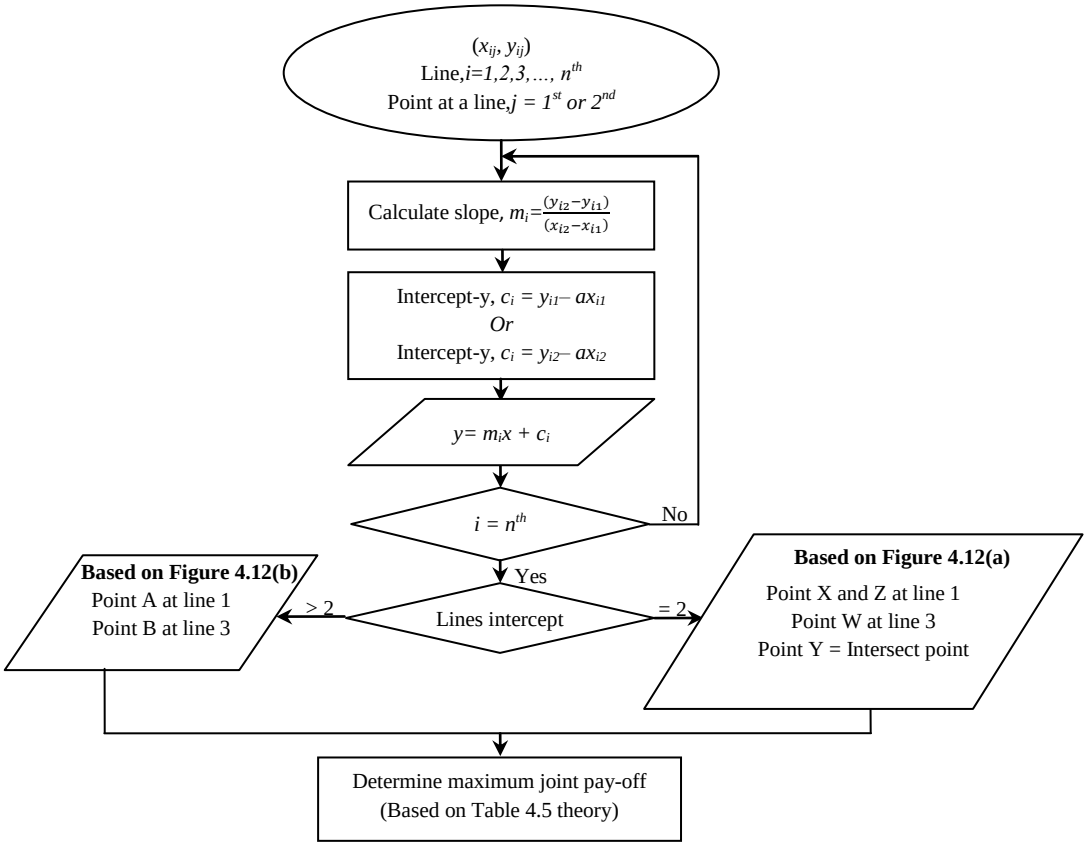


Figure 3.12: Maximum joint pay-off algorithm for straight line function

The straight line function $y = mx + c$ is used as a basic theory in determining the maximum joint pay-off for contractor and supplier. Where, m is a slope and c is the intercept-y for a single straight line function. Basically, algorithm in figure 3.12 starts with identified at least two points located on the same line. It is the first step to determine the straight line function. Next, by using that two known points coordinate (x_{i1}, y_{i1}) and (x_{i2}, y_{i2}), the value of the straight line slope, m can be calculated using the formula of slope.

$$Slope,\ m_i=\frac{(y_{i2}-y_{i1})}{(x_{i2}-x_{i1})}$$

Where, y_{i1}= the first point on a line

y_{i2}= the second point on a line

After the slope of straight line has been calculated, the next process is calculated the intercept-y, c. It used the formula $c_i = y_{i1} - ax_{i1}$ with the coordinate (x_{i1}, y_{i1}) or formula $c_i = y_{i2} - ax_{i2}$ with the coordinate (x_{i2}, y_{i2}). Thus, a straight function can be

determined. The process will be repeated until $i = n^{th}$. After all straight line functions have been determined, the next step is related to identification about the number of lines intersect at the same point.

For the case 'two lines intersect at a same point' in figure 3.11 (a), point X, Y and Z are the unknown points. For Point X and Z, the coordinate can be determined using 1st straight line function ($i=1$) because the point X has the same value of x-axis with (x_{21}, y_{21}). Thus, the value of x_{21} can be used to determine the y value of point X. Same with the point Z, the coordinate of x-axis is equal to coordinate (x_{22}, y_{22}). The value of x_{22} will be used to determine y value for point Z.

However, to determine the coordinates of the point Y, both 1st and 2nd straight line function is needed. It can apply algebra method. As an example of calculation:

$y_{y1} = m_1 x_{y1} + c_1$ … Equation (3.1)
$y_{y2} = m_2 x_{y2} + c_2$ … Equation (3.2)
Where, $y_{y1} = y_{y2}$, $x_{y1} = x_{y2}$, $m_{y1} = -8$, $m_{y2} = 8$, $c_{y1} = 70$ and $c_{y2} = ,10$
Substitute all value into equation 3.1 and 3.2,

$y_{y1} = -8x_{y1} + 70$ *and* $y_{y1} = 8x_{y1} + 10$
Thus, $-8x_{y1} + 70 = 8x_{y1} + 10 \rightarrow x_{y1} = 3.75$
Next, Substitute $x_{y1} = -3.75$ into equation (4.1) or 4.2 $\rightarrow y_{y1} = 40$
Finally, coordinate point Y = $\mathbf{(x_{y1}, y_{y1}) = (x_{y2}, y_{y2}) = \underline{(3.75, 40)}}$

For the case of 'three lines intersect at a same point' in figure 3.11 (b), point A and B is the two unknowns coordinate. The process of calculation is the same as coordinate point X and Z in figure 3.11 (a). After all coordinate point has been determined, next the algorithm continues to calculate the maximum joint pay-off for both the contractor and the supplier. It is applied concept in the table 3.8.

Next, the algorithm continues to analyze the maximum point of joint pay-off for other issues using step function. To analyze the step function, three options are needed to determine. It includes the option that only benefits for the contractor, the option that only benefits the supplier and the option that nearly benefits for both.

The payment term issue in figure 3.13 is an example on how to analyze the step function.

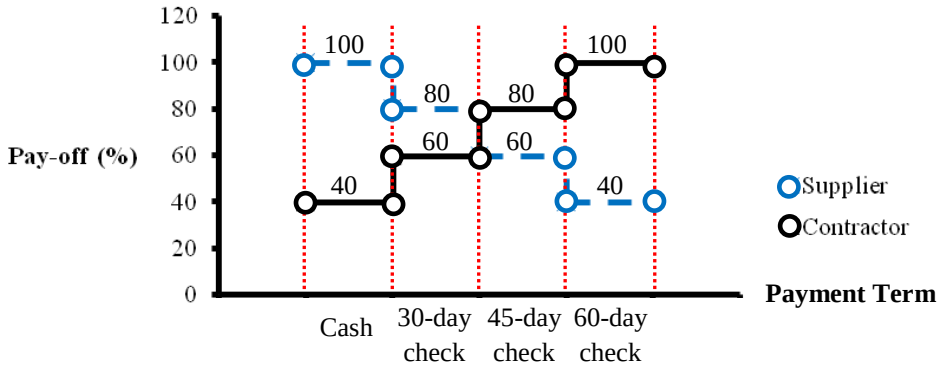


Figure 3.13: The value of single percentage pay-off reversible from each other

An option that only benefits the contractor is the option that has the highest contractor percentage pay-off. But it gives the lowest percentage pay-off for the supplier. Thus, 60-day check represents that option. While the option that only benefits for the supplier is an option has the highest supplier percentage pay-off. But it gives the lowest percentage pay-off for the contractor. Thus, cash represents that option.

Finally, the option that nearly benefits for both has nearly the same percentage pay-off for both contractor and supplier. This also shows that the option has the lowest percentage pay-off differences between the contractor and the supplier. Therefore, 45-day check represents that option.

3.3.4 Optimization of Joint Pay-off

Negotiation in material procurement needs nearly the same benefit between contractor and supplier. Because this kind of condition will actualize the win-win situation and make the negotiation process becomes more equitable.

To analyze the negotiation pay-off function which fulfills that condition, the result must have maximum joint pay-off and have nearly the same benefit between both contractor and supplier. As a guideline to determine the optimum negotiation result, the joint pay-off must be upper and closer to 45º line in figure 3.14.

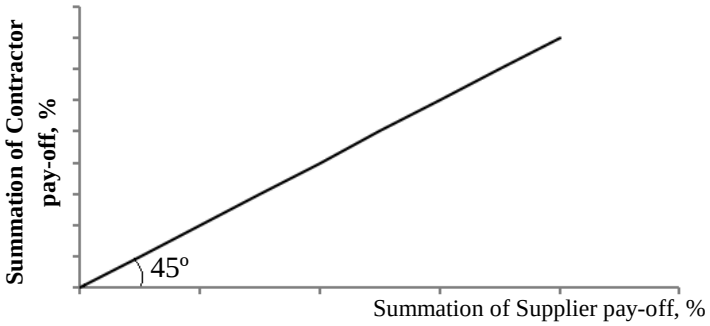


Figure 3.14: Negotiation Optimum line (Dzeng and Lin, 2004)

The power of negotiation will be held on supplier if the joint pay-off is located below than 45º line. In addition, if the point of joint pay-off is located above that line, the contractor will hold the negotiation power. To get a joint pay-off occurring on 45º line is too difficult during the negotiation process. However, the nearest point with 45º line can be used as an optimum result of joint pay-off.

Next, to analyze the pay-off function, three options in each issue needs to determine. It includes the option that benefits for the contractor, the option that benefits for the supplier and the option that benefits for both. An option that only benefits for the contractor is an option has the highest contractor percentage pay-off. But it gives the lowest percentage pay-off for the supplier. Meanwhile, an option that only benefits for the supplier is an option has the highest supplier percentage pay-off. But it gives the lowest percentage pay-off for the contractor. Next, the option that benefits for both has nearly the same percentage pay-off for both. This also shows that the option has the lowest percentage pay-off difference between the contractor and the supplier. Their full analysis will be explained in chapter V and VI.

Based on the option that only benefits for the contractor, the option that only benefits for the supplier and the option that nearly benefits for both. All the three options are used to make nine scenarios/points of total joint pay-off. It includes:

1- Price benefits for the contractor and other issues benefit for the contractor
2- Price benefits for both and other issues benefit for the contractor
3- Price benefits for the supplier and other issues benefit for the contractor
4- Price benefits for the contractor and other issues benefit for both

5- Price benefits for both and other issues benefit for both
6- Price benefits for the supplier and other issues benefit for both
7- Price benefits for the contractor and other issues benefit for the supplier
8- Price benefits for both and other issues benefit for the supplier
9- Price benefits for the supplier and other issues benefit for the supplier

Next, to determine the optimum joint pay-off, the point must be:

1- Upper than 45º line. The procurement items were of an unbalanced market (buyer's market).
2- Nearest to 45º line. It is better to optimize the joint pay-off rather than single pay-off.

These two scenarios can be illustrated as the Venn diagram such in figure 3.15.

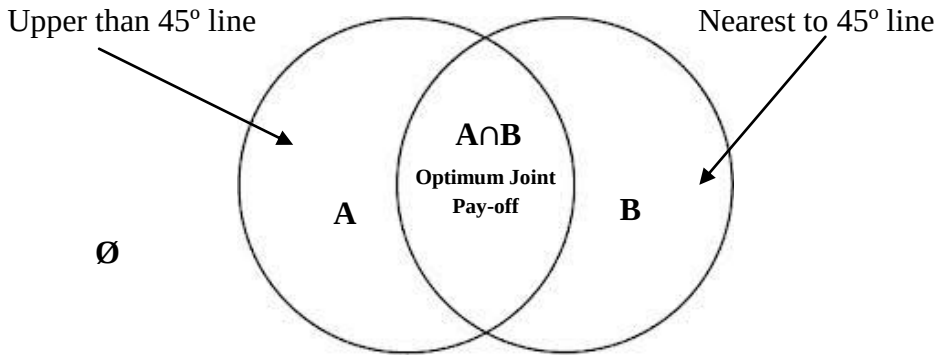


Figure 3.15: The venn diagram

Based on figure 3.15, the diagram consists of two intersecting circles, producing a total of four regions A, B, A∩B and Ø (the empty set, represented by none of the regions occupied). Here, A∩B denotes the intersection of sets A and B. It defined the optimum joint pay-off. Referred the result of subtracting the value of x with the value of y (x value – y value). The optimum joint pay-off is the lowest percentage difference point in positive sign.

3.4 Summary of Chapter

As a summary for this chapter, the research can be divided into part I and part II. The Part I is focused on identifying the current practice of negotiation process. The management of material procurement is used as a case study to analyze. The research

method used in this analysis is a case study. While the Part II will be continued to identify the weight of each issue and the option of percentage pay-off. The method of Analytical Hierarchy Process, (AHP) is used to identify the weight of negotiation issue. Three types of materials are used as a focus group to analyze the joint pay-off function. It includes aggregate stone, cement and ready mix concrete. The selection of materials is based on the materials that are directly purchased by the main contractor. Finally, to analyze the pay-off function, three options in each issue needs to determine. It includes the option that benefits for the contractor, the option that benefits for the supplier and the option that benefits for both.

CHAPTER IV

PROCUREMENT AND NEGOTIATION

Pilot survey has been done to identify the environment material procurement and negotiation in Malaysia construction industry. Thirty five contractors have been selected to answer the questionnaire related to negotiation of construction material procurement with the supplier. The main objective of pilot survey is to get a clear understanding of material procurement and negotiation. The materials are selected to use as a case study in chapter 5. Basically, four groups of materials have been classified according to their purpose in construction work. Based on that group, only three types of materials from the same group will be selected as a case study to achieve the objective of this research.

4.1 Material Procurement in Malaysia Construction Project

The general type of materials in building construction industry can be classified into four groups such in table 4.1. The materials have been classified based on their purpose in construction works including structural, architectural, M/E and finishing works. The structural work is the main civil structural materials. Architectural work is the main architect structure material. Finishing work is material to improve the service and decorative qualities of buildings and mechanical/electrical, M/E work is material related to mechanical and electrical.

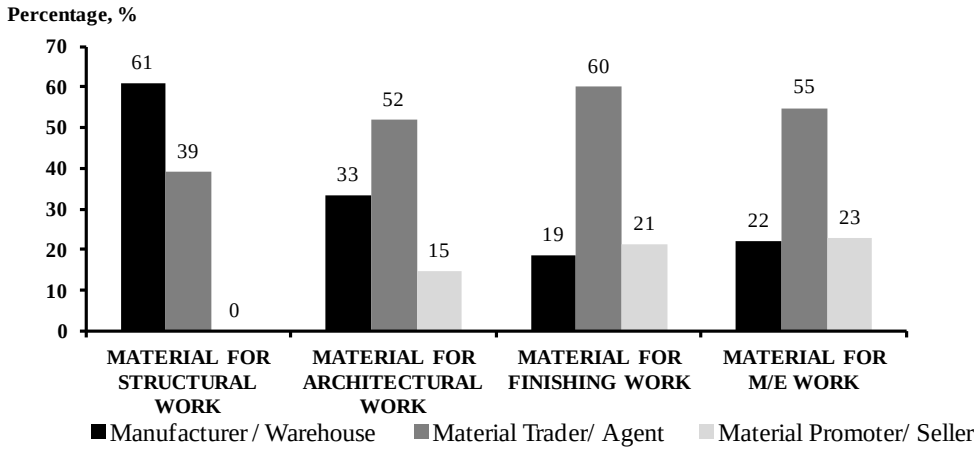


Figure 4.1: Type of materials supplier

Not all material procurement and installation works would be done by the main contractor. The management of each group material is not the same practice especially to get the supply in a construction site.

Table 4.1: General classification of materials

MATERIAL FOR STRUCTURAL WORK
Reinforcement Steel
Steel structure (**H-beam**)
Formwork (**Timber, Wood**)
Ready-mixed Concrete
Cement
Aggregate (**Sand, Gravel**)
Reinforcement Steel
MATERIAL FOR ARCHITECTURAL WORK
Brick (Standifera and Wall Jr)
Ceiling (**Plaster board**)
Door (**Single/Double Wood**)
Roof Timber Truss
Roof Steel Truss
Roof Tile
Window
MATERIAL FOR FINISHING WORK
Painting (**Paint, Brush, Paint scraper, Roller tray**)
Wall and Floor Tile
MATERIAL FOR M/E WORK
Electrical Devices (**Wire, Lamp, Ceiling Fan, Switch**)
Fire protection system (**Pipe, Alarm sensor**)
Mechanical Devices (**Elevator, Escalator, Air-conditioner**)
Sanitary (**Bowl, Sink**)
Sewerage (**Drainage, Manhole**)
Telephone and Internet devices
Water resources (**Water tank, Pipe, Tap**)

Based on figure 4.1, the manufacturer is the materials that are directly purchased from the main maker of supply, material promoter is someone who come to the construction site to promote the materials and material trader is the material purchase from the middle person without involving promoter. Most of materials for structural works were obtained from manufacturer, 61% in total comparative with other types of supplier. The reason is most of material in structural work is raw materials. The production of raw materials is normally high in order to reduce the cost of production in industry. None of product in structural work can get from material promoter or seller coming to the construction site. Differently for other group of construction materials, contractor can get the supply from all three types of the supplier. However, material trader or agent is halfly selected by the contractor which is 52% for material in architectural work, 60% for material in finishing work and 55% for material in M/E

work. The main reason is that materials in these three groups have their own workers to install their materials. Normally their workers are more expert to give an advice in the installation process to decorate owner building especially in architecture and finishing work.

Some materials have their own expert to give an advice to install the materials, thus some material works will be done by sub-contract. However, it depends on the demand of the project owner and the agreement on total cost in the early bidding process before the project owner awarded the project to the main contractor. Therefore, some materials were purchased by the main contractor and some were purchased by sub-contractor. In other words, the sub-contractor would procure the material with agreement from main contractor or project owner. In terms of sub-contract, it can be divided into:

a) Subcontract only labor works

   Main contractor will purchase the materials, but the work will be operated subcontract. Material procurement is depended on main contractor where quality of work is relied on subcontractor expertise.

b) Subcontract works including labor and materials

   The total works done by sub-contractor including procurement of materials.

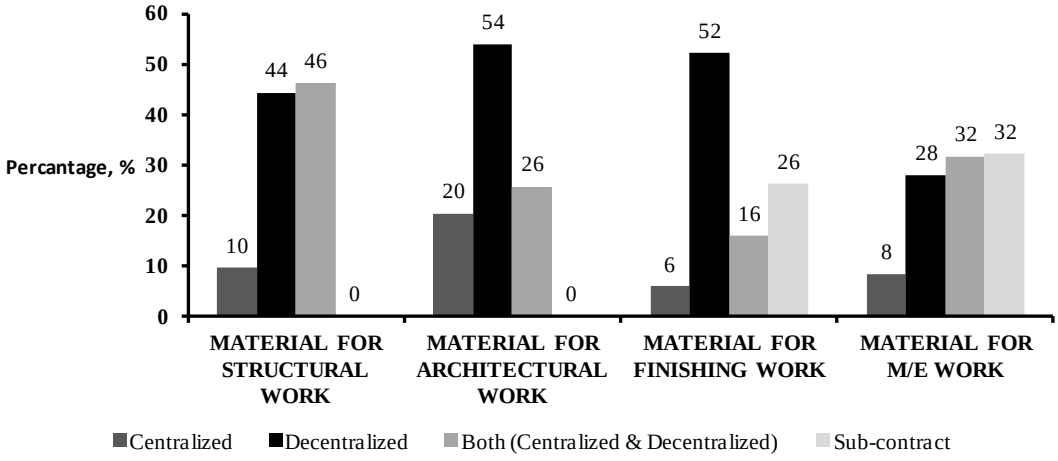


Figure 4.2: Type of purchase materials

Based on figure 4.2, only materials in M/E works are always done by sub-contract because the main contractor lacks of expertise in installation works in M/E.

Thus purchasing the materials will be procured by sub-contractor. Sometime the price of material is including the installation work such as air-conditioning and an elevator. From an interview with Malaysia contractors, material procurement can be done by centralize and decentralize. The centralize means all process in material procurement for every construction project will be processed by staff at the main office under procurement department. While the meaning of decentralize is that the core material procurement activity will be processed separately by project site team and procurement department will only manage the processing of purchase order upon request from project officer. 54% of architectural work and 52% of finishing work, are purchased by decentralize. The reason is that some material specification of architecture and finishing works are provided by the project owner. Decentralization of purchasing materials may reduce work load and control cost. Thus, it can speed up the process in material procurement. Each building construction has their own specification required by the project owner. But 46% of structural materials are made by both decentralize and centralized. Normally the raw materials in structural works are almost same. Thus it is easy to purchase by centralize. For example, specifications of ready mix concrete are the same but only some specification will be depended on the type of building. Basically 80% out of 35 main contractors involved in government projects has procurement department at the construction site. All main contractors have a main procurement department in their main office. It is important to manage the payment and purchasing materials, although some construction sites have internal procurement department at a construction site.

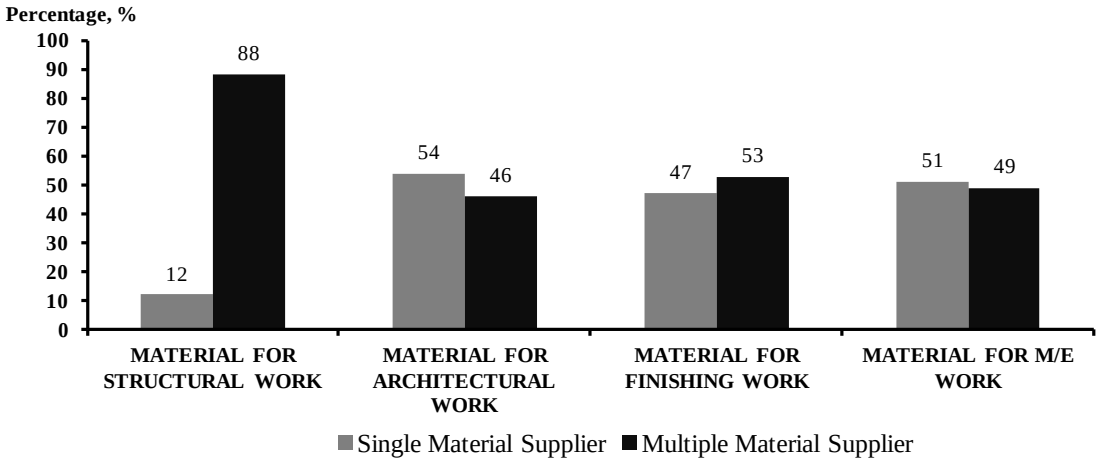


Figure 4.3: Single and multiple suppliers

Some construction materials can be supplied by multiple suppliers to make sure all works follow the project schedule. Based on result in figure 4.3, most structural materials can be purchased from multiple suppliers around 88%. The reason is that most of materials in structural work are raw materials in construction project. These materials are included ready mix concrete, cement, aggregate and also reinforcement steel. Even multiple suppliers can supply the materials, but the specification should be the same to avoid defects in the end of the project.

Although finishing materials are 53% at multiple suppliers, the total materials from the questionnaire interview are only two in that group. Thus making the single and multiple suppliers does not have too much difference, (only 3 % difference). However, most materials in architectural works, (54%) is purchased from a single supplier. Similarly M/E materials, (51%) will be purchased from a single supplier.

Next, the process of material procurement activity can be separated into before (during tender offer) and after project start (project owner awarded the contract to the contractor). Two different periods of the materials will procured by the main contractor is shown in figure 4.4.

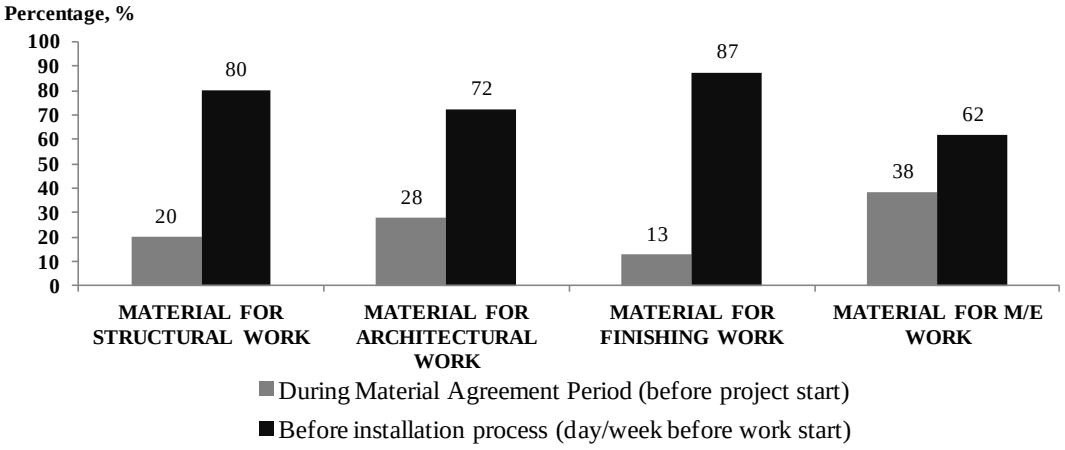


Figure 4.4: Material procurement period

Generally, most of materials in figure 4.4 was procured after the project is awards to main contractor, (80% for structural material, 72% for architectural material, 87% for finishing material and 62% for M/E materials). The reason of M/E materials is the low comparing with others because specification demand is given by the project

owner. Thus, main contractor firstly needs to procure the materials in order to get the estimated price for putting in the total bid price. To explain the timeline of material procurement, figure 4.5 shows the summarized.

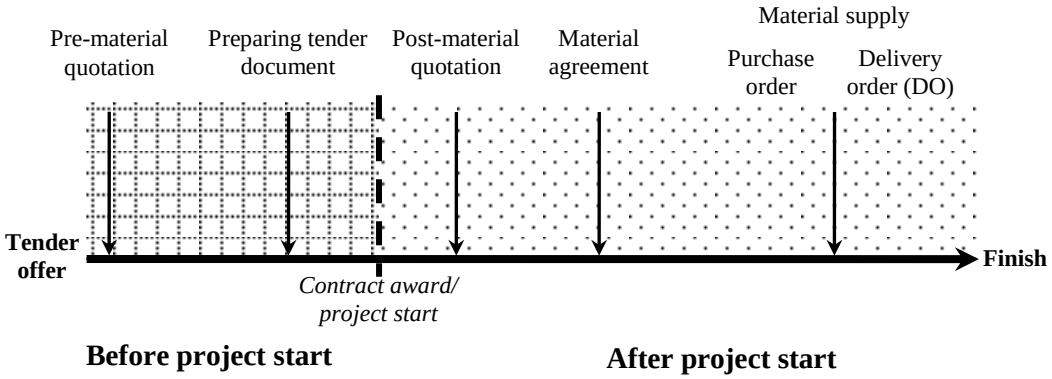


Figure 4.5: Material procurement timeline

4.1.1 Before Project Starts

Mostly the steps before project start are related to tendering the project. During the tendering period, the contractor needed to identify the most relevant supplier to supply the materials at construction site especially after the contract is awarded. Two main activities before project start involved pre-material quotation and preparing tender document.

i- Pre-material quotation

During the first stage, project owner offers a tender. Quantity surveyor starts to identify all materials needed for construction project and their specification. Next, contractors send out enquiries to multiple suppliers and normally recognized suppliers from previous projects. This can be done by sending fax or e-mail about material specification to the supplier and wait for their quotation reply.

Identification of multiple suppliers can give benefits to contractor especially to negotiate material price if the contract is awarded to them. This is important for contractor to make a comparison of material products including price and negotiation issues. For special material request by project owner without previous supplier record, the contractor needs to identify new suppliers to procure that kind of materials.

Generally, the contractor will identify a list of suppliers from manufacturer or trading house. Most architectures and finishing material would get from trading house service but the price is more expensive compared with manufacturer service because it used an agent or middle company. It depends on the contractor situation to decide whether to choose a trading house or manufacturer such as location and the previous record of works. The contractor will decide after the contract is awarded to them.

ii- Preparing tender document

The analysis of supplier list will start after contractor gets the quotation. The main criterion in supplier selection is specification needed by the project owner. Material price will be the second requirement. Normally 3 to 5 suppliers following requirement will be kept in the list for reference during post-material quotation. During tendering process, the quantity surveyor will use the middle price given by multiple suppliers at the same time referring the price getting from Construction Industry Development Board Malaysia (CIDB Malaysia).

The material price and labor wage rate in Malaysia construction are published by the CIDB Malaysia every month under the National Construction Cost Centre (N3C). N3C is responsible to initiate and maintain a construction industry information system as a reference for contractor in Malaysia. The price index reference is important for contractor to avoid over budget during the construction process. After getting the best quotations, the project manager will prepare the tender documents and submit them to the owner.

4.1.2 After Project Starts

The procurement process will fully start after the contract is awarded. When the contractor gets the project, the first step is the creation of a supplier short list. The track record or profile of the supplier is the main criteria in making the short list. The example of track record included previous experience of works (to supply the material) and history during the previous project (delivery on time, problem occurring and solving). Some project owners also have the supplier tract record especially for government project which keep by public work department (Jabatan Kerja Raya,

JKR). Thus, the contractor needs to do double check if the project owner is a government. Some material specifications will also be checked by JKR as a consultant of government project before the installation process. If materials are not following the original specification, the contractor needed to identify another supplier. Three main activities after the project start consist of post-material quotation, material agreement and material supply.

i- Post-material quotation

Some material price might be changed from previous during tendering stage. It is following current value but under acceptable price given by CIDB Malaysia. This has happened because of world economy changers such as increasing in raw material price especially fuel and gas. The project manager will contact again all relevant suppliers during the tendering stage and try to get new quotation. Normally the price is still under acceptable budget because during the tendering stage, the contractor does not take the price directly from supplier quotation. The contractor would estimate using average price to make sure it is under budget especially during the construction process. Thus, the importance of post material quotation is to make a confirmation for current material price.

ii- Material agreement

After getting current prices from post material quotation, the contractor needs to make the final decision to select the most suitable supplier for their project. To make a decision, the contractor will negotiate the price according the issue related with the environment of projects such as distance of construction site with supplier location (freightage issue). Only selected suppliers will contact for the negotiation process and make an agreement to procure the material. The most relevant quotation of post-material that meets the contractor requirement will be selected.

iii- Material supply

The next step is getting material to supply at the construction site for the construction process. Normally project engineer will request to supply the materials according to stage of construction or work process. After getting a request, the project

manager will fill in the purchase order form and submit to the procurement department at the main office.

4.2 Negotiation During Procurement Process

The most important of negotiation for a contractor is to get a better price by referring to the requirement of project (related to the negotiation issues and options). At the same time it depends on the willingness of supplier to supply the materials. Only if both parties agreed according to the negotiation issues, an agreement could make.

Negotiation during procurement process needs to be done before making an agreement between both parties. The process could only be started if the contractor confirmed to select the most relevant supplier before making a conversation. The contractor should not purchase the material after making an agreement. The tract record of the contractor from supplier perception will be unfavorable if this kind of situation has happened. It also could affect for the future procurement process. Moreover, some suppliers will charge the contractor as a penalty for cancelling an agreement.

Some materials can be supplied by multiple suppliers such as brick, ready-mixed concrete, steel and wood for installing formwork. The selection of supplier depends on the material available during installation or construction. For example, some ready-mixed concrete supplier is fully booked during concreting works by another contractor on a same date. The contractor can change the date or find another supplier to supply the concrete as long as it can follow the requirement of building designed specification.

4.3 Issues of Negotiation

Based on interview result, all contractors do not use any advanced technology in negotiating the procurement construction materials such as agent base system. Most of them use the telephone as a medium to start the communication and sometime use

email or fax. At the end of the negotiation, physical meeting between contractor and supplier will be used to confirm the purchasing of the materials. Figure 4.6 is a summary of result related to the issues in negotiating in material procurement.

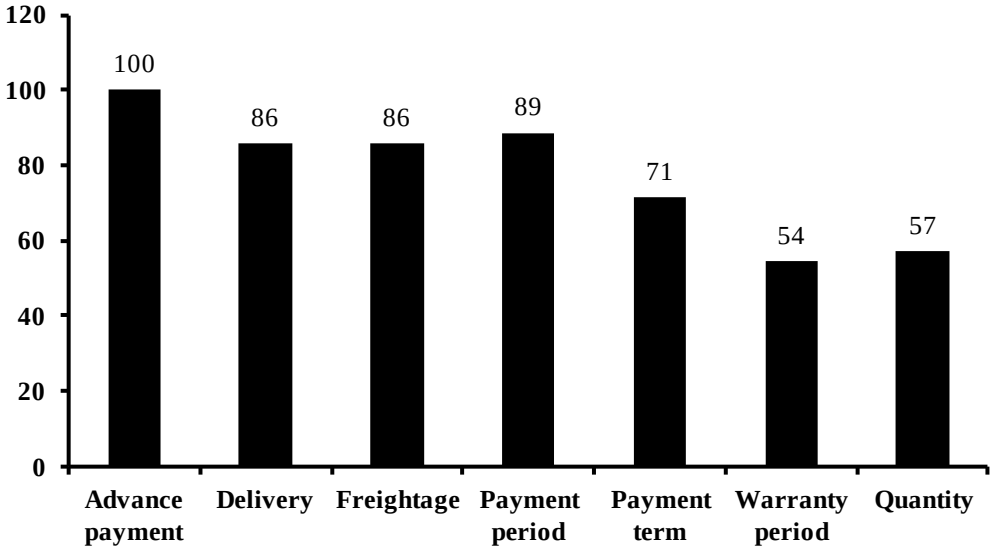


Figure 4.6: Issue of negotiation in material procurement

The result shows that all contractors, (100%) totally agreed to choose an advance payment during the negotiation process. 89% out of 35 respondent selecting payment period and 86% agreed to choose an issue of freightage and delivery. The lowest percentage is 54% out of 35 agreed with the issue of warranty period. The reason is that the issue of warranty period is only related with some materials not all. For example structural materials from both supplier and contractor view point did not include warranty period issue to negotiate.

The issue of negotiation depends on the environment of construction project needed. The project manager re-inquiries all previous suppliers list and tries to get a better price according the negotiation issues. Most of the issues are similar to negotiate and not affected by the type of material (structural, architecture, finishes and services). The factors influencing supplier to select the issues of negotiation can be:

i- Advance payment, payment period and payment term

- The period of relationship between contractor and supplier will affect the options of issue in advance payment, payment period and payment term.

- Normally, common supplier is easier to get longer payment period comparing to a new supplier. Normally, new supplier with contractor's company will ask to fill in a form (or make an agreement) and involve a longer period to negotiate the price and options of each issue.

ii- Freightage

- Some materials are needed to purchase from eastern Malaysia (Sabah and Sarawak). Such supplier will deliver material by ship or airplane. Thus, the issue of the freightage is needed to negotiate to get a better price.
- Distance of supplier from construction site is needed to supply the material.

iii- Warranty period or future prospect

- The contractor needed to give a warranty period to the project owner after finished constructing the project. Within that period the contractor will purchase same pavement material from same supplier if they can give a good price. This is included for repairing a broken product during the warranty period.
- Some suppliers will install a product by their own to give a warranty of installation to the contractor. Especially for special products.

iv- Quantity

- Size of the project will affect the quantity of materials needed for construction projects. To make sure the contractor willing to take more material, the price will be decreased. This is because of the period needed to supply the materials and payment of mobilization of materials for construction site including payment of labor by the supplier.

Size and work duration of project is the main influences to select the option of each issue. For example for the issue of the payment term, the contractor will try to get 45 or 60 days option from the supplier if the project size is big and the project duration is long. This is important to maintain the total cash in their project account.

4.4 Summary of chapter

Based on the overall result in pilot questionnaire, the materials that are selected as a case study in chapter 5 consist of an aggregate, cement and ready mix concrete. The

reason is most of materials in structural works are purchased by the main contractor. In addition, the procurement of these three materials has the same condition. Thus, it makes easier to make the comparison between these three materials at the end of the analysis. Basically, seven issue excluded price can be used as overall issues to negotiate in material procurement. However, only five issues are selected in next analysis including advance payment, payment period, payment term, the delivery and freightage. Warranty period and quantity are excluded. The reason is warranty period does not relate to procurement negotiation of structural materials and the quantity issue is taken as constant.

CHAPTER V

APPLIED MATHEMATICAL FUNCTION IN MATERIAL PROCUREMENT NEGOTIATION

This chapter aims to apply mathematic functions in material procurement negotiation. Three materials have been selected to conduct a survey on percentage pay-off. All materials in this case study are from the structural work group. It includes aggregate (granite stone ¾"), cement (Ordinary Portland cement) and ready mix concrete (normal mix – grade 35, granite). To apply mathematical functions in this analysis, linear and step functions were used.

The total negotiations issues have been considered in this analysis are six. The summary of the issue and option have shown in table 5.1. Only price will be applied the linear function in this analysis. The reason is the percentage pay-off linearly changes with the changing of the option. The other issues will be applied the step function because each percentage pay-off is represented only a single option.

Table 5.1: Issue and type of mathematical function

Mathematical Function	Issue	Option
Linear Function	Price	Maximum acceptable price Minimum acceptable price Maximum desired price Minimum desired price
Step Function	Payment term	60-day check, 45-day check, 10-day check and cash
	Payment period	On delivery, on completion of milestone, on completion, monthly and bi-weekly
	Advance payment	10%, 15%, 20%, 25% and 30%
	Delivery	Single, multiple and on-call
	Freightage	Included, excluded

To create a normal negotiation case study, each material consists of a single contractor negotiated with two suppliers (multiple suppliers). Thus, three different contractors and six suppliers have been selected to provide information in this research analysis.

During the negotiation process, each party has a percentage level of importance for each single option in each issue. It can be represented by percentage pay-off. To analyze it, contractor and supplier need to determine their percentage pay-off for each option. 100 percentage pay-off means the option is desired for their own benefits.

5.1 Linear and Step Function

Figure 5.2 is the linear function graph to analyze the price issue. This graph should be represented as figure 5.1. But it has a limitation to get the price minimum (P_{min}, P'_{min}) and the price maximum (P_{max}). Thus, figure 5.2 will be used in this analysis.

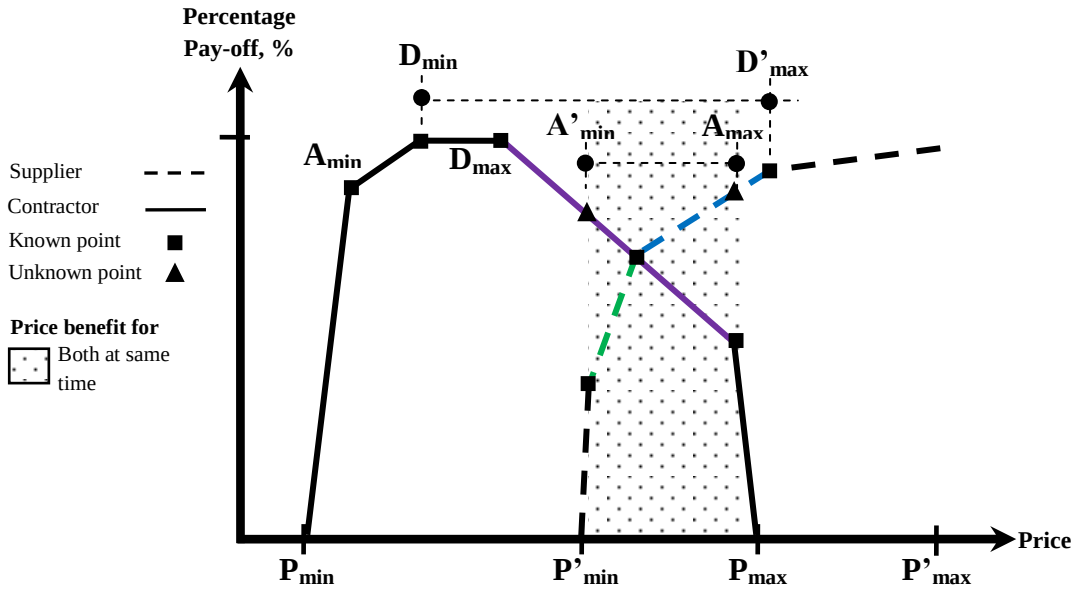


Figure 5.1: Complete linear function graph for price issue

The desired minimum price, (D_{min}) is the contractor most acceptable price. While the desired maximum, (D'_{max}) is the supplier most acceptable price. The range between Acceptable minimum, (A'_{min}) and Acceptable maximum, (A_{max}) is the possible range to use for negotiation. To analyze the data, three options of price are

needed to determine. It includes the price that only benefits for the contractor, the price that only benefits for the supplier and the price that benefits for both.

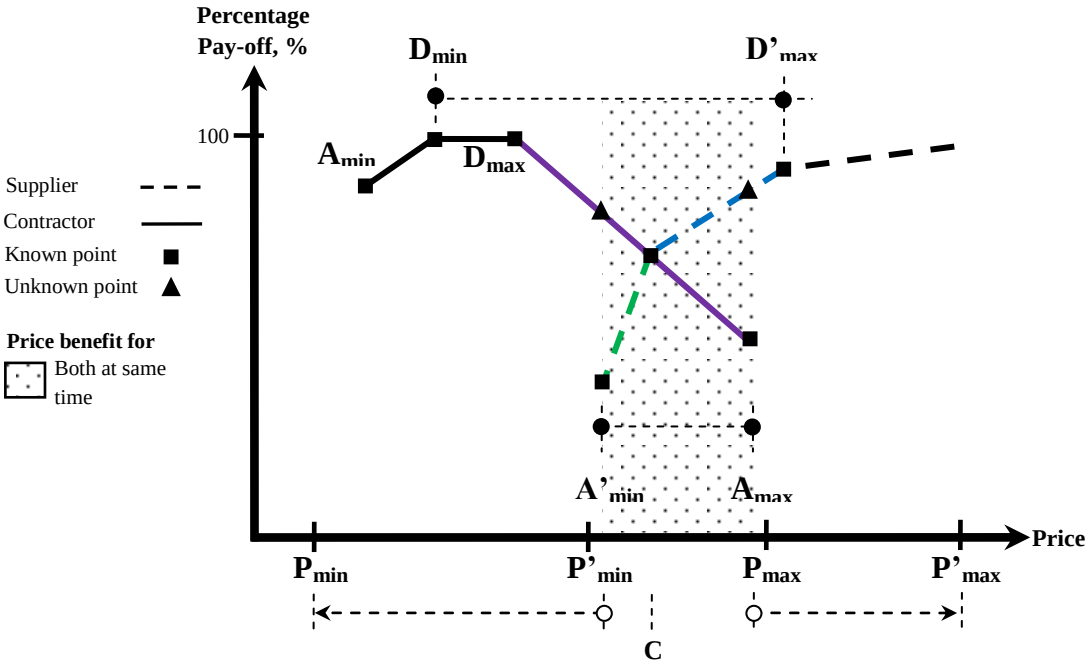


Figure 5.2: Linear function graph

Based on figure 5.2, only contractor who gets the benefit of price should be at the contractor desired minimum price, (D_{min}). On the other hand, the supplier has percentage pay-off less than the point A. This point is unknown from supplier viewpoint. Thus, point A is selected as the price that only benefits for the contractor.

Next, only supplier who gets the benefit of price should be at the supplier desired maximum price, (D'_{max}). But the percentage pay-off from contractor has value more than the point B. This point is also unknown from contractor viewpoint. As the result, the point B is selected as the price that only benefit for the supplier.

Finally, both that get the same benefit of price should be at the intercept point. Because the contractor and the supplier percentage pay-off are the same at this point. Therefore, the point C is selected as the price that benefits for both parties. Figure 5.3 is the step function graph to analyze payment term, payment period, advance payment, delivery and freightage issue. In mathematical symbol:

Circle with white color inside ○ : Excluded

Circle with black color inside ● : Included

Based on figure 5.3, the percentage pay-off for a single option did not include the value of other adjoin options.

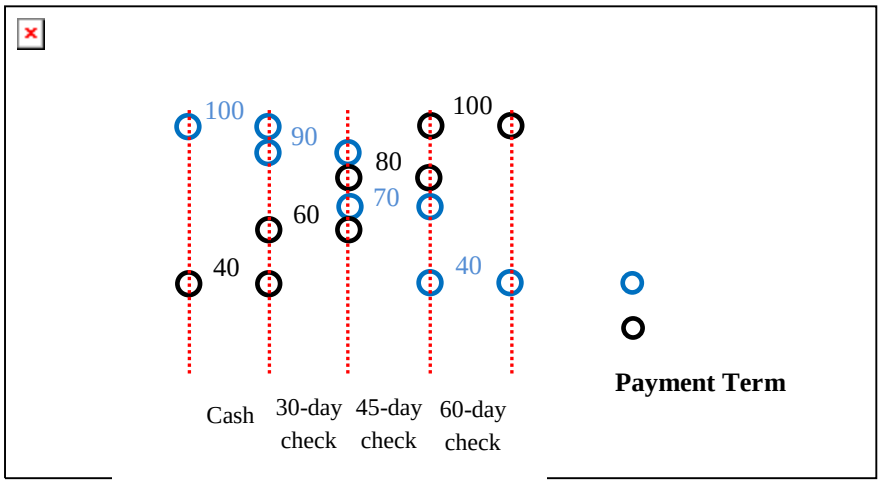


Figure 5.3: Step function graph

Same as the price issue, three options are needed to determine. It includes the option that only benefits for the contractor, the option that only benefits for the supplier and the option that nearly benefits for both. The payment term issue in figure 5.3 is an example on how to analyze the step function.

An option that only benefits for the contractor is an option has the highest contractor percentage pay-off. But it gives the lowest percentage pay-off for the supplier. Thus, 60-day check represents that option. While the option that only benefits for the supplier is an option has the highest supplier percentage pay-off. But it gives the lowest percentage pay-off for the contractor.

Thus, cash represents that option. Finally, the option that nearly benefits for both has nearly the same percentage pay-off for both the contractor and the supplier. This also shows that the option has the lowest percentage pay-off difference between the contractor and the supplier. Therefore, 45-day check represents that option.

5.1.1 Option in Price Issue

In the price issue analysis, two prices are needed to be considered. It includes the supplier minimum acceptable price, (A'_{min}) and the contractor maximum acceptable

price, (A_{max}). These two prices are important in identifying the price that only benefits for the contractor and the price that only benefits for the supplier. Another price that needs to be considered is the price that has an interception with the percentage pay-off. It is used to determine the price that benefits for both the contractor and the supplier.

Figure 5.4 (a) is the line chart that shows the percentage pay-off of aggregate stone, figure 5.4 (b) illustrates the percentage pay-off of cement and figure 5.4 (c) shows percentage pay-off of ready mix concrete. The cross marker represents supplier-S1, the square marker represents supplier-S2 and the triangle marker represents percentage pay-off of contractor. In the following tables, the joint pay-off in each table is the summation of single percentage pay-off from contractor and supplier. The currency of the price issue is in Malaysia Ringgit, MYR.

A) Aggregate Stone Price Issue

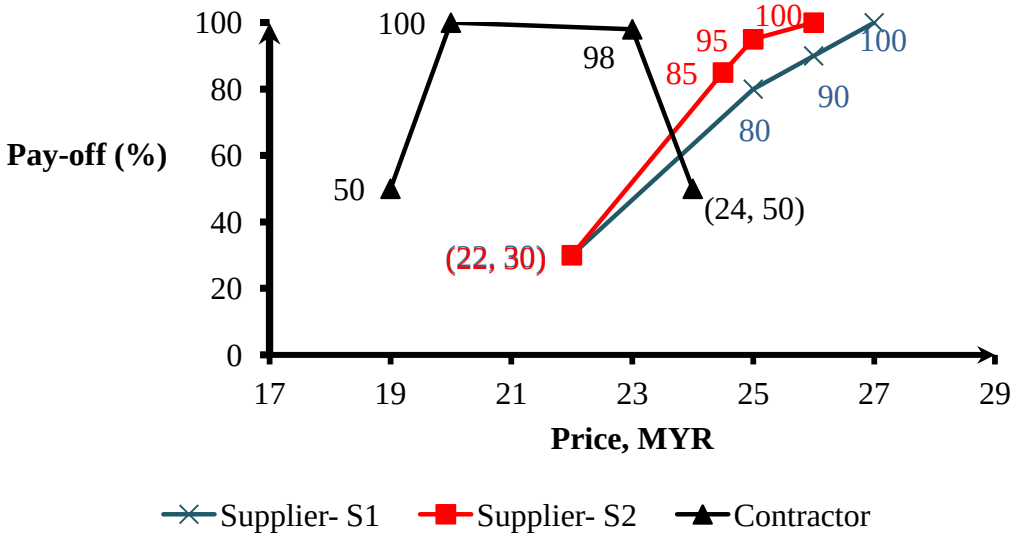


Figure 5.4 (a): Price for aggregate stone

In figure 5.4 (a), MYR 22.00 is the price only that benefits for the contractor. The contractors percentage pay-off at this price is 98.67%. The summary of results is shown in table 5.2 (a). The percentage pay-off from supplier-S1 and supplier-S2 are intercepted at the minimum acceptable price, (A'_{min}) at the point (22, 30). Thus, this results in both suppliers having the same percentage pay-off.

Table 5.2 (a): The price only benefits the contractor

Point	Option (MYR)	Supplier Pay-off, (%)	Contractor Pay-off, (%)	Joint Pay-off, (%)
Supplier-S1	22.00	30.00	98.67	128.67
Supplier-S2	22.00	30.00	98.67	128.67

Meanwhile, MYR 24.00 is the price that only benefits for the supplier. The contractor's percentage pay-off at this price is 50.00%. The summary of results is shown in table 5.2 (b). At MYR 24.00, the percentage pay-off from supplier-S1 is 63.33% while the percentage pay-off from supplier-S2 is 74.00%. The main reason is that the gradients of the graph for both suppliers are different. Thus, this makes both percentage pay-off having the different value at this price.

Table 5.2 (b): The price only benefits the supplier

Point	Option (MYR)	Contractor Pay-off, (%)	Supplier Pay-off, (%)	Joint Pay-off, (%)
Supplier-S1	24.00	50.00	63.33	113.33
Supplier-S2	24.00	50.00	74.00	124.00

Next is the price that has an interception with the percentage pay-off. It is used to determine the price that benefits for both. The summary of results is shown in table 5.2 (c). Supplier-S1 intercepts with the contractor at the point (23.79, 59.90). On the other hand, supplier-S2 intercepts with the contractor at point (23.66, 66.46). Based on this result, supplier-S1 intercepts at price MYR 22.79 and supplier-S2 intercepts at price MYR 23.66. Therefore, both suppliers did not have too much difference in terms of price. However, the percentage pay-off increases as the price decreases.

Table 5.2 (c): The price that benefits both contractor and supplier

Point	Option (MYR)	Contractor and Supplier Pay-off, (%)	Joint Pay-off, (%)
Intercept price Contractor & S1	23.79	59.90	119.79
Intercept price Contractor & S2	23.66	66.46	132.91

B) Cement Price Issue

In figure 5.4 (b), the contractor has two differences of the price that only benefits for the contractor. MYR 323.00 is a minimum acceptable price, (A'_{min}) from supplier-

S1. The percentage pay-off for supplier-S1 at this price is 40%. While the percentage pay-off for contractor is 98.80%. Next, MYR 322.00 is a minimum acceptable price, (A'_{min}) for supplier-S2. The percentage pay-off from supplier-S2 at this price is 50% while the contractor percentage pay-off is 99.20%.

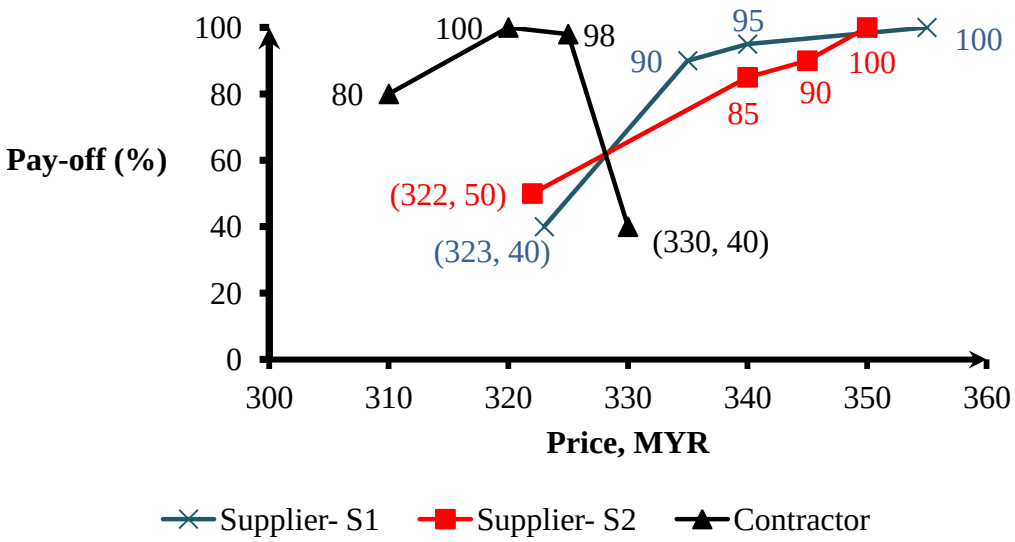


Figure 5.4 (b): Price for cement

The summary of results has shown in table 5.3 (a). Both price and percentage pay-off from supplier-S1 and supplier-S2 at a minimum acceptable price, (A'_{min}) did not intercept. Thus, it makes both suppliers having a different percentage pay-off and price.

Table 5.3 (a): The price only benefits the contractor

Point	Option (MYR)	Supplier Pay-off, (%)	Contractor Pay-off, (%)	Joint Pay-off, (%)
Supplier-S1	323.00	40.00	98.80	138.80
Supplier-S2	322.00	50.00	99.20	149.20

MYR 330.00 is the price that only benefits for the supplier. The contractor's percentage pay-off at this price is 40.00%. The summary of results is shown in table 5.3 (b). At MYR 330.00, the percentage pay-off from supplier-S1 is 69.17% while percentage pay-off from supplier-S2 is 65.56%. The main reason is that the gradients of the graph for both suppliers are different. Thus, this makes both percentage pay-off having the different value the same at this price.

Table 5.3 (b): The price only benefits the supplier

Point	Option (MYR)	Contractor Pay-off, (%)	Supplier Pay-off, (%)	Joint Pay-off, (%)
Supplier-S1	330.00	40.00	69.17	109.17
Supplier-S2	330.00	40.00	65.56	105.56

Focused on the price that has an interception with the percentage pay-off, the summary of results has shown in table 5.3 (c). Supplier-S1 intercepts with the contractor at the point (328.15, 61.46). On the other hand, supplier-S2 intercepts with the contractor at the point (328.11, 61.89). Based on this result, supplier-S1 intercepts at price MYR 328.15 and supplier-S2 intercepts at price MYR 328.11. Therefore, both suppliers did not have too much difference in terms of price and percentage pay-off. However, the percentage pay-off increases as the price decreases.

Table 5.3 (c): The price that benefits both contractor and supplier

Point	Option (MYR)	Contractor and Supplier Pay-off, (%)	Joint Pay-off, (%)
Intercept price Contractor & S1	328.15	61.46	122.92
Intercept price Contractor & S2	328.11	61.89	123.77

C) Ready Mix Concrete Price Issue

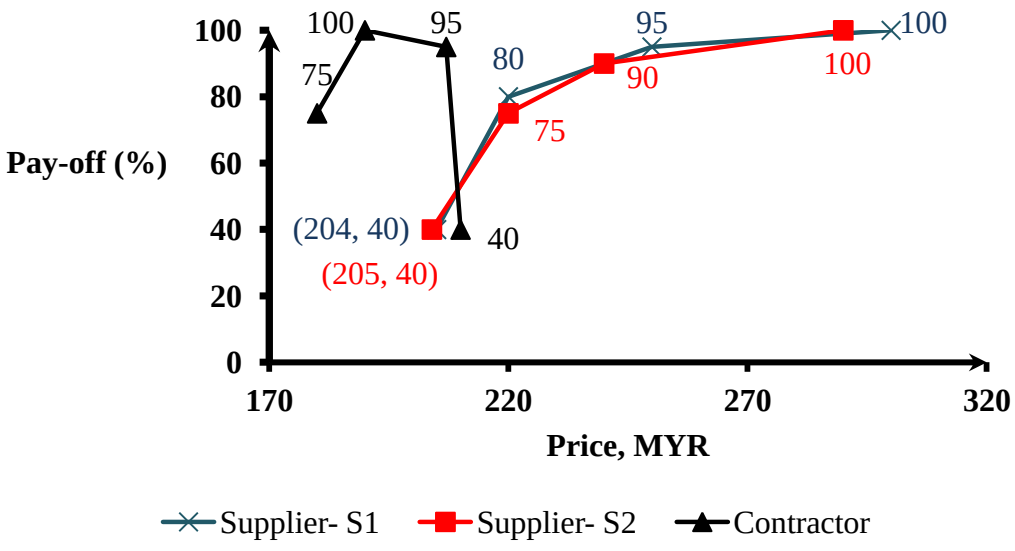


Figure 5.4 (c): Price for ready mix concrete

In figure 5.4 (c), the contractor has two differences value of the price only benefits the contractor. MYR 205.00 is a minimum acceptable price, (A'_{min}) for supplier-S1. The percentage pay-off from supplier-S1 at this price is 40%. While the percentage pay-off is 95.59% from contractor viewpoint. Next, MYR 204.00 is a minimum acceptable price, (A'_{min}) for supplier-S2. The supplier-S2 percentage pay-off at this price is 40% while the percentage pay-off from contractor is 95.88%.

The summary of results has shown in table 5.4 (a). Both price and percentage pay-off from supplier-S1 and supplier-S2 at a minimum acceptable price, (A'_{min}) did not intercept. Thus, it makes both suppliers having a different price.

Table 5.4 (a): The price only benefits the contractor

Point	Option (MYR)	Supplier Pay-off, (%)	Contractor Pay-off, (%)	Joint Pay-off, (%)
Supplier-S1	205.00	40.00	95.59	135.59
Supplier-S2	204.00	40.00	95.88	135.88

Meanwhile, MYR 210.00 is the price that only benefits for the supplier. The contractor's percentage pay-off at this price is 40.00%. The summary of results is shown in table 5.4 (b). At MYR 210.00, the percentage pay-off from supplier-S1 is 53.33% while percentage pay-off for supplier-S2 is 53.13%. The main reason is that the gradients of the graph for both suppliers are different. Thus, this makes both percentage pay-off having the different value at this price.

Table 5.4 (b): The price only benefits the supplier

Point	Option (MYR)	Contractor Pay-off, (%)	Supplier Pay-off, (%)	Joint Pay-off, (%)
Supplier-S1	210.00	40.00	53.33	93.33
Supplier-S2	210.00	40.00	53.13	93.13

Finally is the price that has an interception with the percentage pay-off. It is used to determine the price that benefits for both. The summary of results is shown in table 5.4 (c). Supplier-S1 intercepts with the contractor at the point (209.37, 51.64) while the supplier-S2 intercepts with the contractor at the point (209.36, 51.73). Based on this result, supplier-S1 intercepts at price MYR 209.37 and supplier-S2 intercepts at price MYR 209.36. Thus, both suppliers did not have too much difference in terms of

price percentage pay-off. However, the percentage pay-off increases as the price decreases.

Table 5.4 (c): The price that benefits both contractor and supplier

Point	Option (MYR)	Contractor and Supplier Pay-off, (%)	Joint Pay-off, (%)
Intercept price Contractor & S1	209.37	51.64	103.28
Intercept price Contractor & S2	209.36	51.73	103.45

5.1.2 Options in Payment Term Issue

In the payment term issue, it consists of four options need to choose during the negotiation process. It includes cash, 30-day check, 45-day check and 60-day check. Figure 5.5 (a) is the line chart that shows the percentage pay-off of aggregate stone, figure 5.5 (b) illustrates of cement and figure 5.5 (c) shows percentage pay-off of ready mix concrete. The cross marker represents supplier-S1, the square marker represents supplier-S2 and the triangle marker represents contractor percentage pay-off.

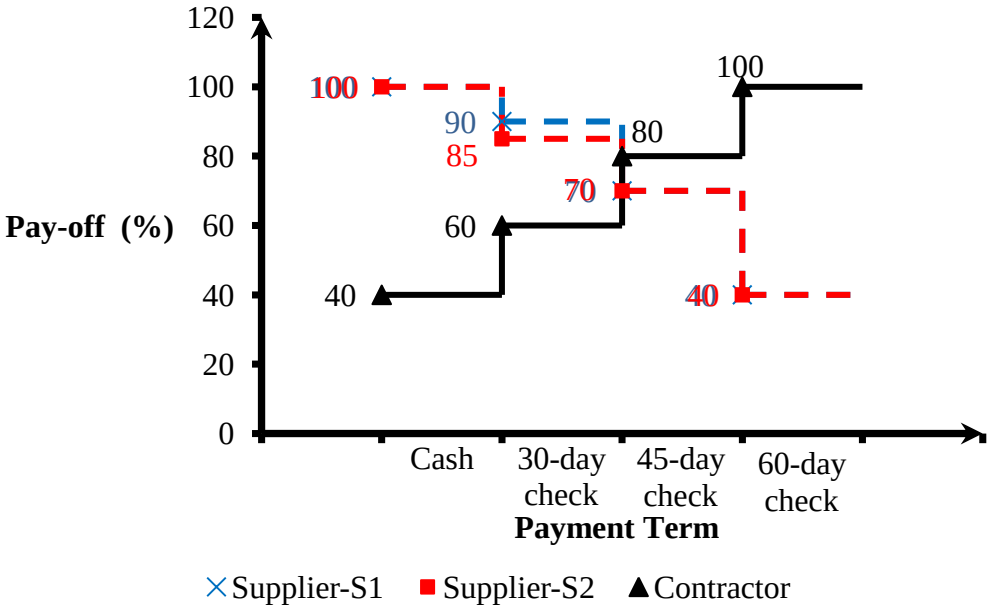


Figure 5.5 (a): Payment term for aggregate stone

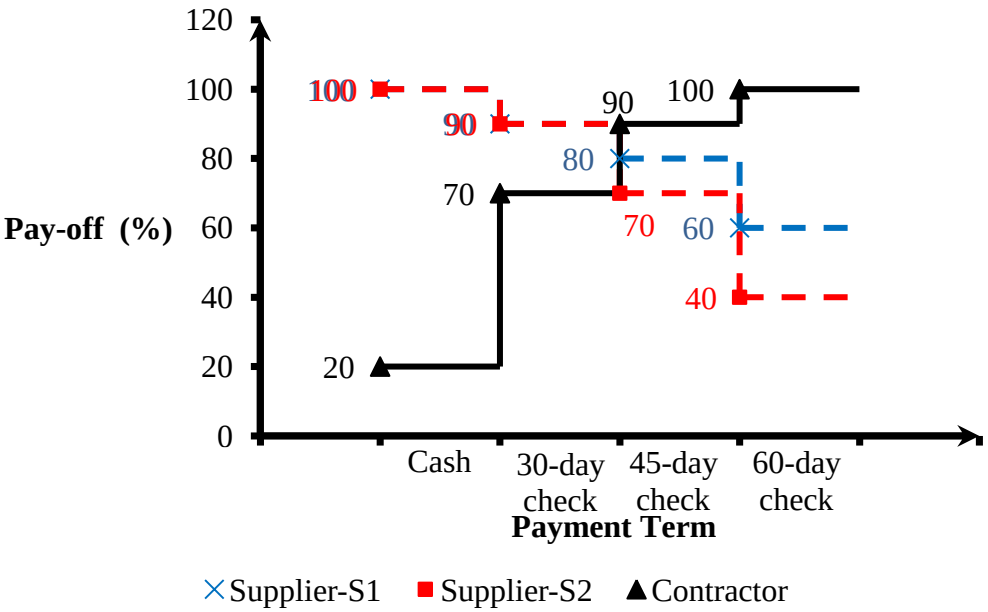


Figure 5.5 (b): Payment term for cement

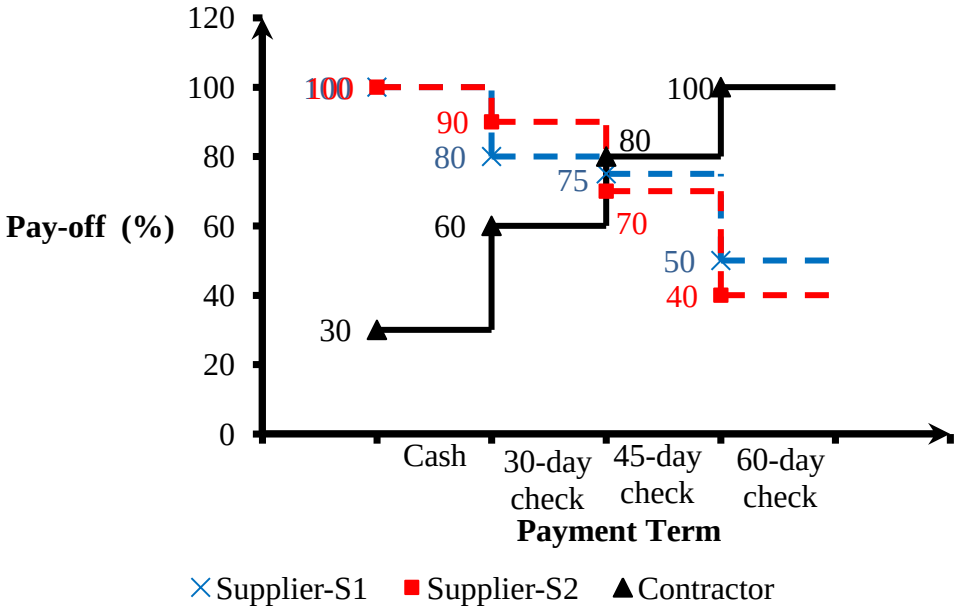


Figure 5.5 (c): Payment term for ready mix concrete

The desired option for a contractor or supplier is an option can give the highest benefit for single side (either contractor or supplier). All graphs show that the desired option for a contractor is 60-day check. The reason is the contractor needs the longest payment term in order maintained the cash flow in their accounts while the desired

option from the supplier is cash. The reason is that the supplier needs to reduce debt load from the contractor.

Finally the option that nearly benefits for both in each material is 45-day check. Although the percentage difference in the option of 30-day check and 45-day check in figure 5.5 (b) are the same (between contractor and supplier-S2), 45-day check option is selected as the intersection point because the contractor is a consumer during material procurement. Thus, the option that contractor has higher percentage pay-off than supplier must be selected.

5.1.3 Options in Payment Period Issue

Only five options in the payment period issue. It includes on delivery, on completion of milestones, on completion, bi weekly and monthly. Thus, the contractor needs to choose the possible period of payment during purchasing the materials. Figure 5.6 (a) is the line chart that shows the percentage pay-off of aggregate stone, figure 5.6 (b) illustrates percentage pay-off of cement and figure 5.6 (c) shows percentage pay-off of ready mix concrete. The cross marker represents supplier-S1, the square marker represents supplier-S2 and the triangle marker represents contractor percentage pay-off.

The desired option for a contractor or supplier is an option can give the highest benefit for single side (either contractor or supplier). All graphs of materials show that the desired option from a contractor is monthly period. The reason is the contractor needs the longest payment term in order maintained the cash flow in their accounts. While the desired option for the supplier is on delivery. The reason is that the supplier needs to reduce debt load from the contractor. Similar to the payment term issue, the selection of option is dependent on the strength of cash flow in contractor and supplier accounts. Normally, if the contractor has strong cash flow, contractor will select the shortest period to make a payment.

However, the option that nearly benefits for both the contractor and the supplier does not present the same value in each figure. In figure 5.6 (a), on completion option

can give the nearly benefits for both the contractor and the supplier. Supplier-S1 and supplier-S2 has the same percentage pay-off at this option, 70%. Thus, the lowest difference of percentage pay-off is 15% between contractor and both supplier.

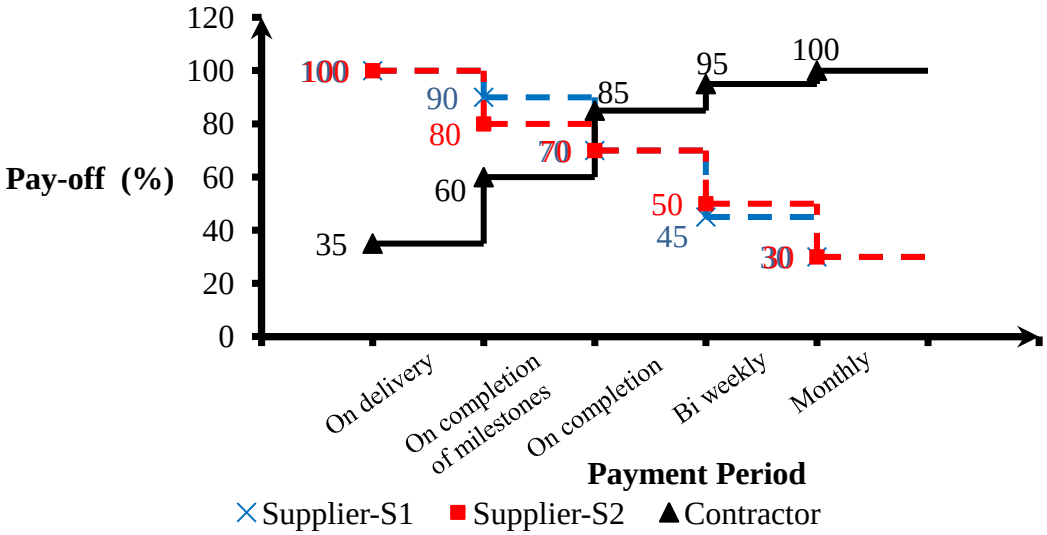


Figure 5.6 (a): Payment period for aggregate stone

In figure 5.6 (b), on completion option is the option that nearly benefits for both the contractor and the supplier-S1. However, the option that nearly benefits for both the contractor and the supplier-S2 is on completion of milestones. The percentage pay-off differences between contractor and both suppliers are the same, 10%.

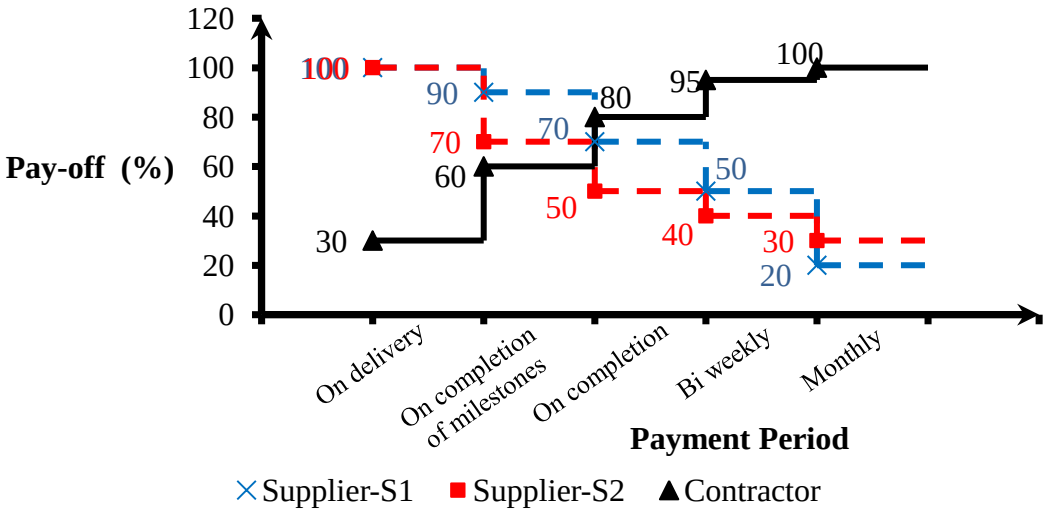


Figure 5.6 (b): Payment period for cement

Lastly in figure 5.6 (c), the option that nearly benefits for both the contractor and the supplier is on completion. The percentage difference is equal to 10%. Supplier-S1 and supplier-S2 has the same percentage pay-off at this option, 60%.

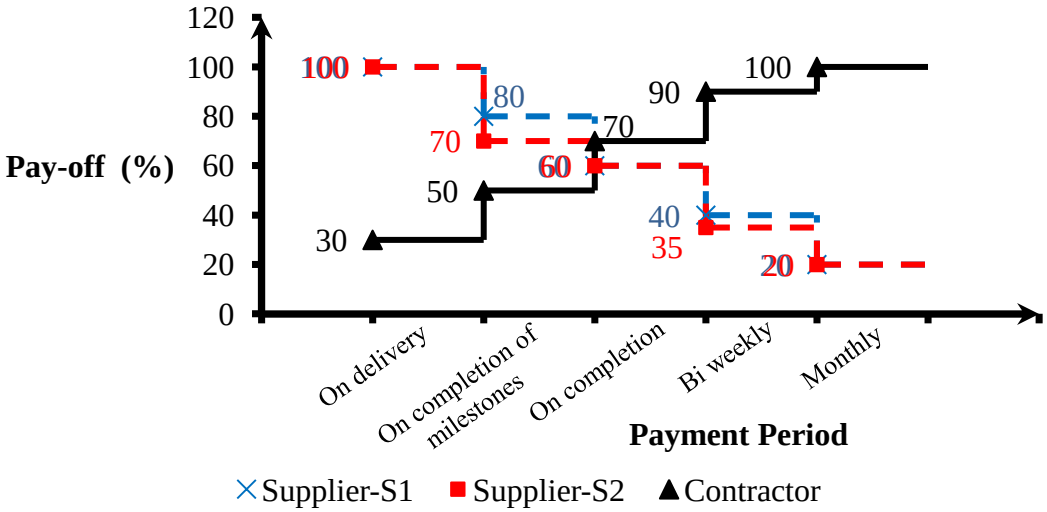


Figure 5.6 (c): Payment period for ready mix concrete

5.1.4 Options in Advance Payment Issue

Advance payment is the issue about the first payment of the price before the material will be delivered. Normally the options can be represented in percentage payment from the total price. Based on Malaysia material procurement, the percentage can be either 10%, 15%, 20%, 25% or 30. Figure 5.7 (a) is the line chart that shows the percentage pay-off of aggregate stone, figure 5.7 (b) illustrates percentage pay-off of cement and figure 5.7 (c) shows percentage pay-off of ready mix concrete. The cross marker represents supplier-S1, the square marker represents supplier-S2 and the triangle marker represents contractor percentage pay-off.

The desired option for a contractor or supplier is an option can give the highest benefit for single side (either contractor or supplier). All graphs of materials show that the desired option for the contractor is 10% while the desired option for the supplier is 30%. The advance payment is a guaranty for the contractor to purchase the materials. The selection of an option is dependent on the trust of single party to another. To avoid the contractor will cancel the purchase order, the supplier will ask contractor to

pay higher percentage advanced payment. Finally the option that nearly benefits both the contractor and the supplier is 20%.

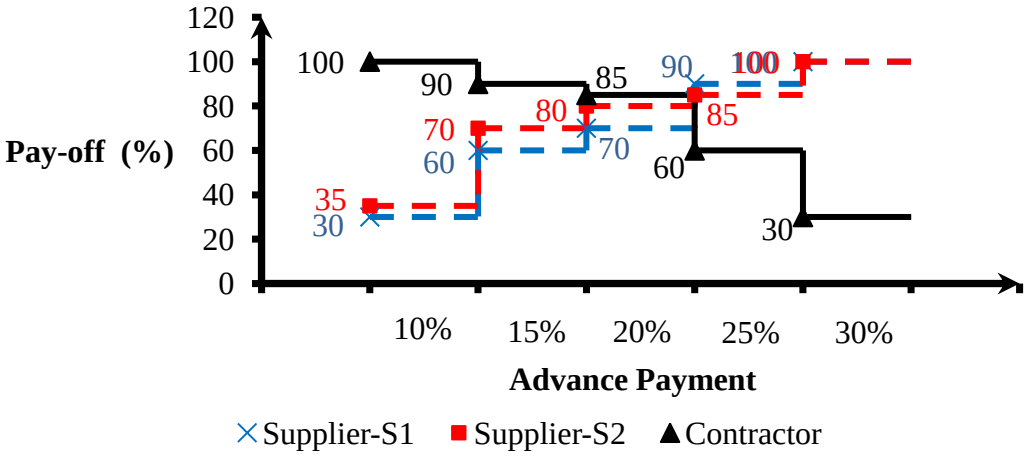


Figure 5.7 (a): Advance payment for aggregate stone

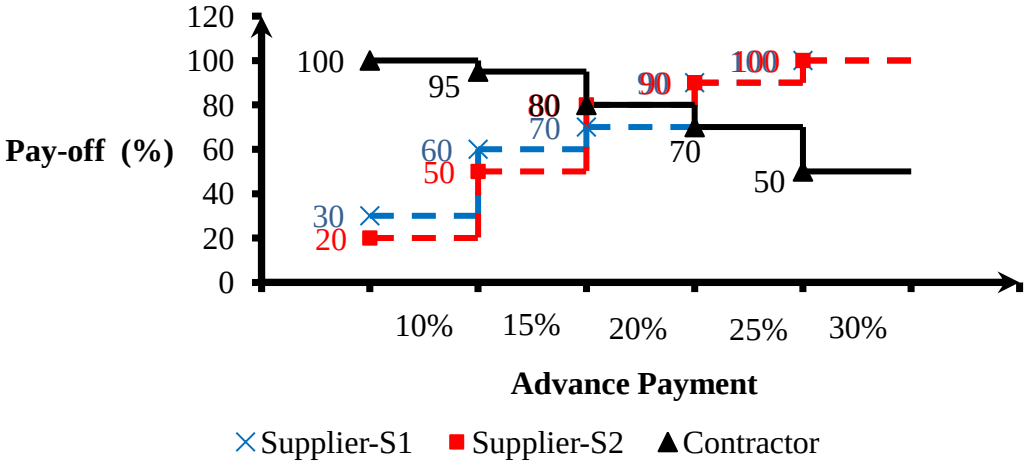


Figure 5.7 (b): Advance payment for cement

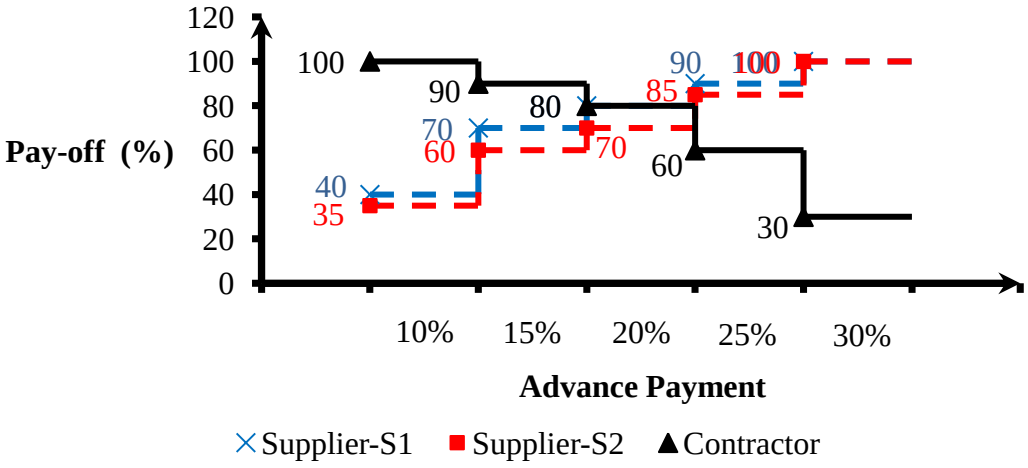


Figure 5.7 (c): Advance payment for ready mix concrete

5.1.5 Options in Delivery Issue

Delivery is an important issue related to the workload or time limitation at a construction site. If the workload is high the supplier needs to deliver the materials as soon as possible. The contractor will select the supplier that can deliver the materials followed their work schedule. Only three options related to delivery issue. It includes single delivery, multiple delivery and on call delivery.

Figure 5.8 (a) is the line chart that shows the percentage pay-off for aggregate stone, figure 5.8 (b) illustrates percentage pay-off of cement and figure 5.8 (c) shows percentage pay-off of ready mix concrete. The cross marker represents supplier-S1, the square marker represents supplier-S2 and the triangle marker represents contractor percentage pay-off. The desired option for a contractor or supplier is an option that can give the highest benefit for single side (either contractor or supplier). All graphs of materials show that the desired option for the contractor is on call delivery. But, this type of option is improper to choose because the supplier does not deal with a single contractor. To make sure the supply can be delivered on time. The supplier needs to manage the transportation schedule. However, the desired option in each figure from the supplier is single delivery. The reason is that the supplier needs to avoid waste on time and cost of transportation. Finally the option that nearly benefits for both in each figure is multiple delivery. It occurs in the middle of each graph.

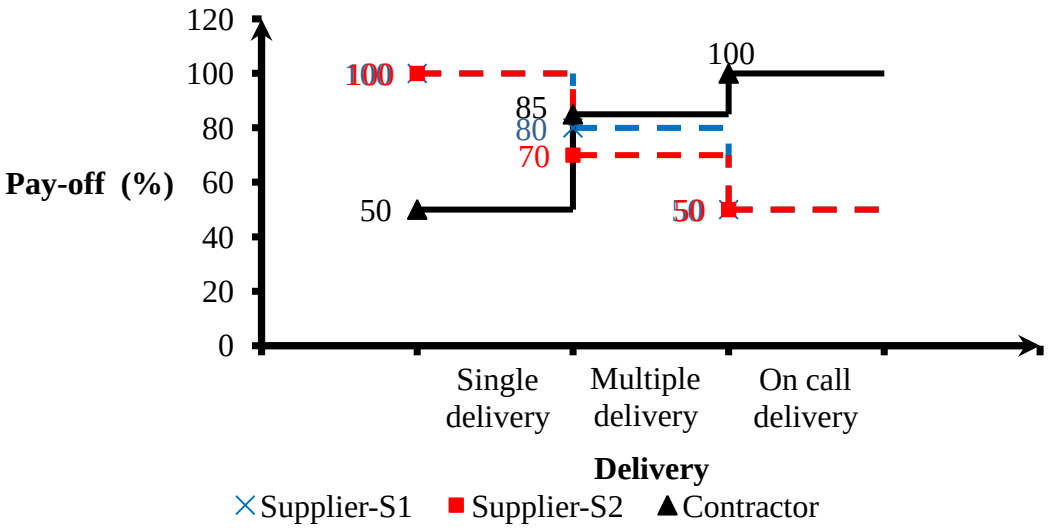


Figure 5.8 (a): Delivery for aggregate stone

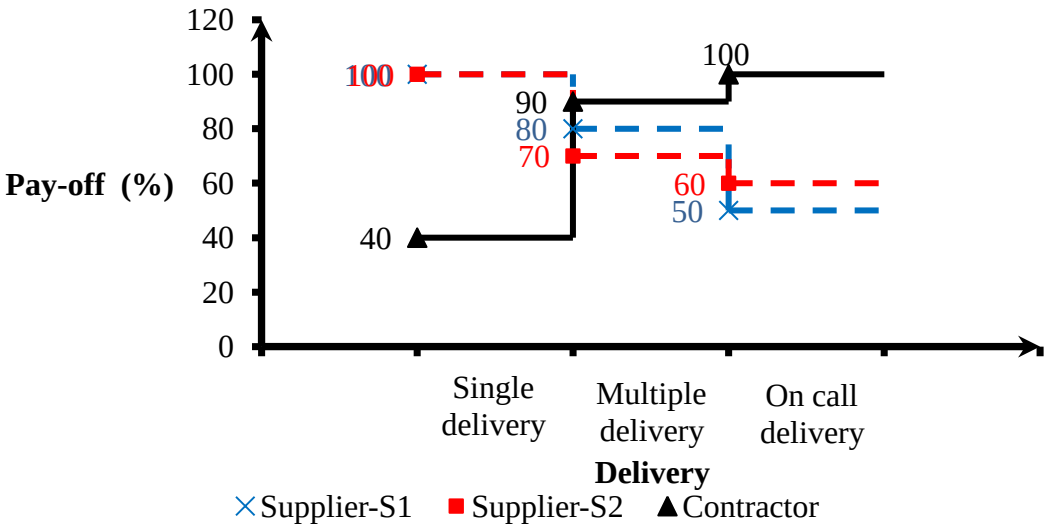


Figure 5.8 (b): Delivery for cement

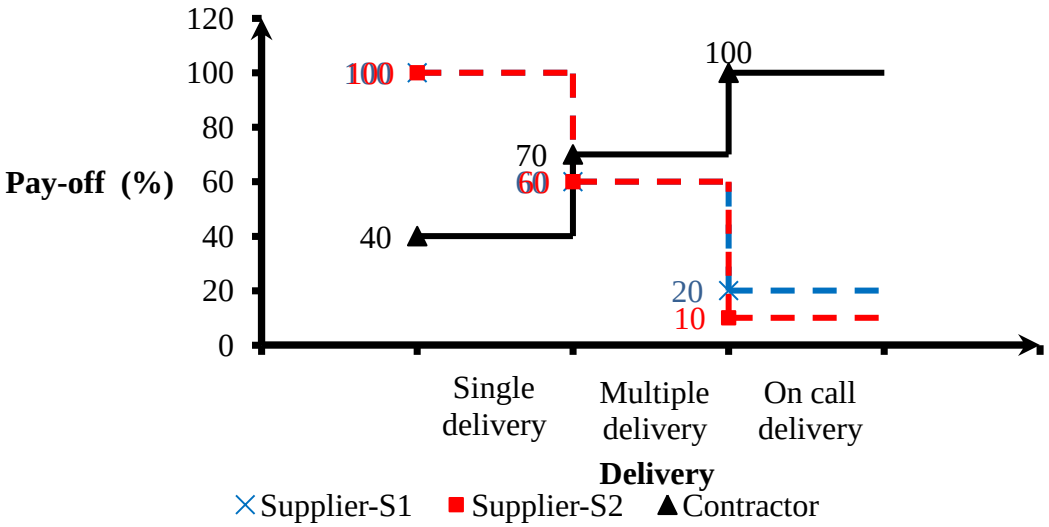


Figure 5.8 (c): Delivery for ready mix concrete

5.1.6 Options in Freightage Issue

The most important about freightage issue is related to the type of materials and availability of transportation. Some materials must include the transportation such as ready mix concrete. Because, only the supplier can provide the transit mixer to supply the ready mix concrete on site. Most of contractor does not have that facility. But some materials do not compulsory for supplier to prepare the transportation. The reason is that contractor has their own facility to transport the supply. Two options related to freightage issue. It is included and excluded the freightage.

Figure 5.9 (a) is the line chart that shows the percentage pay-off of aggregate stone, figure 5.9 (b) illustrates percentage pay-off of cement and figure 5.9 (c) shows percentage pay-off of ready mix concrete. The cross marker represents supplier-S1, the square marker represents supplier-S2 and the triangle marker represents contractor percentage pay-off.

The desired option for a contractor or supplier is an option that can give the highest benefit for one side (either contractor or supplier). All graphs of materials show that the desired option for the contractor is included the freightage. The reason is the contractor wants to avoid lack of supplies if the company is run out of transportation. Thus, the desired option for the supplier is excluded. The reason is that the supplier wants to reduce the workload to manage the schedule for delivering the materials.

Figure 5.9 (a): Freightage for aggregate stone

In freightage issue, the option that nearly benefits for both can be the desired option for contractor or supplier. The reason is only two options related to this issue. The smallest percentage difference will be selected as the option that nearly benefits for both. In figure 5.9 (a), the option that nearly benefits both the contractor and the supplier-S2 is excluded. The percentage difference is equal to 50%.

However, the option that nearly benefits for both the contractor and the supplier-S1 is included. The different percentage is also 50%. Although the option of excluded has the same value of percentage difference between contractor and supplier-S1, the included option is selected. The reason is the contractor has a higher percentage pay-off than the supplier. Moreover, the contractor is a consumer during purchasing the materials. Therefore, the contractor should get that advantage.

Meanwhile, in figure 5.9 (b) is the option that nearly benefits for both the contractor and suppliers are included the freightage. The percentage pay-off difference between contractor and supplier-S1 is equal to 30%. However, the different percentage for contractor and supplier-S2 is equal to 60%. Supplier-S2 has a lower percentage pay-off than supplier-S1 for included option. Thus, the possibility for supplier-S1 to provide the freightage is higher than supplier-S2.

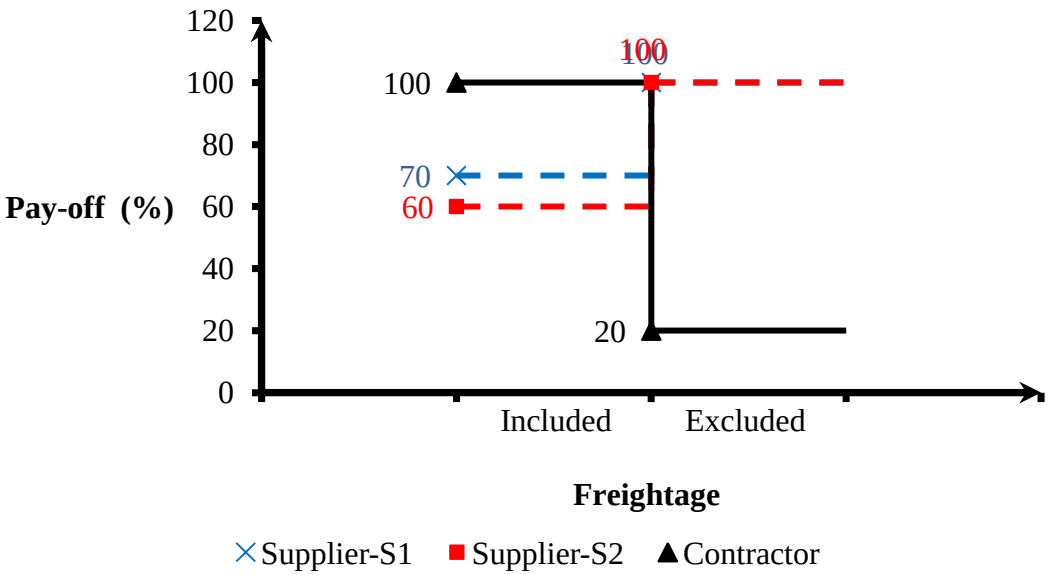


Figure 5.9 (b): Freightage for cement

Finally in figure 5.9 (c), the option that nearly benefits for both the contractor and both suppliers are included the freightage. The different percentage pay-off between contractor and suppliers are equal to 60%. Both suppliers have the same percentage pay-off for included option, 40%. Thus, the possibility for supplier-S1 and supplier-S2 to provide the freightage are same.

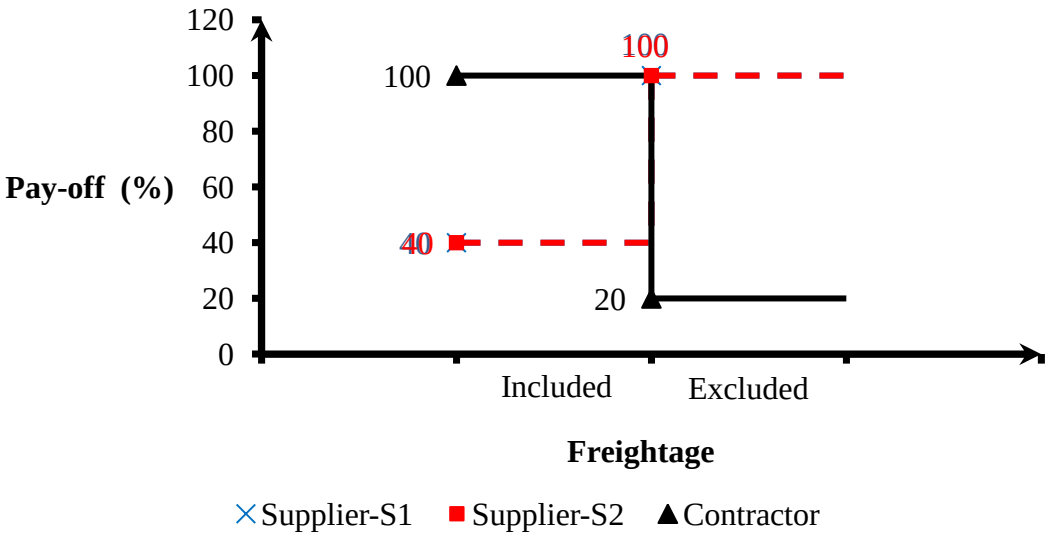


Figure 5.9 (c): Freightage for ready mix concrete

5.2 Optimization of Results

The joint pay-off benefits for the contractor or the supplier can be determined by plotting each point on 45º line graph. Figure 5.10 shows the 45º line graph. If the point upper than 45º line, the joint pay-off only benefits for the contractor. If the point is lower than that line, the joint pay-off only benefits for the supplier. Based on figure 5.10, the y-axis represents the summation of single contractor percentage pay-off while the x-axis represents the summation of single supplier percentage pay-off. Thus, it can be represented as:

(x, y) = (Summation of supplier pay-off, Summation of contractor pay-off).

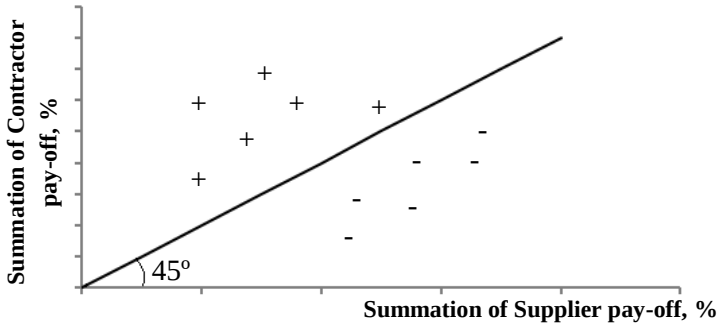


Figure 5.10: 45º line graphs

To prove each point is upper or lower than 45º line, the result of subtracting the value of x with the value of y can be helped (x value – y value). It's also known as

different percentage value. If the result sign is negative, that point is lower than 45º line. Meanwhile, the result sign is positive, that point is upper than 45º line. The reason is only points locate on 45º line have the same value of x-axis and y-axis. Thus, the result of the subtraction will be zero. Other than that point, the result of subtracting will have the sign of negative or positive.

Next, to determine the optimum joint pay-off in this analysis, the point must be:

3- Upper than 45º line. The procurement items were an unbalanced market (buyer's market).
4- Nearest to 45º line. It is better to optimize the joint pay-off rather than single pay-off.

These two scenarios can be illustrated as the Venn diagram such in figure 5.11.

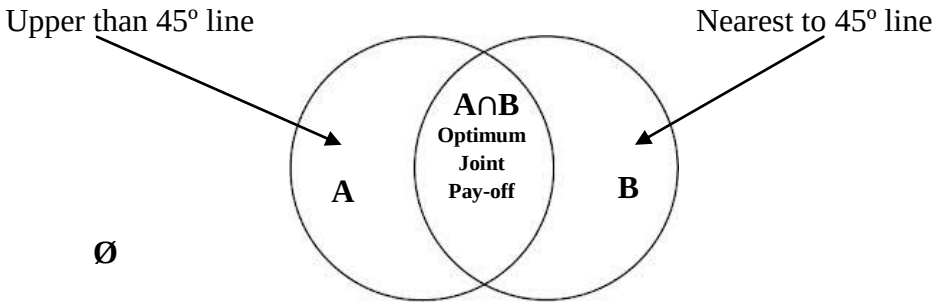


Figure 5.11: The venn diagram

Based on figure 5.11, the diagram consists of two intersecting circles, producing a total of four regions A, B, A∩B and Ø (the empty set, represented by none of the regions occupied). Here, A∩B denotes the intersection of sets A and B. It is defined as the optimum joint pay-off. Referring the result of subtracting the value of x with the value of y (x value – y value). The optimum joint pay-off is the lowest value of percentage difference point in positive sign. All analysis data in chapter 5.1 has been summarized in the following tables. Each table consists of six issues related to material procurement negotiation. The summation of single percentage pay-off is the average of single percentage pay-off while the joint pay-off is a summation of the contractor and the supplier average single percentage pay-off. Finally, the different percentage column shows the location of each point either upper (positive sign) or lower (negative sign) than 45º line. The lowest value of percentage difference point in positive sign will selected as an optimum joint pay-off.

5.2.1 Joint Pay-off of Aggregate Stone

Table 5.5 (a): Summary of total joint pay-off from contractor and supplier-S1

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S1	30.00	40	30	30	50	50	38.33	61.45
		Contractor	98.67	100	100	100	100	100	99.78	
2	Both	Supplier-S1	59.90	40	30	30	50	50	43.32	50
		Contractor	59.90	100	100	100	100	100	93.32	
3	Supplier	Supplier-S1	63.33	40	30	30	50	50	43.89	47.78
		Contractor	50.00	100	100	100	100	100	91.67	

Point	Price Benefits for			Other Issues Benefit for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
4	Contractor	Supplier-S1	30.00	70	70	70	80	50	61.67	27.27
		Contractor	98.67	80	85	85	85	100	88.94	
5	Both	Supplier-S1	59.90	70	70	70	80	50	66.65	15.83
		Contractor	59.90	80	85	85	85	100	82.48	
6	**Supplier**	**Supplier-S1**	**63.33**	**70**	**70**	**70**	**80**	**50**	**67.22**	**13.61**
		Contractor	**50.00**	**80**	**85**	**85**	**85**	**100**	**80.83**	

Point	Price Benefits for			Other Issues Benefit for the Supplier						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S1	30.00	100	100	100	100	100	88.33	-37.72
		Contractor	98.67	40	35	30	50	50	50.61	
8	Both	Supplier-S1	59.90	100	100	100	100	100	93.32	-49.17
		Contractor	59.90	40	35	30	50	50	44.15	
9	Supplier	Supplier-S1	63.33	100	100	100	100	100	93.89	-51.39
		Contractor	50.00	40	35	30	50	50	42.50	

Table 5.5 (b): Summary of option from contractor and supplier-S1

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	22.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	23.79	45-day check	On Completion	0.2	Multiple Delivery	Included
Supplier	24.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Table 5.6 (a): Summary of total joint pay-off from contractor and supplier-S2

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S2	30.00	40	30	35	50	40	37.50	62.28
		Contractor	98.67	100	100	100	100	100	99.78	
2	Both	Supplier-S2	66.46	40	30	35	50	40	43.58	50.83
		Contractor	66.46	100	100	100	100	100	94.41	
3	Supplier	Supplier-S2	74.00	40	30	35	50	40	44.83	46.84
		Contractor	50.00	100	100	100	100	100	91.67	

Point	Price Benefits for			Other Issues Benefit for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
4	**Contractor**	**Supplier-S2**	**30.00**	**70**	**70**	**80**	**70**	**100**	**70.00**	**10.61**
		Contractor	**98.67**	**80**	**85**	**85**	**85**	**50**	**80.61**	
5	Both	Supplier-S2	66.46	70	70	80	70	100	76.08	-0.84
		Contractor	66.46	80	85	85	85	50	75.24	
6	Supplier	Supplier-S2	74.00	70	70	80	70	100	77.33	-4.83
		Contractor	50.00	80	85	85	85	50	72.50	

Point	Price Benefits for			Other Issues Benefit for the Supplier						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S2	30.00	100	100	100	100	100	88.33	-37.72
		Contractor	98.67	40	35	30	50	50	50.61	
8	Both	Supplier-S2	66.46	100	100	100	100	100	94.41	-49.17
		Contractor	66.46	40	35	30	50	50	45.24	
9	Supplier	Supplier-S2	74.00	100	100	100	100	100	95.67	-53.17
		Contractor	50.00	40	35	30	50	50	42.50	

Table 5.6 (b): Summary of option from contractor and supplier-S2

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	22.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	23.66	45-day check	On Completion	0.2	Multiple Delivery	Excluded
Supplier	24.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Figure 5.12 illustrates nine scenarios of joint pay-off for aggregate stone. The x-axis represents summation of supplier percentage pay-off. Meanwhile the y-axis represents summation of contractor percentage pay-off. The black points with S1 labels represent the joint pay-off from contractor and supplier-S1 viewpoint. The coordinates of each point have been shown in table 5.5 (a) at the average single pay-off column. Table 5.5 (b) is the summation of each option. Next, the red points with S2 labels represent the joint pay-off from contractor and supplier-S2 viewpoint. The coordinates of each point have been shown in table 5.6 (a) at the average single pay-off column. Table 5.6 (b) is the summation of each option. The type of each point symbol is shown in the remarks.

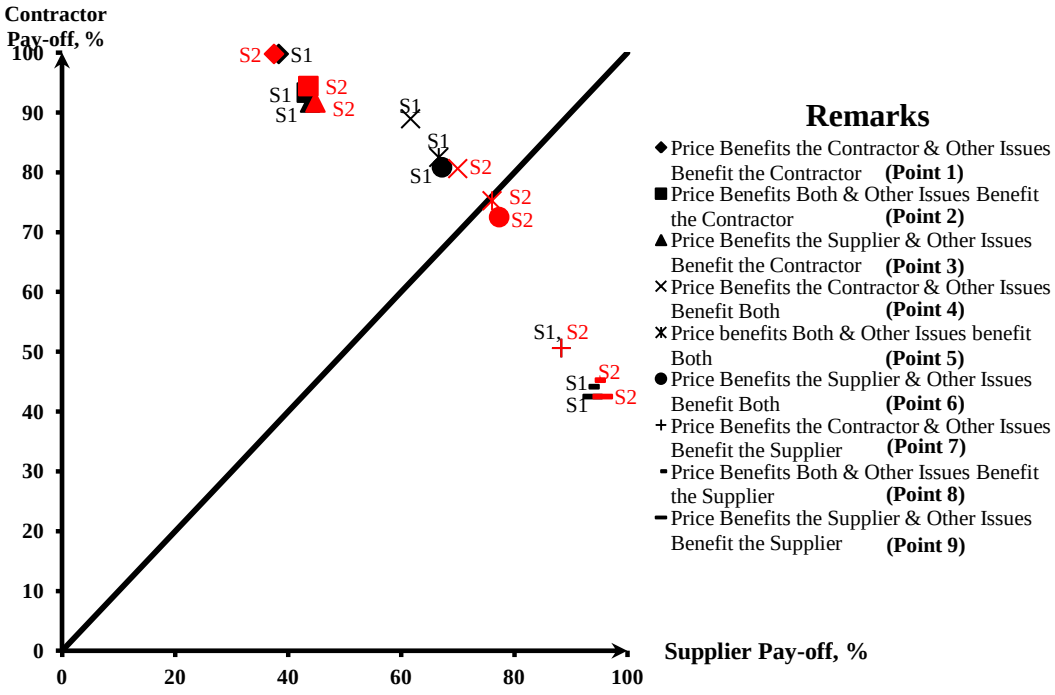


Figure 5.12: The joint pay-off of aggregate stone – unconsidered weight

For the contractor and supplier-S1 joint pay-off, six points are located above than 45º line. It includes point number 1, 2, 3, 4, 5 and 6. Based on these six points, the optimum joint pay-off is point 6 because it is nearest point to 45º line. The option of this point is the Price Benefits for the Supplier and other Issues Benefit for Both. While, only four points are located above than 45º line. It includes point number 1, 2, 3 and 4. Based on these four points, the optimum joint pay-off is point number 4 because it is located nearest to 45º. The option of this point is the Price Benefits for the Contractor and other Issues Benefit for Both.

5.2.2 Joint Pay-off of Cement

Table 5.7 (a): Summary of total joint pay-off from contractor and supplier-S1

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S1	40.00	60	20	30	50	70	45.00	54.8
		Contractor	98.80	100	100	100	100	100	99.80	
2	Both	Supplier-S1	61.46	60	20	30	50	70	48.58	45
		Contractor	61.46	100	100	100	100	100	93.58	
3	Supplier	Supplier-S1	69.17	60	20	30	50	70	49.86	40.14
		Contractor	40.00	100	100	100	100	100	90.00	

Point	Price Benefits for			Other Issues Benefits for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
4	Contractor	Supplier-S1	40.00	80	70	70	80	70	68.33	21.47
		Contractor	98.80	90	80	80	90	100	89.80	
5	Both	Supplier-S1	61.46	80	70	70	80	70	71.91	11.67
		Contractor	61.46	90	80	80	90	100	83.58	
6	**Supplier**	**Supplier-S1**	**69.17**	**80**	**70**	**70**	**80**	**70**	**73.19**	**6.81**
		Contractor	**40.00**	**90**	**80**	**80**	**90**	**100**	**80.00**	

Point	Price Benefits for			Other Issues Benefit for the Supplier						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S1	40.00	100	100	100	100	100	90.00	-46.87
		Contractor	98.80	20	30	50	40	20	43.13	
8	Both	Supplier-S1	61.46	100	100	100	100	100	93.58	-56.67
		Contractor	61.46	20	30	50	40	20	36.91	
9	Supplier	Supplier-S1	69.17	100	100	100	100	100	94.86	-61.53
		Contractor	40.00	20	30	50	40	20	33.33	

Table 5.7 (b): Summary of option from contractor and supplier-S1

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	323.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	328.15	45-day check	On Completion	0.2	Multiple Delivery	Included
Supplier	330.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Table 5.8 (a): Summary of total joint pay-off from contractor and supplier-S2

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S2	50.00	40	30	20	60	60	43.33	56.54
		Contractor	99.20	100	100	100	100	100	99.87	
2	Both	Supplier-S2	61.89	40	30	20	60	60	45.31	48.34
		Contractor	61.89	100	100	100	100	100	93.65	
3	Supplier	Supplier-S2	65.56	40	30	20	60	60	45.93	44.07
		Contractor	40.00	100	100	100	100	100	90.00	

Point	Price Benefits for			Other Issues Benefit for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
4	Contractor	Supplier-S2	50.00	70	70	80	70	60	66.67	19.86
		Contractor	99.20	90	60	80	90	100	86.53	
5	Both	Supplier-S2	61.89	70	70	80	70	60	68.65	11.66
		Contractor	61.89	90	60	80	90	100	80.31	
6	**Supplier**	**Supplier-S2**	**65.56**	**70**	**70**	**80**	**70**	**60**	**69.26**	**7.41**
		Contractor	**40.00**	**90**	**60**	**80**	**90**	**100**	**76.67**	

Point	Price Benefits for			Other Issues Benefit for the Supplier						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S2	50.00	100	100	100	100	100	91.67	-48.47
		Contractor	99.20	20	30	50	40	20	43.20	
8	Both	Supplier-S2	61.89	100	100	100	100	100	93.65	-56.67
		Contractor	61.89	20	30	50	40	20	36.98	
9	Supplier	Supplier-S2	65.56	100	100	100	100	100	94.26	-60.93
		Contractor	40.00	20	30	50	40	20	33.33	

Table 5.8 (b): Summary of option from contractor and supplier-S2

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	322.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	328.11	45-day check	On Completion of Milestone	0.2	Multiple Delivery	Included
Supplier	330.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Figure 5.13 illustrates nine scenarios of joint pay-off for cement. The x-axis represents supplier percentage pay-off. Meanwhile the y-axis represents summation of contractor percentage pay-off. The black points with S1 labels represent the joint pay-off from contractor and supplier-S1 viewpoint. The coordinates of each point have been shown in table 5.7 (a) at the average single pay-off column. Table 5.7 (b) is the summation of each option. Next, the red points with S2 labels represent the joint pay-off from contractor and supplier-S2 viewpoint. The coordinates of each point have been shown in table 5.8 (a) at the average single pay-off column. Table 5.8 (b) is the summation of each option. The type of each point symbol is shown in the remarks.

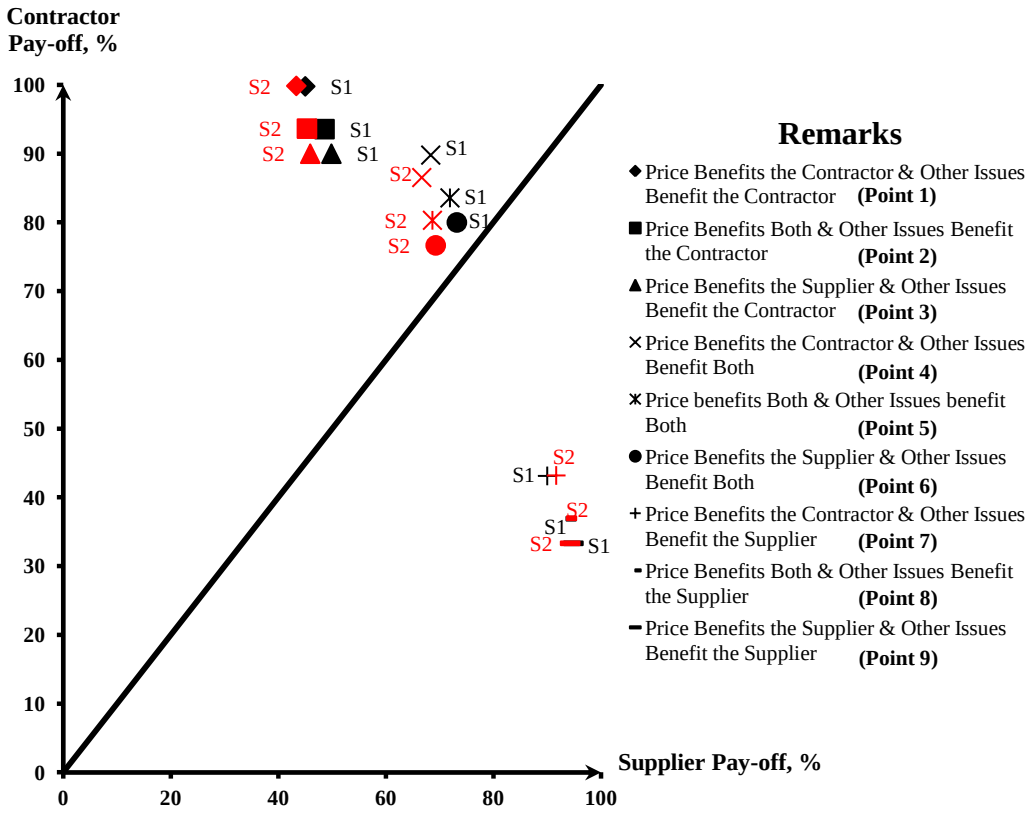


Figure 5.13: The joint pay-off of cement – unconsidered weight

For the contractor and supplier-S1 joint pay-off, six points are located above than 45º line. The contractor and supplier-S2 joint pay-off also have six points are above than 45º line. It includes point number 1, 2, 3, 4, 5 and 6. Based on these six points, the optimum joint pay-off is point number 6 because it is nearest to 45º line. The option of this point is the Price Benefits for the Supplier and other Issues Benefit for Both.

5.2.3 Joint Pay-off of Ready Mix Concrete

Table 5.9 (a): Summary of total joint pay-off from contractor and supplier-S1

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S1	40.00	50	20	40	20	40	35.00	64.26
		Contractor	95.59	100	100	100	100	100	99.26	
2	Both	Supplier-S1	51.64	50	20	40	20	40	36.94	55
		Contractor	51.64	100	100	100	100	100	91.94	
3	Supplier	Supplier-S1	53.33	50	20	40	20	40	37.22	52.78
		Contractor	40.00	100	100	100	100	100	90.00	

Point	Price Benefits for			Other Issues Benefit for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
4	Contractor	Supplier-S1	40.00	75	60	80	60	40	59.17	23.43
		Contractor	95.59	80	70	80	70	100	82.60	
5	Both	Supplier-S1	51.64	75	60	80	60	40	61.11	14.16
		Contractor	51.64	80	70	80	70	100	75.27	
6	**Supplier**	**Supplier-S1**	**53.33**	**75**	**60**	**80**	**60**	**40**	**61.39**	**11.94**
		Contractor	**40.00**	**80**	**70**	**80**	**70**	**100**	**73.33**	

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S1	40.00	100	100	100	100	100	90.00	-49.07
		Contractor	95.59	30	30	30	40	20	40.93	
8	Both	Supplier-S1	51.64	100	100	100	100	100	91.94	-58.33
		Contractor	51.64	30	30	30	40	20	33.61	
9	Supplier	Supplier-S1	53.33	100	100	100	100	100	92.22	-60.55
		Contractor	40.00	30	30	30	40	20	31.67	

Table 5.9 (b): Summary of option from contractor and supplier-S1

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	205.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	209.37	45-day check	On Completion	0.2	Multiple Delivery	Included
Supplier	210.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Table 5.10 (a): Summary of total joint pay-off from contractor and supplier-S2

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S2	40.00	40	20	35	10	40	30.83	68.48
		Contractor	95.88	100	100	100	100	100	99.31	
2	Both	Supplier-S2	51.73	40	20	35	10	40	32.79	59.16
		Contractor	51.73	100	100	100	100	100	91.95	
3	Supplier	Supplier-S2	53.13	40	20	35	10	40	33.02	56.98
		Contractor	40.00	100	100	100	100	100	90.00	

Point	Price Benefits for			Other Issues Benefit for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
4	Contractor	Supplier-S2	40.00	70	60	70	60	40	56.67	25.98
		Contractor	95.88	80	70	80	70	100	82.65	
5	Both	Supplier-S2	51.73	70	60	70	60	40	58.62	16.67
		Contractor	51.73	80	70	80	70	100	75.29	
6	**Supplier**	**Supplier-S2**	**53.13**	**70**	**60**	**70**	**60**	**40**	**58.85**	**14.48**
		Contractor	**40.00**	**80**	**70**	**80**	**70**	**100**	**73.33**	

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Average Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S2	40.00	100	100	100	100	100	90.00	-49.02
		Contractor	95.88	30	30	30	40	20	40.98	
8	Both	Supplier-S2	51.73	100	100	100	100	100	91.95	-58.33
		Contractor	51.73	30	30	30	40	20	33.62	
9	Supplier	Supplier-S2	53.13	100	100	100	100	100	92.19	-60.52
		Contractor	40.00	30	30	30	40	20	31.67	

Table 5.10 (b): Summary of option from contractor and supplier-S2

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	204.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	209.36	45-day check	On Completion	0.2	Multiple Delivery	Included
Supplier	210.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Figure 5.14 illustrates nine scenarios of joint pay-off for ready mix concrete. The x-axis represents supplier percentage pay-off. Meanwhile the y-axis represents summation of contractor percentage pay-off. The black points with S1 labels represent the joint pay-off from contractor and supplier-S1 viewpoint. The coordinates of each point have been shown in table 5.9 (a) at the average single pay-off column. Table 5.9 (b) is the summation of each option. Next, the red points with S2 labels represent the joint pay-off from contractor and supplier-S2 viewpoint. The coordinates of each point have been shown in table 5.10 (a) at the average single pay-off column. Table 5.10 (b) is the summation of each option. The type of each point symbol has shown in the remarks.

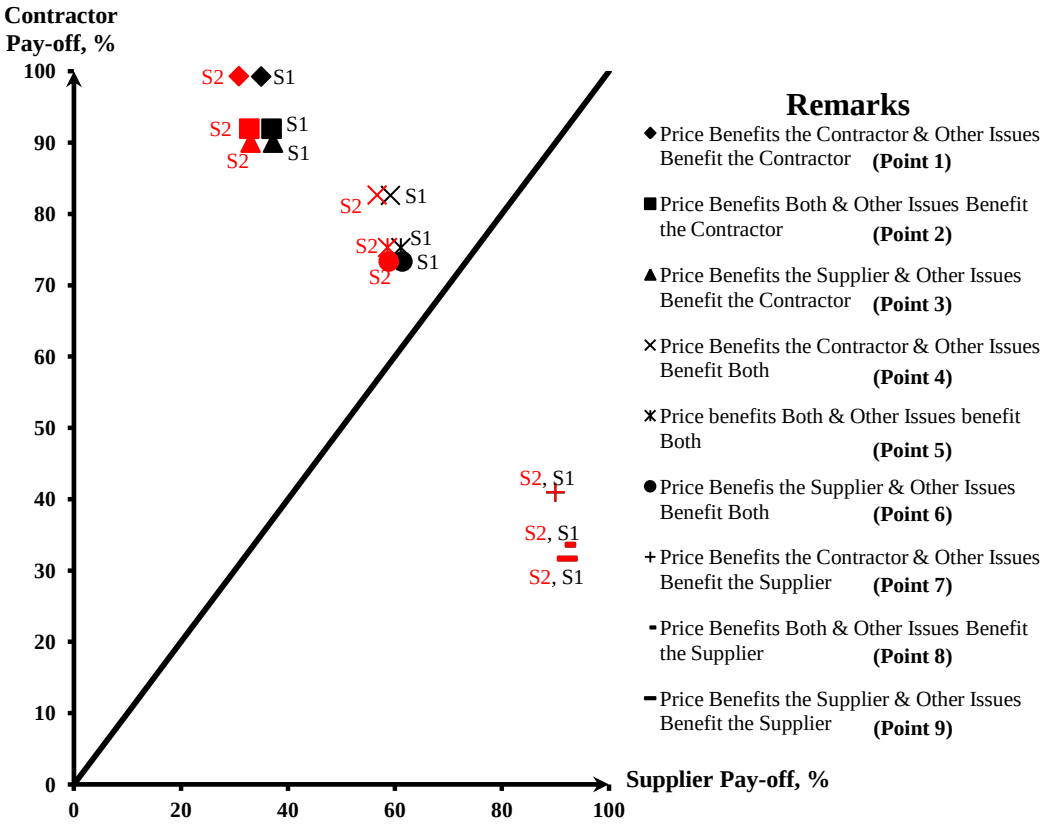


Figure 5.14: The joint pay-off of ready mix concrete – unconsidered weight

For the contractor and supplier-S1 joint pay-off, six points are located above than 45º line. The contractor and supplier-S2 joint pay-off also have six points are above than 45º line. It includes point number 1, 2, 3, 4, 5 and 6. Based on these six points, the optimum joint pay-off is point 6 because it is nearest to 45º line. The option of this point is the Price Benefits for the Supplier and other Issues Benefit for Both.

5.3 Summary of Chapter

The joint pay-off benefits for both contractor and supplier in the issue of price occurred at intersection point. While the other issues for option nearly benefits for both is occurred at the lowest different percentage. In the issue of payment term, 45-day check is option benefit for both, on completion for the issue of payment period, 20% is for the issue advance payment, the multiple delivery and finally for the issue of freightage option included give nearly same benefit for both contractor and supplier.

Next, for the point give optimum joint pay-off, the option point number 4 which is the Price Benefits for the Contractor and other Issues Benefit for Both is selected for negotiation in aggregate stone (Supplier-S1). While the option point number 6 which is the Price Benefits for the Supplier and other Issues Benefit for Both (Supplier-S2). Both supplier-S1 and supplier-S2 in the negotiation of cement have the same optimum joint pay-off which is point number 6 (Price Benefits for the Supplier and other Issues Benefit for Both). This optimum joint pay-off point is also same in the negotiation of ready mix concrete.

CHAPTER VI

CONSIDER WEIGHT IN MATERIAL PROCUREMENT NEGOTIATION ISSUES

The Analytical Hierarchical process, AHP is the most suitable method to determine the weight of each issue. It represents the important level for each issue. The same three contractors and six suppliers in chapter V are involved to answer the survey question. The result of weight will be multiplied with the percentage pay-off in chapter V. Same as chapter V analysis, three options are need to determine. It includes the option only benefits for the contractor, the option only benefits for the supplier and the option benefits for both contractor and supplier. Next, the most option in each issue provides the benefit for the contractor during the negotiation process optimization graph could help. The point of joint pay-off that is located higher than 45º line will be benefit for the contractor while the point location is lower than 45º lines will be benefit for the supplier.

6.1 Weight of Each Issue

The summation of all the weights is equal to 1. The importance level of each issue is based on the value of weight. The highest weight shows that the issue is the most important. Each weight represents the important percentage of single issue for the single party (contractor or supplier). Each party has their own value of weight in each issue. It relies on the size of a company, the strength of cash flow account, facilities and even age of a company. As an example, only the issue of freightage and payment term in material procurement negotiation. Some companies have higher strength of cash flow and need an airplane to transport the construction material from East Malaysia to Peninsular. This kind of condition will make the weight of payment term lower than the weight of freightage issue. As precautions in this analysis, the case study is limited to contractors in the state of Perak, Malaysia. Other than that, the contractors must be registered with the Contraction Industry Development Board, CIDB in class G7. The table 6.1, 6.2 and 6.3 consist of a single contractor negotiated with two suppliers. It involves six issues related to material procurement negotiation.

6.1.1 Weight of Issues for Aggregate Stone

In table 6.1, the rank of the issue starts from the highest to the lowest weight. From the contractor viewpoint, the first rank is price followed by delivery, freightage, payment term, payment period and advance payment. While for the supplier-S1 and the supplier-S2, the price is ranked first, followed by payment term, payment period, delivery, freightage and advance payment. The value of each weight has shown in table 6.1. All parties have the highest weight on the issue of price because it is the main issue that needs to be considered during material procurement negotiation.

In general, the next five types of issue can be separated into two groups. Payment term, payment period and advance payment are in a group of the price payment. Meanwhile, delivery and freightage are in a group of the transportation facility.

Table 6.1: Weight of issues for aggregate stone

Issue	Contractor		Supplier-S1		Supplier-S2	
	Rank	**Weight**	**Rank**	**Weight**	**Rank**	**Weight**
Price	1	0.57	1	0.54	1	0.55
Payment Term	4	0.08	2	0.14	2	0.14
Payment Period	5	0.06	3	0.13	3	0.12
Advance Payment	6	0.05	5	0.06	5	0.06
Delivery	2	0.13	4	0.07	4	0.07
Freightage	3	0.11	5	0.06	5	0.06
Total		**1.00**		**1.00**		**1.00**

In aggregate stone procurement, contractor needs a transportation facility to get the supply of aggregate stone. Thus, it makes the delivery and the freightage become the next important issue after the price. The advance payment, payment period and payment term are the three issues that are held by the contractor at the lowest weight. All these three issues related to the price payment. This contractor is registered with the Contraction Industry Development Board, CIDB in class G7. Thus, it has strong cash flow and the price does not a big problem for them to deal with the supplier.

Supplier-S1 and Supplier-S2 have nearly the same importance level of each issue. The payment term and the payment period are the next important issue after the price. The reason is the supplier did not compulsory to prepare transportation. It depends on

the choice selected by the contractor. However, the selection of an option by the contractor may affect the issue of payment term and payment period. The supplier will decide the option that should be taken by the contractor in this both issues.

6.1.2 Weight of Issues for Cement

In table 6.2, the rank of the issue starts from the highest to the lowest weight. From the contractor viewpoint, the first rank is price followed by delivery, payment term, freightage, payment period and advance payment. While, from the supplier-S1 and the supplier-S2, the price is ranked first, followed by payment term, payment period, delivery, freightage and advance payment. The value of each weight has shown in that table. All parties have the highest weight on the issue of price because it is the main issue that needs to be considered during material procurement negotiation.

In general, the next five types of issue can be separated into two groups. Payment term, payment period and advance payment are in a group of the price payment. Meanwhile, delivery and freightage are in a group of the transportation facility.

Table 6.2: Weight of issues for cement

Issue	Contractor		Supplier-S1		Supplier-S2	
	Rank	**Weight**	**Rank**	**Weight**	**Rank**	**Weight**
Price	1	0.57	1	0.56	1	0.55
Payment Term	3	0.13	2	0.13	2	0.13
Payment Period	5	0.06	3	0.12	3	0.13
Advance Payment	6	0.05	5	0.06	5	0.06
Delivery	2	0.10	4	0.07	4	0.07
Freightage	4	0.08	5	0.06	5	0.06
Total		**1.00**		**1.00**		**1.00**

In cement procurement, the contractor has choice to include or exclude the freightage. It depends on the total quantity of cement to purchase, availability of supplier freightage and the option of payment term can get from the supplier. As long, the supply of cement can be followed the work schedule at a construction site. Because of that, it makes the delivery becomes the next important issue after the price. However, before the contractor makes a decision to include or exclude the

freightage. They will consider the possible option that can get from the supplier in the issue of the payment term.

Supplier-S1 and Supplier-S2 have nearly the same importance level of each issue. The payment term and the payment period are the next important issue after the price. The reason is that the supplier did not compulsory to prepare transportation. It depends on the choice selected by the contractor. However, the selection of an option by the contractor may affect the issue of payment term and payment period. The supplier will decide the option that should be taken by the contractor in this both issues.

6.1.3 Weight of Issues for Ready Mix Concrete

In table 6.3, the rank of the issue starts from the highest to the lowest weight. From the contractor viewpoint, the first rank is price followed by payment term, payment period, advance payment, freightage and delivery. While for the supplier-S1 and the supplier-S2, the price is ranked first, followed by freightage, delivery, payment term, payment period and lastly advance payment. The value of each weight has shown in that table. All parties have the highest weight on the issue of price because it is the main issue that needs to be considered during material procurement negotiation.

In general, the next five types of issue can be separated into two groups. Payment term, payment period and advance payment are in a group of the price payment. Meanwhile delivery and freightage are in a group of the transportation facility.

Table 6.3: Weight of issues for ready mix concrete

Issue	Contractor		Supplier-S1		Supplier-S2	
	Rank	**Weight**	**Rank**	**Weight**	**Rank**	**Weight**
Price	1	0.52	1	0.55	1	0.54
Payment Term	2	0.15	4	0.09	4	0.10
Payment Period	3	0.11	5	0.06	5	0.06
Advance Payment	4	0.08	6	0.05	6	0.05
Delivery	6	0.06	3	0.11	3	0.12
Freightage	5	0.07	2	0.15	2	0.14
Total		**1.00**		**1.00**		**1.00**

Supplier-S1 and Supplier-S2 have nearly the same importance level of each issue. In ready mix concrete procurement, supplier needs to provide a transportation facility for contractors because the contractor did not have a transit mixer to transport the supply. Thus, it makes the delivery and the freightage become the next important issue after the price. The advance payment, payment period and payment term are the three issues that are held by the supplier at the lowest weight.

The contractor needs to consider the payment term, the payment period and advance payment for the next issue after the price. The reason is the transportation facility to supply the ready mix concrete is on demand. Thus, it makes the contractor to choose the most suitable option in the issue of payment term, payment period and advance payment. The freightage and the delivery are the two issues that are held by the contractor at the lowest weight.

6.2 Option and Percentage Pay-off

Figure 6.1 (from chapter V) illustrates the issue of the payment term without the consideration of the weight. While figure 6.2 shows the issue of payment term with the consideration of the weight.

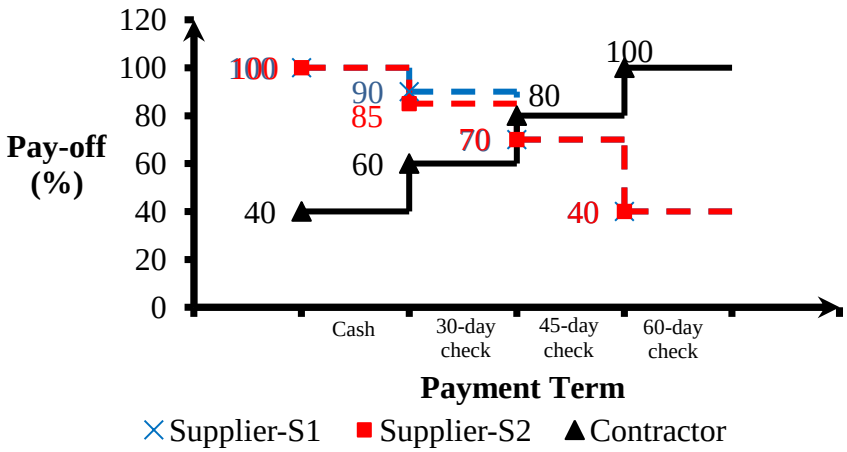


Figure 6.1: Payment term for aggregate stone – unconsidered weight

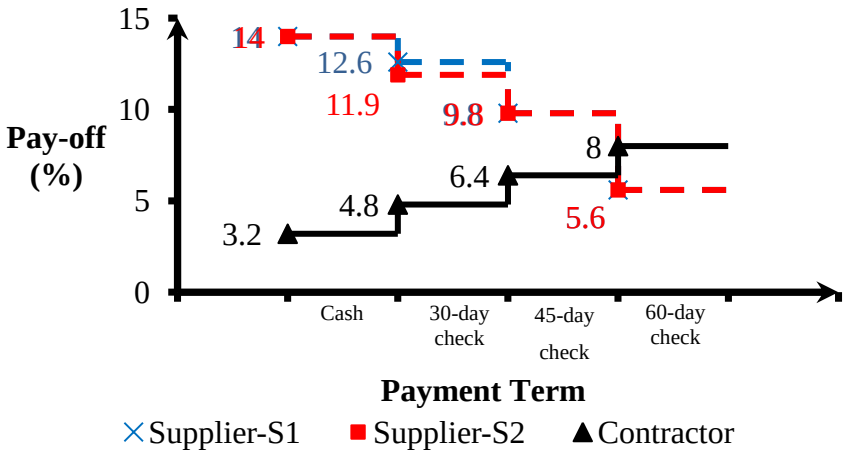


Figure 6.2: Payment term for aggregate stone – considered weight

Same as the mathematical function in chapter V, three options need to consider. It includes the option only benefits for the contractor, the option only benefits for the supplier and the option that benefits for both. To analyze the mathematical function with the consideration of the weight, each option will be multiplied by the weight of the issue. By doing this, the option that benefits only the contractor or the supplier might be the same as the option without considering the weight. However, the value of the percentage pay-off will be changed. This is because the percentage pay-off is affected by the weight of the issue. These scenarios also happen when analyzed the linear function in price issue.

As an example in figures 6.1 and 6.2, the option that benefits only the contractor is 60-day check. The percentage pay-off is 100% without the weight consideration and 8% with the weight consideration. Meanwhile, the option that benefits only the supplier is cash. The percentage pay-off is 100% without the weight consideration and 14% with the weight consideration. On the other hand, the option that benefits both is changed because the gradient of the graph is affected by the weight. Therefore, the value of the percentage pay-off will also change. These scenarios also happen when analyzed the linear function in price issue. As an example in figures 6.1 and 6.2, the option benefits both without the weight consideration is 45-day check. While, the option is a 60-day check if the weight is considered. The percentage pay-off also does not same.

6.3 Optimization of Results with Considering the Weight

The joint pay-off benefits for the contractor or the supplier can be determined by plotting each point on 45º line graph. Figure 6.3 shows the 45º line graph. If the point upper than 45º line, the joint pay-off only benefits the contractor. If lower than that line, the joint pay-off only benefits the supplier. Based on figure 6.3, the y-axis represents the summation of single contractor percentage pay-off while the x-axis represents the summation of single supplier percentage pay-off.

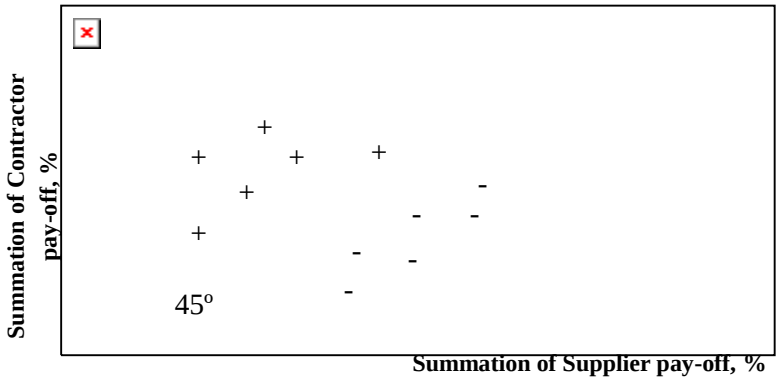


Figure 6.3: 45º line graphs

To prove each point is upper or lower than 45º line, the result of subtracting the value of x with the value of y can be helped (x value – y value). It's also known as percentage difference. If the result sign is negative, that point is lower than 45º line. Meanwhile, the result sign is positive, that point is upper than 45º line. The reason is only points locate on 45º line have the same value of x-axis and y-axis. Thus, the result of the subtraction will be zero. Other than that point, the result of subtracting will have the sign of negative or positive.

Same as chapter V, the optimum joint pay-off is the lowest percentage difference point in positive sign. The result of joint pay-off has been summarized in the following tables. Each table consists of six issues related to material procurement negotiation. The total of single percentage pay-off is the summation of single percentage pay-off. Finally, in the column of percentage difference shows the location of each point either upper (positive sign) or lower (negative sign) than 45º line. The point that presents the value of lowest percentage difference in positive sign will selected as an optimum joint pay-off.

6.3.1 Joint Pay-off of Aggregate Stone

Table 6.4 (a): Summary of total joint pay-off from contractor and supplier-S1

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S1	16.20	5.6	3.9	1.8	3.5	3	34.00	65.24
		Contractor	56.24	8	6	5	13	11	99.24	
2	Both	Supplier-S1	32.79	5.6	3.9	1.8	3.5	3	50.59	25.2
		Contractor	32.79	8	6	5	13	11	75.79	
3	Supplier	Supplier-S1	34.20	5.6	3.9	1.8	3.5	3	52.00	19.5
		Contractor	28.50	8	6	5	13	11	71.50	

Point	Price Benefits for			Other Issues Benefit for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
4	Contractor	Supplier-S1	16.20	5.6	5.85	4.2	7	6	44.85	41.34
		Contractor	56.24	8	5.7	4.25	6.5	5.5	86.19	
5	**Both**	**Supplier-S1**	**32.79**	**5.6**	**5.85**	**4.2**	**7**	**6**	**61.44**	**1.3**
		Contractor	**32.79**	**8**	**5.7**	**4.25**	**6.5**	**5.5**	**62.74**	
6	Supplier	Supplier-S1	34.20	5.6	5.85	4.2	7	6	62.85	-4.4
		Contractor	28.50	8	5.7	4.25	6.5	5.5	58.45	

Point	Price Benefits for			Other Issues Benefit for the Supplier						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S1	16.20	14	13	6	7	6	62.20	12.84
		Contractor	56.24	3.2	2.1	1.5	6.5	5.5	75.04	
8	Both	Supplier-S1	32.79	14	13	6	7	6	78.79	-27.2
		Contractor	32.79	3.2	2.1	1.5	6.5	5.5	51.59	
9	Supplier	Supplier-S1	34.20	14	13	6	7	6	80.20	-32.9
		Contractor	28.50	3.2	2.1	1.5	6.5	5.5	47.30	

Table 6.4 (b): Summary of option from contractor and supplier-S1

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	22.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	23.84	60-day check	Bi Weekly	0.2	Single Delivery	Excluded
Supplier	24.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Table 6.5 (a): Summary of total joint pay-off from contractor and supplier-S2

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S2	16.50	5.6	3.6	2.1	3.5	2.4	33.70	65.54
		Contractor	56.24	8	6	5	13	11	99.24	
2	Both	Supplier-S2	36.96	5.6	3.6	2.1	3.5	2.4	54.16	25.8
		Contractor	36.96	8	6	5	13	11	79.96	
3	Supplier	Supplier-S2	40.70	5.6	3.6	2.1	3.5	2.4	57.90	13.6
		Contractor	28.50	8	6	5	13	11	71.50	

Point	Price Benefits for			Other Issues Benefit for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
4	Contractor	Supplier-S2	16.50	5.6	6	4.2	7	6	45.30	41.14
		Contractor	56.24	8	5.7	4.5	6.5	5.5	86.44	
5	**Both**	**Supplier-S2**	**36.96**	**5.6**	**6**	**4.2**	**7**	**6**	**65.76**	**1.4**
		Contractor	**36.96**	**8**	**5.7**	**4.5**	**6.5**	**5.5**	**67.16**	
6	Supplier	Supplier-S2	40.70	5.6	6	4.2	7	6	69.50	-10.8
		Contractor	28.50	8	5.7	4.5	6.5	5.5	58.70	

Point	Price Benefits for			Other Issues Benefits for the Supplier						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S2	16.50	14	12	6	7	6	61.50	13.54
		Contractor	56.24	3.2	2.1	1.5	6.5	5.5	75.04	
8	Both	Supplier-S2	36.96	14	12	6	7	6	81.96	-26.2
		Contractor	36.96	3.2	2.1	1.5	6.5	5.5	55.76	
9	Supplier	Supplier-S2	40.70	14	12	6	7	6	85.70	-38.4
		Contractor	28.50	3.2	2.1	1.5	6.5	5.5	47.30	

Table 6.5 (b): Summary of option from contractor and supplier-S2

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	22.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	23.69	60-day check	Bi Weekly	0.15	Single Delivery	Excluded
Supplier	24.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Figure 6.4 illustrates nine scenarios of joint pay-off for aggregate stone. The x-axis represents summation of supplier percentage pay-off. Meanwhile the y-axis represents contractor percentage pay-off. The black points with S1 labels represent the joint pay-off from contractor and supplier-S1 viewpoint. The coordinates of each point have been shown in table 6.4 (a) at the total single pay-off column. Table 6.4 (b) is the summation of each option. Next, the red points with S2 labels represent the joint pay-off from contractor and supplier-S2 viewpoint. The coordinates of each point have been shown in table 6.5 (a) at the total single pay-off column. Table 6.5 (b) is the summation of each option. The type of each point symbol is shown in the remarks.

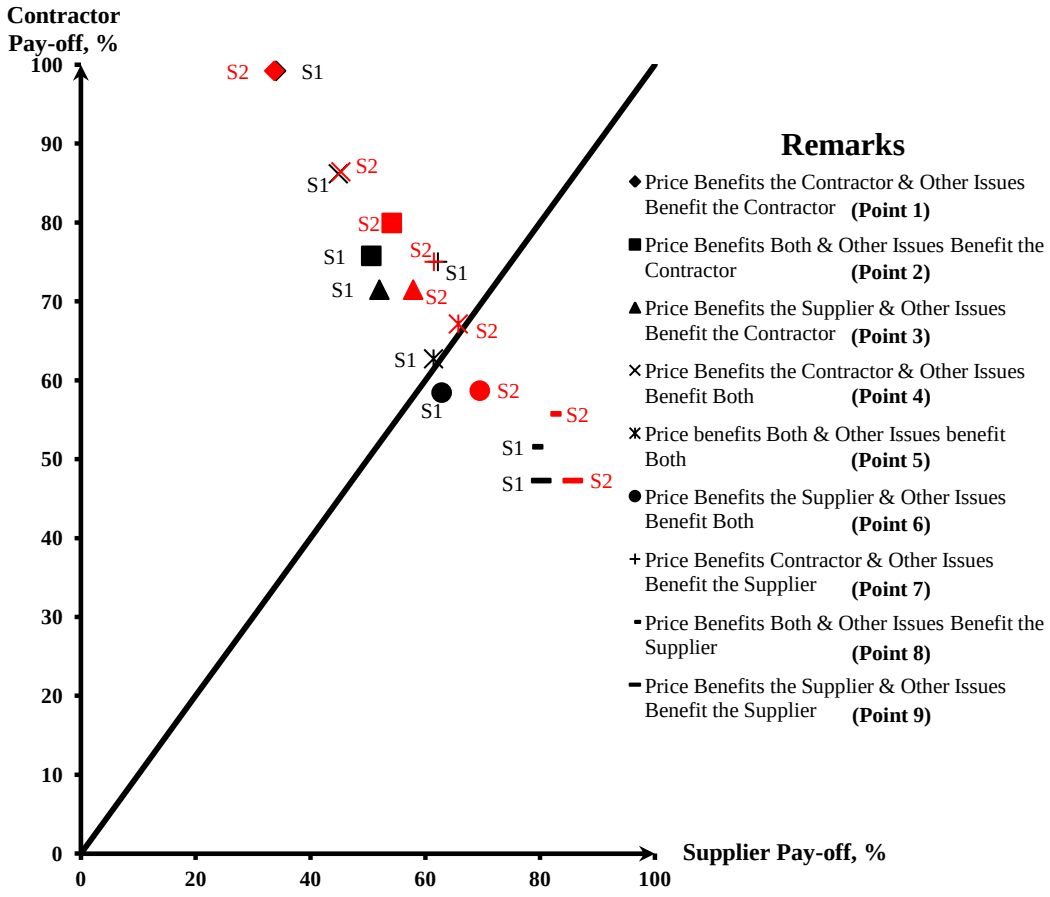


Figure 6.4: The joint pay-off of aggregate stone – considered weight

For the contractor and supplier-S1 joint pay-off, six points are located above than 45º line. The contractor and supplier-S2 joint pay-off also have six points are above than 45º line. It includes point number 1, 2, 3, 4, 5 and 7. Based on these six points, the optimum joint pay-off is point number 5 because nearest to 45º line. The option of this point is the Price Benefits for Both and other Issues Benefit for Both.

6.3.2 Joint Pay-off of Cement

Table 6.6 (a): Summary of total joint pay-off from contractor and supplier-S1

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S1	22.40	7.8	2.4	1.8	3.5	4.2	42.10	56.22
		Contractor	56.32	13	6	5	10	8	98.32	
2	Both	Supplier-S1	34.58	7.8	2.4	1.8	3.5	4.2	54.28	22.3
		Contractor	34.58	13	6	5	10	8	76.58	
3	Supplier	Supplier-S1	38.73	7.8	2.4	1.8	3.5	4.2	58.43	6.37
		Contractor	22.80	13	6	5	10	8	64.80	

Point	Price Benefits for			Other Issues Benefit for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
4	Contractor	Supplier-S1	22.40	10.4	6	4.2	7	4.2	54.20	35.52
		Contractor	56.32	11.7	5.7	4	4	8	89.72	
5	**Both**	**Supplier-S1**	**34.58**	**10.4**	**6**	**4.2**	**7**	**4.2**	**66.38**	**1.6**
		Contractor	**34.58**	**11.7**	**5.7**	**4**	**4**	**8**	**67.98**	
6	Supplier	Supplier-S1	38.73	10.4	6	4.2	7	4.2	70.53	-14.33
		Contractor	22.80	11.7	5.7	4	4	8	56.20	

Point	Price Benefits for			Other Issues Benefits for the Supplier						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S1	22.40	13	12	6	7	6	66.40	2.42
		Contractor	56.32	2.6	1.8	2.5	4	1.6	68.82	
8	Both	Supplier-S1	34.58	13	12	6	7	6	78.58	-31.5
		Contractor	34.58	2.6	1.8	2.5	4	1.6	47.08	
9	Supplier	Supplier-S1	38.73	13	12	6	7	6	82.73	-47.43
		Contractor	22.80	2.6	1.8	2.5	4	1.6	35.30	

Table 6.6 (b): Summary of option from contractor and supplier-S1

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	323.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	328.22	45-day check	Bi Weekly	0.2	Single Delivery	Included
Supplier	330.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Table 6.7 (a): Summary of total joint pay-off from contractor and supplier-S2

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S2	27.50	5.2	3.9	1.2	4.2	3.6	45.60	52.94
		Contractor	56.54	13	6	5	10	8	98.54	
2	Both	Supplier-S2	34.21	5.2	3.9	1.2	4.2	3.6	52.31	23.9
		Contractor	34.21	13	6	5	10	8	76.21	
3	Supplier	Supplier-S2	36.06	5.2	3.9	1.2	4.2	3.6	54.16	10.64
		Contractor	22.80	13	6	5	10	8	64.80	

Point	Price Benefits for			Other Issues Benefit for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
4	Contractor	Supplier-S2	27.50	9.1	5.2	4.8	7	3.6	57.20	32.74
		Contractor	56.54	11.7	5.7	4	4	8	89.94	
5	**Both**	**Supplier-S2**	**34.21**	**9.1**	**5.2**	**4.8**	**7**	**3.6**	**63.91**	**3.7**
		Contractor	**34.21**	**11.7**	**5.7**	**4**	**4**	**8**	**67.61**	
6	Supplier	Supplier-S2	36.06	9.1	5.2	4.8	7	3.6	65.76	-9.56
		Contractor	22.80	11.7	5.7	4	4	8	56.20	

Point	Price Benefits for			Other Issues Benefit for the Supplier						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S2	27.50	13	13	6	7	6	72.50	-3.46
		Contractor	56.54	2.6	1.8	2.5	4	1.6	69.04	
8	Both	Supplier-S2	34.21	13	13	6	7	6	79.21	-32.5
		Contractor	34.21	2.6	1.8	2.5	4	1.6	46.71	
9	Supplier	Supplier-S2	36.06	13	13	6	7	6	81.06	-45.76
		Contractor	22.80	2.6	1.8	2.5	4	1.6	35.30	

Table 6.7 (b): Summary of option from contractor and supplier-S2

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	322.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	328.27	45-day check	Bi Weekly	0.2	Single Delivery	Included
Supplier	330.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Figure 6.5 illustrates nine scenarios of joint pay-off for cement. The x-axis represents supplier percentage pay-off. Meanwhile the y-axis represents summation of contractor percentage pay-off. The black points with S1 labels represent the joint pay-off from contractor and supplier-S1 viewpoint. The coordinates of each point have been shown in table 6.6 (a) at the total single pay-off column. Table 6.6 (b) is the summation of each option. Next, the red points with S2 labels represent the joint pay-off from contractor and supplier-S2 viewpoint. The coordinates of each point have been shown in table 6.7 (a) at the total single pay-off column. Table 6.7 (b) is the summation of each option. The type of each point symbol has shown in the remarks.

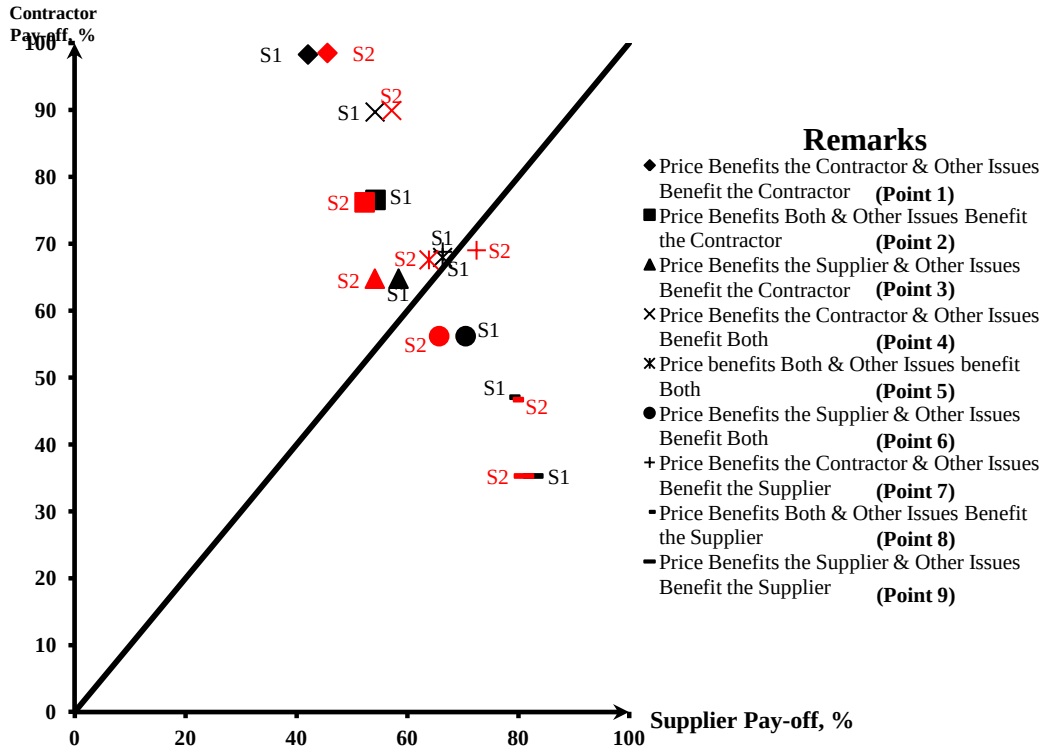


Figure 6.5: The joint pay-off of cement –considered weight

For the contractor and supplier-S1 joint pay-off, six points are located above than 45º line. It includes point number 1, 2, 3, 4, 5 and 7. Based on these six points, the optimum joint pay-off is point number 5 because nearest to 45º line. The point is the Price Benefits for Both and other Issues Benefit for Both. While, for the contractor and supplier-S2 joint pay-off, only five points are located above than 45º line. It includes point number 1, 2, 3, 4 and 5. Based on these four points, the optimum joint pay-off is point number 5 because nearest to 45º. The option of this point is the Price Benefits for Both and other Issues Benefit for Both.

6.3.3 Joint Pay-off of Ready Mix Concrete

Table 6.8 (a): Summary of total joint pay-off from contractor and supplier-S1

Point	Price Benefit for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S1	22.00	4.5	1.2	2	2.2	6	37.90	58.81
		Contractor	49.71	15	11	8	6	7	96.71	
2	Both	Supplier-S1	28.20	4.5	1.2	2	2.2	6	44.10	31.1
		Contractor	28.20	15	11	8	6	7	75.20	
3	Supplier	Supplier-S1	29.33	4.5	1.2	2	2.2	6	45.23	22.57
		Contractor	20.80	15	11	8	6	7	67.80	

Point	Price Benefits for			Other Issues Benefits for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
4	Contractor	Supplier-S1	22.00	7.2	4.8	4.5	6.6	6	51.10	29.11
		Contractor	49.71	9	5.5	4.8	4.2	7	80.21	
5	**Both**	**Supplier-S1**	**28.20**	**7.2**	**4.8**	**4.5**	**6.6**	**6**	**57.30**	**1.4**
		Contractor	**28.20**	**9**	**5.5**	**4.8**	**4.2**	**7**	**58.70**	
6	Supplier	Supplier-S1	29.33	7.2	4.8	4.5	6.6	6	58.43	-7.13
		Contractor	20.80	9	5.5	4.8	4.2	7	51.30	

Point	Price Benefits for			Other Issues Benefit for the Supplier						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S1	22.00	9	6	5	11	15	68.00	-4.29
		Contractor	49.71	4.5	3.3	2.4	2.4	1.4	63.71	
8	Both	Supplier-S1	28.20	9	6	5	11	15	74.20	-32
		Contractor	28.20	4.5	3.3	2.4	2.4	1.4	42.20	
9	Supplier	Supplier-S1	29.33	9	6	5	11	15	75.33	-40.53
		Contractor	20.80	4.5	3.3	2.4	2.4	1.4	34.80	

Table 6.8 (b): Summary of option from contractor and supplier-S1

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	205.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	209.22	30-day check	On Completion of Milestone	0.25	Multiple Delivery	Included
Supplier	210.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Table 6.9 (a): Summary of total joint pay-off from contractor and supplier-S2

Point	Price Benefits for			Other Issues Benefit for the Contractor						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
1	Contractor	Supplier-S2	21.60	4	1.2	1.75	1.2	5.6	35.35	61.51
		Contractor	49.86	15	11	8	6	7	96.86	
2	Both	Supplier-S2	27.82	4	1.2	1.75	1.2	5.6	41.57	33.25
		Contractor	27.82	15	11	8	6	7	74.82	
3	Supplier	Supplier-S2	28.69	4	1.2	1.75	1.2	5.6	42.44	25.36
		Contractor	20.80	15	11	8	6	7	67.80	

Point	Price Benefits for			Other Issues Benefit for Both						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
4	Contractor	Supplier-S2	21.60	9	4.2	4.25	7.2	5.6	51.85	28.51
		Contractor	49.86	9	5.5	4.8	4.2	7	80.36	
5	**Both**	**Supplier-S2**	**27.82**	**9**	**4.2**	**4.25**	**7.2**	**5.6**	**58.07**	**0.25**
		Contractor	**27.82**	**9**	**5.5**	**4.8**	**4.2**	**7**	**58.32**	
6	Supplier	Supplier-S2	28.69	9	4.2	4.25	7.2	5.6	58.94	-7.64
		Contractor	20.80	9	5.5	4.8	4.2	7	51.30	

Point	Price Benefits for			Other Issues Benefit for the Supplier						
				Payment Term, (%)	Payment Period, (%)	Advance Payment, (%)	Delivery, (%)	Freightage, (%)	Total Single Pay-off, (%)	Percentage Difference, (%)
7	Contractor	Supplier-S2	21.60	10	6	5	12	14	68.60	-4.74
		Contractor	49.86	4.5	3.3	2.4	2.4	1.4	63.86	
8	Both	Supplier-S2	27.82	10	6	5	12	14	74.82	-33
		Contractor	27.82	4.5	3.3	2.4	2.4	1.4	41.82	
9	Supplier	Supplier-S2	28.69	10	6	5	12	14	75.69	-40.89
		Contractor	20.80	4.5	3.3	2.4	2.4	1.4	34.80	

Table 6.9 (b): Summary of option from contractor and supplier-S2

All Options Benefits for	Price (MYR)	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	204.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	209.26	30-day check	On Completion of Milestone	0.25	Multiple Delivery	Included
Supplier	210.00	Cash	On Delivery	0.3	Single Delivery	Excluded

Figure 6.6 illustrates nine scenarios of joint pay-off for ready mix concrete. The x-axis represents supplier percentage pay-off. Meanwhile the y-axis represents summation of contractor percentage pay-off. The black points with S1 labels represent the joint pay-off from contractor and supplier-S1. The coordinates of each point have been shown in table 6.8 (a) at the total single pay-off column. Table 6.8 (b) is the summarized of each option. Next, the red points with S2 labels represent the joint pay-off from contractor and supplier-S2 viewpoint. The coordinates of each point have been shown in table 6.9 (a) at the total single pay-off column. Table 6.9 (b) is the summation of each option. The type of each point symbol has shown in the remarks.

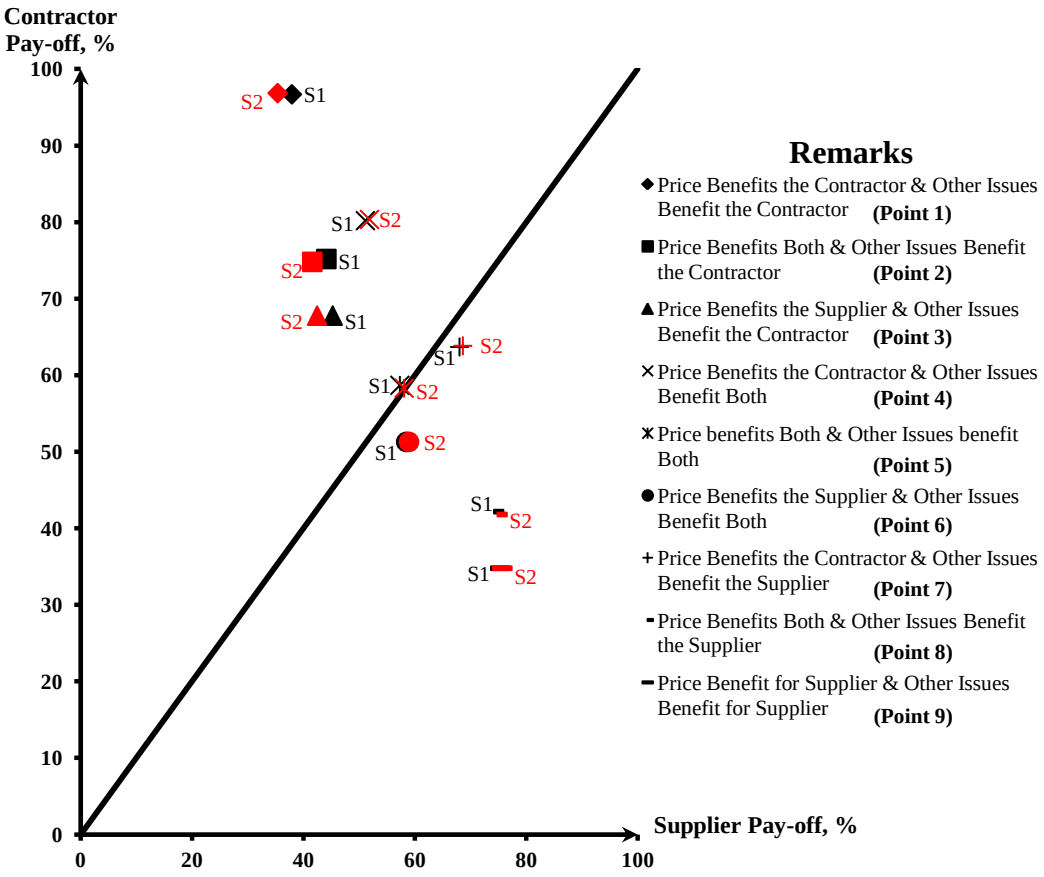


Figure 6.6: The joint pay-off of ready mix concrete – considered weight

For the contractor and supplier-S1 joint pay-off, six points are located above than 45º line. The contractor and supplier-S2 joint pay-off also have five points are located above than 45º line. It includes point number 1, 2, 3, 4 and 5. Based on these six points, the optimum joint pay-off is point number 5 because nearest to 45º line. The point is the Price Benefits for Both and other Issues Benefit for Both.

6.4 Summary of Chapter

Based on data analysis for the weight of issues for aggregate, from the contractor viewpoint, the first rank is price followed by delivery, freightage, payment term, payment period and advance payment. While for the supplier-S1 and the supplier-S2, the price is ranked first, followed by payment term, payment period, delivery, freightage and advance payment.

Next, in the analysis for the weight of issues for cement, from the contractor viewpoint, the first rank is price followed by delivery, payment term, freightage, payment period and advance payment. While, from the supplier-S1 and the supplier-S2, the price is ranked first, followed by payment term, payment period, delivery, freightage and advance payment.

Finally for the weight of issues of ready mix concrete, from the contractor viewpoint, the first rank is price followed by payment term, payment period, advance payment, freightage and delivery. While for the supplier-S1 and the supplier-S2, the price is ranked first, followed by freightage, delivery, payment term, payment period and lastly advance payment.

For the point give optimum joint pay-off (considered the weight), the option point number 5 which is the Price Benefits for Both and other Issues Benefit for Both is selected for negotiation in aggregate stone (Supplier-S1 and supplier-S2 have the same point). This optimum joint pay-off point is also same in the negotiation of cement and ready mix concrete. The result shows, the optimum joint pay-off is more consistency for the negotiation considering the weight compared unconsidered weight.

CHAPTER VII

OPTIMIZATION OF JOINT PAY-OFF

Based on the joint pay-off results in chapter V (unconsidered the weight) and chapter VI (considered the weight), there are nine scenarios of joint pay-off point. Each point was named based on their result of option. However, the joint pay-off coordinate does not similar between both results (considered and unconsidered the weight). The coordinate is depended on the single percentage pay-off from the contractor and the supplier because the x-axis of the graph represents the single pay-off for the contractor. Meanwhile, the y-axis represents the single pay-off for the supplier. Other than that, some joint pay-off points are located at incorrect position. To determine the most optimum joint pay-off, both results (considered or unconsidered the weight) is needed to compare. If the number of incorrect point is lesser than another, that joint pay-off is considered as the most optimum joint pay-off to use during the negotiation process.

In addition, that result will be compared with the joint pay-off in actual cases. The number of joint pay-off that are used in the negotiation process will be determined. The reason selected of supplier by the contractor during the negotiation process will be explained in this analysis.

7.1 The Most Optimum Joint Pay-off

To analyze the result of both joint pay-off (considered and unconsidered the weight), the order of each point needs to determine. It can be identified based on the subtraction result in chapter 5.2 and 6.3. The order of the joint pay-off should be started from the highest value to the lowest. However, to clarify the order of joint pay-off point locates at the correct position in the 45º line graph, it must be followed all these conditions:

1- If all issues benefit a single party (contractor or supplier):
   i) That joint pay-off point must be at the top of the graph (all issues benefit the contractor).

ii) That joint pay-off point must be at the bottom of the graph (all issues benefit the supplier).

2- If some of the issues benefit for both contractor and supplier, the joint pay-off must closer to the joint pay-off benefit for a single party.

3- If any joint pay-off has an issue benefits for the contractor, the joint point pay-off point must be above than 45º lines because the procurement items were of an unbalanced market (buyer's market). Thus, the contractor should get that advantage.

4- All issues benefit for both the contractor and the supplier must be the point nearest to 45º lines. The different percentage of single pay-off should be in positive sign. Because it is optimized the joint pay-off rather than single joint pay-off.

Thus, the order of the joint pay-off point must be:

1- Price benefits for the contractor and other issues benefit for the contractor (Point 1)
2- Price benefits for the contractor and other issues benefit for both (Point 4)
3- Price benefits for both and other issues benefit for the contractor (Point 2)
4- Price benefits for the supplier and other issues benefit for the contractor (Point 3)
5- Price benefits for the contractor and other issues benefit for the supplier (Point 7)
6- Price benefits for both and other issues benefit for both (Point 5)
7- Price benefits for the supplier and other issues benefit for both (Point 6)
8- Price benefits for both and other issues benefit for the supplier (Point 8)
9- Price benefits for the supplier and other issues benefit for the supplier (Point 9)

The order of each point in chapter 5.1 and 6.3 has been summarized in the following tables. Each table consists of nine points. Each point illustrates the scenarios of joint pay-off.

7.1.1 The Comparison of Joint Pay-off for Aggregate

In table 7.1, the order of joint pay-off starts from the highest to the lowest percentage difference. Each joint pay-off consist two negotiations. It is a single

contractor negotiated with two suppliers. Same as normal practice, the contractor needs to negotiate with multiple suppliers.

Based on the order of point in chapter 6.1, some of the joint pay-off is not similar to that given order. The X symbol in the column of the position means that point is incorrect position. Meanwhile, the bold value shows that joint pay-off is optimum to use during the negotiation process. In other words, that point is the nearest and closest to 45º line graph.

Table 7.1: The order of joint pay-off point for the aggregate stone

The Joint Pay-off – Unconsidered weight A Single Contractor with						**The Joint Pay-off – Considered weight A Single Contractor with**					
Supplier-S1			**Supplier-S2**			**Supplier-S1**			**Supplier-S2**		
Position	**Percentage Difference, (%)**	**Point**	**Position**	**Percentage Difference, (%)**	**Point**	**Position**	**Percentage Difference, (%)**	**Point**	**Position**	**Percentage Difference, (%)**	**Point**
	61.45	1		62.28	1		65.24	1		65.54	1
X	50.00	2	X	50.83	2		41.34	4		41.14	4
X	47.78	3	X	46.84	3		25.20	2		25.80	2
X	27.27	4	X	**10.61**	**4**		19.50	3		13.60	3
X	15.83	5	X	-0.84	5		12.84	7		13.54	7
X	**13.61**	**6**	X	-4.83	6		**1.30**	**5**		**1.14**	**5**
X	-37.72	7	X	-37.72	7		-4.40	6		-10.80	6
	-49.17	8		-49.17	8		-27.20	8		-26.20	8
	-51.39	9		-53.17	9		-32.90	9		-38.40	9

The joint pay-off unconsidered the weight consist of six points are incorrect position. It includes point number 2, 3, 4, 5, 6 and 7. By comparing the result for a single contractor negotiate with the supplier-S1 and the supplier-S2. The negotiation with the supplier-S2 has the lower consistency compared with supplier-S1. The reason is five joint pay-off points appear in negative sign. All that five joint pay-off points are benefit the supplier. However, in the real case it should be three points benefit the supplier.

Meanwhile, all joint pay-off considered the weight followed the correct position. Based on this result, the joint pay-off considered the weight is the most optimum and consistence comparing to the joint pay-off unconsidered the weight.

7.1.2 The Comparison of Joint Pay-off for Cement

In table 7.2, the order of joint pay-off starts from the highest to the lowest percentage difference. Each joint pay-off consist two negotiations. It is a single contractor negotiated with two suppliers. Same as normal practice, the contractor needs to negotiate with multiple suppliers.

Based on the order of point in chapter 6.1, some of the joint pay-off is not similar to that given order. The X symbol in the column of the position means that point is incorrect position. Meanwhile, the bold value shows that joint pay-off is optimum to use during the negotiation process. In other words, that point is the nearest and closest to 45º line graph.

Table 7.2: The order of joint pay-off point for the cement

The Joint Pay-off – Unconsidered weight A Single Contractor with						**The Joint Pay-off – Considered weight A Single Contractor with**					
Supplier-S1			**Supplier-S2**			**Supplier-S1**			**Supplier-S2**		
Position	**Percentage Difference, (%)**	**Point**	**Position**	**Percentage Difference, (%)**	**Point**	**Position**	**Percentage Difference, (%)**	**Point**	**Position**	**Percentage Difference, (%)**	**Point**
	54.80	1		56.54	1		56.22	1		52.94	1
X	45.00	2	X	48.34	2		35.52	4		32.74	4
X	40.14	3	X	44.07	3		22.30	2		23.90	2
X	21.47	4	X	19.86	4		6.37	3		10.64	3
X	11.67	5	X	11.66	5		2.42	7		**3.70**	**5**
X	**6.81**	**6**	X	**7.41**	**6**		**1.60**	**5**	X	-3.46	7
X	-46.87	7	X	-48.47	7		-14.33	6		-9.56	6
	-56.67	8		-56.67	8		-31.50	8		-32.50	8
	-61.53	9		-60.93	9		-47.43	9		-45.76	9

The joint pay-off unconsidered the weight consist of six points are incorrect position. It includes point number 2, 3, 4, 5, 6 and 7. Based on the result of a single contractor negotiate with the supplier-S1 and the supplier-S2, both negotiations have the same consistency. The numbers of joint pay-off point only benefits the supplier is same as the real case.

The joint pay-off considered the weight has the different number of point's incorrect positions. Negotiation between the contractor and the supplier-S1 shows that all joint pay-off points followed the correct position. However, the negotiation

between the contractor and the supplier-S2 shows that point number 7 is incorrect position. Based on the order of the joint pay-off point in part 7.1 it should be before point 5.

Based on this result, the joint pay-off considered the weight is the most optimum and consistence comparing to the joint pay-off unconsidered the weight. The reason is that error position for the joint pay-off considered the weight is lower than error position for the point joint pay-off unconsidered the weight.

7.1.3 The Comparison of Joint Pay-off for Ready Mix Concrete

In table 7.3, the order of joint pay-off starts from the highest to the lowest percentage difference. Each joint pay-off consist two negotiations. It is a single contractor negotiated with two suppliers. Same as normal practice, the contractor needs to negotiate with multiple suppliers.

Based on the order of point in chapter 6.1, some of the joint pay-off is not similar to that given order. The X symbol in column the position means that point is incorrect position. Meanwhile, the bold value shows that joint pay-off is optimum to use during the negotiation process. In other words, that point is the nearest and closest to 45^{o} line graph.

Table 7.3: The order of joint pay-off point for the ready mix concrete

The Joint Pay-off – Unconsidered weight A Single Contractor with						**The Joint Pay-off – Considered weight A Single Contractor with**					
Supplier-S1			**Supplier-S2**			**Supplier-S1**			**Supplier-S2**		
Position	**Percentage Difference, (%)**	**Point**	**Position**	**Percentage Difference, (%)**	**Point**	**Position**	**Percentage Difference, (%)**	**Point**	**Position**	**Percentage Difference, (%)**	**Point**
	64.26	1		68.48	1		58.81	1		61.51	1
X	55.00	2	X	59.16	2		29.11	4		33.25	2
X	52.78	3	X	56.98	3		31.10	2	X	28.51	4
X	23.43	4	X	25.98	4		22.57	3		25.36	3
X	14.16	5	X	16.67	5		**1.40**	**5**		**0.25**	**5**
X	**11.94**	**6**	X	**14.48**	**6**		-4.29	7	X	-4.74	7
X	-49.07	7	X	-49.02	7		-7.13	6		-7.64	6
	-58.33	8		-58.33	8		-32.00	8		-33.00	8
	-60.55	9		-60.52	9		-40.53	9		-40.89	9

The joint pay-off unconsidered the weight consist of six points are incorrect position. It includes point number 2, 3, 4, 5, 6 and 7. Both contractor negotiations with the supplier-S1 and the supplier-S2 have the same consistency because the number of joint pay-off point benefits the supplier is same as the real case.

The joint pay-off considered the weight has two points that are incorrect position. Negotiation between the contractor and the supplier-S1 shows that all joint pay-off points followed the correct order. However based on the order of the joint pay-off point in part 7.1, the negotiation between the contractor and the supplier-S2 shows the point number 4 and the point number 7 is incorrect position. Based on this result, the joint pay-off considered the weight is the most optimum and consistence compared with the joint pay-off unconsidered the weight. The main reason is that the number error position for the joint pay-off considered the weight is lower than r position for the point joint pay-off unconsidered the weight.

7.2 The Comparison of Joint Pay-off with Actual Cases

As a summary of the results in chapter 7.1, the joint pay-off considered the weight is the most suitable to use in negotiations because the number of error positions are lower than unconsidered the weight. Thus, the joint pay-off considered the weight is used to compare with the actual joint pay-off. In this analysis, the possible joint pay-off can be used during the negotiation process will be determined.

7.2.1 Aggregate Stone Actual Joint Pay-off

Table 7.4 shows the order of joint pay-off point for aggregate stone. This table will be used to compare the actual joint pay-off point.

The nearest point with the actual joint pay-off is selected as a reference point to be used during the negotiation process. Meanwhile, the range from that joint pay-off until optimum joint pay-off (bold value) is a most suitable point to use during the negotiation.

Table 7.4: Nine points of joint pay-off of aggregate stone

The Joint Pay-off A Single Contractor with			
Supplier-S1		**Supplier-S2**	
Percentage Difference, (%)	**Point**	**Percentage Difference, (%)**	**Point**
65.24	1	65.54	1
41.34	4	41.14	4
25.20	2	25.80	2
19.50	3	13.60	3
12.84	7	13.54	7
1.30	**5**	**1.14**	**5**
-4.40	6	-10.80	6
-27.20	8	-26.20	8
-32.90	9	-38.40	9

Next, the table 7.5 shows the actual coordinate of joint pay-off that has been used by the contractor to negotiate with the supplier-S1 (51.70, 94.54) and the supplier-S2 (54.10, 94.56). The x value is the supplier single pay-off, while the y value is the contractor single pay-off. The value of the column percentage difference will show the nearest joint pay-off with the actual joint pay-off. From that point, the range of joint pay-off can be determined. Based on the interview with the contractor session, the selected supplier during the negotiation process is the supplier-S2.

Table 7.5: The actual joint pay-off percentage difference of aggregate stone

The Actual Joint Pay-off A Single Contractor with			
Supplier-S1		**Supplier-S2**	
Coordinate	**Percentage Difference, (%)**	**Coordinate**	**Percentage Difference, (%)**
(51.70, 94.54)	42.86	(54.10, 94.56)	40.46

Figure 7.1 illustrates the joint pay-off from both negotiations. All nine scenarios of joint pay-off are based on the joint pay-off considered the weight. The coordinates of actual joint pay-off have been shown in table 7.5.

Based on figure 7.1, the coordinate of actual joint pay-off point for negotiation between contractor and supplier-S1 is lower than point 1. The next point after actual joint pay-off is point 4, the Price Benefits for the Contractor & Other Issues Benefit

for Both. Thus, the possible joint pay-off points can be used during the negotiation is point 2, 3, 4, 5 and 7.

Meanwhile, the coordinate of actual joint pay-off point for negotiation between contractor and supplier-S2 is lower than point 4. The next point after actual joint pay-off is point 2, the Price Benefits for Both & Other Issues Benefit for the Contractor. Thus, the possible joint pay-off point can be used during the negotiation is point 2, 3, 5 and 7.

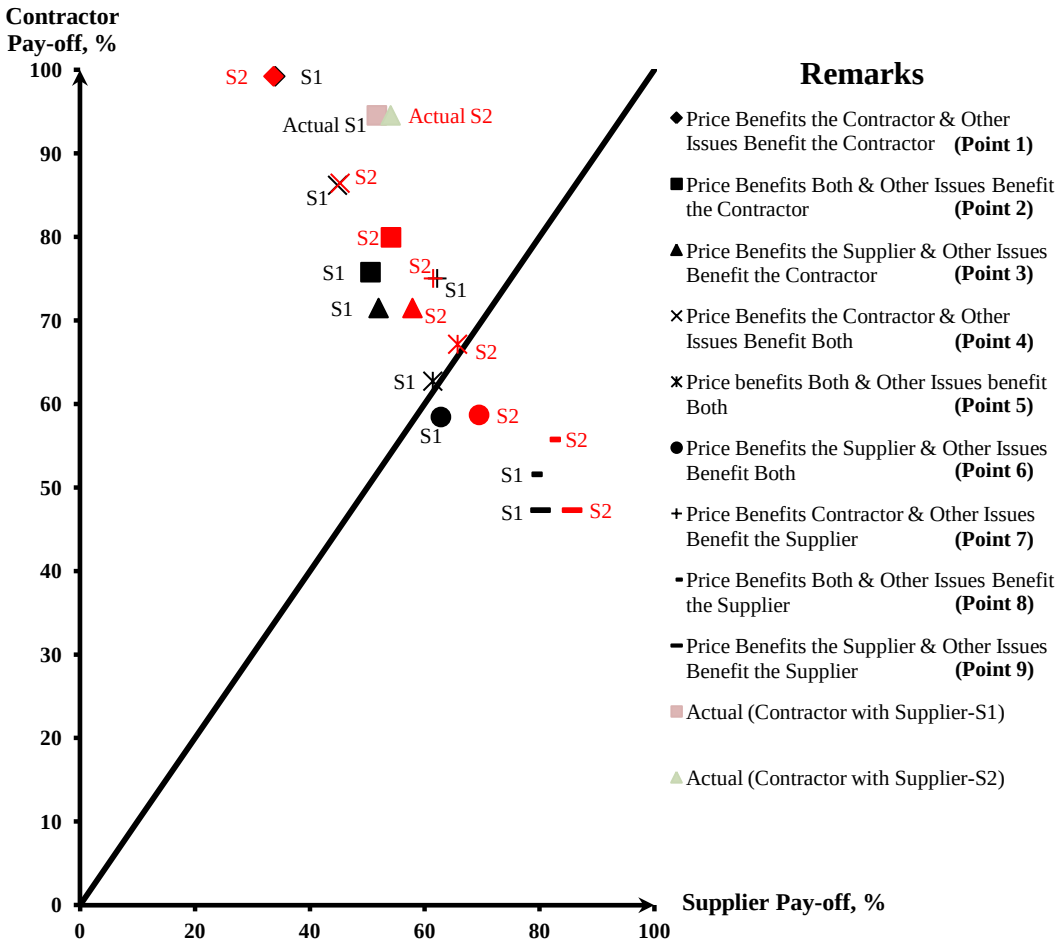


Figure 7.1: Actual joint pay-off for aggregate stone

Based on the interview with the contractor session, the selected supplier during the negotiation process is the supplier-S2. Based on figure 7.1 analysis, the actual joint pay-off negotiated with the supplier-S2 is closer to 45º line graph comparing to the supplier-S1. It proved that the actual joint pay-off for supplier-S2 is more optimal than supplier-S1. Because the percentage difference is lower than supplier-S1.

7.2.2 Cement Actual Joint Pay-off

Table 7.6 shows the order of joint pay-off point for cement. This table will be used to compare the actual joint pay-off point. The nearest point with the actual joint pay-off is selected as a reference point to be used during the negotiation process. Meanwhile, the range from that joint pay-off until the optimum joint pay-off (bold value) is a most suitable point to use during the negotiation.

Table 7.6: Nine points of joint pay-off of cement

The Joint Pay-off A Single Contractor with			
Supplier-S1		**Supplier-S2**	
Percentage Difference, (%)	**Point**	**Percentage Difference, (%)**	**Point**
56.22	1	52.94	1
35.52	4	32.74	4
22.30	2	23.90	2
6.37	3	10.64	3
2.42	7	**3.70**	**5**
1.60	**5**	-3.46	7
-14.33	6	-9.56	6
-31.50	8	-32.50	8
-47.43	9	-45.76	9

Next, the table 7.7 shows the actual coordinate of joint pay-off that has been used by the contractor to negotiate with the supplier-S1 (62.07, 89.44) and the supplier-S2 (66.21, 89.51). The x value is the supplier single pay-off, while the y value is the contractor single pay-off.

Table 7.7: The actual joint pay-off percentage difference of cement

The Actual Joint Pay-off A Single Contractor with			
Supplier-S1		**Supplier-S2**	
Coordinate	**Percentage Difference, (%)**	**Coordinate**	**Percentage Difference, (%)**
(62.07, 89.44)	27.44	(66.21, 89.51)	23.30

The value of the column percentage difference will show the nearest joint pay-off with the actual joint pay-off. From that point, the range of joint pay-off can be

determined. Based on the interview with the contractor session, the selected supplier during the negotiation process is the supplier-S2.

Figure 7.2 illustrates the joint pay-off from both negotiations. All nine scenarios of joint pay-off are based on the joint pay-off considered the weight. The coordinates of actual joint pay-off have been shown in table 7.8.

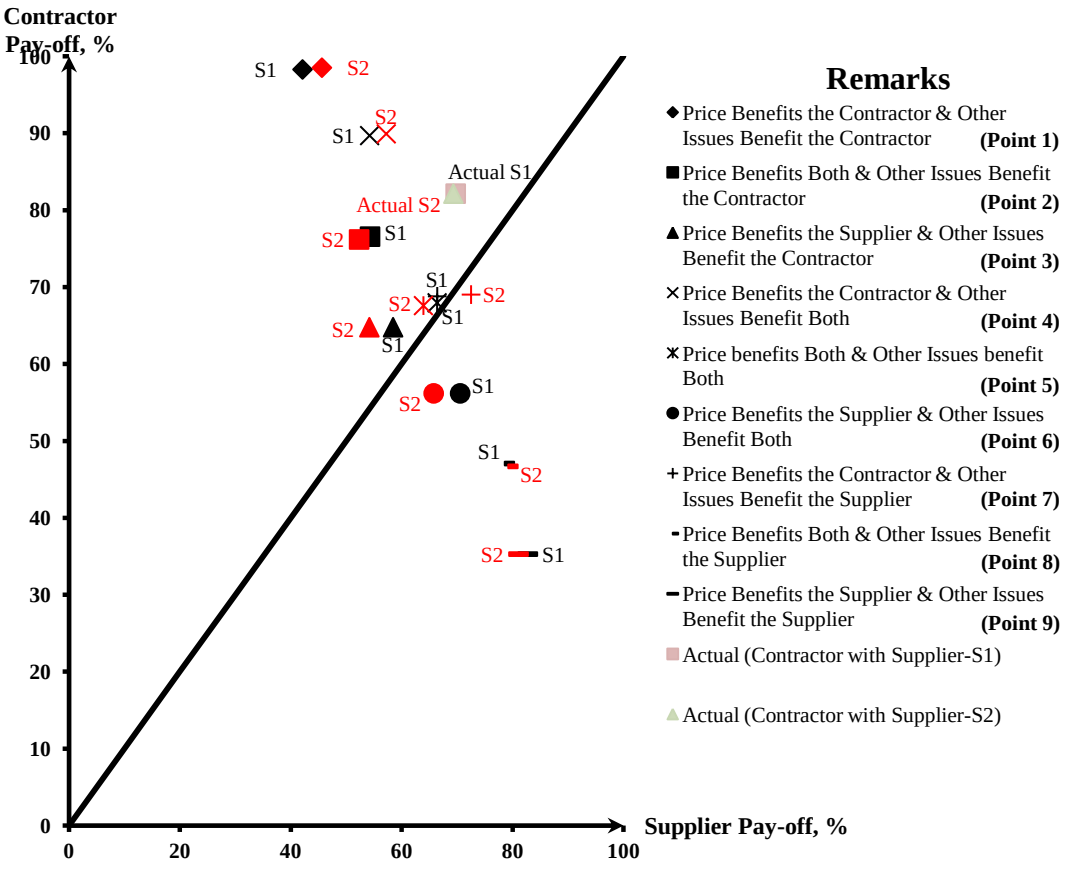


Figure 7.2: Actual joint pay-off for cement

Based on figure 7.2, the coordinate of actual joint pay-off point for negotiation between contractor and supplier-S1 is lower than point 4. The next point after actual joint pay-off is point 2, the Price Benefits for Both & Other Issues Benefit for the Contractor. Thus, the possible joint pay-off point can be used during the negotiation is point 2, 3, 5 and 7.

Meanwhile, the coordinate of actual joint pay-off point for negotiation between contractor and supplier-S2 is lower than point 2. The next point after actual joint pay-off is point 3, the Price Benefits the Supplier & Other Issues Benefit the Contractor.

Thus, the possible joint pay-off point can be used during the negotiation is the point 3 and 5. Based on the interview with the contractor session, the selected supplier during the negotiation process is the supplier-S2. Based on figure 7.2 analysis, the actual joint pay-off negotiated with the supplier-S2 is closer to 45º line graph comparing to the supplier-S1. It proved that the actual joint pay-off supplier-S2 is more optimal than supplier-S1. Because the percentage difference is lower than supplier-S1.

7.2.3 Ready Mix Concrete Actual Joint Pay-off

Table 7.8 shows the order of joint pay-off point for ready mix concrete. This table will be used to compare the actual joint pay-off point.

Table 7.8: Nine points of joint pay-off of ready mix concrete

The Joint Pay-off A Single Contractor with			
Supplier-S1		**Supplier-S2**	
Percentage Difference, (%)	**Point**	**Percentage Difference, (%)**	**Point**
58.81	1	61.51	1
29.11	4	33.25	2
31.10	2	28.51	4
22.57	3	25.36	3
1.40	**5**	**0.25**	**5**
-4.29	7	-4.74	7
-7.13	6	-7.64	6
-32.00	8	-33.00	8
-40.53	9	-40.89	9

Next, the table 7.9 shows the actual coordinate of joint pay-off that has been used by the contractor to negotiate with the supplier-S1 (55.78, 58.90) and the supplier-S2 (55.09, 58.90). The x value is the supplier single pay-off, while the y value is the contractor single pay-off. The value of the column percentage difference will show the nearest joint pay-off with the actual joint pay-off. From that point, the range of joint pay-off can be determined. Based on the interview with the contractor session, the selected supplier during the negotiation process is the supplier-S1.

Table 7.9: The actual joint pay-off percentage difference of ready mix concrete

The Actual Joint Pay-off A Single Contractor with			
Supplier-S1		**Supplier-S2**	
Coordinate	**Percentage Difference, (%)**	**Coordinate**	**Percentage Difference, (%)**
(55.78, 58.90)	3.12	(55.09, 58.90)	3.81

Figure 7.3 illustrates the joint pay-off from both negotiations. All nine scenarios of joint pay-off are based on the joint pay-off considered the weight. The coordinates of actual joint pay-off have been shown in table 7.11.

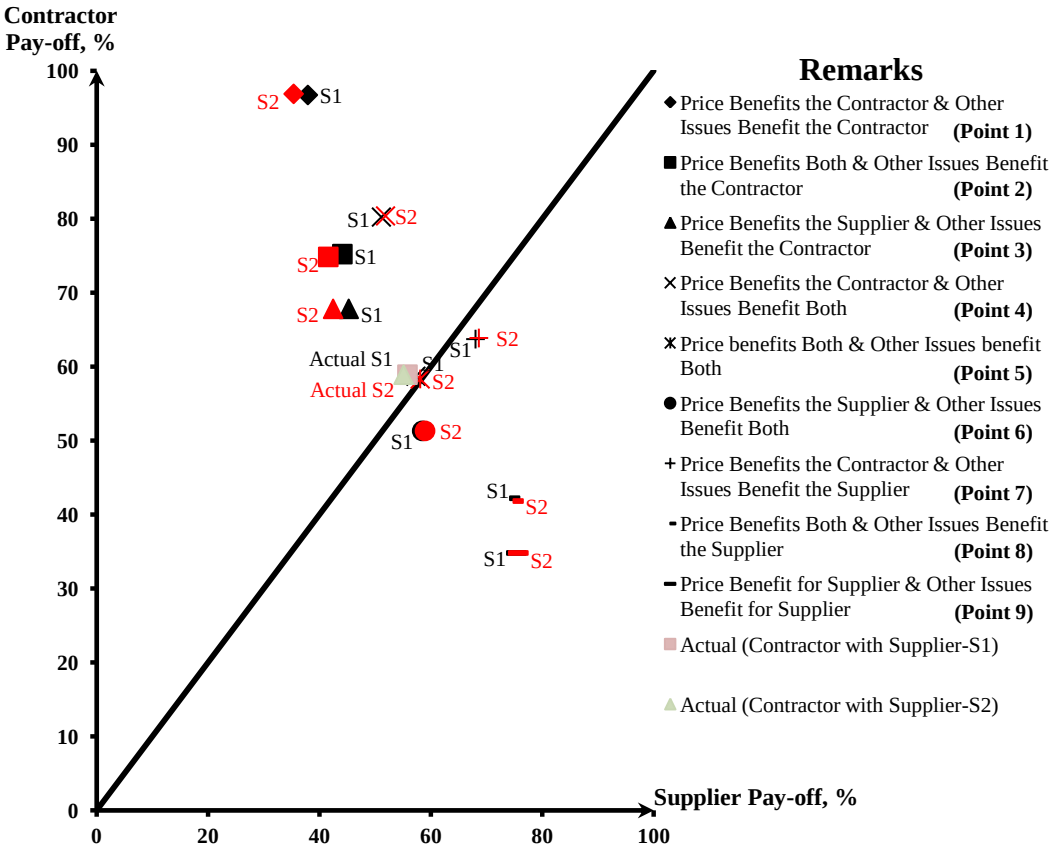


Figure 7.3: Actual joint pay-off for ready mix concrete

Based on figure 7.3, the coordinate of actual joint pay-off point for negotiation between contractor and supplier-S1 is lower than point 3. The next point after actual joint pay-off is point 5, the Price Benefits for Both & Other Issues Benefit for Both. Thus, the possible joint pay-off point can be used during the negotiation is only point 5.

Meanwhile, the coordinate of actual joint pay-off point for negotiation between contractor and supplier-S2 is lower than point 5. The next point after actual joint pay-off is point 5, the Price Benefits for Both & Other Issues Benefit for Both. Thus, the possible joint pay-off point can be used during the negotiation is only point 5.

Based on the interview with the contractor session, the selected supplier during the negotiation process is the supplier-S2. Based on figure 7.3 analysis, the actual joint pay-off negotiated with the supplier-S2 is closer to 45^{o} line graph comparing to the supplier-S1. It proved that the actual joint pay-off the supplier-S2 is more optimal than the supplier-S1. Because the percentage difference is lower than supplier-S2.

7.3 Summary of Chapter

Based on data analysis result, the joint pay-off considered the weight is the most optimum and consistence comparing to the joint pay-off unconsidered the weight. The reason is that error position for the joint pay-off considered the weight is lower than error position for the point joint pay-off unconsidered the weight.

In the analysis of supplier selection by main contractor, it is proved that the actual joint pay-off for supplier selected is more optimal than supplier unselected. Thus, the joint pay-off can be used as a method to measure the suitability of supplier selection. As a conclusion, mathematic functions may help contractor to choose the most suitable supplier during negotiation process.

CHAPTER VIII

CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

From a pilot study in Malaysia construction industry, the environment of procuring aggregate stone, cement and ready mix concrete are almost the same. The materials in structural work are the main items purchased by main contractor. Mostly the materials in architectural and mechanical/electrical works have a different option for a main contractor to purchase that material. Normally they will sub-contract the works together with the materials. The reason is that some contractors might not have the capability to install that material. Moreover, sometimes the price is included together with the cost of installation.

Based on the pilot study, there are seven issues need to be considered during material procurement negotiation. Its included price, payment term, payment period, advance payment, delivery and freightage. Based on the weight getting from Analytical Hierarchical Process, (AHP) all three materials have their own important issues that need to be used during the negotiation process between contractor and supplier. The three most important issues in aggregate procurement is price, payment term and payment period from the supplier view. While price, delivery and freightage are issue that need to be used by the contractor. The three important issues in cement procurement are same as aggregate from the supplier view. Meanwhile it has a little bit different in the issues that need to be used from the contractor viewpoint. These issues are price, payment term and delivery. Lastly, the three important issues in ready mix concrete procurement for the supplier is price, delivery and freightage. However, the contractor view is price, payment term and payment period. Basically the issue of price is the most important to use during the negotiation process because it is the main issue related to cash flow account and affecting the total cost of a construction project.

Two mathematic functions have been used in this research including linear and step functions. Only price can be apply a linear function in the material procurement

negotiation because the option is linearly changed. However, for other issue such as advance payment, delivery, freightage, payment term and payment period, the step function needs to be applied. Because of the percentage pay-off does not linearly change from one option to another option. In general, both mathematical functions could be used in determining the most relevant joint pay-off between a contractor and supplier. Next, the graph 45º line might help in optimizing the selection of joint pay-off. Based on that analysis result, all options benefit for both the contractor and the supplier is selected as the optimum joint pay-off. The joint pay-off considered the weight give the most optimum result compared with the joint pay-off unconsidered the weight. As a conclusion of this research, all objectives have accomplished.

8.2 Recommendation

Some of recommendation for future study:

- To get a better result in AHP method, the comparison might need between all three materials selected in the analysis. Thus, the comparison of weight should start between the three different materials in the same project. Next, the comparison of weight with all materials should be analyzed from the three different projects. However, it might take a long period in an interview process. It also needs full commitment from the interviewer.
- In analyzing step function, the fault tree analysis might help to determine the characteristics of all joint pay-off in step function. Thus, it will show the full figure of joint pay-off between contractor and supplier.

References

Abdullah, M. R., Rahman, I. A., et al. (2010). "Causes of Delay in MARA Management Procurement Construction Projects " **Journal of Surveying, Construction and Property 1**(1): 123-138.

Ballard, G., Tommelein, I., et al. (2002). **Lean Construction Tools and Techniques**, Butterworth-Heinemann, Elsevier Science Ltd.

Bazerman, M. H. (1990). **Judgement in Management Decision Making**. New York, John Wiley & Son.

Benton, W. C. and McHenry, L. F. (2010). **Construction purchasing and supply chain management**, McGraw-Hill.

Burt, D. N., Dobler, D. W., et al. (2003). **World class supply management : the key to supply chain management** Boston : McGraw-Hill.

Dzeng, R.-J. and Lin, Y.-C. (2004). "Intelligent agents for supporting construction procurement negotiation." **Expert Systems with Applications 27**(1): 107-119.

Egan, J. Rethinking Construction [Online].2011. Available from: http://www.construction.detr.gov.uk/cis/rethink/index.htm. [2011, July]

Gaosheng, Y., Ge, H., et al. (2010). "Research on the Strategy of Construction Material Procurement When the Price Fluctuation Is Considered ": 1 - 4pg

Hadikusumo, B. H. W., Petchpong, S., et al. (2005). "Construction material procurement using Internet-based agent system." **Automation in Construction 14**(6): 736-749.

Houlihan, J. B. (1987). "International Supply Chain Management." **International Journal of Physical Distribution & Materials Management 17**(2): 51-66.

Kong, C. W., Li, H., et al. (2001). "An e-commerce system for construction material procurement." **Construction Innovation: Information, Process, Management 1**(1): 43 - 54.

Kong, S. C. W., Li, H., et al. (2004). "Enabling information sharing between E-commerce systems for construction material procurement." **Automation in Construction 13**(2): 261-276.

Manavazhi, M. R. and Adhikari, D. K. (2002). "Material and equipment procurement delays in highway projects in Nepal." **International Journal of Project Management 20**(8): 627-632.

Perdomo, J. L. and Tabet, W. (2006). "Automated Field Material Procurement using Pocket PCs." **Fourth LACCEI International Latin American and Caribbean Conference for Engineering and Technology (LACCET'2006)**(Breaking Frontiers and Barriers in Engineering: Education, Research and Practice).

Rao, A. S. Technology Acceptance Model for Complex Technologies in a Period of Rapid Catching-Up [Online].2011. Available from: http://ssrn.com/abstract=1016012 [2011, Dicember]

Ruikar, K., Anumba, C. J., et al. (2003). "Reengineering construction business processes through electronic commerce." **The TQM Magazine 15**(3): 197 - 212.

Saaty, T. L. (1980). The Analytic Hierarchy Process: Planning, Priority Setting, Resource Allocation (Decision Making Series), McGraw-Hill, Inc.

Sambasivan, M. and Soon, Y. W. (2007). "Causes and effects of delays in Malaysian construction industry." **International Journal of Project Management 25**(5): 517-526.

Standifera, R. L. and Wall Jr, J. A. (2003). "Managing conflict in B2B e-commerce." **Business Horizons 46**(2): 65-70.

Tommelein, I. D. (2004). **The Value Chain: Adding Value to the Supply Chain**. Chantilly, VA., Mechanical Contracting Education & Research Foundation (MCERF).

Tommelein, I. D., Ballard, G., et al. (2008). **Supply Chain Management for Lean Project Delivery**.

Trauner Jr, T. J., Manginelli, W. A., et al. (2009). Chapter 2 - Types of Construction Delays. **Construction Delays (Second Edition)**. Boston, Butterworth-Heinemann**:** 25-36.

Wang, Y., Yang, J., et al. (2007). "The application of electronic commerce and information integration in the construction industry." **International Journal of Project Management 25**(2): 158-163.

Wisner, J. D., Tan, K.-C., et al. (2009). **Principles of supply chain management : a balanced approach** Mason, OH : South-Western

Zhang, H.-p. and Huang, D.-c. (2011). "Plan and Coordination of Agile Supply Chain Based on Multi-Agent " **Energy Procedia 13**: 10134-10142

Zhang, Y. (2009). "The Agent Negotiation in Materials Procurement and Management." **Management and Service Science, 2009. MASS '09. International Conference**: 1-3.

APPENDICES

APPENDIX A

Questionnaires

จุฬาลงกรณ์มหาวิทยาลัย
CHULALONGKORN UNIVERSITY
ภาควิชาวิศวกรรมโยธา คณะวิศวกรรมศาสตร์ ถนนพญาไท ปทุมวัน กรุงเทพฯ 10330
Department of Civil Engineering, Faculty of Engineering
Phayathai Rd., Pathumwan, Bangkok 10330 Tel : (662) 218-6460 to 62, Fax : (662) 251-7304

Ref. No.: /2012 Date: 8th October 2012

Sir / Madam,

REQUEST ON CONDUCTING INTERVIEW SESSION FOR MY MASTER'S THESIS

Referring to the statement mentioned above, I am Rafiuddin Bin Yeob Ramli (ID 547 0518021) masters student from Department of Construction Engineering and Management, Faculty of Engineering, Chulalongkorn University, Thailand. I am currently conducting a research entitle 'Improving Agent-based Negotiation in Material Procurement'.

1. The objective of the research is to develop agent-based system for facilitating negotiation process in material procurement by applying mathematical function.

2. Interview session will be conducted in order to support my thesis progress; this is where I can know more about the Malaysia framework of negotiation in material procurement process. Construction Manager who is in-charge in the material procurement and has experience in the negotiation process is needed.

It's would be much appreciated if you could give co-operation in data collection process. Here is my e-mail for any further inquiry Rafiuddinbin.Y@student.chula.ac.th. Thank you in advance.

Sincerely Yours,

(Dr. Vachara Peansupap)
Assistant Professor
Construction Eng. and Management
Department of Civil Engineering
Chulalongkorn University
Bangkok, Thailand

(Rafiuddin Bin Yeob Ramli)
Masters Student
Construction Eng. and Management
Department of Civil Engineering
Chulalongkorn University
Bangkok, Thailand

จุฬาลงกรณ์มหาวิทยาลัย
Chulalongkorn University
Pillar of the Kingdom

Faculty of Engineering
Department of Civil Engineering
(Construction Engineering and Management)

SURVEY ON MATERIAL PROCUREMENT NEGOTIATION

This survey is a part of research program at Chulalongkorn University. It is a survey on material procurement negotiation within the **Malaysia construction sector**. It focused the negotiation between **contractors and suppliers organization**. Structured questions have been formulated to achieve this goal. Your response to this questionnaire is highly valued and will be treated with the strictest confidence. It will used for academic purposes only. This survey need to **ANSWER BY the senior manager or any position who involved or responsible with material procurement in your organization**.

Part [1]: Background information				
1.1	Company name			
1.2	Address			
	URL			
1.3	No. of employees		Company age	
1.4	Name of respondent			
	Position			
	E-mail			
	Tel		Fax	
	Signature			

Please indicate which category best describe your organization:

☐ Contractor ☐ Supplier

The important of this research will **beneficial to the contractor and supplier** in the **management of construction process**. Do you want me to provide the result of this study after my research has been done?

☐ Yes ☐ No

Part [2]: Basic Information

Instruction*: Please* ***mark*** **[X] only one answer** for each question.

2.1 Please indicate which category best describe your organization :

☐ Supplier: .....

Contractor registered with CIDB under grade

☐ G1 ☐ G2 ☐ G3 ☐ G4 ☐ G5 ☐ G6 ☐ G7

2.2 Did your organization **estimated or identified the future material price** during tendering process??

☐ Yes ☐ No

Part [3]: Material Procurement

Instruction*: Please* ***mark*** **[X] only one answer** for each question.

3.1 Did your organisation have procurement department at main office?

☐ Yes ☐ No

3.2 Did your organisation have procurement department at construction project?

☐ Yes ☐ No

3.3 Who are involved in the following task?
(Exp: Project manager, project engineer, quantity surveyor, accountant etc)

Material Procurement Process	Managed by
BEFORE PROJECT OWNER AWARDED CONSTRUCTION PROJECT	
Identify material specification and estimate the cost during tendering stage	
Identify material supplier and get the material price quotation	
Make material supplier short list	
Preparing tender document with material supplier	
AFTER PROJECT OWNER AWARDED CONSTRUCTION PROJECT	
Material price negotiation	
Requisition of material before construction works	
Purchase order (Hadikusumo, Petchpong and Charoenngam)	
Material Quality Inspection	
Keep the invoice issued by the supplier when material arrive on site	
Make a payment to supplier	
Delivery order (DO)	

3.4 Please identify procurement flow of material that used along negotiation construction project.
Centralize: Done by procurement department at **main office**
Decentralize: Done by procurement section/department **project site**

Types of Construction Material	Main contractor			Sub-contract
	Centralize	Decentralize	Both	
MATERIAL FOR STRUCTURAL WORK				
Reinforcement Steel				
Steel structure (**H-beam**)				
Formwork (**Timber, Wood**)				
Ready-mixed Concrete				
Cement				
Aggregate (**Sand, Gravel**)				
MATERIAL FOR ARCHITECTURAL WORK				
Brick (Standifera and Wall Jr)				
Ceiling (**Plaster board**)				
Door (**Single/Double Wood**)				
Roof Timber Truss				
Roof Steel Truss				
Roof Tile				
Window				
MATERIAL FOR FINISHING WORK				
Painting (**Paint, Brush, Paint scraper, Roller tray**)				
Wall and Floor Tile				
MATERIAL FOR M/E WORK				
Electrical Devices (**Wire, Lamp, Ceiling Fan, Switch**)				
Fire protection system (**Pipe, Alarm sensor**)				
Mechanical Devices (**Elevator, Escalator, Air-conditioner**)				
Sanitary (**Bowl, Sink**)				
Sewerage (**Drainage, Manhole**)				
Telephone and Internet devices				
Water resources (**Water tank, Pipe, Tap**)				

3.5 Please indicate the material be supplied by multiple suppliers or single supplier.

Types of Construction Material	Single Material Supplier	Multiple Material Supplier
MATERIAL FOR STRUCTURAL WORK		
Reinforcement Steel		
Steel structure (**H-beam**)		
Formwork (**Timber, Wood**)		
Ready-mixed Concrete		
Cement		
Aggregate (**Sand, Gravel**)		
MATERIAL FOR ARCHITECTURAL WORK		
Brick (Standifera and Wall Jr)		
Ceiling (**Plaster board**)		
Door (**Single/Double Wood**)		
Roof Timber Truss		
Roof Steel Truss		
Roof Tile		
Window		
MATERIAL FOR FINISHING WORK		
Painting (**Paint, Brush, Paint scraper, Roller tray**)		
Wall and Floor Tile		
MATERIAL FOR M/E WORK		
Electrical Devices (**Wire, Lamp, Ceiling Fan, Switch**)		
Fire protection system (**Pipe, Alarm sensor**)		
Mechanical Devices (**Elevator, Escalator, Air-conditioner**)		
Sanitary (**Bowl, Sink**)		
Sewerage (**Drainage, Manhole**)		
Telephone and Internet devices		
Water resources (**Water tank, Pipe, Tap**)		

3.6 Please indicate service material supplier type will be used to procure the material.

Manufacturer/Warehouse: Directly purchased construction materials from supplier factory

Material Trader/Agent: Purchase construction materials from supplier dealer

Material Promoter/Seller: Purchase construction materials from material seller comes to the site

Types of Construction Material	Service Type		
	Warehouse	Agent	Seller
MATERIAL FOR STRUCTURAL MATERIAL			
Reinforcement Steel			
Steel structure (**H-beam**)			
Formwork (**Timber, Wood**)			
Ready-mixed Concrete			
Cement			
Aggregate (**Sand, Gravel**)			
MATERIAL FOR ARCHITECTURAL MATERIAL			
Brick (Standifera and Wall Jr)			
Ceiling (**Plaster board**)			
Door (**Single/Double Wood**)			
Roof Timber Truss			
Roof Steel Truss			
Roof Tile			
Window			
MATERIAL FOR FINISHES MATERIAL			
Painting (**Paint, Brush, Paint scraper, Roller tray**)			
Wall and Floor Tile			
MATERIAL FOR M/E MATERIAL			
Electrical Devices (**Wire, Lamp, Ceiling Fan, Switch**)			
Fire protection system (**Pipe, Alarm sensor**)			
Mechanical Devices (**Elevator, Escalator, Air-conditioner**)			
Sanitary (**Bowl, Sink**)			
Sewerage (**Drainage, Manhole**)			
Telephone and Internet devices			
Water resources (**Water tank, Pipe, Tap**)			

Part [4]: Negotiation of Material Procurement

Instruction*: Please* ***mark*** **[X] only one answer** for each question.

4.1 How your organization conducted material procurement negotiation?

☐ Telephone ☐ E-mail
☐ Fax ☐ Physical

4.2 Did your organisation **use other technology** to make negotiation process in material procurement such as agent-based system?

☐ Yes ☐ No

4.3 How **long the negotiation process** will take-in for one material (specify unit)?
…… (hour/day/week/month)

4.4 What are the relevant issues will be used during the negotiation process in material procurement?

☐ Advance payment ☐ Delivery
☐ Freightage ☐ Payment period
☐ Payment term ☐ Warranty period
☐ Quantity ☐

Others: _____

4.5 Are there any problems occur during procurement of material negotiation process after project owner awarded the contract?

_____
_____

4.6 Please identify possible period that the negotiation of material procurement will occur after project owner award the contract?
Remark: Related with question 3.4. Only material that main contractor buys from supplier

Types of Construction Material	During material agreement period (before project start)	Before installation process (**day**/**week** before work start)
MATERIAL FOR STRUCTURAL MATERIAL		
Reinforcement Steel		
Steel structure (**H-beam**)		
Formwork (**Timber, Wood**)		
Ready-mixed Concrete		
Cement		
Aggregate (**Sand, Gravel**)		
Brick (Standifera and Wall Jr)		
Ceiling (**Plaster board**)		
Door (**Single/Double Wood**)		
Roof Timber Truss		
Roof Steel Truss		
Roof Tile		
Window		
Painting (**Paint, Brush, Paint scraper, Roller tray**)		
Wall and Floor Tile		
Electrical Devices (**Wire, Lamp, Ceiling Fan, Switch**)		
Fire protection system (**Pipe, Alarm sensor**)		
Mechanical Devices (**Elevator, Escalator, Air-conditioner**)		
Sanitary (**Bowl, Sink**)		
Sewerage (**Drainage, Manhole**)		
Telephone and Internet devices		
Water resources (**Water tank, Pipe, Tap**)		

จุฬาลงกรณ์มหาวิทยาลัย
Chulalongkorn University
Pillar of the Kingdom

Faculty of Engineering
Department of Civil Engineering
(Construction Engineering and Management)

SURVEY ON MATERIAL PROCUREMENT NEGOTIATION

This survey is a part of research program at Chulalongkorn University. It is a survey on material procurement negotiation within the **Malaysia construction sector**. It focused the negotiation between **contractors and suppliers organization**. Structured questions have been formulated to achieve this goal. Your response to this questionnaire is highly valued and will be treated with the strictest confidence. It will used for academic purposes only. This survey need to **ANSWER BY the senior manager or any position who involved or responsible with material procurement in your organization**.

Part [1]: Background information				
1.1	Company name			
1.2	Address			
	URL			
1.3	No. of employees		Company age	
1.4	Name of respondent			
	Position			
	E-mail			
	Tel		Fax	
	Signature			

Please indicate which category best describe your organization:

☐ Contractor ☐ Supplier

The important of this research will **beneficial to the contractor and supplier** in the **management of construction process**. Do you want me to provide the result of this study after my research has been done?

☐ Yes ☐ No

Part [2]: Price of Material Procurement

Instruction*:* *Please mark* [X] only one answer for each question.

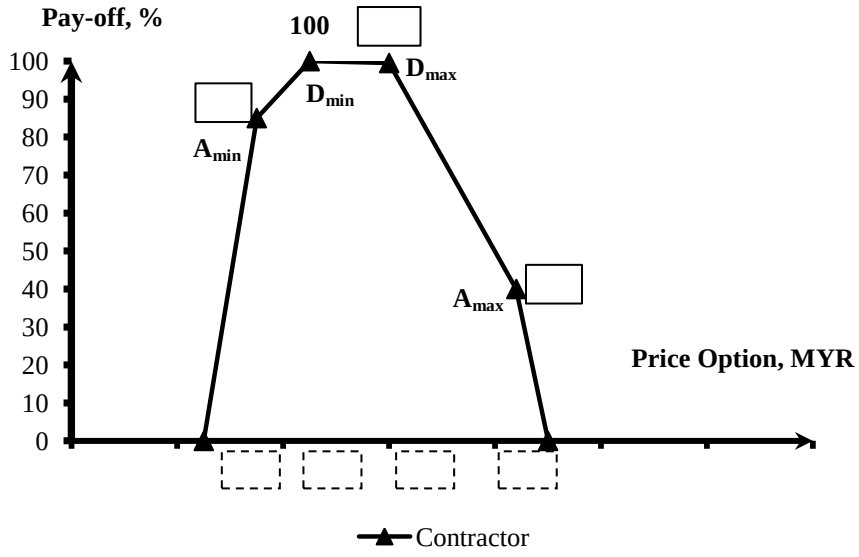
CASE STUDY:

Type of material :
Specification :

CONTRACTOR:

ACCEPTABLE RANGE		
Contractor	A_{min}	A_{max}
Acceptable Price (MYR)		
Percentage Acceptable Pay-off (%)		

DESIRED RANGE		
Contractor	D_{min}	D_{max}
Desired Price (MYR)		
Percentage Desired Pay-off (%)	**100**	



Part [3]: Selected Option Based on each Issue

Instruction: *Please Percentage Pay-off, % for each option issues based on your experience in material procurement negotiation.*

Explanation: The **percentage acceptable, %** of your organization with option given **based on the price of material in the case study in Part [2]**.

3.1 Negotiation issue: **Payment Period**

Option	Percentage Pay-off, %
On delivery	
On completion of milestones	
On completion	
Bi-weekly	
Monthly	

3.2 Negotiation issue: **Advance Payment**

Option	Percentage Pay-off, %
10%	
15%	
20%	
25%	
30%	

3.3 Negotiation issue: **Delivery**

Option	Percentage Pay-off, %
Single delivery	
Multiple delivery	
On-call delivery	

3.4 Negotiation issue: **Warranty Period**

Option	Percentage Pay-off, %
2-years	
3-years	
5-years	
7-years	

3.5 Negotiation issue: **Payment Terms**

Option	Percentage Pay-off, %
Cash	
30-day check	
45-day check	
60-day check	

3.6 Negotiation issue: **Freightage**

Option	Percentage Pay-off, %
Included	
Excluded	

Part [4]: The weight/important of Issues in Negotiation of Material Procurement

Instruction*:* *Please mark*[X] only one answer for each question.

What is **the weight of each issues comparing** with another issues during negotiation process?

Negotiation Issues	Absolutely		Strongly		Weakly		Equal	Weakly		Strongly		Absolutely		Negotiation Issues
	7	6	5	4	3	2	1	2	3	4	5	6	7	
Price														Payment Term
Price														Payment Period
Price														Advance Payment
Price														Delivery
Price														Freightage
Payment Term														Payment Period
Payment Term														Advance Payment
Payment Term														Delivery
Payment Term														Freightage
Payment Period														Advance Payment
Payment Period														Delivery
Payment Period														Freightage
Advance Payment														Delivery
Advance Payment														Freightage
Delivery														Freightage

List of Supplier and Material Supply

Material 1: Ready-mix Concrete

	Supplier 1	**Supplier 2**
Company Name		
Address		
Contact Person		
Tel		

Material 2: Sand

	Supplier 1	**Supplier 2**
Company Name		
Address		
Contact Person		
Tel		

Material 3: Tile

	Supplier 1	**Supplier 2**
Company Name		
Address		
Contact Person		
Tel		

จุฬาลงกรณ์มหาวิทยาลัย
Chulalongkorn University
Pillar of the Kingdom

Faculty of Engineering
Department of Civil Engineering
(Construction Engineering and Management)

SURVEY ON MATERIAL PROCUREMENT NEGOTIATION

This survey is a part of research program at Chulalongkorn University. It is a survey on material procurement negotiation within the **Malaysia construction sector**. It focused the negotiation between **contractors and suppliers organization**. Structured questions have been formulated to achieve this goal. Your response to this questionnaire is highly valued and will be treated with the strictest confidence. It will used for academic purposes only. This survey need to **ANSWER BY the senior manager or any position who involved or responsible with material procurement in your organization**.

Part [1]: Background information				
1.1	Company name			
1.2	Address			
	URL			
1.3	No. of employees		Company age	
1.4	Name of respondent			
	Position			
	E-mail			
	Tel		Fax	
	Signature			

Please indicate which category best describe your organization:

☐ Contractor ☐ Supplier

The important of this research will **beneficial to the contractor and supplier** in the **management of construction process**. Do you want me to provide the result of this study after my research has been done?

☐ Yes ☐ No

Part [2]: Price of Material Procurement

Instruction*:* *Please mark* [X] only one answer for each question.

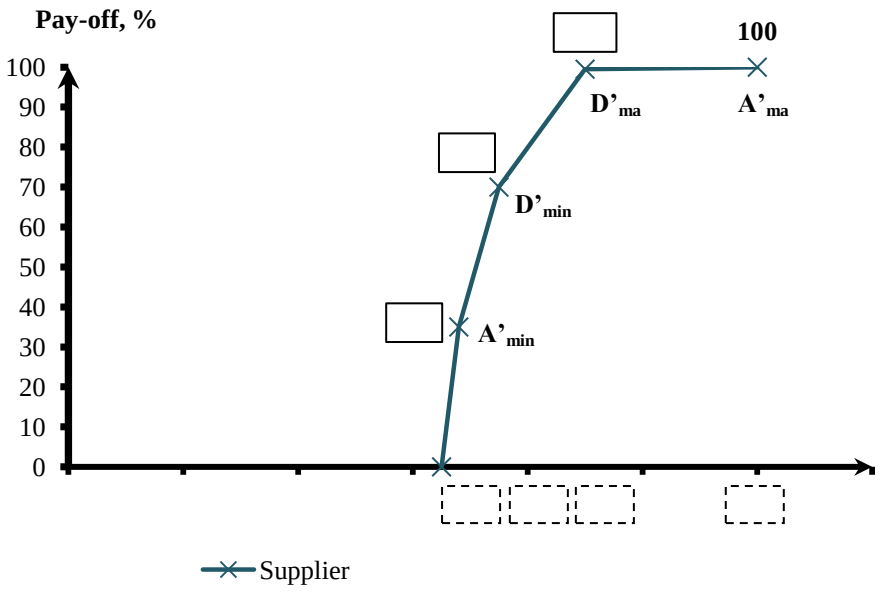
CASE STUDY:

Type of material :
Specification :

SUPPLIER:

ACCEPTABLE RANGE		
Supplier	A'_{min}	A'_{max}
Acceptable Price (MYR)		
Percentage Acceptable Pay-off (%)		**100**

DESIRED RANGE		
Supplier	D'_{min}	D'_{max}
Desired Price (MYR)		
Percentage Desired Pay-off (%)		



Part [3]: Selected Option Based on each Issue

Instruction: *Please Percentage Pay-off, % for each option issues based on your experience in material procurement negotiation.*

Explanation: The **percentage acceptable, %** of your organization with option given **based on the price of material in the case study in Part [2]**.

3.1 Negotiation issue: **Payment Period**

Option	Percentage Pay-off, %
On delivery	
On completion of milestones	
On completion	
Bi-weekly	
Monthly	

3.2 Negotiation issue: **Advance Payment**

Option	Percentage Pay-off, %
10%	
15%	
20%	
25%	
30%	

3.3 Negotiation issue: **Delivery**

Option	Percentage Pay-off, %
Single delivery	
Multiple delivery	
On-call delivery	

3.4 Negotiation issue: **Warranty Period**

Option	Percentage Pay-off, %
2-years	
3-years	
5-years	
7-years	

3.5 Negotiation issue: **Payment Terms**

Option	Percentage Pay-off, %
Cash	
30-day check	
45-day check	
60-day check	

3.6 Negotiation issue: **Freightage**

Option	Percentage Pay-off, %
Included	
Excluded	

Part [4]: The weight/important of Issues in Negotiation of Material Procurement

Instruction*:* *Please mark* [X] only one answer for each question.

What is **the weight of each issues comparing** with another issues during negotiation process?

Negotiation Issues	Absolutely		Strongly		Weakly		Equal	Weakly		Strongly		Absolutely		Negotiation Issues
	7	6	5	4	3	2	1	2	3	4	5	6	7	
Price														Payment Term
Price														Payment Period
Price														Advance Payment
Price														Delivery
Price														Freightage
Payment Term														Payment Period
Payment Term														Advance Payment
Payment Term														Delivery
Payment Term														Freightage
Payment Period														Advance Payment
Payment Period														Delivery
Payment Period														Freightage
Advance Payment														Delivery
Advance Payment														Freightage
Delivery														Freightage

APPENDIX B

Data Calculation

APPENDIX B1

Data Calculation PART A1

3.1 Did your organisation have procurement department at main office?

Yes	No
100	0

3.2 Did your organisation have procurement department at construction project?

Yes	No
100	0

3.4 Please identify procurement flow of material that used along negotiation construction project.

Centralize: Done by procurement department at **main office**

Decentralize: Done by procurement section/department **project site**

Types of Construction Material	Main contractor			Sub-contract
	Centralize	Decentralize	Both	
MATERIAL FOR STRUCTURAL WORK				
Reinforcement Steel	6	9	86	0
Steel structure (**H-beam**)	14	23	63	0
Formwork (**Timber, Wood**)	9	11	80	0
Ready-mixed Concrete	9	77	14	0
Cement	11	74	14	0
Aggregate (**Sand, Gravel**)	9	71	20	0
MATERIAL FOR ARCHITECTURAL WORK				
Brick (Standifera and Wall Jr)	11	74	14	0
Ceiling (**Plaster board**)	20	57	23	0
Door (**Single/Double Wood**)	20	23	57	0
Roof Timber Truss	23	60	17	0
Roof Steel Truss	20	57	23	0
Roof Tile	23	54	23	0
Window	26	51	23	0
MATERIAL FOR FINISHING WORK				
Painting (**Paint, Brush, Paint scraper, Roller tray**)	0	91	9	0
Wall and Floor Tile	11	14	23	51
MATERIAL FOR M/E WORK				
Electrical Devices (**Wire, Lamp, Ceiling Fan, Switch**)	0	11	17	71
Fire protection system (**Pipe, Alarm sensor**)	0	20	17	63
Mechanical Devices (**Elevator, Escalator, Air-conditioner**)	0	14	0	86
Sanitary (**Bowl, Sink**)	6	23	71	0
Sewerage (**Drainage, Manhole**)	20	17	63	0
Telephone and Internet devices	17	63	20	0
Water resources (**Water tank, Pipe, Tap**)	17	50	33	0

Types of Construction material	Main contractor (%)			Sub-contract
	Centralized	Decentralized	Both (Centralized & Decentralized)	
MATERIAL FOR STRUCTURAL WORK	10	44	46	0
MATERIAL FOR ARCHITECTURAL WORK	20	54	26	0
MATERIAL FOR FINISHING WORK	6	52	16	26
MATERIAL FOR M/E WORK	8	28	32	32

3.5 Please indicate the material be supplied by multiple suppliers or single supplier.

Types of Construction Material	Single Material Supplier	Multiple Material Supplier
MATERIAL FOR STRUCTURAL WORK		
Reinforcement Steel	14	86
Steel structure (**H-beam**)	14	86
Formwork (**Timber, Wood**)	29	71
Ready-mixed Concrete	0	100
Cement	14	86
Aggregate (**Sand, Gravel**)	0	100
MATERIAL FOR ARCHITECTURAL WORK		
Brick (Standifera and Wall Jr)	20	80
Ceiling (**Plaster board**)	20	80
Door (**Single/Double Wood**)	71	29
Roof Timber Truss	20	80
Roof Steel Truss	77	23
Roof Tile	83	17
Window	86	14
MATERIAL FOR FINISHING WORK		
Painting (**Paint, Brush, Paint scraper, Roller tray**)	49	51
Wall and Floor Tile	46	54
MATERIAL FOR M/E WORK		
Electrical Devices (**Wire, Lamp, Ceiling Fan, Switch**)	43	57
Fire protection system (**Pipe, Alarm sensor**)	57	43
Mechanical Devices (**Elevator, Escalator, Air-conditioner**)	57	43
Sanitary (**Bowl, Sink**)	31	69
Sewerage (**Drainage, Manhole**)	43	57
Telephone and Internet devices	69	31
Water resources (**Water tank, Pipe, Tap**)	57	43

Types of Construction material	Single Material Supplier	Multiple Material Supplier
MATERIAL FOR STRUCTURAL WORK	12	88
MATERIAL FOR ARCHITECTURAL WORK	54	46
MATERIAL FOR FINISHING WORK	47	53
MATERIAL FOR M/E WORK	51	49

3.6 Please indicate service material supplier type will be used to procure the material.

Manufacturer/Warehouse: Directly purchased construction materials from supplier factory

Material Trader/Agent: Purchase construction materials from supplier dealer

Material Promoter/Seller: Purchase construction materials from material seller comes to the site

Types of Construction Material	Service Type		
	Manufacturer /Warehouse	Material Trader/Agent	Material Promoter/Seller
MATERIAL FOR STRUCTURAL MATERIAL			
Reinforcement Steel	51	49	0
Steel structure (**H-beam**)	57	43	0
Formwork (**Timber, Wood**)	54	46	0
Ready-mixed Concrete	83	17	0
Cement	43	57	0
Aggregate (**Sand, Gravel**)	77	23	0
MATERIAL FOR ARCHITECTURAL MATERIAL			
Brick (Standifera and Wall Jr)	71	29	0
Ceiling (**Plaster board**)	31	57	11
Door (**Single/Double Wood**)	23	63	14
Roof Timber Truss	57	43	0
Roof Steel Truss	20	63	17
Roof Tile	17	51	31
Window	**14**	57	29
MATERIAL FOR FINISHES MATERIAL			
Painting (**Paint, Brush, Paint scraper, Roller tray**)	29	57	14
Wall and Floor Tile	9	63	29
MATERIAL FOR M/E MATERIAL			
Electrical Devices (**Wire, Lamp, Ceiling Fan, Switch**)	0	57	43
Fire protection system (**Pipe, Alarm sensor**)	0	71	29
Mechanical Devices (**Elevator, Escalator, Air-conditioner**)	40	44	16
Sanitary (**Bowl, Sink**)	40	43	17
Sewerage (**Drainage, Manhole**)	23	57	20
Telephone and Internet devices	29	51	20
Water resources (**Water tank, Pipe, Tap**)	29	57	14

Types of Construction material	Service Type (%)		
	Manufacturer / Warehouse	Material Trader/ Agent	Material Promoter/ Seller
MATERIAL FOR STRUCTURAL WORK	61	39	0
MATERIAL FOR ARCHITECTURAL WORK	33	52	15
MATERIAL FOR FINISHING WORK	19	60	21
MATERIAL FOR M/E WORK	22	55	23

4.1 How your organization conducted material procurement negotiation?

Telephone	Fax	E-mail	Physical
100	29	34	86

4.2 Did your organisation **use other technology** to make negotiation process in material procurement such as agent-based system?

Yes	No
0	100

4.4 What are the relevant issues will be used during the negotiation process in material procurement?

Advance Payment	Delivery	Freightage	Payment Period	Payment Term	Warranty Period	Quantity
100	86	86	89	71	54	57

4.6 Please identify possible period that the negotiation of material procurement will occur after project owner award the contract?

Remark: Related with question 3.4. Only material that main contractor buys from supplier

Types of Construction Material	During material agreement period (before project start)	Before installation process (**day/week** before work start)
MATERIAL FOR STRUCTURAL MATERIAL		
Reinforcement Steel	14	86
Steel structure (**H-beam**)	20	80
Formwork (**Timber, Wood**)	20	80
Ready-mixed Concrete	9	91
Cement	43	57
Aggregate (**Sand, Gravel**)	14	86
Brick (Standifera and Wall Jr)	14	86
Ceiling (**Plaster board**)	20	80
Door (**Single/Double Wood**)	23	77
Roof Timber Truss	26	74
Roof Steel Truss	14	86
Roof Tile	54	46
Window	43	57
Painting (**Paint, Brush, Paint scraper, Roller tray**)	9	91
Wall and Floor Tile	17	83
Electrical Devices (**Wire, Lamp, Ceiling Fan, Switch**)	86	14
Fire protection system (**Pipe, Alarm sensor**)	20	80
Mechanical Devices (**Elevator, Escalator, Air-conditioner**)	14	86
Sanitary (**Bowl, Sink**)	49	51
Sewerage (**Drainage, Manhole**)	20	80
Telephone and Internet devices	49	51
Water resources (**Water tank, Pipe, Tap**)	31	69

Types of Construction material	During Material Agreement Period (before project start)	Before installation process (day/week before work start)
MATERIAL FOR STRUCTURAL WORK	20	80
MATERIAL FOR ARCHITECTURAL WORK	28	72
MATERIAL FOR FINISHING WORK	13	87
MATERIAL FOR M/E WORK	38	62

APPENDIX B2

Data Calculation PART A2

AGGREGATE [Granite Aggregate 3/4"]:

Price Issue – Without Weight

Contractor	P_{min}	A_{min}	D_{min}	D_{max}	A_{max}	P_{max}
Pay-off		50	100	98	50	
Option		19	20	23	24	

Supplier-S1	P'_{min}	A'_{min}	D'_{min}	D'_{max}	A'_{max}	P'_{max}
Pay-off		30	80	90	100	
Option		22	25	26	27	

Supplie-S2	P''_{min}	A''_{min}	D''_{min}	D''_{max}	A''_{max}	P''_{max}
Pay-off		30	85	95	100	
Option		22	24.5	25	26	

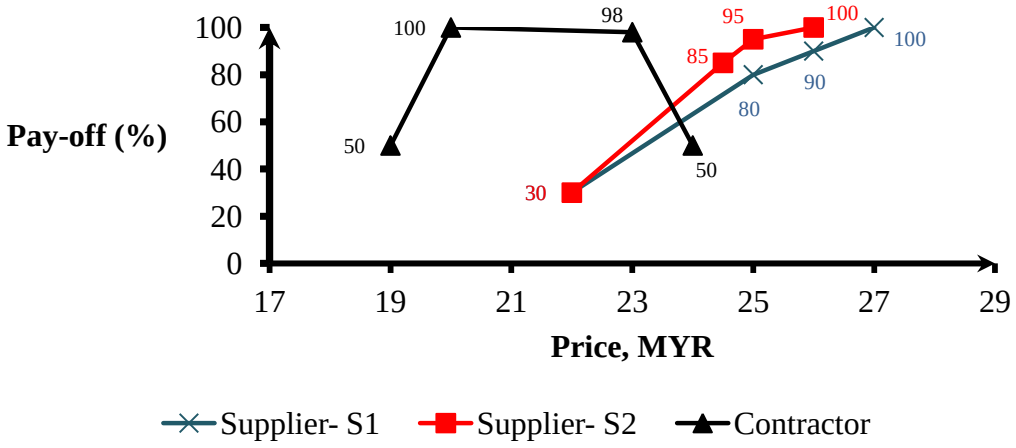


Figure: Price Issue – Without Weight

Single Benefit-Supplier

Point	Option (MYR)	Contractor Pay-off, %	Pay-off, %	Joint Pay-off
Supplier-S1	24.00	50.00	63.33	113.33
Supplier-S2	24.00	50.00	74.00	124.00

Single Benefit-Contractor

Point	Option (MYR)	Supplier Pay-off, %	Pay-off, %	Joint Pay-off
Contractor & S1	22.00	30.00	98.67	128.67
Contractor & S2	22.00	30.00	98.67	128.67

Both benefit

Point	Option (MYR)	Pay-off, %	Joint Pay-off
Intercept price Contractor & S1	23.79	59.90	119.79
Intercept price Contractor & S2	23.66	66.46	132.91

AGGREGATE [Granite Aggregate 3/4"]:

Payment Term Issue – Without Weight

Option		Cash	30-day check	45-day check	60-day check
Supplier-S1	**Pay-off**	100	90	70	40
Supplier-S2	**Pay-off**	100	85	70	40
Contractor	**Pay-off**	40	60	80	100

Option		Cash	30-day check	45-day check	60-day check
Joint-1	**Pay-off**	140	150	150	140
Joint-2	**Pay-off**	140	145	150	140

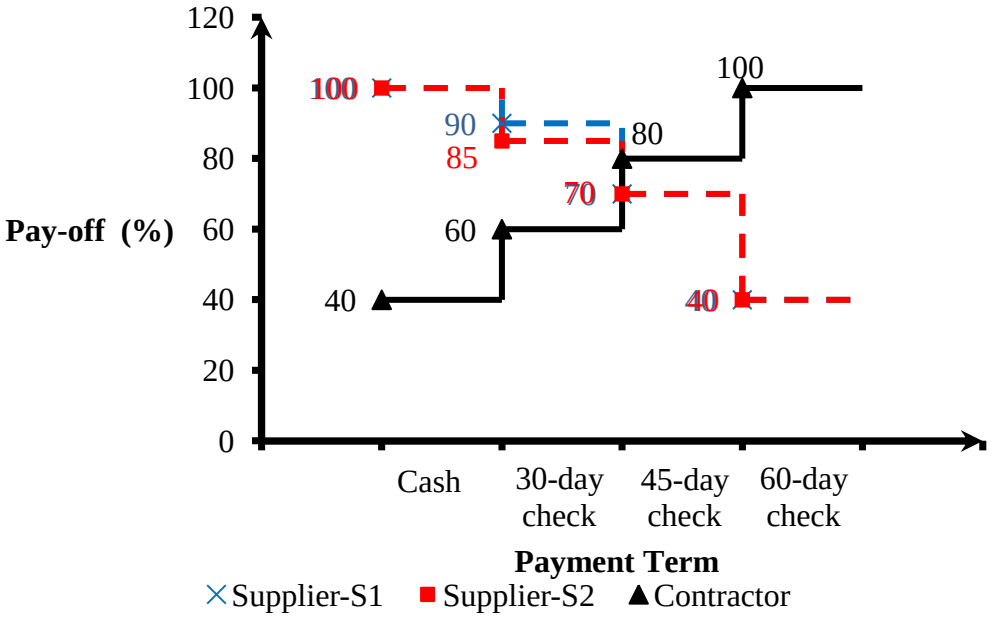


Figure: Payment Term Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Cash	100	40	140
Supplier-S2	Cash	100	40	140

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	60-day check	100	40	140
Contractor & S2	60-day check	100	40	140

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	45-day check	80	70	150
Both-2	45-day check	80	70	150

AGGREGATE [Granite Aggregate 3/4"]:

Payment Period Issue – Without Weight

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Supplier-S1	**Pay-off**	100	90	70	45	30
Supplier-S2	**Pay-off**	100	80	70	50	30
Contractor	**Pay-off**	35	60	85	95	100

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Joint-1	**Pay-off**	135	150	155	140	130
Joint-2	**Pay-off**	135	140	155	145	130

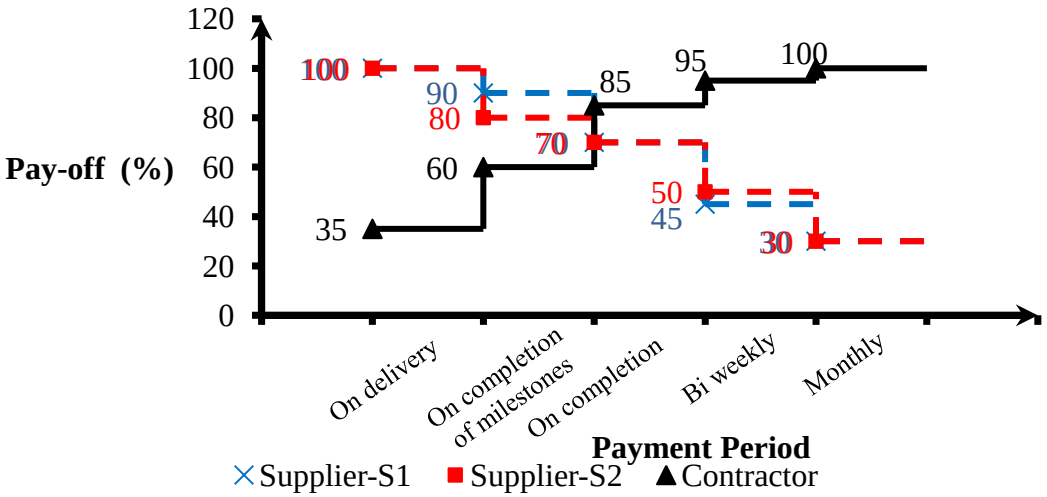


Figure: Payment Period Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	On Delivery	100	35	135
Supplier-S2	On Delivery	100	35	135

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Monthly	100	30	130
Contractor & S2	Monthly	100	30	130

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	On Completion	85	70	155
Both-2	On Completion	85	70	155

AGGREGATE [Granite Aggregate 3/4"]:

Advance Payment Issue – Without Weight

Option		10%	15%	20%	25%	30%
Supplier-S1	**Pay-off**	30	60	70	90	100
Supplier-S2	**Pay-off**	35	70	80	85	100
Contractor	**Pay-off**	100	90	85	60	30

Option		10%	15%	20%	25%	30%
Joint-1	**Pay-off**	130	150	155	150	130
Joint-2	**Pay-off**	135	160	165	145	130

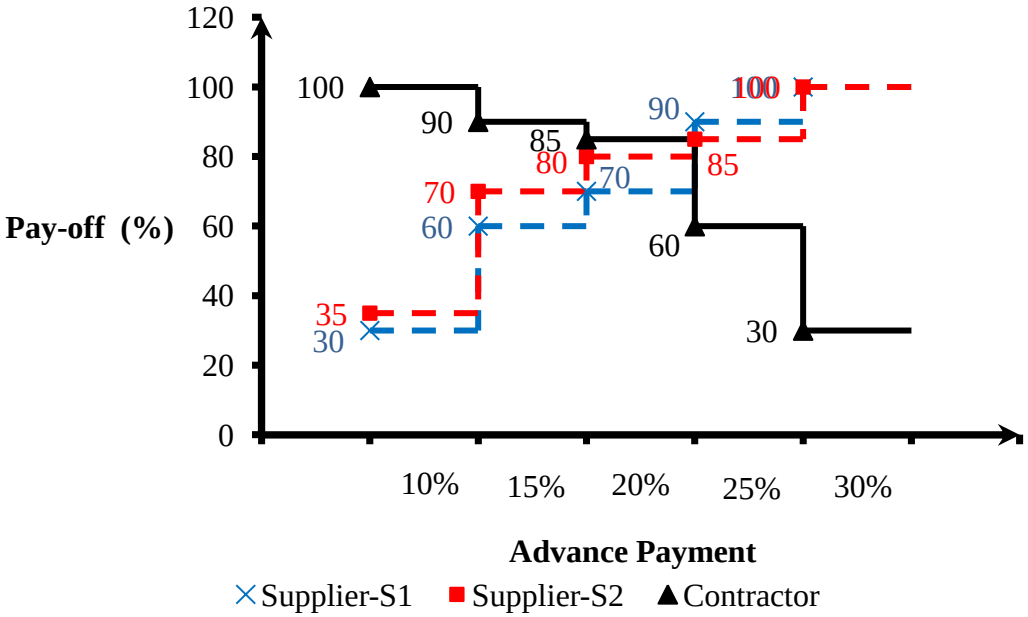


Figure: Advance Payment Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	0.3	100	30	130
Supplier-S2	0.3	100	30	130

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	0.1	100	30	130
Contractor & S2	0.1	100	35	135

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	0.2	85	70	155
Both-2	0.2	85	80	165

AGGREGATE [Granite Aggregate 3/4"]:

Delivery Issue – Without Weight

Option		Single Delivery	Multiple Delivery	On Call Delivery
Supplier-S1	**Pay-off**	100	80	50
Supplier-S2	**Pay-off**	100	70	50
Contractor	**Pay-off**	50	85	100

Option		Cash	30-day check	45-day check
Joint-1	**Pay-off**	150	165	150
Joint-2	**Pay-off**	150	155	150

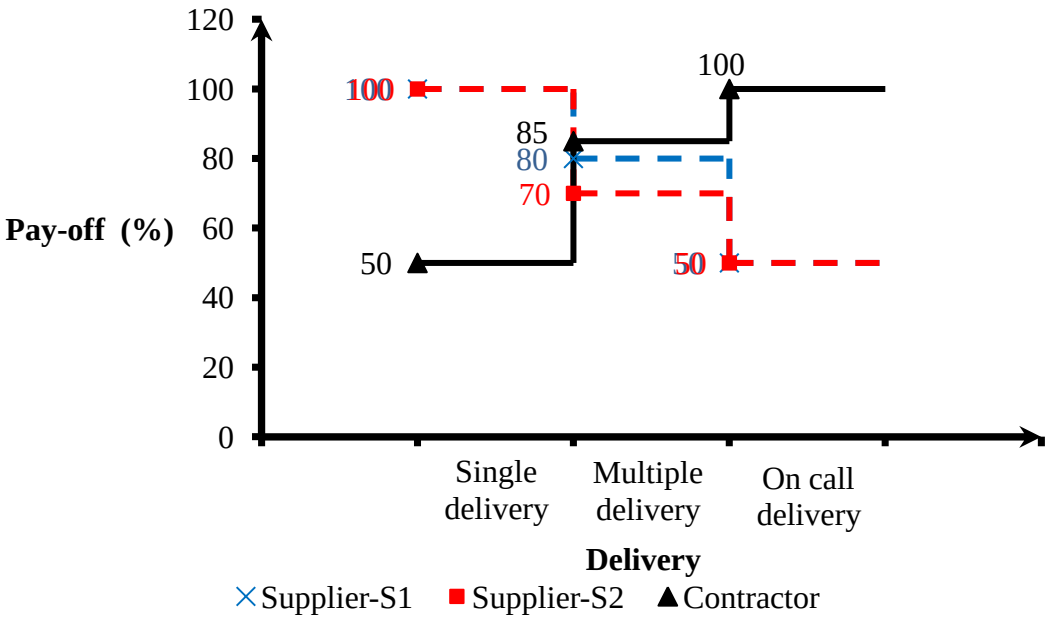


Figure: Delivery Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Single Delivery	100	50	150
Supplier-S2	Single Delivery	100	50	150

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	On Call Delivery	100	50	150
Contractor & S2	On Call Delivery	100	50	150

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Multiple Delivery	85	80	165
Both-2	Multiple Delivery	85	70	155

AGGREGATE [Granite Aggregate 3/4"]:

Freightage Issue – Without Weight

Option		Included	Excluded
Supplier-S1	**Pay-off**	50	100
Supplier-S2	**Pay-off**	40	100
Contractor	**Pay-off**	100	50

Option		Included	Excluded
Joint-1	**Pay-off**	150	150
Joint-2	**Pay-off**	140	150

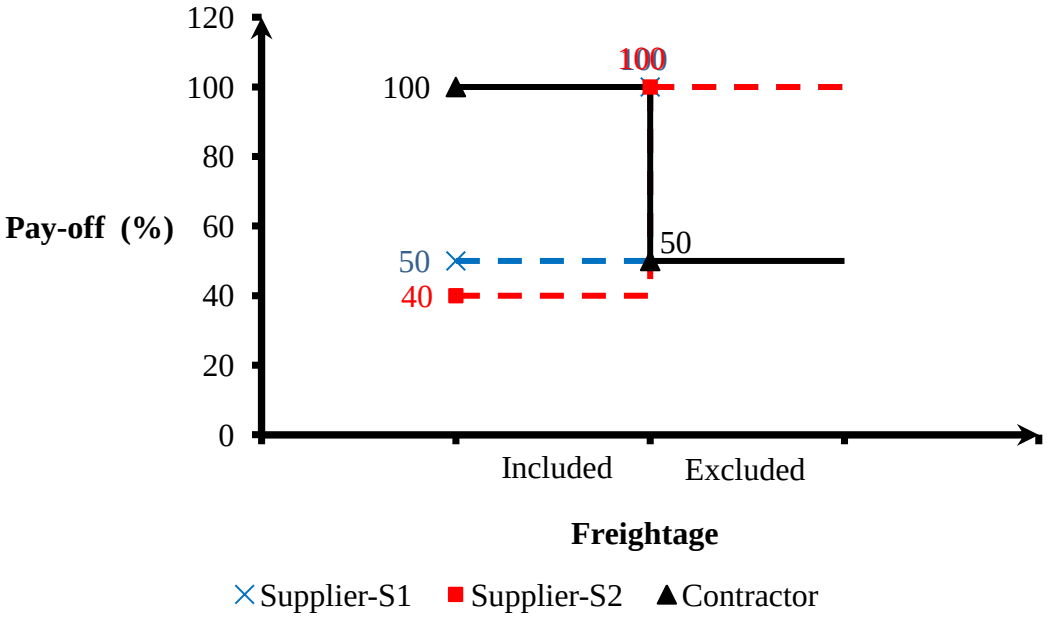


Figure: Freightage Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Excluded	100	50	150
Supplier-S2	Excluded	100	50	150

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Included	100	50	150
Contractor & S2	Included	100	40	140

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Included	100	50	150
Both-2	Excluded	50	100	150

AGGREGATE [Granite Aggregate 3/4"]

Summary Contractor and Supplier-S1
(TOTAL JOIN PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	128.67	140	130	130	150	150	828.67	138.11
Both	119.79	140	130	130	150	150	819.79	136.63
Supplier	113.33	140	130	130	150	150	813.33	135.56

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	128.667	150	155	155	165	150	903.67	150.61
Both	119.794	150	155	155	165	150	894.79	149.13
Supplier	113.333	150	155	155	165	150	888.33	148.06

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	128.667	140	135	130	150	150	833.67	138.94
Both	119.794	140	135	130	150	150	824.79	137.47
Supplier	113.333	140	135	130	150	150	818.33	136.39

AGGREGATE [Granite Aggregate 3/4"]

Summary Contractor and Supplier-S1
(TOTAL SINGLE PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	30.00	40	30	30	50	50	230.00	38.33
Contractor & S1	98.67	100	100	100	100	100	598.67	99.78
Supplier-S1	59.90	40	30	30	50	50	259.90	43.32
Contractor & S1	59.90	100	100	100	100	100	559.90	93.32
Supplier-S1	63.33	40	30	30	50	50	263.33	43.89
Contractor & S1	50.00	100	100	100	100	100	550.00	91.67

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	30.00	70	70	70	80	50	370.00	61.67
Contractor & S1	98.67	80	85	85	85	100	533.67	88.94
Supplier-S1	59.90	70	70	70	80	50	399.90	66.65
Contractor & S1	59.90	80	85	85	85	100	494.90	82.48
Supplier-S1	63.33	70	70	70	80	50	403.33	67.22
Contractor & S1	50.00	80	85	85	85	100	485.00	80.83

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	30.00	100	100	100	100	100	530.00	88.33
Contractor & S1	98.67	40	35	30	50	50	303.67	50.61
Supplier-S1	59.90	100	100	100	100	100	559.90	93.32
Contractor & S1	59.90	40	35	30	50	50	264.90	44.15
Supplier-S1	63.33	100	100	100	100	100	563.33	93.89
Contractor & S1	50.00	40	35	30	50	50	255.00	42.50

AGGREGATE [Granite Aggregate 3/4"]

Summary Contractor and Supplier-S1
(OPTION JOIN PAY-OFF) – Without weight

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	22.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	23.79	45-day check	On Completion	0.2	Multiple Delivery	Included
Supplier	24.00	Cash	On Delivery	0.3	Single Delivery	Excluded

AGGREGATE [Granite Aggregate 3/4"]

Summary Contractor and Supplier-S2
(TOTAL JOIN PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	128.67	140	130	135	150	140	823.67	137.28
Both	132.91	140	130	135	150	140	827.91	137.99
Supplier	124.00	140	130	135	150	140	819.00	136.50

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	128.667	150	155	165	155	150	903.67	150.61
Both	132.914	150	155	165	155	150	907.91	151.32
Supplier	124	150	155	165	155	150	899.00	149.83

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	128.667	140	135	130	150	150	833.67	138.94
Both	132.914	140	135	130	150	150	837.91	139.65
Supplier	124	140	135	130	150	150	829.00	138.17

AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S2
(TOTAL SINGLE PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S2	30.00	40	30	35	50	40	225.00	37.50
Contractor & S2	98.67	100	100	100	100	100	598.67	99.78
Supplier-S2	66.46	40	30	35	50	40	261.46	43.58
Contractor & S2	66.46	100	100	100	100	100	566.46	94.41
Supplier-S2	74.00	40	30	35	50	40	269.00	44.83
Contractor & S2	50.00	100	100	100	100	100	550.00	91.67

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S2	30.00	70	70	80	70	100	420.00	70.00
Contractor & S2	98.67	80	85	85	85	50	483.67	80.61
Supplier-S2	66.46	70	70	80	70	100	456.46	76.08
Contractor & S2	66.46	80	85	85	85	50	451.46	75.24
Supplier-S2	74.00	70	70	80	70	100	464.00	77.33
Contractor & S2	50.00	80	85	85	85	50	435.00	72.50

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S2	30.00	100	100	100	100	100	530.00	88.33
Contractor & S2	98.67	40	35	30	50	50	303.67	50.61
Supplier-S2	66.46	100	100	100	100	100	566.46	94.41
Contractor & S2	66.46	40	35	30	50	50	271.46	45.24
Supplier-S2	74.00	100	100	100	100	100	574.00	95.67
Contractor & S2	50.00	40	35	30	50	50	255.00	42.50

AGGREGATE [Granite Aggregate 3/4"]

Summary Contractor and Supplier-S2 (OPTION JOIN PAY-OFF) – Without weight

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	22.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	23.66	45-day check	On Completion	0.2	Multiple Delivery	Excluded
Supplier	24.00	Cash	On Delivery	0.3	Single Delivery	Excluded

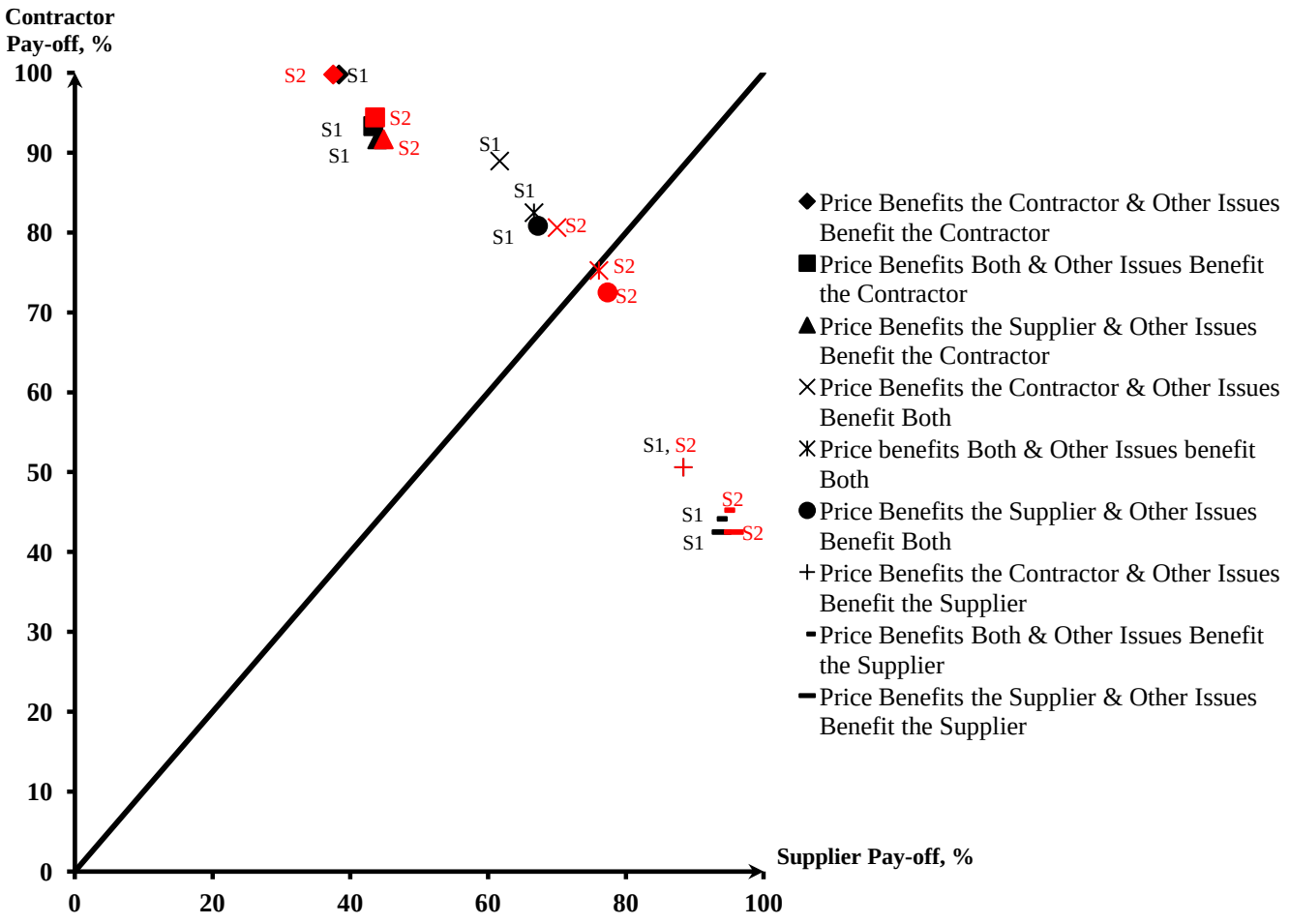


Figure: Optimization Joint Pay-off–Without Weight (AGGREGATE [Granite Aggregate 3/4"])

AGGREGATE [Granite Aggregate 3/4"]: Contractor

	Negotiation Issue	Absolutely		Strongly		Weakly		Equal	Weakly		Strongly		Absolutely		Negotiation Issue	
		7	6	5	4	3	2	1	2	3	4	5	6	7		
I1	Price	/													Payment Term	I2
I1	Price	/													Payment Period	I3
I1	Price	/													Advance Payment	I4
I1	Price	/													Delivery	I5
I1	Price	/													Freightage	I6
I2	Payment Term						/								Payment Period	I3
I2	Payment Term						/								Advance Payment	I4
I2	Payment Term								/						Delivery	I5
I2	Payment Term								/						Freightage	I6
I3	Payment Period						/								Advance Payment	I4
I3	Payment Period								/						Delivery	I5
I3	Payment Period								/						Freightage	I6
I4	Advance Payment								/						Delivery	I5
I4	Advance Payment									/					Freightage	I6
I5	Delivery						/								Freightage	I6

AGGREGATE [Granite Aggregate 3/4"]: Supplier-S1

	Negotiation Issue	Absolutely		Strongly		Weakly		Equal	Weakly		Strongly		Absolutely		Negotiation Issue	
		7	6	5	4	3	2	1	2	3	4	5	6	7		
I1	Price	/													Payment Term	I2
I1	Price	/													Payment Period	I3
I1	Price	/													Advance Payment	I4
I1	Price			/											Delivery	I5
I1	Price		/												Freightage	I6
I2	Payment Term							/							Payment Period	I3
I2	Payment Term					/									Advance Payment	I4
I2	Payment Term					/									Delivery	I5
I2	Payment Term						/								Freightage	I6
I3	Payment Period					/									Advance Payment	I4
I3	Payment Period						/								Delivery	I5
I3	Payment Period						/								Freightage	I6
I4	Advance Payment						/								Delivery	I5
I4	Advance Payment								/						Freightage	I6
I5	Delivery					/									Freightage	I6

AGGREGATE [Granite Aggregate 3/4"]: Supplier-S2

	Negotiation Issue	Absolutely		Strongly		Weakly		Equal	Weakly		Strongly		Absolutely		Negotiation Issue	
		7	6	5	4	3	2	1	2	3	4	5	6	7		
I1	Price	/													Payment Term	I2
I1	Price	/													Payment Period	I3
I1	Price	/													Advance Payment	I4
I1	Price		/												Delivery	I5
I1	Price		/												Freightage	I6
I2	Payment Term							/							Payment Period	I3
I2	Payment Term					/									Advance Payment	I4
I2	Payment Term					/									Delivery	I5
I2	Payment Term					/									Freightage	I6
I3	Payment Period					/									Advance Payment	I4
I3	Payment Period						/								Delivery	I5
I3	Payment Period						/								Freightage	I6
I4	Advance Payment						/								Delivery	I5
I4	Advance Payment								/						Freightage	I6
I5	Delivery					/									Freightage	I6

AHP: AGGREGATE [Granite Aggregate 3/4"]: Contractor

Negotiation Issue	I1	I2	I3	I4	I5	I6	Multiply	n^{th} Root	Normalize
I1	1.00	7.00	7.00	7.00	7.00	7.00	16807.000	5.061	0.57
I2	0.14	1.00	2.00	2.00	0.50	0.50	0.143	0.723	0.08
I3	0.14	0.50	1.00	2.00	0.50	0.50	0.036	0.574	0.06
I4	0.14	0.50	0.50	1.00	0.50	0.33	0.006	0.426	0.05
I5	0.14	2.00	2.00	2.00	1.00	2.00	2.286	1.148	0.13
I6	0.14	2.00	2.00	3.00	0.50	1.00	0.857	0.975	0.11
							SUM	8.91	1.00

$$\begin{Bmatrix} 1.00 & 7.00 & 7.00 & 7.00 & 7.00 & 7.00 \\ 0.14 & 1.00 & 2.00 & 2.00 & 0.50 & 0.50 \\ 0.14 & 0.50 & 1.00 & 2.00 & 0.50 & 0.50 \\ 0.14 & 0.50 & 0.50 & 1.00 & 0.50 & 0.33 \\ 0.14 & 2.00 & 2.00 & 2.00 & 1.00 & 2.00 \\ 0.14 & 2.00 & 2.00 & 3.00 & 0.50 & 1.00 \end{Bmatrix} \text{X} \begin{Bmatrix} 0.57 \\ 0.08 \\ 0.06 \\ 0.05 \\ 0.13 \\ 0.11 \end{Bmatrix} = \begin{Bmatrix} 3.59 \\ 0.51 \\ 0.40 \\ 0.30 \\ 0.82 \\ 0.69 \end{Bmatrix} = \begin{Bmatrix} 6.318 \\ 6.233 \\ 6.223 \\ 6.333 \\ 6.330 \\ 6.302 \end{Bmatrix}$$

Average, λ_{max} =	6.290
Consistency Index, C.I. =	0.058
where n = 7, then Ratio Index, R.I. =	1.24
Consistency Ratio, C.R. =	0.0467

AHP: AGGREGATE [Granite Aggregate 3/4"]: Supplier-S1

Negotiation Issue	I1	I2	I3	I4	I5	I6	Multiply	n^{th} Root	Normalize
I1	1.00	7.00	7.00	7.00	5.00	6.00	10290.000	4.664	0.54
I2	0.14	1.00	1.00	3.00	3.00	2.00	2.571	1.170	0.14
I3	0.14	1.00	1.00	3.00	2.00	2.00	1.714	1.094	0.13
I4	0.14	0.33	0.33	1.00	2.00	0.50	0.016	0.501	0.06
I5	0.20	0.33	0.50	0.50	1.00	3.00	0.050	0.607	0.07
I6	0.17	0.50	0.50	2.00	0.33	1.00	0.028	0.550	0.06
							SUM	8.59	1.00

$$\begin{Bmatrix} 1.00 & 7.00 & 7.00 & 7.00 & 5.00 & 6.00 \\ 0.14 & 1.00 & 1.00 & 3.00 & 3.00 & 2.00 \\ 0.14 & 1.00 & 1.00 & 3.00 & 2.00 & 2.00 \\ 0.14 & 0.33 & 0.33 & 1.00 & 2.00 & 0.50 \\ 0.20 & 0.33 & 0.50 & 0.50 & 1.00 & 3.00 \\ 0.17 & 0.50 & 0.50 & 2.00 & 0.33 & 1.00 \end{Bmatrix} \text{ X } \begin{Bmatrix} 0.54 \\ 0.14 \\ 0.13 \\ 0.06 \\ 0.07 \\ 0.06 \end{Bmatrix} = \begin{Bmatrix} 3.54 \\ 0.86 \\ 0.79 \\ 0.40 \\ 0.51 \\ 0.43 \end{Bmatrix} = \begin{Bmatrix} 6.510 \\ 6.285 \\ 6.169 \\ 6.805 \\ 7.214 \\ 6.659 \end{Bmatrix}$$

Average, λ_{max} = 6.607

Consistency Index, C.I. = 0.121

where n = 7, then Ratio Index, R.I. = 1.24

Consistency Ratio, C.R. = 0.0979

AHP: AGGREGATE [Granite Aggregate 3/4"]: Supplier-S2

Negotiation Issue	I1	I2	I3	I4	I5	I6	Multiply	n^{th} Root	Normalize
I1	1.00	7.00	7.00	7.00	6.00	6.00	12348.000	4.808	0.55
I2	0.14	1.00	1.00	3.00	3.00	3.00	3.857	1.252	0.14
I3	0.14	1.00	1.00	3.00	2.00	2.00	1.714	1.094	0.12
I4	0.14	0.33	0.33	1.00	2.00	0.50	0.016	0.501	0.06
I5	0.17	0.33	0.50	0.50	1.00	3.00	0.042	0.589	0.07
I6	0.17	0.33	0.50	2.00	0.33	1.00	0.019	0.514	0.06
							SUM	8.76	1.00

$$\begin{Bmatrix} 1.00 & 7.00 & 7.00 & 7.00 & 6.00 & 6.00 \\ 0.14 & 1.00 & 1.00 & 3.00 & 3.00 & 3.00 \\ 0.14 & 1.00 & 1.00 & 3.00 & 2.00 & 2.00 \\ 0.14 & 0.33 & 0.33 & 1.00 & 2.00 & 0.50 \\ 0.17 & 0.33 & 0.50 & 0.50 & 1.00 & 3.00 \\ 0.17 & 0.33 & 0.50 & 2.00 & 0.33 & 1.00 \end{Bmatrix} \text{X} \begin{Bmatrix} 0.55 \\ 0.14 \\ 0.12 \\ 0.06 \\ 0.07 \\ 0.06 \end{Bmatrix} = \begin{Bmatrix} 3.58 \\ 0.90 \\ 0.77 \\ 0.39 \\ 0.47 \\ 0.40 \end{Bmatrix} = \begin{Bmatrix} 6.523 \\ 6.266 \\ 6.164 \\ 6.792 \\ 7.045 \\ 6.764 \end{Bmatrix}$$

Average, λ_{max} = 6.592

Consistency Index, C.I. = 0.118

where n = 7, then Ratio Index, R.I. = 1.24

Consistency Ratio, C.R. = 0.0955

AGGREGATE [Granite Aggregate 3/4"]:

Price Issue

Contractor	P_{min}	A_{min}	D_{min}	D_{max}	A_{max}	P_{max}
Pay-off		28.5	57	55.86	28.5	
Option		19	20	23	24	

Supplier-S1	P'_{min}	A'_{min}	D'_{min}	D'_{max}	A'_{max}	P'_{max}
Pay-off		16.2	43.2	48.6	54	
Option		22	25	26	27	

Supplie-S2	P''_{min}	A''_{min}	D''_{min}	D''_{max}	A''_{max}	P''_{max}
Pay-off		16.5	46.75	52.25	55	
Option		22	24.5	25	26	

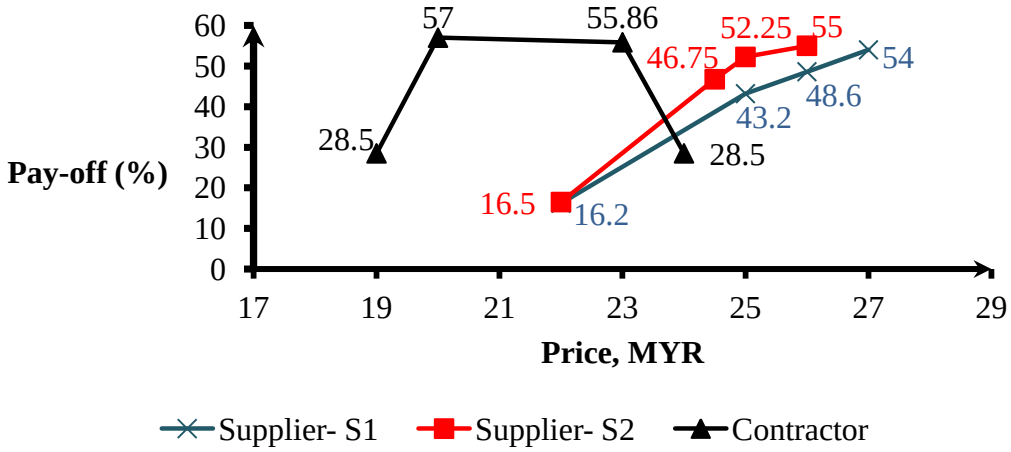


Figure: Price Issue

Single Benefit-Supplier

Point	Option (MYR)	Contractor Pay-off, %	Pay-off, %	Joint Pay-off
Supplier-S1	24.00	28.50	34.20	62.70
Supplier-S2	24.00	28.50	40.70	69.20

Single Benefit-Contractor

Point	Option (MYR)	Supplier Pay-off, %	Pay-off, %	Joint Pay-off
Contractor & S1	22.00	16.20	56.24	72.44
Contractor & S2	22.00	16.50	56.24	72.74

Both benefit

Point	Option (MYR)	Pay-off, %	Joint Pay-off
Intercept price Contractor & S1	23.84	32.79	65.58
Intercept price Contractor & S2	23.69	36.96	73.92

AGGREGATE [Granite Aggregate 3/4"]:

Payment Term Issue

Option		Cash	30-day check	45-day check	60-day check
Supplier-S1	**Pay-off**	14	12.6	9.8	5.6
Supplier-S2	**Pay-off**	14	11.9	9.8	5.6
Contractor	**Pay-off**	3.2	4.8	6.4	8

Option		Cash	30-day check	45-day check	60-day check
Joint-1	**Pay-off**	17.2	17.4	16.2	13.6
Joint-2	**Pay-off**	17.2	16.7	16.2	13.6

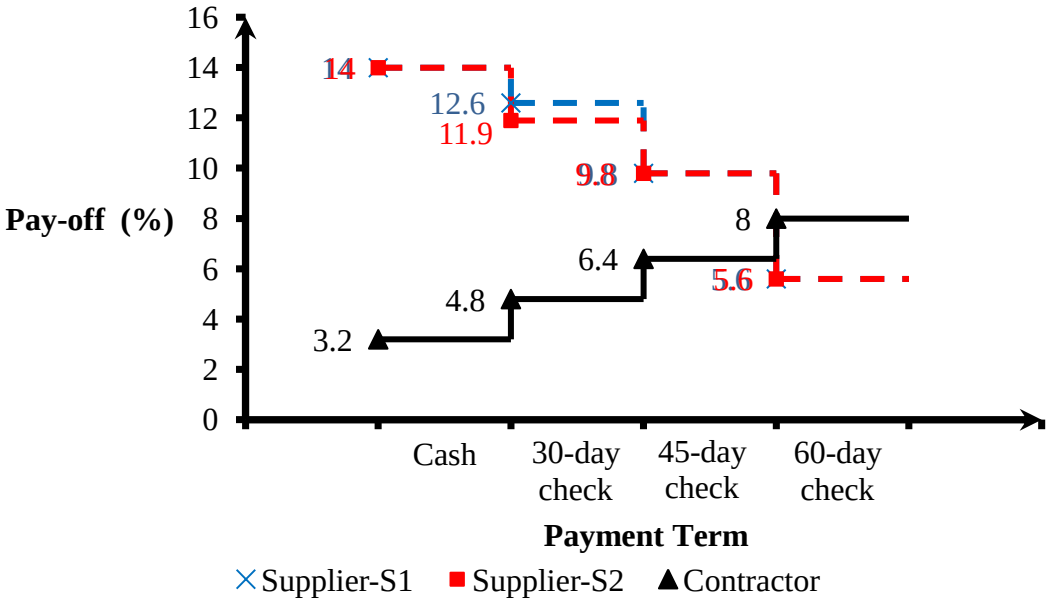


Figure: Payment Term Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Cash	14	3.2	17.2
Supplier-S2	Cash	14	3.2	17.2

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	60-day check	8	5.6	13.6
Contractor & S2	60-day check	8	5.6	13.6

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	60-day check	8	5.6	13.6
Both-2	60-day check	8	5.6	13.6

AGGREGATE [Granite Aggregate 3/4"]:

Payment Period Issue

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Supplier-S1	**Pay-off**	13	11.7	9.1	5.85	3.9
Supplier-S2	**Pay-off**	12	9.6	8.4	6	3.6
Contractor	**Pay-off**	2.1	3.6	5.1	5.7	6

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Joint-1	**Pay-off**	15.1	15.3	14.2	11.55	9.9
Joint-2	**Pay-off**	14.1	13.2	13.5	11.7	9.6

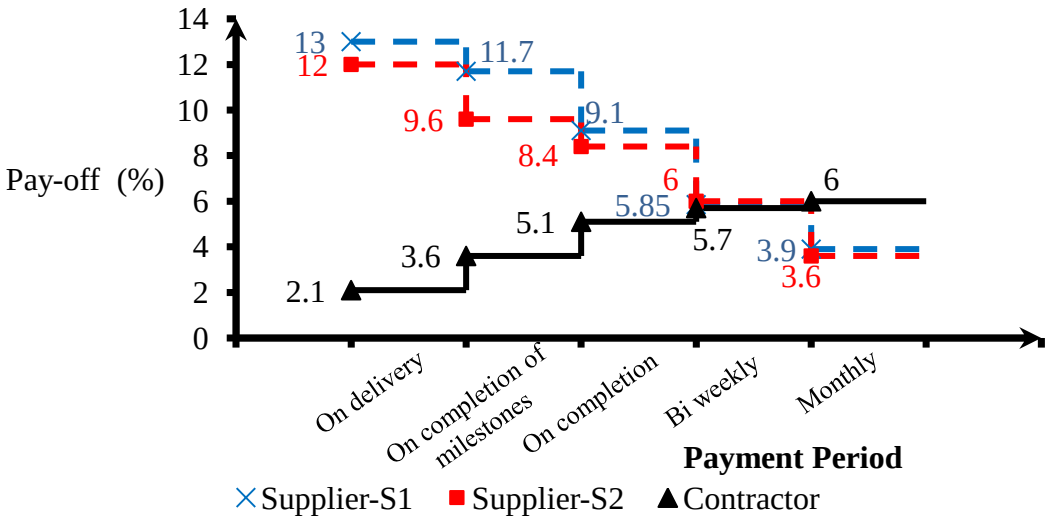


Figure: Payment Period Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	On Delivery	13	2.1	15.1
Supplier-S2	On Delivery	12	2.1	14.1

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Monthly	6	3.9	9.9
Contractor & S2	Monthly	6	3.6	9.6

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Bi Weekly	5.7	5.85	11.55
Both-2	Bi Weekly	5.7	6	11.7

AGGREGATE [Granite Aggregate 3/4"]:

Advance Payment Issue

Option		10%	15%	20%	25%	30%
Supplier-S1	**Pay-off**	1.8	3.6	4.2	5.4	6
Supplier-S2	**Pay-off**	2.1	4.2	4.8	5.1	6
Contractor	**Pay-off**	5	4.5	4.25	3	1.5

Option		10%	15%	20%	25%	30%
Joint-1	**Pay-off**	6.8	8.1	8.45	8.4	7.5
Joint-2	**Pay-off**	7.1	8.7	9.05	8.1	7.5

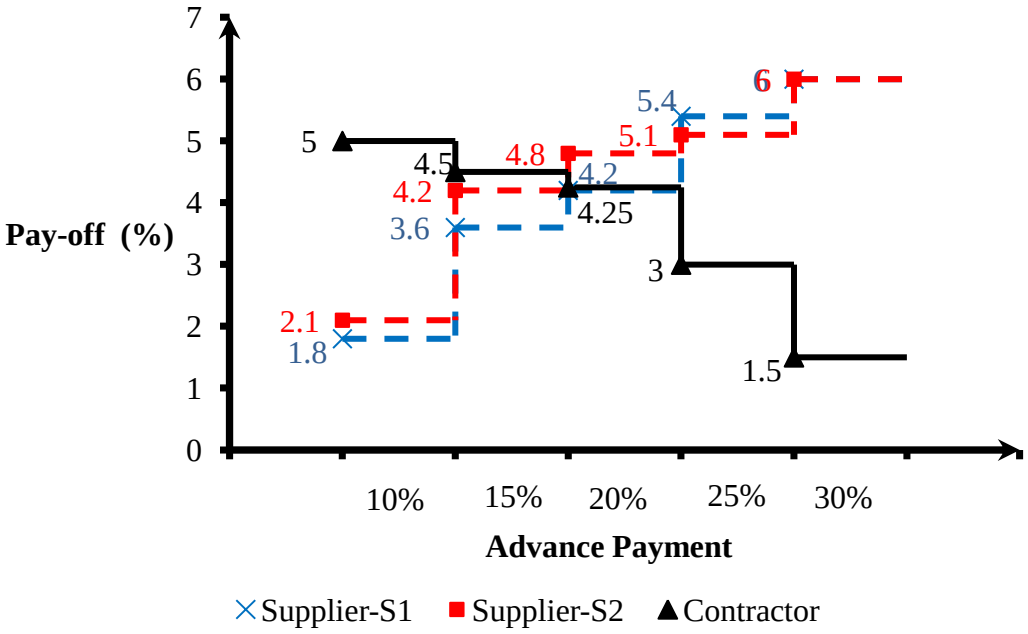


Figure: Advance Payment Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	0.3	6	1.5	7.5
Supplier-S2	0.3	6	1.5	7.5

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	0.1	5	1.8	6.8
Contractor & S2	0.1	5	2.1	7.1

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	0.2	4.25	4.2	8.45
Both-2	0.15	4.5	4.2	8.7

AGGREGATE [Granite Aggregate 3/4"]:

Delivery Issue

Option		Single Delivery	Multiple Delivery	On Call Delivery
Supplier-S1	**Pay-off**	7	5.6	3.5
Supplier-S2	**Pay-off**	7	4.9	3.5
Contractor	**Pay-off**	6.5	11.05	13

Option		Single Delivery	Multiple Delivery	On Call Delivery
Joint-1	**Pay-off**	13.5	16.65	16.5
Joint-2	**Pay-off**	13.5	15.95	16.5

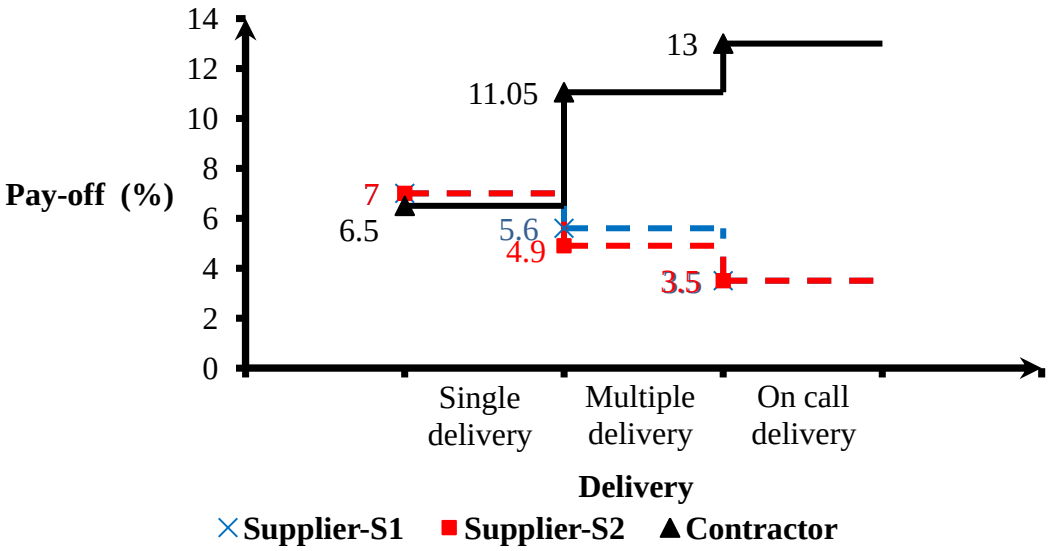


Figure: Delivery Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Single Delivery	7	6.5	13.5
Supplier-S2	Single Delivery	7	6.5	13.5

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	On Call Delivery	13	3.5	16.5
Contractor & S2	On Call Delivery	13	3.5	16.5

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Single Delivery	6.5	7	13.5
Both-2	Single Delivery	6.5	7	13.5

AGGREGATE [Granite Aggregate 3/4"]:

Freightage Issue

Option		Included	Excluded
Supplier-S1	**Pay-off**	3	6
Supplier-S2	**Pay-off**	2.4	6
Contractor	**Pay-off**	11	5.5

Option		Included	Excluded
Joint-1	**Pay-off**	14	11.5
Joint-2	**Pay-off**	13.4	11.5

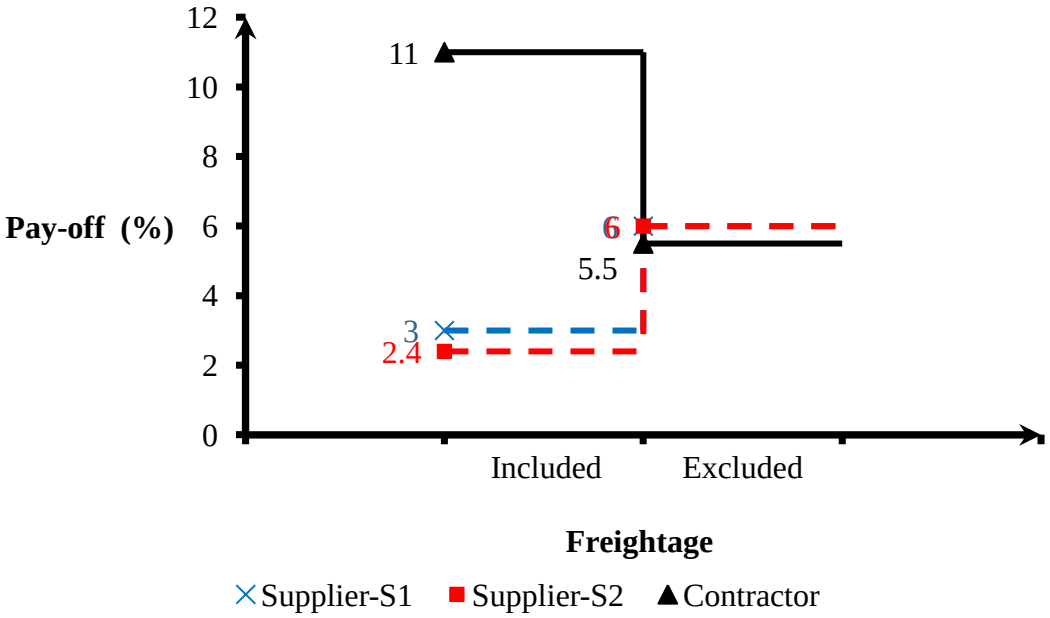


Figure: Freightage Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Excluded	6	5.5	11.5
Supplier-S2	Excluded	6	5.5	11.5

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Included	11	3	14
Contractor & S2	Included	11	2.4	13.4

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Excluded	5.5	6	11.5
Both-2	Excluded	5.5	6	11.5

AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S1
(TOTAL JOIN PAY-OFF)

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	72.44	13.6	9.9	6.8	16.5	14	133.24
Both	65.58	13.6	9.9	6.8	16.5	14	126.38
Supplier	62.70	13.6	9.9	6.8	16.5	14	123.50

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	72.44	13.6	11.55	8.45	13.5	11.5	131.04
Both	65.5782	13.6	11.55	8.45	13.5	11.5	124.18
Supplier	62.7	13.6	11.55	8.45	13.5	11.5	121.30

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	72.44	17.2	15.1	7.5	13.5	11.5	137.24
Both	65.5782	17.2	15.1	7.5	13.5	11.5	130.38
Supplier	62.7	17.2	15.1	7.5	13.5	11.5	127.50

AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S1
(TOTAL SINGLE PAY-OFF)

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	16.20	5.6	3.9	1.8	3.5	3	34.00
Contractor & S1	56.24	8	6	5	13	11	99.24
Supplier-S1	32.79	5.6	3.9	1.8	3.5	3	50.59
Contractor & S1	32.79	8	6	5	13	11	75.79
Supplier-S1	34.20	5.6	3.9	1.8	3.5	3	52.00
Contractor & S1	28.50	8	6	5	13	11	71.50

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	16.20	5.6	5.85	4.2	7	6	44.85
Contractor & S1	56.24	8	5.7	4.25	6.5	5.5	86.19
Supplier-S1	32.79	5.6	5.85	4.2	7	6	61.44
Contractor & S1	32.79	8	5.7	4.25	6.5	5.5	62.74
Supplier-S1	34.20	5.6	5.85	4.2	7	6	62.85
Contractor & S1	28.50	8	5.7	4.25	6.5	5.5	58.45

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	16.20	14	13	6	7	6	62.20
Contractor & S1	56.24	3.2	2.1	1.5	6.5	5.5	75.04
Supplier-S1	32.79	14	13	6	7	6	78.79
Contractor & S1	32.79	3.2	2.1	1.5	6.5	5.5	51.59
Supplier-S1	34.20	14	13	6	7	6	80.20
Contractor & S1	28.50	3.2	2.1	1.5	6.5	5.5	47.30

AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S1
(OPTION JOIN PAY-OFF)

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	22.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	23.84	60-day check	Bi Weekly	0.2	Single Delivery	Excluded
Supplier	24.00	Cash	On Delivery	0.3	Single Delivery	Excluded

AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S2
(TOTAL JOIN PAY-OFF)

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	72.74	13.6	9.6	7.1	16.5	13.4	132.94
Both	73.92	13.6	9.6	7.1	16.5	13.4	134.12
Supplier	69.20	13.6	9.6	7.1	16.5	13.4	129.40

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	72.74	13.6	11.7	8.7	13.5	11.5	131.74
Both	73.918	13.6	11.7	8.7	13.5	11.5	132.92
Supplier	69.2	13.6	11.7	8.7	13.5	11.5	128.20

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	72.74	17.2	14.1	7.5	13.5	11.5	136.54
Both	73.918	17.2	14.1	7.5	13.5	11.5	137.72
Supplier	69.2	17.2	14.1	7.5	13.5	11.5	133.00

AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S2
(TOTAL SINGLE PAY-OFF)

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	16.50	5.6	3.6	2.1	3.5	2.4	33.70
Contractor & S2	56.24	8	6	5	13	11	99.24
Supplier-S2	36.96	5.6	3.6	2.1	3.5	2.4	54.16
Contractor & S2	36.96	8	6	5	13	11	79.96
Supplier-S2	40.70	5.6	3.6	2.1	3.5	2.4	57.90
Contractor & S2	28.50	8	6	5	13	11	71.50

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	16.50	5.6	6	4.2	7	6	45.30
Contractor & S2	56.24	8	5.7	4.5	6.5	5.5	86.44
Supplier-S2	36.96	5.6	6	4.2	7	6	65.76
Contractor & S2	36.96	8	5.7	4.5	6.5	5.5	67.16
Supplier-S2	40.70	5.6	6	4.2	7	6	69.50
Contractor & S2	28.50	8	5.7	4.5	6.5	5.5	58.70

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	16.50	14	12	6	7	6	61.50
Contractor & S2	56.24	3.2	2.1	1.5	6.5	5.5	75.04
Supplier-S2	36.96	14	12	6	7	6	81.96
Contractor & S2	36.96	3.2	2.1	1.5	6.5	5.5	55.76
Supplier-S2	40.70	14	12	6	7	6	85.70
Contractor & S2	28.50	3.2	2.1	1.5	6.5	5.5	47.30

AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S2
(OPTION JOIN PAY-OFF)

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	22.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	23.69	60-day check	Bi Weekly	0.15	Single Delivery	Excluded
Supplier	24.00	Cash	On Delivery	0.3	Single Delivery	Excluded

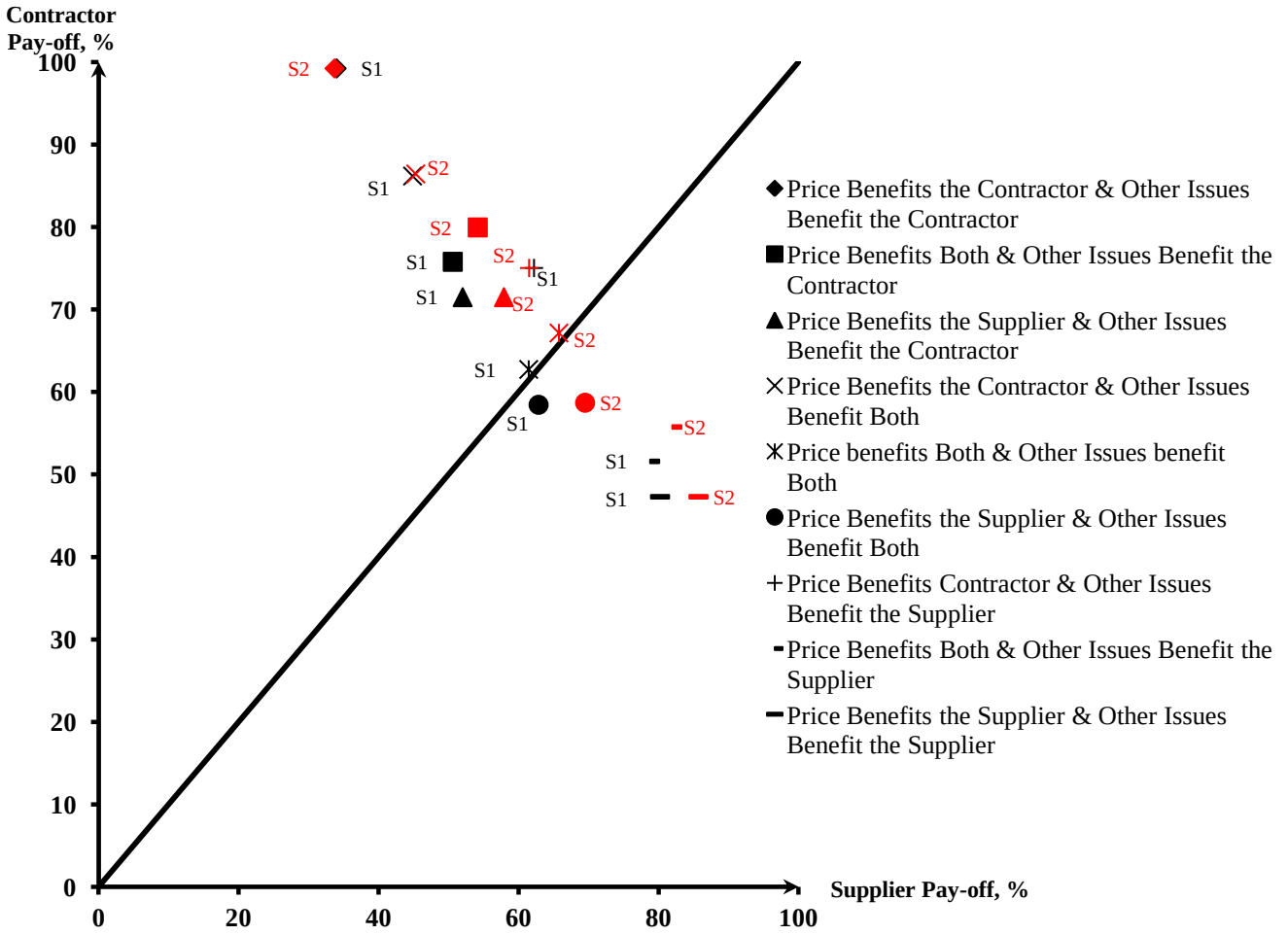


Figure: Optimization Joint Pay-off–(AGGREGATE [Granite Aggregate 3/4"])

ACTUAL: AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S1 (TOTAL SINGLE PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Single Pay-off/6
Supplier-S1	46.67	70	30	70	80	50	346.67	57.78
Contractor & S1	98.00	80	100	85	85	100	548.00	91.33

ACTUAL: AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S1 (OPTION JOIN PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S1	23.00	45-day check	Monthly	0.2	Multiple Delivery	Included

ACTUAL: AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S2 (TOTAL SINGLE PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Single Pay-off/6
Supplier-S2	52.00	70	30	80	70	40	342.00	57.00
Contractor & S2	98.00	80	100	85	85	100	548.00	91.33

ACTUAL: AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S2 (OPTION JOIN PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S2	23.00	45-day check	Monthly	0.2	Multiple Delivery	Included

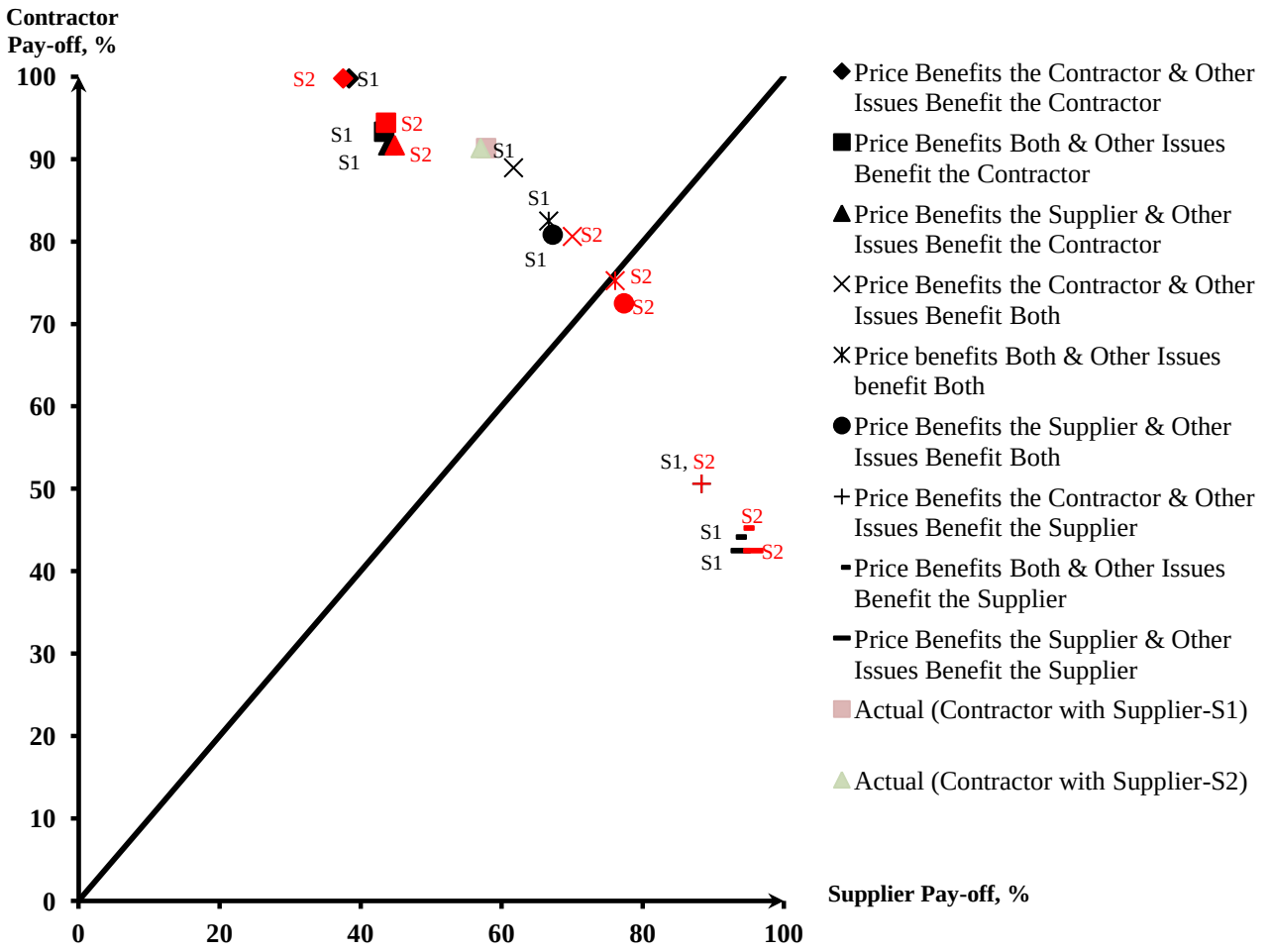


Figure: Actual Optimization Joint Pay-off – (AGGREGATE [Granite Aggregate 3/4"]) – Without weight

ACTUAL: AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S1 (TOTAL SINGLE PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	25.20	9.8	3.9	4.2	5.6	3	51.70
Contractor & S1	55.86	6.4	6	4.25	11.05	11	94.56

ACTUAL: AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S1 (OPTION JOIN PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S1	23.00	45-day check	Monthly	0.2	Multiple Delivery	Included

ACTUAL: AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S2 (TOTAL SINGLE PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	28.60	9.8	3.6	4.8	4.9	2.4	54.10
Contractor & S2	55.86	6.4	6	4.25	11.05	11	94.56

ACTUAL: AGGREGATE [Granite Aggregate 3/4"]
Summary Contractor and Supplier-S2 (OPTION JOIN PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S2	23.00	45-day check	Monthly	0.2	Multiple Delivery	Included

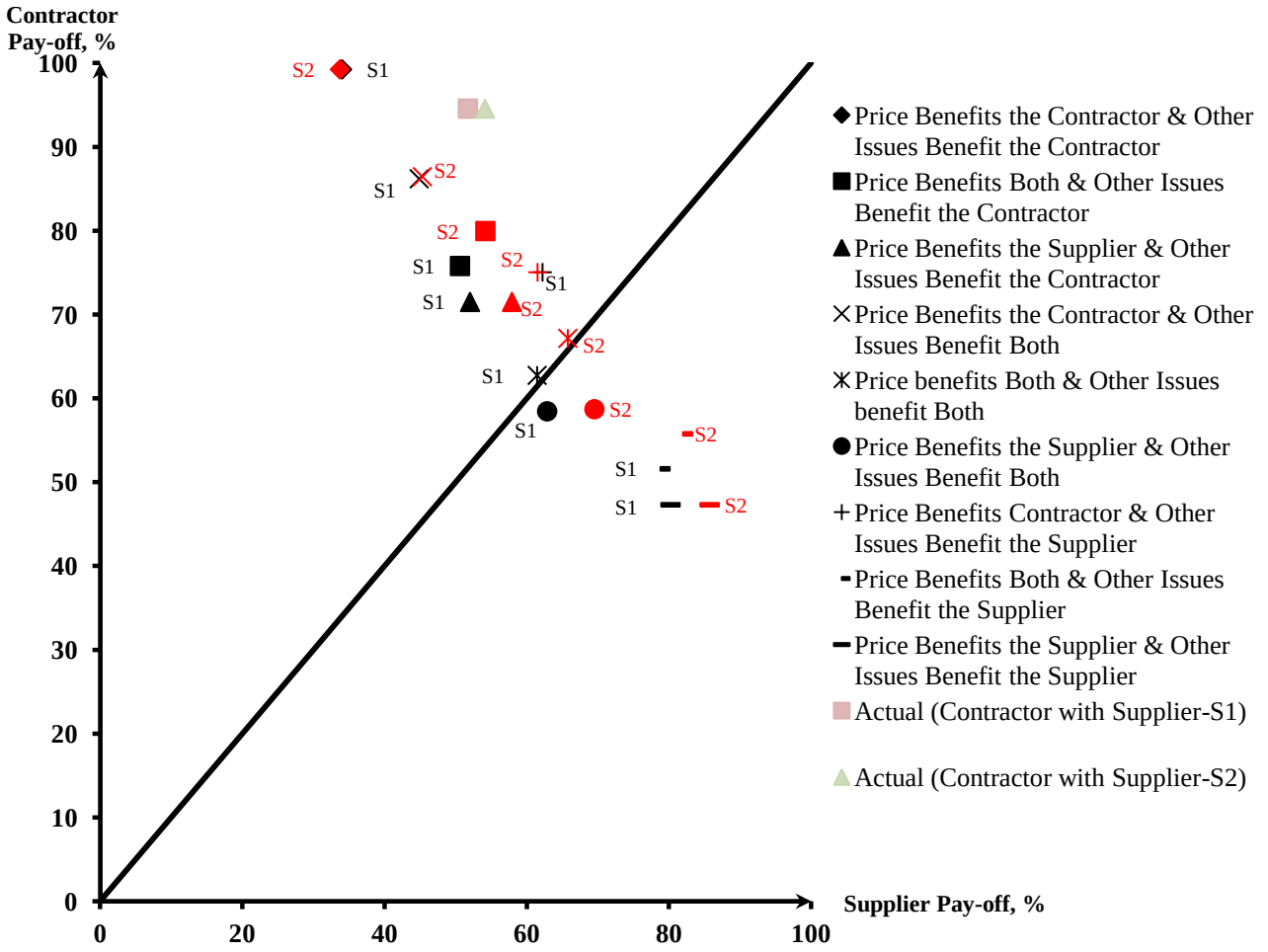


Figure: Actual Optimization Joint Pay-off – (AGGREGATE [Granite Aggregate 3/4"])

CEMENT [Ordinary Portland Cement]:

Price Issue – Without Weight

Contractor	P_{min}	A_{min}	D_{min}	D_{max}	A_{max}	P_{max}
Pay-off		80	100	98	40	
Option		310	320	325	330	

Supplier-S1	P'_{min}	A'_{min}	D'_{min}	D'_{max}	A'_{max}	P'_{max}
Pay-off		40	90	95	100	
Option		323	335	340	355	

Supplie-S2	P''_{min}	A''_{min}	D''_{min}	D''_{max}	A''_{max}	P''_{max}
Pay-off		50	85	90	100	
Option		322	340	345	350	

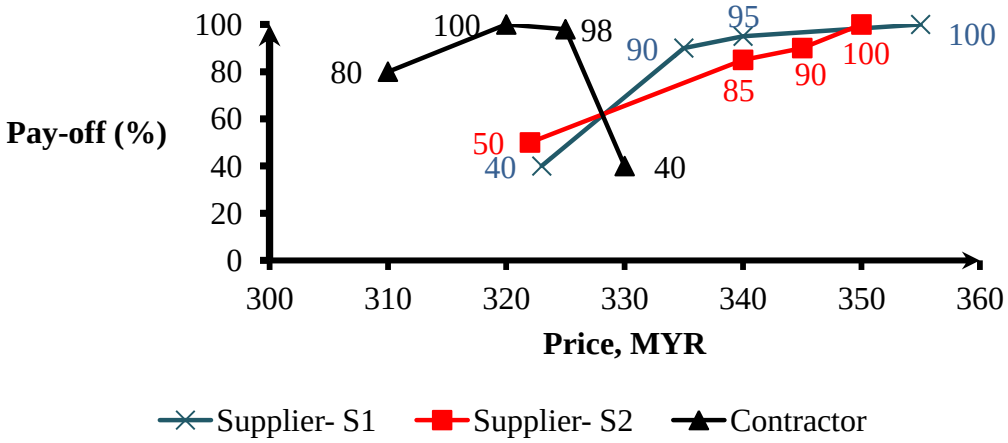


Figure: Price Issue – Without Weight

Single Benefit-Supplier

Point	Option (MYR)	Contractor Pay-off, %	Pay-off, %	Joint Pay-off
Supplier-S1	330.00	40.00	69.17	109.17
Supplier-S2	330.00	40.00	65.56	105.56

Single Benefit-Contractor

Point	Option (MYR)	Supplier Pay-off, %	Pay-off, %	Joint Pay-off
Contractor & S1	323.00	40.00	98.80	138.80
Contractor & S2	322.00	50.00	99.20	149.20

Both benefit

Point	Option (MYR)	Pay-off, %	Joint Pay-off
Intercept price Contractor & S1	328.15	61.46	122.92
Intercept price Contractor & S2	328.11	61.89	123.77

CEMENT [Ordinary Portland Cement]:

Payment Term Issue – Without Weight

Option		Cash	30-day check	45-day check	60-day check
Supplier-S1	**Pay-off**	100	90	80	60
Supplier-S2	**Pay-off**	100	90	70	40
Contractor	**Pay-off**	20	70	90	100

Option		Cash	30-day check	45-day check	60-day check
Joint-1	**Pay-off**	120	160	170	160
Joint-2	**Pay-off**	120	160	160	140

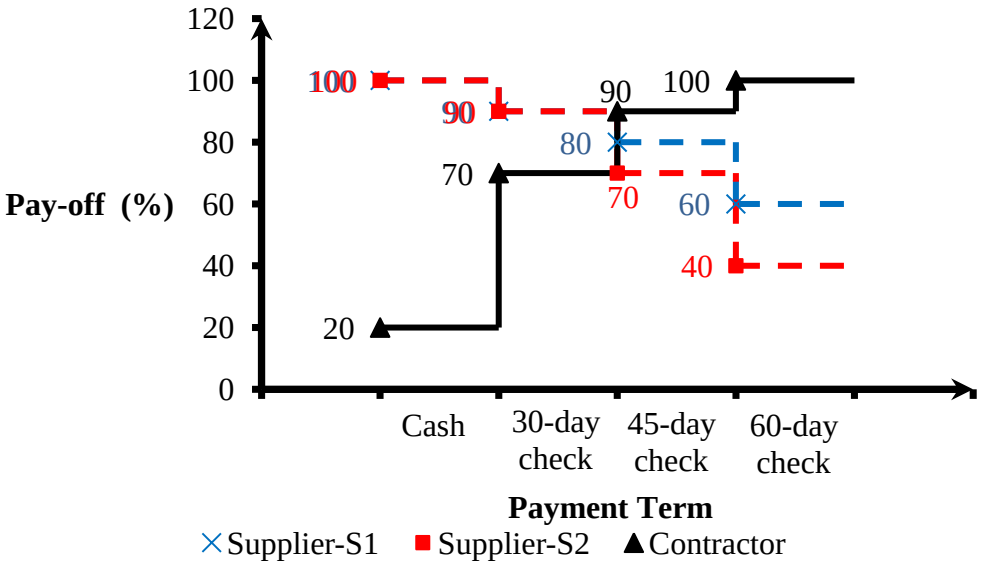


Figure: Payment Term Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Cash	100	20	120
Supplier-S2	Cash	100	20	120

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	60-day check	100	60	160
Contractor & S2	60-day check	100	40	140

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	45-day check	90	80	170
Both-2	45-day check	90	70	160

CEMENT [Ordinary Portland Cement]:

Payment Period Issue – Without Weight

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Supplier-S1	**Pay-off**	100	90	70	50	20
Supplier-S2	**Pay-off**	100	70	50	40	30
Contractor	**Pay-off**	30	60	80	95	100

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Joint-1	**Pay-off**	130	150	150	145	120
Joint-2	**Pay-off**	130	130	130	135	130

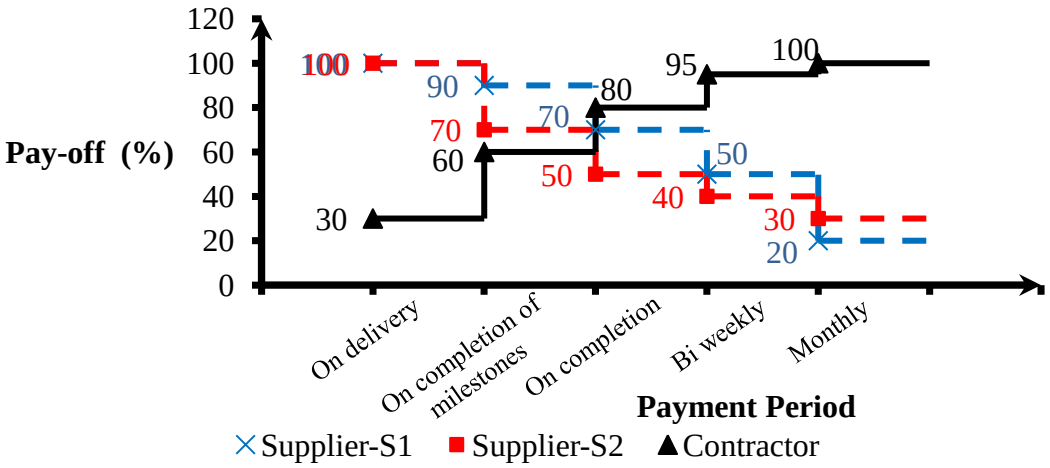


Figure: Payment Period Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	On Delivery	100	30	130
Supplier-S2	On Delivery	100	30	130

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Monthly	100	20	120
Contractor & S2	Monthly	100	30	130

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	On Completion	80	70	150
Both-2	On Completion of Milestone	60	70	130

CEMENT [Ordinary Portland Cement]:

Advance Payment Issue – Without Weight

Option		10%	15%	20%	25%	30%
Supplier-S1	**Pay-off**	30	60	70	90	100
Supplier-S2	**Pay-off**	20	50	80	90	100
Contractor	**Pay-off**	100	95	80	70	50

Option		10%	15%	20%	25%	30%
Joint-1	**Pay-off**	130	155	150	160	150
Joint-2	**Pay-off**	120	145	160	160	150

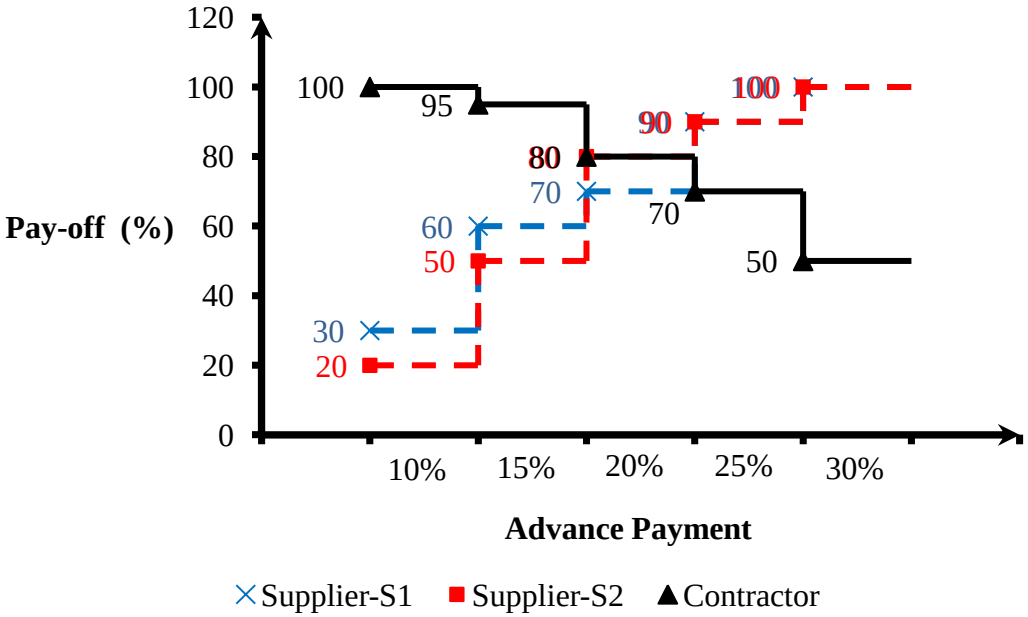


Figure: Advance Payment Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	0.3	100	50	150
Supplier-S2	0.3	100	50	150

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	0.1	100	30	130
Contractor & S2	0.1	100	20	120

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	0.2	80	70	150
Both-2	0.2	80	80	160

CEMENT [Ordinary Portland Cement]:

Delivery Issue – Without Weight

Option		Single Delivery	Multiple Delivery	On Call Delivery
Supplier-S1	**Pay-off**	100	80	50
Supplier-S2	**Pay-off**	100	70	60
Contractor	**Pay-off**	40	90	100

Option		Cash	30-day check	45-day check
Joint-1	**Pay-off**	140	170	150
Joint-2	**Pay-off**	140	160	160

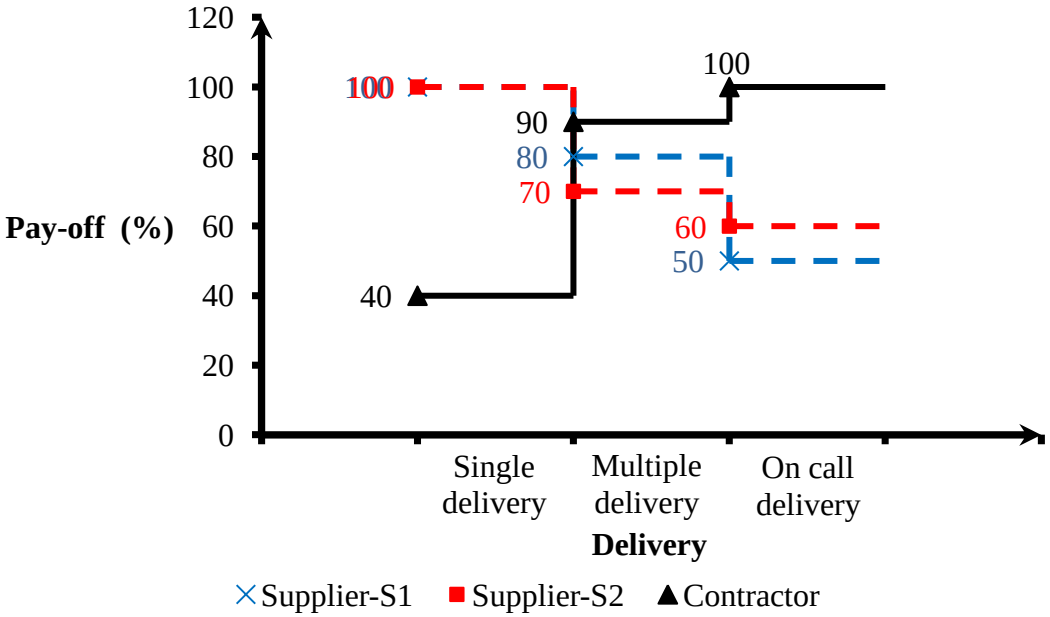


Figure: Delivery Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Single Delivery	100	40	140
Supplier-S2	Single Delivery	100	40	140

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	On Call Delivery	100	50	150
Contractor & S2	On Call Delivery	100	60	160

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Multiple Delivery	90	80	170
Both-2	Multiple Delivery	90	70	160

CEMENT [Ordinary Portland Cement]:

Freightage Issue – Without Weight

Option		Included	Excluded
Supplier-S1	**Pay-off**	70	100
Supplier-S2	**Pay-off**	60	100
Contractor	**Pay-off**	100	20

Option		Included	Excluded
Joint-1	**Pay-off**	170	120
Joint-2	**Pay-off**	160	120

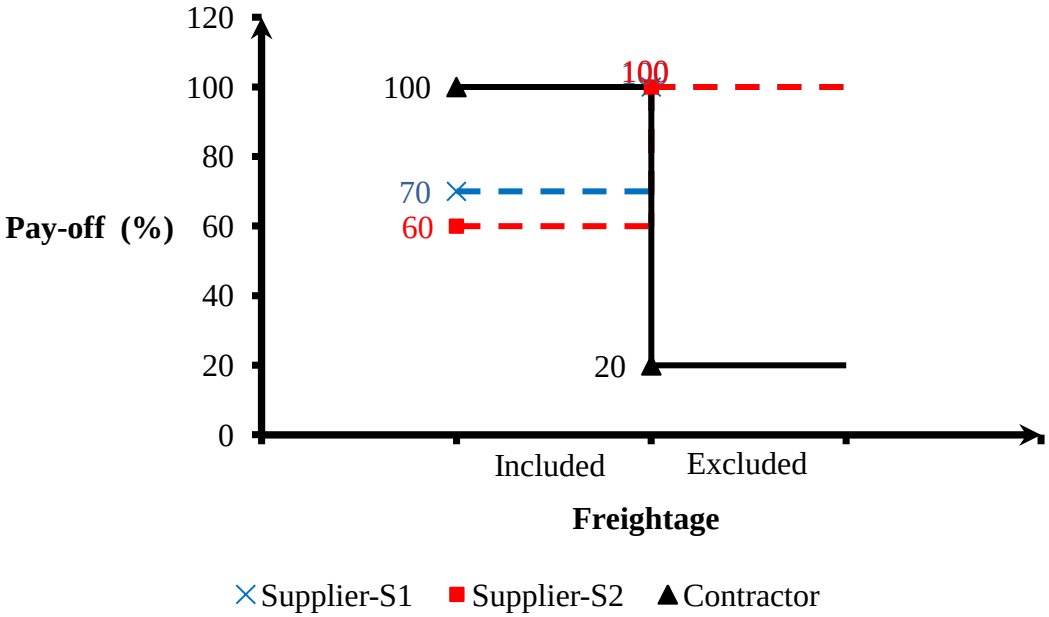


Figure: Freightage Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Excluded	100	20	120
Supplier-S2	Excluded	100	20	120

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Included	100	70	170
Contractor & S2	Included	100	60	160

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Included	100	70	170
Both-2	Included	100	60	160

CEMENT [Ordinary Portland Cement]

Summary Contractor and Supplier-S1
(TOTAL JOIN PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	138.80	160	120	130	150	170	868.80	144.80
Both	122.92	160	120	130	150	170	852.92	142.15
Supplier	109.17	160	120	130	150	170	839.17	139.86

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	138.8	170	150	150	170	170	948.80	158.13
Both	122.918	170	150	150	170	170	932.92	155.49
Supplier	109.167	170	150	150	170	170	919.17	153.19

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	138.8	120	130	150	140	120	798.80	133.13
Both	122.918	120	130	150	140	120	782.92	130.49
Supplier	109.167	120	130	150	140	120	769.17	128.19

CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S1
(TOTAL SINGLE PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	40.00	60	20	30	50	70	270.00	45.00
Contractor & S1	98.80	100	100	100	100	100	598.80	99.80
Supplier-S1	61.46	60	20	30	50	70	291.46	48.58
Contractor & S1	61.46	100	100	100	100	100	561.46	93.58
Supplier-S1	69.17	60	20	30	50	70	299.17	49.86
Contractor & S1	40.00	100	100	100	100	100	540.00	90.00

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	40.00	80	70	70	80	70	410.00	68.33
Contractor & S1	98.80	90	80	80	90	100	538.80	89.80
Supplier-S1	61.46	80	70	70	80	70	431.46	71.91
Contractor & S1	61.46	90	80	80	90	100	501.46	83.58
Supplier-S1	69.17	80	70	70	80	70	439.17	73.19
Contractor & S1	40.00	90	80	80	90	100	480.00	80.00

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	40.00	100	100	100	100	100	540.00	90.00
Contractor & S1	98.80	20	30	50	40	20	258.80	43.13
Supplier-S1	61.46	100	100	100	100	100	561.46	93.58
Contractor & S1	61.46	20	30	50	40	20	221.46	36.91
Supplier-S1	69.17	100	100	100	100	100	569.17	94.86
Contractor & S1	40.00	20	30	50	40	20	200.00	33.33

CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S1
(OPTION JOIN PAY-OFF) – Without weight

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	323.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	328.15	45-day check	On Completion	0.2	Multiple Delivery	Included
Supplier	330.00	Cash	On Delivery	0.3	Single Delivery	Excluded

CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S2
(TOTAL JOIN PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	149.20	140	130	120	160	160	859.20	143.20
Both	123.77	140	130	120	160	160	833.77	138.96
Supplier	105.56	140	130	120	160	160	815.56	135.93

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	149.2	160	130	160	160	160	919.20	153.20
Both	123.774	160	130	160	160	160	893.77	148.96
Supplier	105.556	160	130	160	160	160	875.56	145.93

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	149.2	120	130	150	140	120	809.20	134.87
Both	123.774	120	130	150	140	120	783.77	130.63
Supplier	105.556	120	130	150	140	120	765.56	127.59

CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S2
(TOTAL SINGLE PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S2	50.00	40	30	20	60	60	260.00	43.33
Contractor & S2	99.20	100	100	100	100	100	599.20	99.87
Supplier-S2	61.89	40	30	20	60	60	271.89	45.31
Contractor & S2	61.89	100	100	100	100	100	561.89	93.65
Supplier-S2	65.56	40	30	20	60	60	275.56	45.93
Contractor & S2	40.00	100	100	100	100	100	540.00	90.00

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S2	50.00	70	70	80	70	60	400.00	66.67
Contractor & S2	99.20	90	60	80	90	100	519.20	86.53
Supplier-S2	61.89	70	70	80	70	60	411.89	68.65
Contractor & S2	61.89	90	60	80	90	100	481.89	80.31
Supplier-S2	65.56	70	70	80	70	60	415.56	69.26
Contractor & S2	40.00	90	60	80	90	100	460.00	76.67

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S2	50.00	100	100	100	100	100	550.00	91.67
Contractor & S2	99.20	20	30	50	40	20	259.20	43.20
Supplier-S2	61.89	100	100	100	100	100	561.89	93.65
Contractor & S2	61.89	20	30	50	40	20	221.89	36.98
Supplier-S2	65.56	100	100	100	100	100	565.56	94.26
Contractor & S2	40.00	20	30	50	40	20	200.00	33.33

CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S2
(OPTION JOIN PAY-OFF) – Without weight

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	322.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	328.11	45-day check	On Completion of Milestone	0.2	Multiple Delivery	Included
Supplier	330.00	Cash	On Delivery	0.3	Single Delivery	Excluded

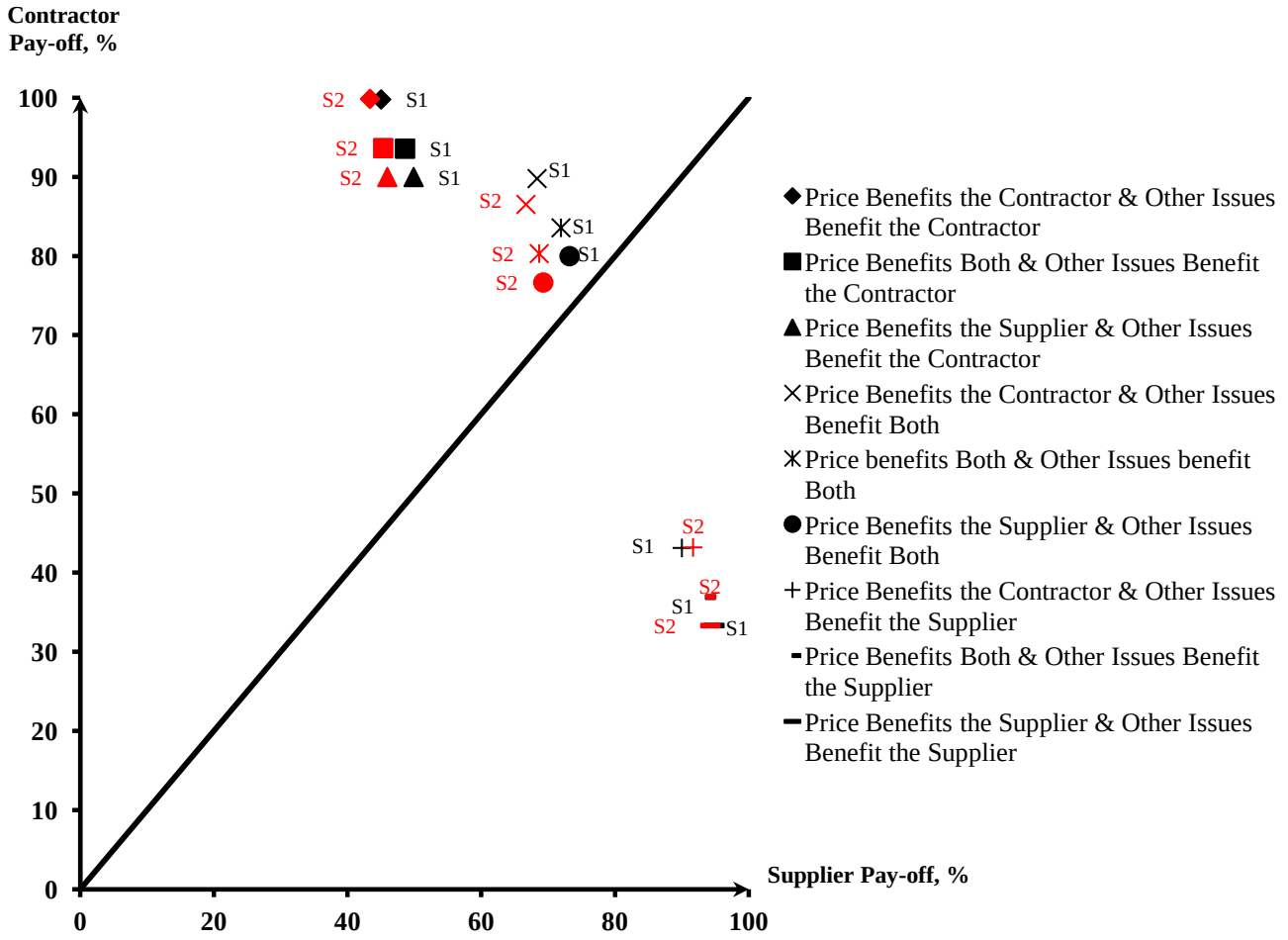


Figure: Optimization Joint Pay-off–Without Weight (CEMENT [Ordinary Portland Cement])

CEMENT [Ordinary Portland Cement]: Contractor

	Negotiation Issue	Absolutely		Strongly		Weakly		Equal	Weakly		Strongly		Absolutely		Negotiation Issue	
		7	6	5	4	3	2	1	2	3	4	5	6	7		
I1	Price	/													Payment Term	I2
I1	Price	/													Payment Period	I3
I1	Price	/													Advance Payment	I4
I1	Price	/													Delivery	I5
I1	Price	/													Freightage	I6
I2	Payment Term						/								Payment Period	I3
I2	Payment Term						/								Advance Payment	I4
I2	Payment Term						/								Delivery	I5
I2	Payment Term						/								Freightage	I6
I3	Payment Period						/								Advance Payment	I4
I3	Payment Period								/						Delivery	I5
I3	Payment Period								/						Freightage	I6
I4	Advance Payment								/						Delivery	I5
I4	Advance Payment								/						Freightage	I6
I5	Delivery						/								Freightage	I6

CEMENT [Ordinary Portland Cement]: Supplier-S1

	Negotiation Issue	Absolutely		Strongly		Weakly		Equal	Weakly		Strongly		Absolutely		Negotiation Issue	
		7	6	5	4	3	2	1	2	3	4	5	6	7		
I1	Price	/													Payment Term	I2
I1	Price	/													Payment Period	I3
I1	Price	/													Advance Payment	I4
I1	Price		/												Delivery	I5
I1	Price	/													Freightage	I6
I2	Payment Term							/							Payment Period	I3
I2	Payment Term					/									Advance Payment	I4
I2	Payment Term					/									Delivery	I5
I2	Payment Term						/								Freightage	I6
I3	Payment Period					/									Advance Payment	I4
I3	Payment Period						/								Delivery	I5
I3	Payment Period						/								Freightage	I6
I4	Advance Payment						/								Delivery	I5
I4	Advance Payment								/						Freightage	I6
I5	Delivery					/									Freightage	I6

CEMENT [Ordinary Portland Cement]: Supplier-S2

	Negotiation Issue	Absolutely		Strongly		Weakly		Equal	Weakly		Strongly		Absolutely		Negotiation Issue	
		7	6	5	4	3	2	1	2	3	4	5	6	7		
I1	Price	/													Payment Term	I2
I1	Price	/													Payment Period	I3
I1	Price	/													Advance Payment	I4
I1	Price		/												Delivery	I5
I1	Price		/												Freightage	I6
I2	Payment Term							/							Payment Period	I3
I2	Payment Term					/									Advance Payment	I4
I2	Payment Term					/									Delivery	I5
I2	Payment Term						/								Freightage	I6
I3	Payment Period					/									Advance Payment	I4
I3	Payment Period						/								Delivery	I5
I3	Payment Period						/								Freightage	I6
I4	Advance Payment								/						Delivery	I5
I4	Advance Payment						/								Freightage	I6
I5	Delivery							/							Freightage	I6

AHP: CEMENT [Ordinary Portland Cement]: Contractor

Negotiation Issue	I1	I2	I3	I4	I5	I6	Multiply	n^{th} Root	Normalize
I1	1.00	7.00	7.00	7.00	7.00	7.00	16807.000	5.061	0.57
I2	0.14	1.00	2.00	2.00	2.00	2.00	2.286	1.148	0.13
I3	0.14	0.50	1.00	2.00	0.50	0.50	0.036	0.574	0.06
I4	0.14	0.50	0.50	1.00	0.50	0.50	0.009	0.455	0.05
I5	0.14	0.50	2.00	2.00	1.00	2.00	0.571	0.911	0.10
I6	0.14	0.50	2.00	2.00	0.50	1.00	0.143	0.723	0.08
							SUM	8.87	1.00

$$\begin{Bmatrix} 1.00 & 7.00 & 7.00 & 7.00 & 7.00 & 7.00 \\ 0.14 & 1.00 & 2.00 & 2.00 & 2.00 & 2.00 \\ 0.14 & 0.50 & 1.00 & 2.00 & 0.50 & 0.50 \\ 0.14 & 0.50 & 0.50 & 1.00 & 0.50 & 0.50 \\ 0.14 & 0.50 & 2.00 & 2.00 & 1.00 & 2.00 \\ 0.14 & 0.50 & 2.00 & 2.00 & 0.50 & 1.00 \end{Bmatrix} \text{ X } \begin{Bmatrix} 0.57 \\ 0.13 \\ 0.06 \\ 0.05 \\ 0.10 \\ 0.08 \end{Bmatrix} = \begin{Bmatrix} 3.58 \\ 0.81 \\ 0.41 \\ 0.32 \\ 0.64 \\ 0.51 \end{Bmatrix} = \begin{Bmatrix} 6.271 \\ 6.271 \\ 6.271 \\ 6.271 \\ 6.271 \\ 6.271 \end{Bmatrix}$$

Average, λ_{max} = 6.271

Consistency Index, C.I. = 0.054

where n = 7, then Ratio Index, R.I. = 1.24

Consistency Ratio, C.R. = 0.0437

AHP: CEMENT [Ordinary Portland Cement]: Supplier-S1

Negotiation Issue	I1	I2	I3	I4	I5	I6	Multiply	n^{th} Root	Normalize
I1	1.00	7.00	7.00	7.00	6.00	7.00	14406.000	4.933	0.56
I2	0.14	1.00	1.00	3.00	3.00	2.00	2.571	1.170	0.13
I3	0.14	1.00	1.00	3.00	2.00	2.00	1.714	1.094	0.12
I4	0.14	0.33	0.33	1.00	2.00	0.50	0.016	0.501	0.06
I5	0.17	0.33	0.50	0.50	1.00	3.00	0.042	0.589	0.07
I6	0.14	0.50	0.50	2.00	0.33	1.00	0.024	0.536	0.06
							SUM	8.82	1.00

$$\begin{Bmatrix} 1.00 & 7.00 & 7.00 & 7.00 & 6.00 & 7.00 \\ 0.14 & 1.00 & 1.00 & 3.00 & 3.00 & 2.00 \\ 0.14 & 1.00 & 1.00 & 3.00 & 2.00 & 2.00 \\ 0.14 & 0.33 & 0.33 & 1.00 & 2.00 & 0.50 \\ 0.17 & 0.33 & 0.50 & 0.50 & 1.00 & 3.00 \\ 0.14 & 0.50 & 0.50 & 2.00 & 0.33 & 1.00 \end{Bmatrix} \text{X} \begin{Bmatrix} 0.56 \\ 0.13 \\ 0.12 \\ 0.06 \\ 0.07 \\ 0.06 \end{Bmatrix} = \begin{Bmatrix} 3.58 \\ 0.83 \\ 0.76 \\ 0.39 \\ 0.48 \\ 0.40 \end{Bmatrix} = \begin{Bmatrix} 6.402 \\ 6.247 \\ 6.146 \\ 6.795 \\ 7.146 \\ 6.660 \end{Bmatrix}$$

Average, λ_{max} = 6.566

Consistency Index, C.I. = 0.113

where n = 7, then Ratio Index, R.I. = 1.24

Consistency Ratio, C.R. = 0.0913

AHP: CEMENT [Ordinary Portland Cement]: Supplier-S2

Negotiation Issue	I1	I2	I3	I4	I5	I6	Multiply	n^{th} Root	Normalize
I1	1.00	7.00	7.00	7.00	6.00	6.00	12348.000	4.808	0.55
I2	0.14	1.00	1.00	3.00	3.00	2.00	2.571	1.170	0.13
I3	0.14	1.00	1.00	3.00	2.00	2.00	1.714	1.094	0.13
I4	0.14	0.33	0.33	1.00	0.50	2.00	0.016	0.501	0.06
I5	0.17	0.33	0.50	2.00	1.00	1.00	0.056	0.618	0.07
I6	0.17	0.50	0.50	0.50	1.00	1.00	0.021	0.525	0.06
							SUM	8.72	1.00

$$\begin{Bmatrix} 1.00 & 7.00 & 7.00 & 7.00 & 6.00 & 6.00 \\ 0.14 & 1.00 & 1.00 & 3.00 & 3.00 & 2.00 \\ 0.14 & 1.00 & 1.00 & 3.00 & 2.00 & 2.00 \\ 0.14 & 0.33 & 0.33 & 1.00 & 0.50 & 2.00 \\ 0.17 & 0.33 & 0.50 & 2.00 & 1.00 & 1.00 \\ 0.17 & 0.50 & 0.50 & 0.50 & 1.00 & 1.00 \end{Bmatrix} \text{ X } \begin{Bmatrix} 0.55 \\ 0.13 \\ 0.13 \\ 0.06 \\ 0.07 \\ 0.06 \end{Bmatrix} = \begin{Bmatrix} 3.56 \\ 0.84 \\ 0.77 \\ 0.38 \\ 0.45 \\ 0.38 \end{Bmatrix} = \begin{Bmatrix} 6.453 \\ 6.286 \\ 6.161 \\ 6.585 \\ 6.287 \\ 6.341 \end{Bmatrix}$$

Average, λ_{max} = 6.352

Consistency Index, C.I. = 0.070

where n = 7, then Ratio Index, R.I. = 1.24

Consistency Ratio, C.R. = 0.0568

CEMENT [Ordinary Portland Cement]:

Price Issue

Contractor	P_{min}	A_{min}	D_{min}	D_{max}	A_{max}	P_{max}
Pay-off		45.6	57	55.86	22.8	
Option		310	320	325	330	

Supplier-S1	P'_{min}	A'_{min}	D'_{min}	D'_{max}	A'_{max}	P'_{max}
Pay-off		22.4	50.4	53.2	56	
Option		323	335	340	355	

Supplie-S2	P''_{min}	A''_{min}	D''_{min}	D''_{max}	A''_{max}	P''_{max}
Pay-off		27.5	46.75	49.5	55	
Option		322	340	345	350	

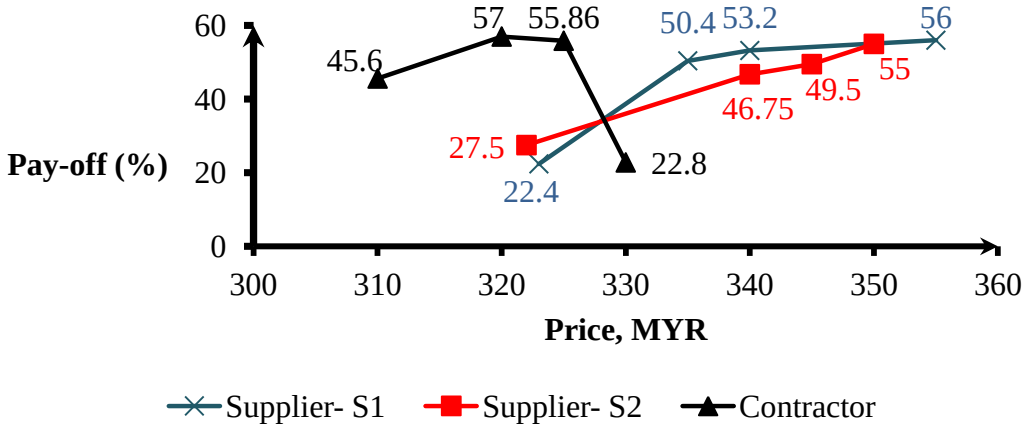


Figure: Price Issue

Single Benefit-Supplier

Point	Option (MYR)	Contractor Pay-off, %	Pay-off, %	Joint Pay-off
Supplier-S1	330.00	22.80	38.73	61.53
Supplier-S2	330.00	22.80	36.06	58.86

Single Benefit-Contractor

Point	Option (MYR)	Supplier Pay-off, %	Pay-off, %	Joint Pay-off
Contractor & S1	323.00	22.40	56.32	78.72
Contractor & S2	322.00	27.50	56.54	84.04

Both benefit

Point	Option (MYR)	Pay-off, %	Joint Pay-off
Intercept price Contractor & S1	328.22	34.58	69.15
Intercept price Contractor & S2	328.27	34.21	68.42

CEMENT [Ordinary Portland Cement]:

Payment Term Issue

Option		Cash	30-day check	45-day check	60-day check
Supplier-S1	**Pay-off**	13	11.7	10.4	7.8
Supplier-S2	**Pay-off**	13	11.7	9.1	5.2
Contractor	**Pay-off**	2.6	9.1	11.7	13

Option		Cash	30-day check	45-day check	60-day check
Joint-1	**Pay-off**	15.6	20.8	22.1	20.8
Joint-2	**Pay-off**	15.6	20.8	20.8	18.2

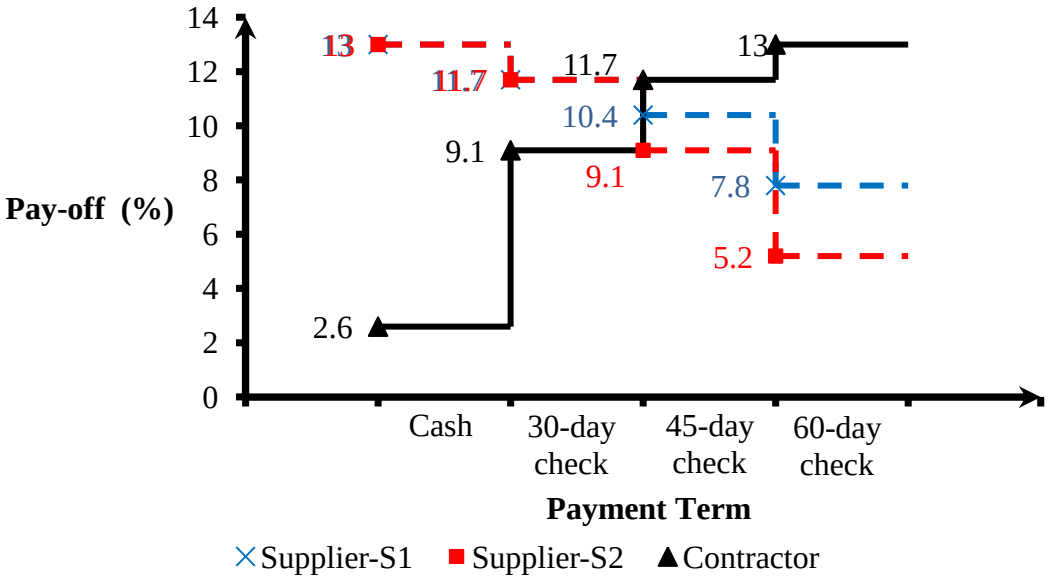


Figure: Payment Term Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Cash	13	2.6	15.6
Supplier-S2	Cash	13	2.6	15.6

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	60-day check	13	7.8	20.8
Contractor & S2	60-day check	13	5.2	18.2

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	45-day check	11.7	10.4	22.1
Both-2	45-day check	11.7	9.1	20.8

CEMENT [Ordinary Portland Cement]:

Payment Period Issue

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Supplier-S1	**Pay-off**	12	10.8	8.4	6	2.4
Supplier-S2	**Pay-off**	13	9.1	6.5	5.2	3.9
Contractor	**Pay-off**	1.8	3.6	4.8	5.7	6

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Joint-1	**Pay-off**	13.8	14.4	13.2	11.7	8.4
Joint-2	**Pay-off**	14.8	12.7	11.3	10.9	9.9

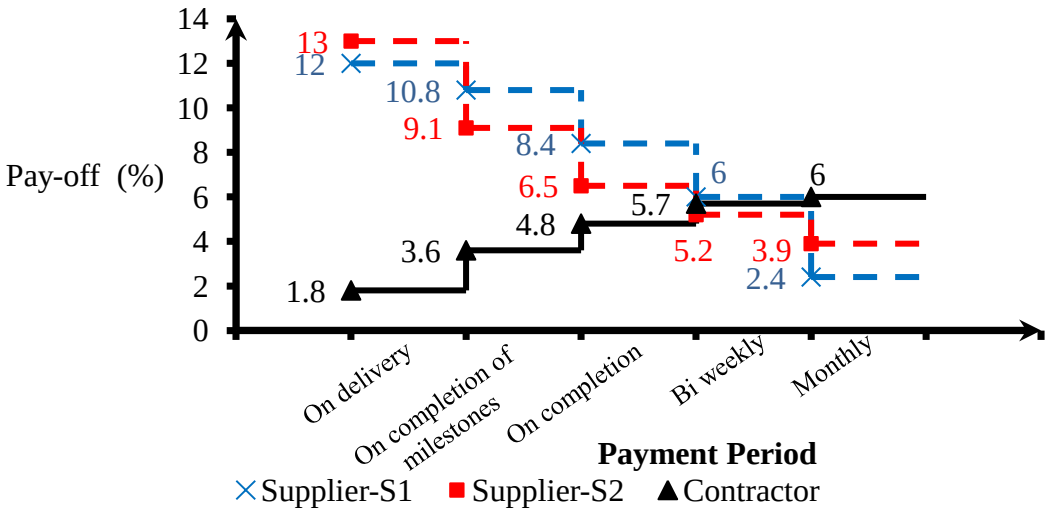


Figure: Payment Period Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	On Delivery	12	1.8	13.8
Supplier-S2	On Delivery	13	1.8	14.8

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Monthly	6	2.4	8.4
Contractor & S2	Monthly	6	3.9	9.9

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Bi Weekly	5.7	6	11.7
Both-2	Bi Weekly	5.7	5.2	10.9

CEMENT [Ordinary Portland Cement]:

Advance Payment Issue

Option		10%	15%	20%	25%	30%
Supplier-S1	**Pay-off**	1.8	3.6	4.2	5.4	6
Supplier-S2	**Pay-off**	1.2	3	4.8	5.4	6
Contractor	**Pay-off**	5	4.75	4	3.5	2.5

Option		10%	15%	20%	25%	30%
Joint-1	**Pay-off**	6.8	8.35	8.2	8.9	8.5
Joint-2	**Pay-off**	6.2	7.75	8.8	8.9	8.5

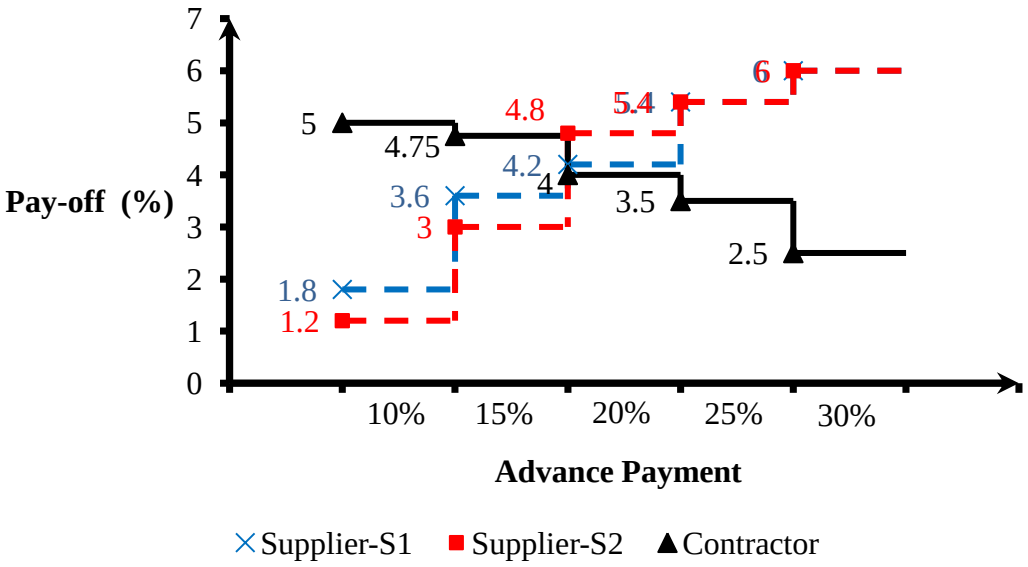


Figure: Advance Payment Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	0.3	6	2.5	8.5
Supplier-S2	0.3	6	2.5	8.5

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	0.1	5	1.8	6.8
Contractor & S2	0.1	5	1.2	6.2

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	0.2	4	4.2	8.2
Both-2	0.2	4	4.8	8.8

CEMENT [Ordinary Portland Cement]:

Delivery Issue

Option		Single Delivery	Multiple Delivery	On Call Delivery
Supplier-S1	**Pay-off**	7	5.6	3.5
Supplier-S2	**Pay-off**	7	4.9	4.2
Contractor	**Pay-off**	4	9	10

Option		Single Delivery	Multiple Delivery	On Call Delivery
Joint-1	**Pay-off**	11	14.6	13.5
Joint-2	**Pay-off**	11	13.9	14.2

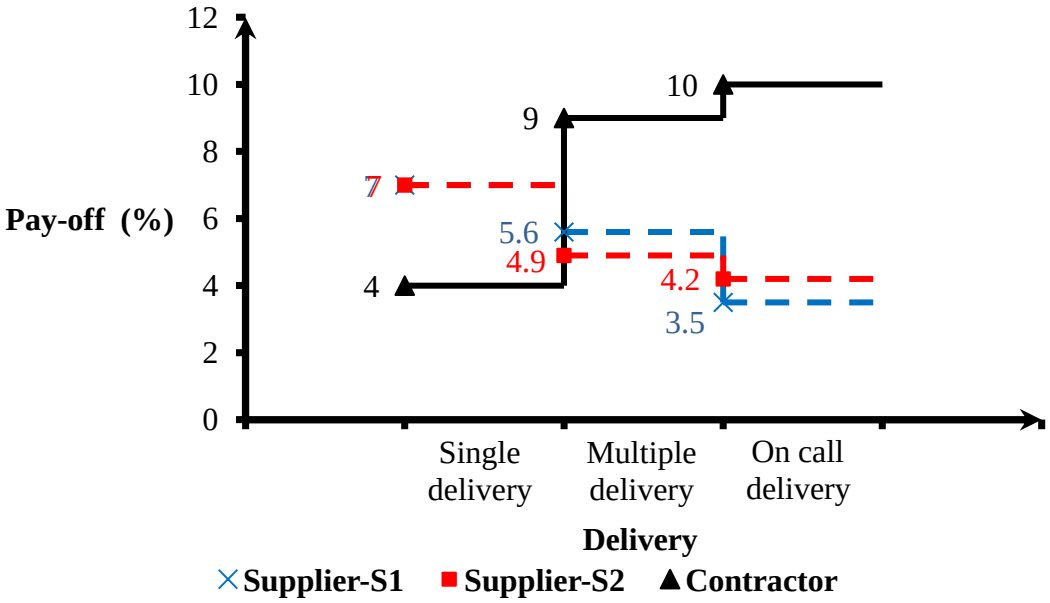


Figure: Delivery Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Single Delivery	7	4	11
Supplier-S2	Single Delivery	7	4	11

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	On Call Delivery	10	3.5	13.5
Contractor & S2	On Call Delivery	10	4.2	14.2

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Single Delivery	4	7	11
Both-2	Single Delivery	4	7	11

CEMENT [Ordinary Portland Cement]:

Freightage Issue

Option		Included	Excluded
Supplier-S1	**Pay-off**	4.2	6
Supplier-S2	**Pay-off**	3.6	6
Contractor	**Pay-off**	8	1.6

Option		Included	Excluded
Joint-1	**Pay-off**	12.2	7.6
Joint-2	**Pay-off**	11.6	7.6

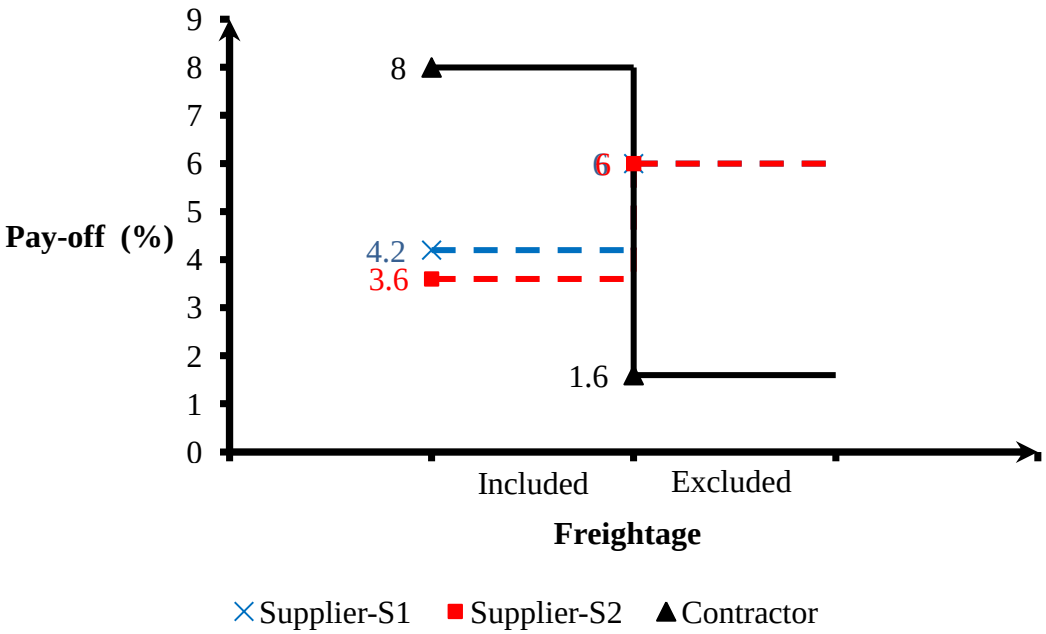


Figure: Freightage Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Excluded	6	1.6	7.6
Supplier-S2	Excluded	6	1.6	7.6

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Included	8	4.2	12.2
Contractor & S2	Included	8	3.6	11.6

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Included	8	4.2	12.2
Both-2	Included	8	3.6	11.6

CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S1
(TOTAL JOIN PAY-OFF)

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	78.72	20.8	8.4	6.8	13.5	12.2	140.42
Both	69.15	20.8	8.4	6.8	13.5	12.2	130.85
Supplier	61.53	20.8	8.4	6.8	13.5	12.2	123.23

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	78.72	22.1	11.7	8.2	11	12.2	143.92
Both	69.1544	22.1	11.7	8.2	11	12.2	134.35
Supplier	61.5333	22.1	11.7	8.2	11	12.2	126.73

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	78.716	15.6	13.8	8.5	11	7.6	135.22
Both	69.1544	15.6	13.8	8.5	11	7.6	125.65
Supplier	61.5333	15.6	13.8	8.5	11	7.6	118.03

CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S1
(TOTAL SINGLE PAY-OFF)

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	22.40	7.8	2.4	1.8	3.5	4.2	42.10
Contractor & S1	56.32	13	6	5	10	8	98.32
Supplier-S1	34.58	7.8	2.4	1.8	3.5	4.2	54.28
Contractor & S1	34.58	13	6	5	10	8	76.58
Supplier-S1	38.73	7.8	2.4	1.8	3.5	4.2	58.43
Contractor & S1	22.80	13	6	5	10	8	64.80

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	22.40	10.4	6	4.2	7	4.2	54.20
Contractor & S1	56.32	11.7	5.7	4	4	8	89.72
Supplier-S1	34.58	10.4	6	4.2	7	4.2	66.38
Contractor & S1	34.58	11.7	5.7	4	4	8	67.98
Supplier-S1	38.73	10.4	6	4.2	7	4.2	70.53
Contractor & S1	22.80	11.7	5.7	4	4	8	56.20

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	22.40	13	12	6	7	6	66.40
Contractor & S1	56.32	2.6	1.8	2.5	4	1.6	68.82
Supplier-S1	34.58	13	12	6	7	6	78.58
Contractor & S1	34.58	2.6	1.8	2.5	4	1.6	47.08
Supplier-S1	38.73	13	12	6	7	6	82.73
Contractor & S1	22.80	2.6	1.8	2.5	4	1.6	35.30

CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S1
(OPTION JOIN PAY-OFF)

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	323.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	328.22	45-day check	Bi Weekly	0.2	Single Delivery	Included
Supplier	330.00	Cash	On Delivery	0.3	Single Delivery	Excluded

CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S2

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	84.04	18.2	9.9	6.2	14.2	11.6	144.14
Both	68.42	18.2	9.9	6.2	14.2	11.6	128.52
Supplier	58.86	18.2	9.9	6.2	14.2	11.6	118.96

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	84.044	20.8	10.9	8.8	11	11.6	147.14
Both	68.4201	20.8	10.9	8.8	11	11.6	131.52
Supplier	58.8556	20.8	10.9	8.8	11	11.6	121.96

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	84.044	15.6	14.8	8.5	11	7.6	141.54
Both	68.4201	15.6	14.8	8.5	11	7.6	125.92
Supplier	58.8556	15.6	14.8	8.5	11	7.6	116.36

CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S2
(TOTAL SINGLE PAY-OFF)

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	27.50	5.2	3.9	1.2	4.2	3.6	45.60
Contractor & S2	56.54	13	6	5	10	8	98.54
Supplier-S2	34.21	5.2	3.9	1.2	4.2	3.6	52.31
Contractor & S2	34.21	13	6	5	10	8	76.21
Supplier-S2	36.06	5.2	3.9	1.2	4.2	3.6	54.16
Contractor & S2	22.80	13	6	5	10	8	64.80

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	27.50	9.1	5.2	4.8	7	3.6	57.20
Contractor & S2	56.54	11.7	5.7	4	4	8	89.94
Supplier-S2	34.21	9.1	5.2	4.8	7	3.6	63.91
Contractor & S2	34.21	11.7	5.7	4	4	8	67.61
Supplier-S2	36.06	9.1	5.2	4.8	7	3.6	65.76
Contractor & S2	22.80	11.7	5.7	4	4	8	56.20

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	27.50	13	13	6	7	6	72.50
Contractor & S2	56.54	2.6	1.8	2.5	4	1.6	69.04
Supplier-S2	34.21	13	13	6	7	6	79.21
Contractor & S2	34.21	2.6	1.8	2.5	4	1.6	46.71
Supplier-S2	36.06	13	13	6	7	6	81.06
Contractor & S2	22.80	2.6	1.8	2.5	4	1.6	35.30

CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S2
(OPTION JOIN PAY-OFF)

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	322.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	328.27	45-day check	Bi Weekly	0.2	Single Delivery	Included
Supplier	330.00	Cash	On Delivery	0.3	Single Delivery	Excluded

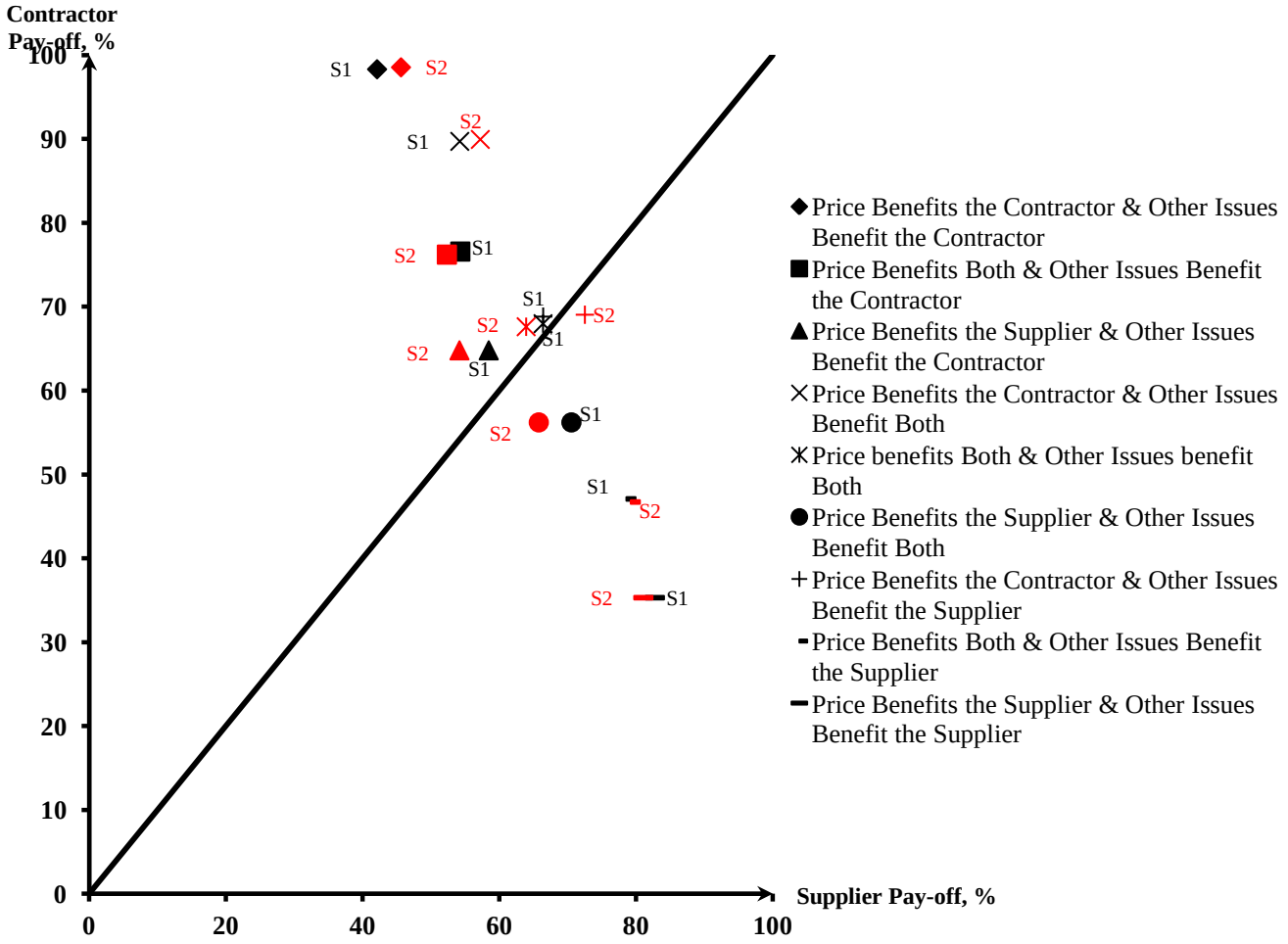


Figure: Optimization Joint Pay-off – (CEMENT [Ordinary Portland Cement])

ACTUAL: CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S1 (TOTAL SINGLE PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Single Pay-off/6
Supplier-S1	48.33	90	100	60	50	70	418.33	69.72
Contractor & S1	98.00	70	30	95	100	100	493.00	82.17

ACTUAL: CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S1 (OPTION JOIN PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S1	325.00	30-day check	On Delivery	0.15	On Call Delivery	Included

ACTUAL: CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S2 (TOTAL SINGLE PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Single Pay-off/6
Supplier-S2	55.83	90	100	50	60	60	415.83	69.31
Contractor & S2	98.00	70	30	95	100	100	493.00	82.17

ACTUAL: CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S2 (OPTION JOIN PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S2	325.00	30-day check	On Delivery	0.15	On Call Delivery	Included

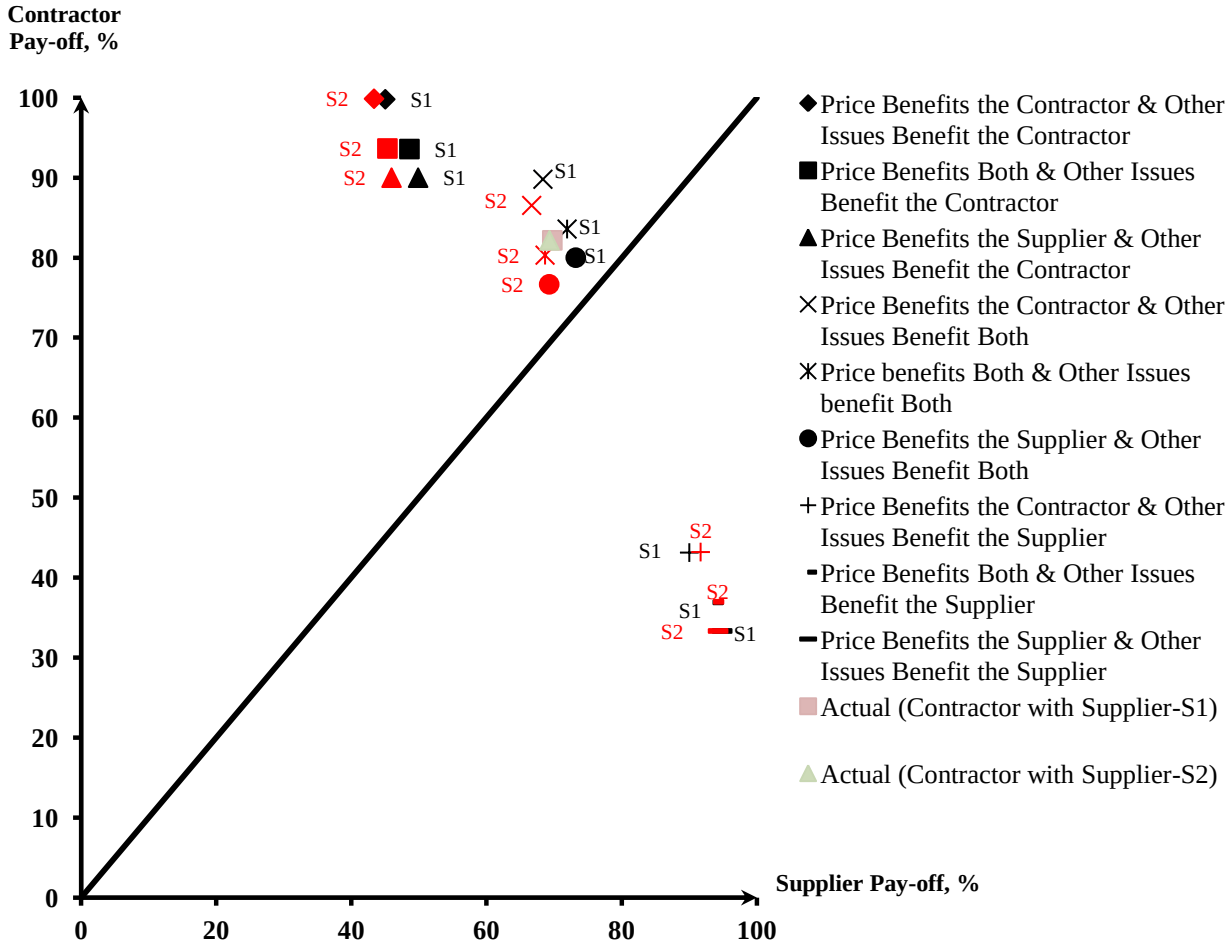


Figure: Actual Optimization Joint Pay-off – (CEMENT [Ordinary Portland Cement]) – Without weight

ACTUAL: CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S1 (TOTAL SINGLE PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	27.07	11.7	12	3.6	3.5	4.2	62.07
Contractor & S1	55.86	9.1	1.8	4.75	10	8	89.51

ACTUAL: CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S1 (OPTION JOIN PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S1	325.00	30-day check	On Delivery	0.15	On Call Delivery	Included

ACTUAL: CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S2 (TOTAL SINGLE PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	30.71	11.7	13	3	4.2	3.6	66.21
Contractor & S2	55.86	9.1	1.8	4.75	10	8	89.51

ACTUAL: CEMENT [Ordinary Portland Cement]
Summary Contractor and Supplier-S2 (OPTION JOIN PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S2	325.00	30-day check	On Delivery	0.15	On Call Delivery	Included

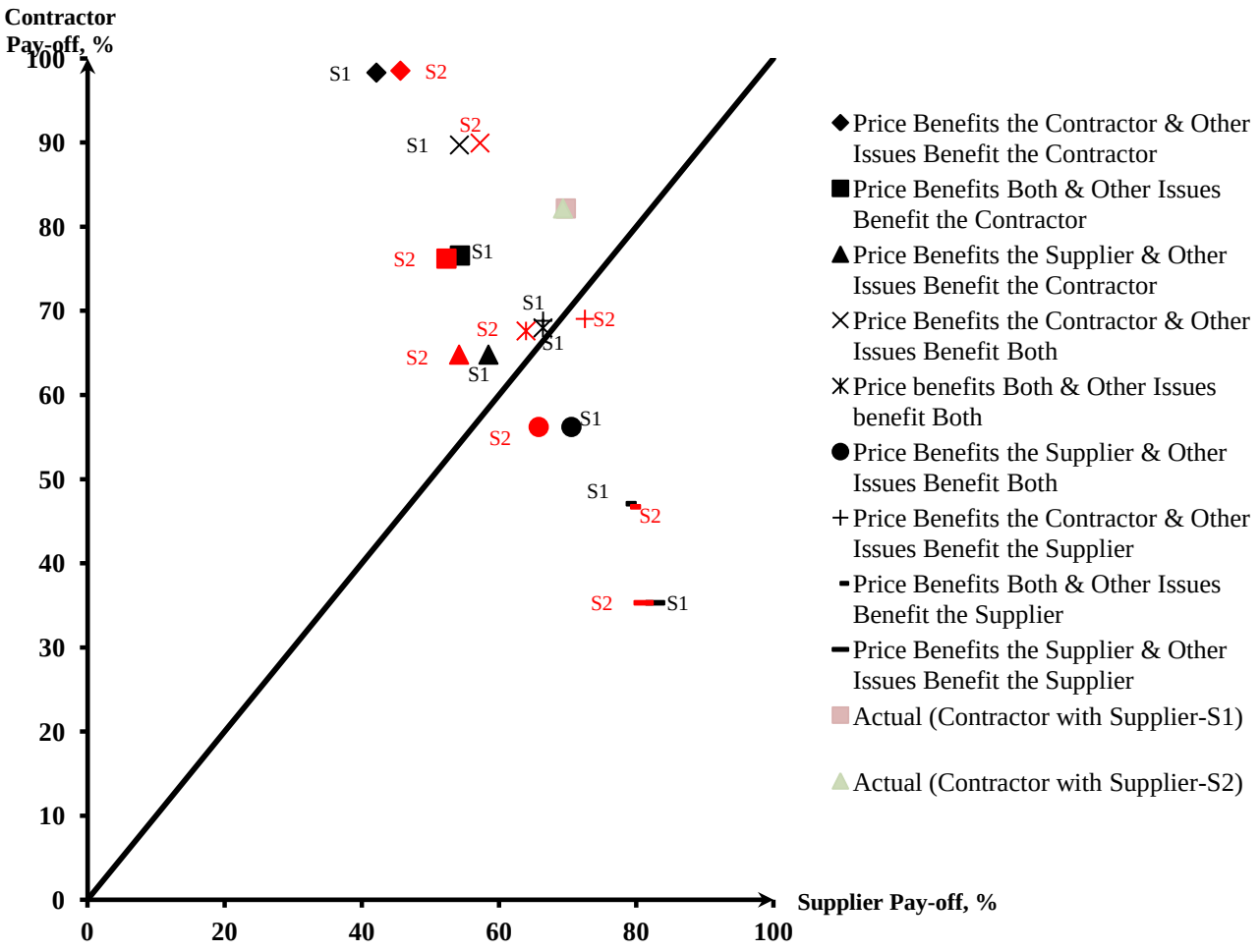


Figure: Actual Optimization Joint Pay-off – (CEMENT [Ordinary Portland Cement])

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Price Issue – Without Weight

Contractor	P_{min}	A_{min}	D_{min}	D_{max}	A_{max}	P_{max}
Pay-off		75	100	95	40	
Option		180	190	207	210	

Supplier-S1	P'_{min}	A'_{min}	D'_{min}	D'_{max}	A'_{max}	P'_{max}
Pay-off		30	80	95	100	
Option		205	220	250	300	

Supplie-S2	P''_{min}	A''_{min}	D''_{min}	D''_{max}	A''_{max}	P''_{max}
Pay-off		40	75	90	100	
Option		204	220	240	290	

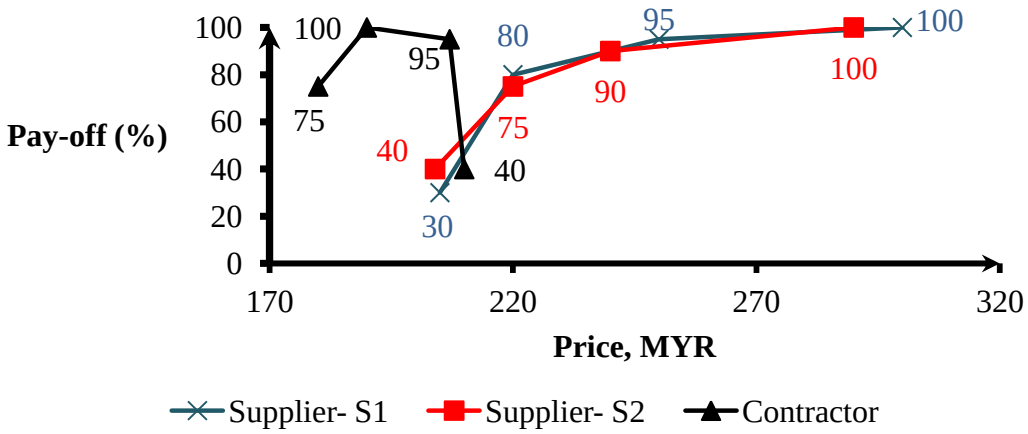


Figure: Price Issue – Without Weight

Single Benefit-Supplier

Point	Option (MYR)	Contractor Pay-off, %	Pay-off, %	Joint Pay-off
Supplier-S1	210.00	40.00	46.67	86.67
Supplier-S2	210.00	40.00	53.13	93.13

Single Benefit-Contractor

Point	Option (MYR)	Supplier Pay-off, %	Pay-off, %	Joint Pay-off
Contractor & S1	205.00	30.00	95.59	125.59
Contractor & S2	204.00	40.00	95.88	135.88

Both benefit

Point	Option (MYR)	Pay-off, %	Joint Pay-off
Intercept price Contractor & S1	209.69	45.64	91.28
Intercept price Contractor & S2	209.36	51.73	103.45

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Payment Term Issue – Without Weight

Option		Cash	30-day check	45-day check	60-day check
Supplier-S1	**Pay-off**	100	80	75	50
Supplier-S2	**Pay-off**	100	90	70	40
Contractor	**Pay-off**	30	60	80	100

Option		Cash	30-day check	45-day check	60-day check
Joint-1	**Pay-off**	130	140	155	150
Joint-2	**Pay-off**	130	150	150	140

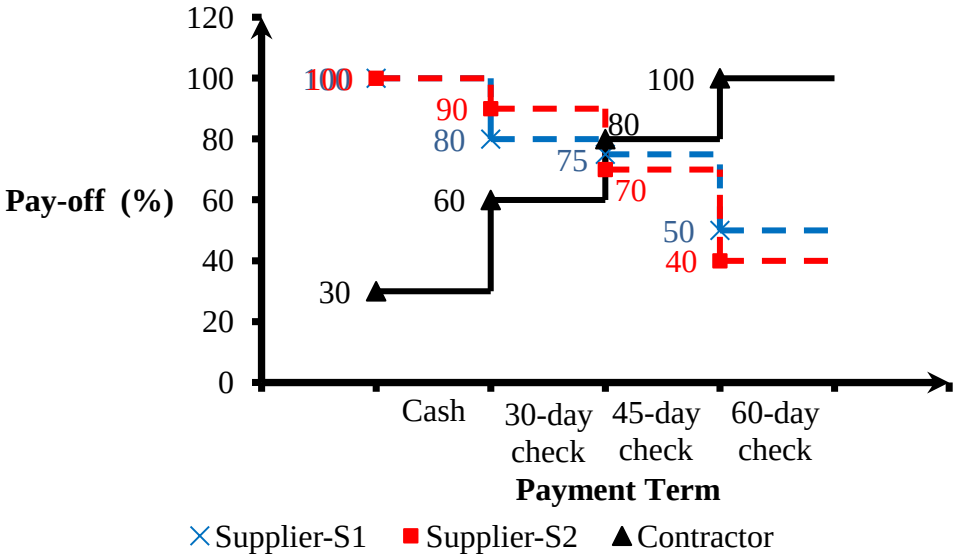


Figure: Payment Term Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Cash	100	30	130
Supplier-S2	Cash	100	30	130

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	60-day check	100	50	150
Contractor & S2	60-day check	100	40	140

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	45-day check	80	75	155
Both-2	45-day check	80	70	150

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Payment Period Issue – Without Weight

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Supplier-S1	**Pay-off**	100	80	60	40	20
Supplier-S2	**Pay-off**	100	70	60	35	20
Contractor	**Pay-off**	30	50	70	90	100

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Joint-1	**Pay-off**	130	130	130	130	120
Joint-2	**Pay-off**	130	120	130	125	120

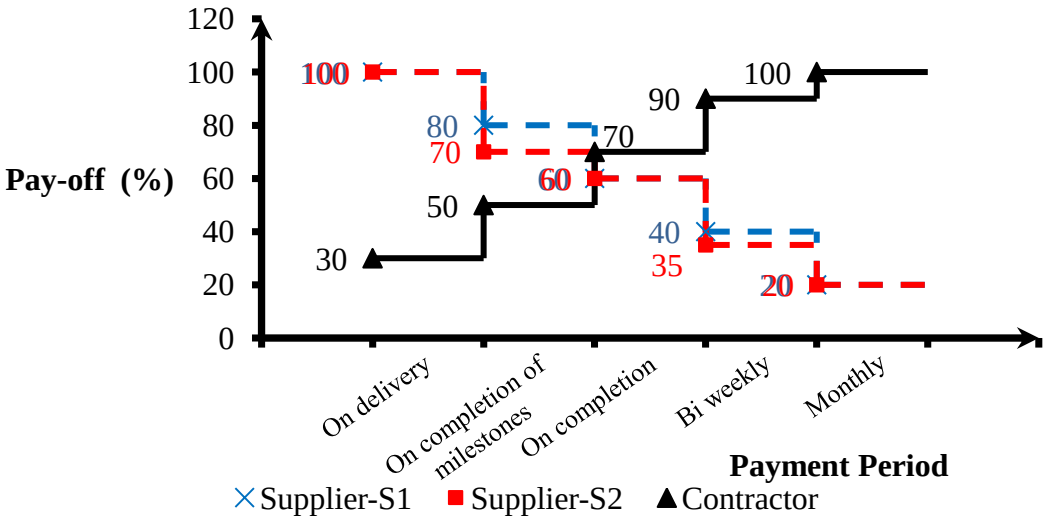


Figure: Payment Period Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	On Delivery	100	30	130
Supplier-S2	On Delivery	100	30	130

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Monthly	100	20	120
Contractor & S2	Monthly	100	20	120

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	On Completion	70	60	130
Both-2	On Completion	70	60	130

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Advance Payment Issue – Without Weight

Option		10%	15%	20%	25%	30%
Supplier-S1	**Pay-off**	40	70	80	90	100
Supplier-S2	**Pay-off**	35	60	70	85	100
Contractor	**Pay-off**	100	90	80	60	30

Option		10%	15%	20%	25%	30%
Joint-1	**Pay-off**	140	160	160	150	130
Joint-2	**Pay-off**	135	150	150	145	130

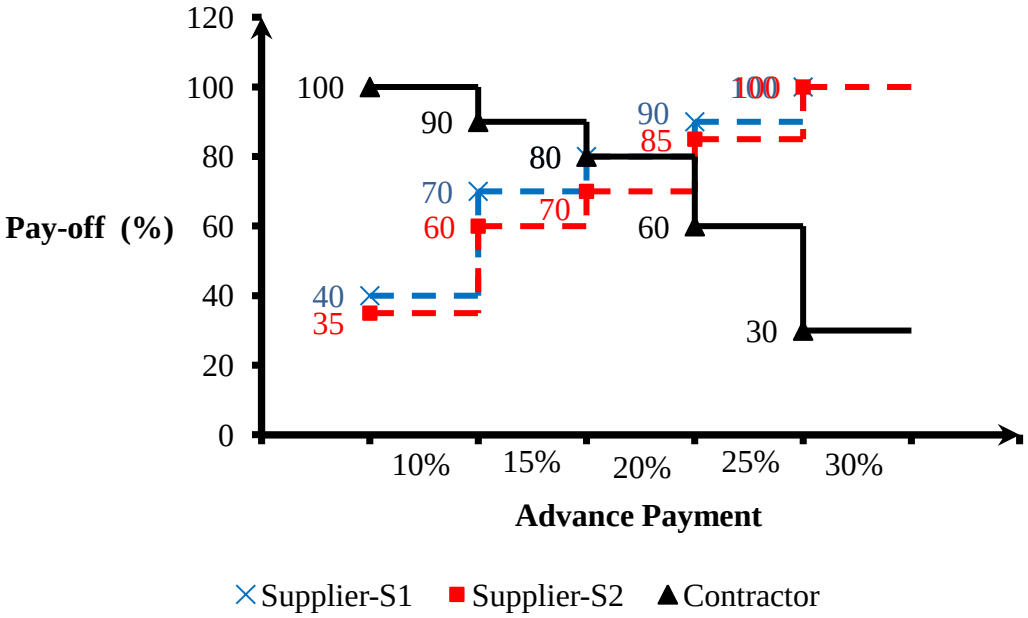


Figure: Advance Payment Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	0.3	100	30	130
Supplier-S2	0.3	100	30	130

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	0.1	100	40	140
Contractor & S2	0.1	100	35	135

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	0.2	80	80	160
Both-2	0.2	80	70	150

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Delivery Issue – Without Weight

Option		Single Delivery	Multiple Delivery	On Call Delivery
Supplier-S1	**Pay-off**	100	60	20
Supplier-S2	**Pay-off**	100	60	10
Contractor	**Pay-off**	40	70	100

Option		Cash	30-day check	45-day check
Joint-1	**Pay-off**	140	130	120
Joint-2	**Pay-off**	140	130	110

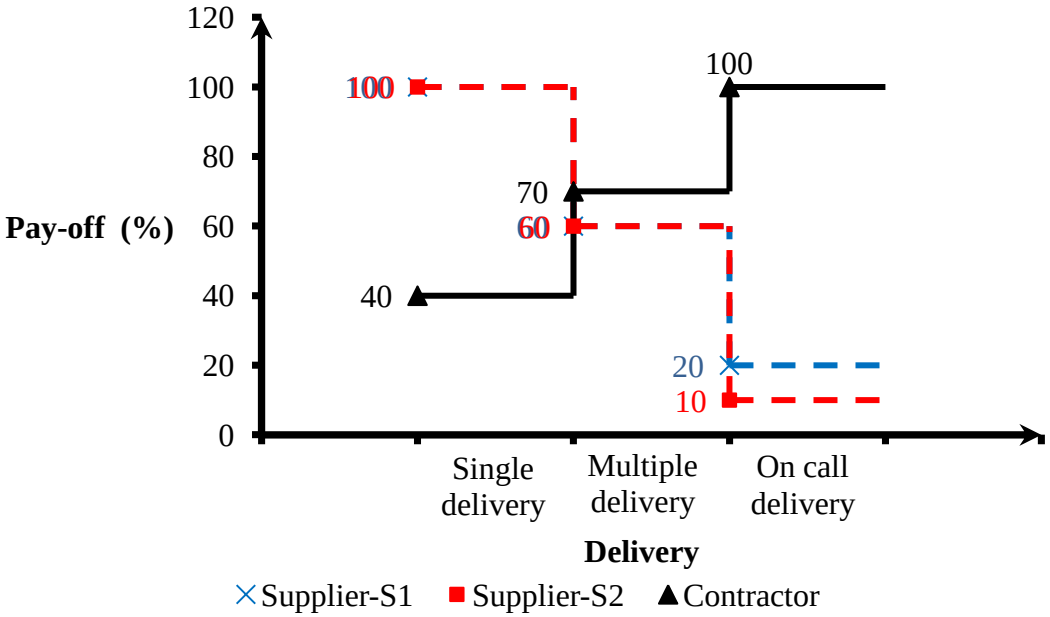


Figure: Delivery Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Single Delivery	100	40	140
Supplier-S2	Single Delivery	100	40	140

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	On Call Delivery	100	20	120
Contractor & S2	On Call Delivery	100	10	110

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Multiple Delivery	70	60	130
Both-2	Multiple Delivery	70	60	130

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Freightage Issue – Without Weight

Option		Included	Excluded
Supplier-S1	**Pay-off**	40	100
Supplier-S2	**Pay-off**	40	100
Contractor	**Pay-off**	100	20

Option		Included	Excluded
Joint-1	**Pay-off**	140	120
Joint-2	**Pay-off**	140	120

Figure: Freightage Issue – Without Weight

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Excluded	100	20	120
Supplier-S2	Excluded	100	20	120

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Included	100	40	140
Contractor & S2	Included	100	40	140

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Included	100	40	140
Both-2	Included	100	40	140

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]

Summary Contractor and Supplier-S1
(TOTAL JOIN PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	125.59	150	120	140	120	140	795.59	132.60
Both	91.28	150	120	140	120	140	761.28	126.88
Supplier	86.67	150	120	140	120	140	756.67	126.11

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	125.59	155	130	160	130	140	840.59	140.10
Both	91.28	155	130	160	130	140	806.28	134.38
Supplier	86.67	155	130	160	130	140	801.67	133.61

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	125.59	130	130	130	140	120	775.59	129.26
Both	91.28	130	130	130	140	120	741.28	123.55
Supplier	86.67	130	130	130	140	120	736.67	122.78

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]

Summary Contractor and Supplier-S1
(TOTAL SINGLE PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	30.00	50	20	40	20	40	200.00	33.33
Contractor & S1	95.59	100	100	100	100	100	595.59	99.26
Supplier-S1	45.64	50	20	40	20	40	215.64	35.94
Contractor & S1	45.64	100	100	100	100	100	545.64	90.94
Supplier-S1	46.67	50	20	40	20	40	216.67	36.11
Contractor & S1	40.00	100	100	100	100	100	540.00	90.00

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	30.00	75	60	80	60	40	345.00	57.50
Contractor & S1	95.59	80	70	80	70	100	495.59	82.60
Supplier-S1	45.64	75	60	80	60	40	360.64	60.11
Contractor & S1	45.64	80	70	80	70	100	445.64	74.27
Supplier-S1	46.67	75	60	80	60	40	361.67	60.28
Contractor & S1	40.00	80	70	80	70	100	440.00	73.33

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	30.00	100	100	100	100	100	530.00	88.33
Contractor & S1	95.59	30	30	30	40	20	245.59	40.93
Supplier-S1	45.64	100	100	100	100	100	545.64	90.94
Contractor & S1	45.64	30	30	30	40	20	195.64	32.61
Supplier-S1	46.67	100	100	100	100	100	546.67	91.11
Contractor & S1	40.00	30	30	30	40	20	190.00	31.67

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]

Summary Contractor and Supplier-S1 (OPTION JOIN PAY-OFF) – Without weight

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	205.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	209.69	45-day check	On Completion	0.2	Multiple Delivery	Included
Supplier	210.00	Cash	On Delivery	0.3	Single Delivery	Excluded

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]

Summary Contractor and Supplier-S2
(TOTAL JOIN PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	135.88	140	120	135	110	140	780.88	130.15
Both	103.45	140	120	135	110	140	748.45	124.74
Supplier	93.13	140	120	135	110	140	738.13	123.02

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	135.88	150	130	150	130	140	835.88	139.31
Both	103.45	150	130	150	130	140	803.45	133.91
Supplier	93.13	150	130	150	130	140	793.13	132.19

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off	Total Joint Pay-off /6
Contractor	135.88	130	130	130	140	120	785.88	130.98
Both	103.45	130	130	130	140	120	753.45	125.58
Supplier	93.13	130	130	130	140	120	743.13	123.85

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]

Summary Contractor and Supplier-S2
(TOTAL SINGLE PAY-OFF) – Without weight

Price Benefit to		Contractor Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	40.00	40	20	35	10	40	185.00	30.83
Contractor & S1	95.88	100	100	100	100	100	595.88	99.31
Supplier-S1	51.73	40	20	35	10	40	196.73	32.79
Contractor & S1	51.73	100	100	100	100	100	551.73	91.95
Supplier-S1	53.13	40	20	35	10	40	198.13	33.02
Contractor & S1	40.00	100	100	100	100	100	540.00	90.00

Price Benefit to		Both Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	40.00	70	60	70	60	40	340.00	56.67
Contractor & S1	95.88	80	70	80	70	100	495.88	82.65
Supplier-S1	51.73	70	60	70	60	40	351.73	58.62
Contractor & S1	51.73	80	70	80	70	100	451.73	75.29
Supplier-S1	53.13	70	60	70	60	40	353.13	58.85
Contractor & S1	40.00	80	70	80	70	100	440.00	73.33

Price Benefit to		Supplier Benefit						
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Joint Pay-off /6
Supplier-S1	40.00	100	100	100	100	100	540.00	90.00
Contractor & S1	95.88	30	30	30	40	20	245.88	40.98
Supplier-S1	51.73	100	100	100	100	100	551.73	91.95
Contractor & S1	51.73	30	30	30	40	20	201.73	33.62
Supplier-S1	53.13	100	100	100	100	100	553.13	92.19
Contractor & S1	40.00	30	30	30	40	20	190.00	31.67

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]

Summary Contractor and Supplier-S2
(OPTION JOIN PAY-OFF) – Without weight

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	204.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	209.36	45-day check	On Completion	0.2	Multiple Delivery	Included
Supplier	210.00	Cash	On Delivery	0.3	Single Delivery	Excluded

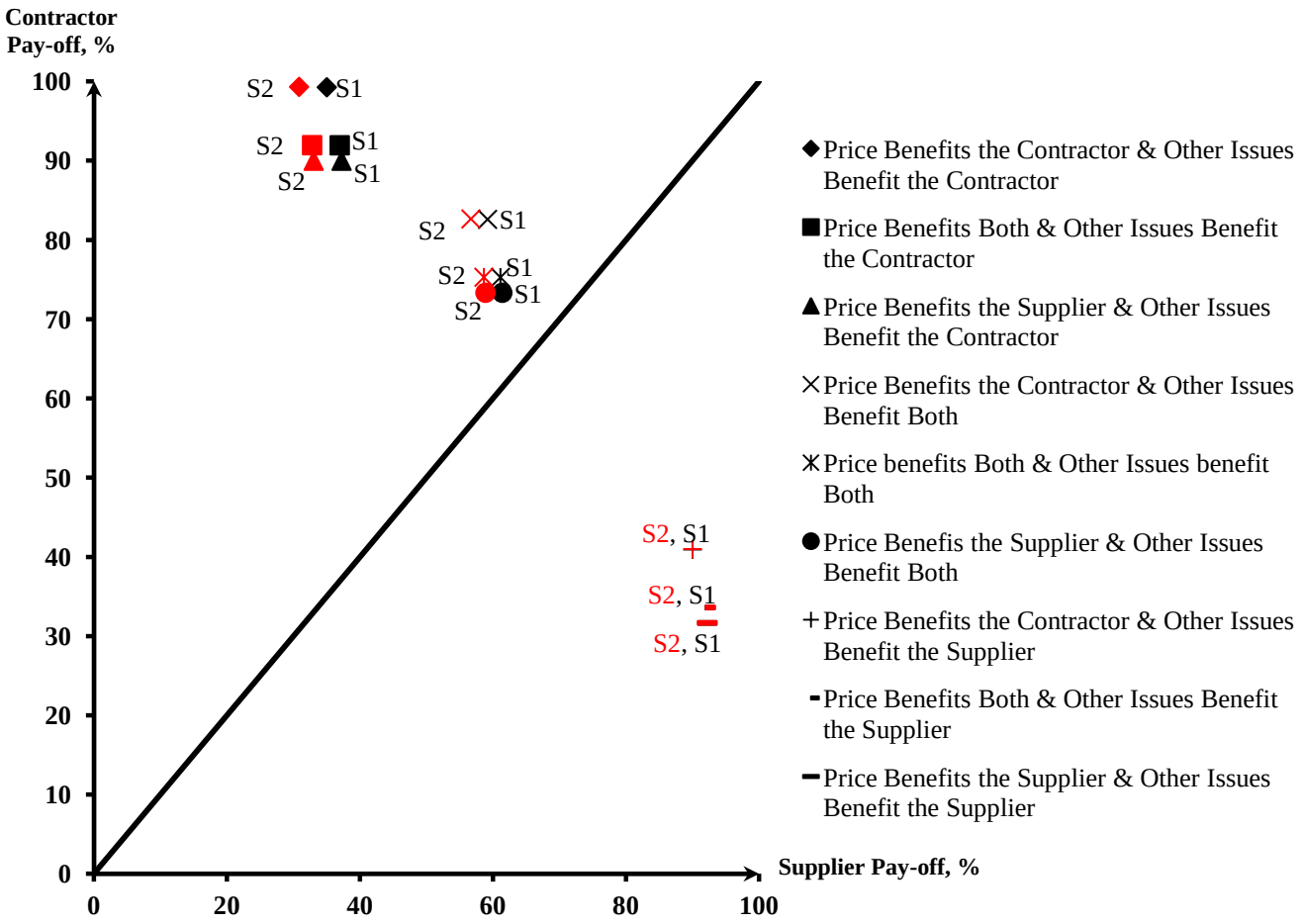


Figure: Optimization Joint Pay-off–Without Weight (READY MIX CONCRETE [Normal Mix - Grade 35, Granite])

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]: Contractor

	Negotiation Issue	Absolutely		Strongly		Weakly		Equal	Weakly		Strongly		Absolutely		Negotiation Issue	
		7	6	5	4	3	2	1	2	3	4	5	6	7		
I1	Price	/													Payment Term	I2
I1	Price		/												Payment Period	I3
I1	Price		/												Advance Payment	I4
I1	Price			/											Delivery	I5
I1	Price			/											Freightage	I6
I2	Payment Term					/									Payment Period	I3
I2	Payment Term						/								Advance Payment	I4
I2	Payment Term						/								Delivery	I5
I2	Payment Term						/								Freightage	I6
I3	Payment Period					/									Advance Payment	I4
I3	Payment Period						/								Delivery	I5
I3	Payment Period						/								Freightage	I6
I4	Advance Payment						/								Delivery	I5
I4	Advance Payment						/								Freightage	I6
I5	Delivery									/					Freightage	I6

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]: Supplier-S1

	Negotiation Issue	Absolutely		Strongly		Weakly		Equal	Weakly		Strongly		Absolutely		Negotiation Issue	
		7	6	5	4	3	2	1	2	3	4	5	6	7		
I1	Price	/													Payment Term	I2
I1	Price	/													Payment Period	I3
I1	Price	/													Advance Payment	I4
I1	Price		/												Delivery	I5
I1	Price		/												Freightage	I6
I2	Payment Term					/									Payment Period	I3
I2	Payment Term						/								Advance Payment	I4
I2	Payment Term								/						Delivery	I5
I2	Payment Term								/						Freightage	I6
I3	Payment Period						/								Advance Payment	I4
I3	Payment Period								/						Delivery	I5
I3	Payment Period									/					Freightage	I6
I4	Advance Payment								/						Delivery	I5
I4	Advance Payment									/					Freightage	I6
I5	Delivery								/						Freightage	I6

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]: Supplier-S2

	Negotiation Issue	Absolutely		Strongly		Weakly		Equal	Weakly		Strongly		Absolutely		Negotiation Issue	
		7	6	5	4	3	2	1	2	3	4	5	6	7		
I1	Price	/													Payment Term	I2
I1	Price	/													Payment Period	I3
I1	Price	/													Advance Payment	I4
I1	Price		/												Delivery	I5
I1	Price			/											Freightage	I6
I2	Payment Term					/									Payment Period	I3
I2	Payment Term					/									Advance Payment	I4
I2	Payment Term								/						Delivery	I5
I2	Payment Term								/						Freightage	I6
I3	Payment Period						/								Advance Payment	I4
I3	Payment Period								/						Delivery	I5
I3	Payment Period								/						Freightage	I6
I4	Advance Payment									/					Delivery	I5
I4	Advance Payment								/						Freightage	I6
I5	Delivery								/						Freightage	I6

AHP: READY MIX CONCRETE [Normal Mix - Grade 35, Granite]: Contractor

Negotiation Issue	I1	I2	I3	I4	I5	I6	Multiply	n^{th} Root	Normalize
I1	1.00	7.00	6.00	6.00	5.00	5.00	6300.000	4.298	0.52
I2	0.14	1.00	3.00	2.00	2.00	2.00	3.429	1.228	0.15
I3	0.17	0.33	1.00	3.00	2.00	2.00	0.667	0.935	0.11
I4	0.17	0.50	0.33	1.00	2.00	2.00	0.111	0.693	0.08
I5	0.20	0.50	0.50	0.50	1.00	0.50	0.013	0.482	0.06
I6	0.20	0.50	0.50	0.50	2.00	1.00	0.050	0.607	0.07
							SUM	8.24	1.00

$$\begin{Bmatrix} 1.00 & 7.00 & 6.00 & 6.00 & 5.00 & 5.00 \\ 0.14 & 1.00 & 3.00 & 2.00 & 2.00 & 2.00 \\ 0.17 & 0.33 & 1.00 & 3.00 & 2.00 & 2.00 \\ 0.17 & 0.50 & 0.33 & 1.00 & 2.00 & 2.00 \\ 0.20 & 0.50 & 0.50 & 0.50 & 1.00 & 0.50 \\ 0.20 & 0.50 & 0.50 & 0.50 & 2.00 & 1.00 \end{Bmatrix} \text{ X } \begin{Bmatrix} 0.52 \\ 0.15 \\ 0.11 \\ 0.08 \\ 0.06 \\ 0.07 \end{Bmatrix} = \begin{Bmatrix} 3.41 \\ 1.00 \\ 0.77 \\ 0.55 \\ 0.37 \\ 0.47 \end{Bmatrix} = \begin{Bmatrix} 6.540 \\ 6.686 \\ 6.759 \\ 6.508 \\ 6.378 \\ 6.356 \end{Bmatrix}$$

Average, λ_{max} =	6.538
Consistency Index, C.I. =	0.108
where n = 7, then Ratio Index, R.I. =	1.24
Consistency Ratio, C.R. =	0.0868

AHP: READY MIX CONCRETE [Normal Mix - Grade 35, Granite]: Supplier-S1

Negotiation Issue	I1	I2	I3	I4	I5	I6	Multiply	n^{th} Root	Normalize
I1	1.00	7.00	7.00	7.00	6.00	6.00	12348.000	4.808	0.55
I2	0.14	1.00	3.00	2.00	0.50	0.50	0.214	0.774	0.09
I3	0.14	0.33	1.00	2.00	0.50	0.33	0.016	0.501	0.06
I4	0.14	0.50	0.50	1.00	0.50	0.33	0.006	0.426	0.05
I5	0.17	2.00	2.00	2.00	1.00	0.50	0.667	0.935	0.11
I6	0.17	2.00	3.00	3.00	2.00	1.00	6.000	1.348	0.15
							SUM	8.79	1.00

$$\begin{Bmatrix} 1.00 & 7.00 & 7.00 & 7.00 & 6.00 & 6.00 \\ 0.14 & 1.00 & 3.00 & 2.00 & 0.50 & 0.50 \\ 0.14 & 0.33 & 1.00 & 2.00 & 0.50 & 0.33 \\ 0.14 & 0.50 & 0.50 & 1.00 & 0.50 & 0.33 \\ 0.17 & 2.00 & 2.00 & 2.00 & 1.00 & 0.50 \\ 0.17 & 2.00 & 3.00 & 3.00 & 2.00 & 1.00 \end{Bmatrix} \text{ X } \begin{Bmatrix} 0.55 \\ 0.09 \\ 0.06 \\ 0.05 \\ 0.11 \\ 0.15 \end{Bmatrix} = \begin{Bmatrix} 3.46 \\ 0.56 \\ 0.37 \\ 0.30 \\ 0.66 \\ 0.95 \end{Bmatrix} = \begin{Bmatrix} 6.325 \\ 6.408 \\ 6.411 \\ 6.264 \\ 6.217 \\ 6.192 \end{Bmatrix}$$

Average, λ_{max} = 6.303

Consistency Index, C.I. = 0.061

where n = 7, then Ratio Index, R.I. = 1.24

Consistency Ratio, C.R. = 0.0489

AHP: READY MIX CONCRETE [Normal Mix - Grade 35, Granite]: Supplier-S2

Negotiation Issue	I1	I2	I3	I4	I5	I6	Multiply	n^{th} Root	Normalize
I1	1.00	7.00	7.00	7.00	6.00	5.00	10290.000	4.664	0.54
I2	0.14	1.00	3.00	3.00	0.50	0.50	0.321	0.828	0.10
I3	0.14	0.33	1.00	2.00	0.50	0.50	0.024	0.536	0.06
I4	0.14	0.33	0.50	1.00	0.33	0.50	0.004	0.398	0.05
I5	0.17	2.00	2.00	3.00	1.00	0.50	1.000	1.000	0.12
I6	0.20	2.00	2.00	2.00	2.00	1.00	3.200	1.214	0.14
							SUM	8.64	1.00

$$\begin{Bmatrix} 1.00 & 7.00 & 7.00 & 7.00 & 6.00 & 5.00 \\ 0.14 & 1.00 & 3.00 & 3.00 & 0.50 & 0.50 \\ 0.14 & 0.33 & 1.00 & 2.00 & 0.50 & 0.50 \\ 0.14 & 0.33 & 0.50 & 1.00 & 0.33 & 0.50 \\ 0.17 & 2.00 & 2.00 & 3.00 & 1.00 & 0.50 \\ 0.20 & 2.00 & 2.00 & 2.00 & 2.00 & 1.00 \end{Bmatrix} \text{ X } \begin{Bmatrix} 0.54 \\ 0.10 \\ 0.06 \\ 0.05 \\ 0.12 \\ 0.14 \end{Bmatrix} = \begin{Bmatrix} 3.36 \\ 0.63 \\ 0.39 \\ 0.29 \\ 0.73 \\ 0.89 \end{Bmatrix} = \begin{Bmatrix} 6.232 \\ 6.529 \\ 6.304 \\ 6.405 \\ 6.306 \\ 6.319 \end{Bmatrix}$$

Average, λ_{max} = 6.349

Consistency Index, C.I. = 0.070

where n = 7, then Ratio Index, R.I. = 1.24

Consistency Ratio, C.R. = 0.0563

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Price Issue

Contractor	P_{min}	A_{min}	D_{min}	D_{max}	A_{max}	P_{max}
Pay-off		39	52	49.4	20.8	
Option		180	190	207	210	

Supplier-S1	P'_{min}	A'_{min}	D'_{min}	D'_{max}	A'_{max}	P'_{max}
Pay-off		16.5	44	52.25	55	
Option		205	220	250	300	

Supplie-S2	A''_{min}	D''_{min}	D''_{max}	A''_{max}	P''_{max}	A''_{min}
Pay-off		21.6	40.5	48.6	54	
Option		204	220	240	290	

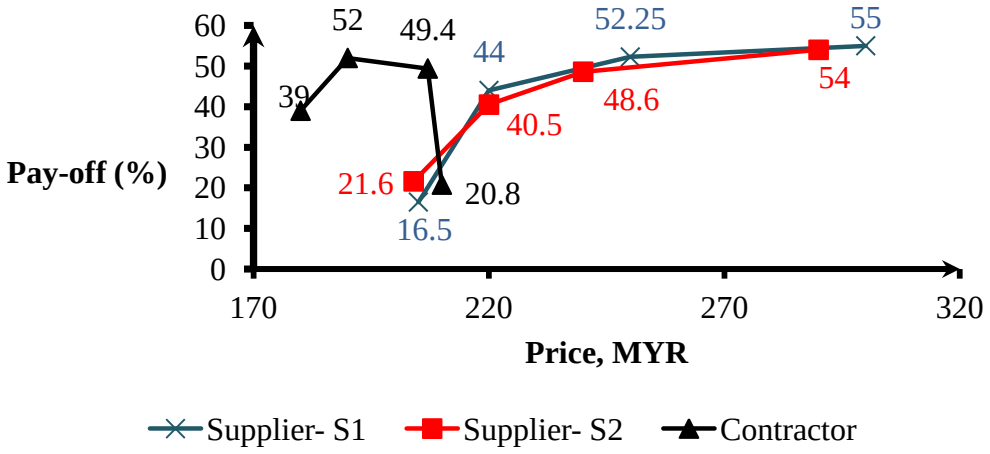


Figure: Price Issue

Single Benefit-Supplier

Point	Option (MYR)	Contractor Pay-off, %	Pay-off, %	Joint Pay-off
Supplier-S1	210.00	20.80	25.67	46.47
Supplier-S2	210.00	20.80	28.69	49.49

Single Benefit-Contractor

Point	Option (MYR)	Supplier Pay-off, %	Pay-off, %	Joint Pay-off
Concractor & S1	205.00	16.50	49.71	66.21
Concractor & S2	204.00	21.60	49.86	71.46

Both benefit

Point	Option (MYR)	Pay-off, %	Joint Pay-off
Intercept price Contractor & S1	209.57	24.88	49.76
Intercept price Contractor & S2	209.26	27.82	55.64

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Payment Term Issue

Option		Cash	30-day check	45-day check	60-day check
Supplier-S1	**Pay-off**	9	7.2	6.75	4.5
Supplier-S2	**Pay-off**	10	9	7	4
Contractor	**Pay-off**	4.5	9	12	15

Option		Cash	30-day check	45-day check	60-day check
Joint-1	**Pay-off**	13.5	16.2	18.75	19.5
Joint-2	**Pay-off**	14.5	18	19	19

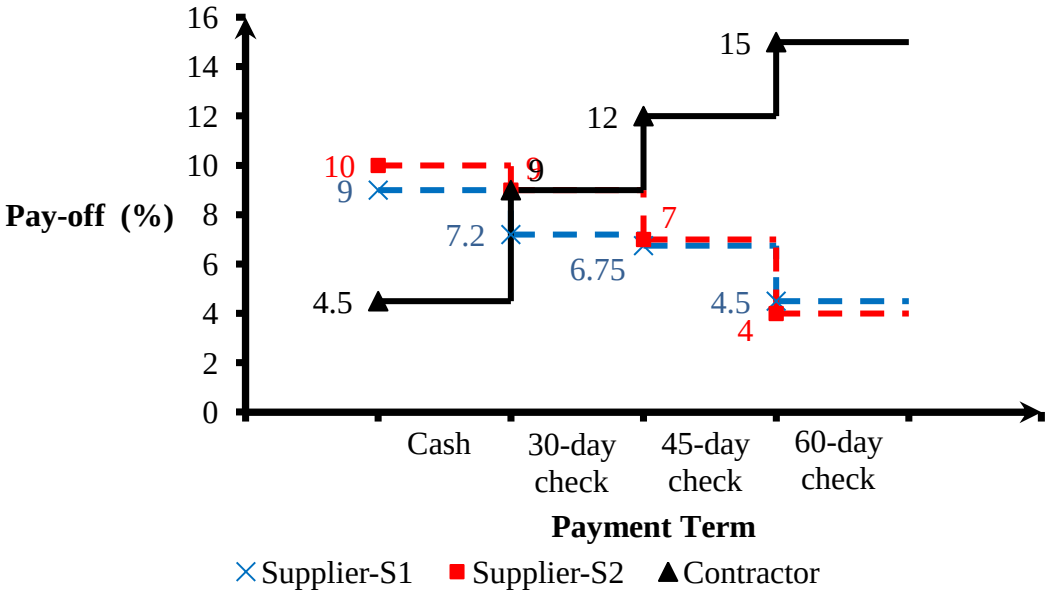


Figure: Payment Term Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Cash	9	4.5	13.5
Supplier-S2	Cash	10	4.5	14.5

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	60-day check	15	4.5	19.5
Contractor & S2	60-day check	15	4	19

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	30-day check	9	7.2	16.2
Both-2	30-day check	9	9	18

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Payment Period Issue

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Supplier-S1	**Pay-off**	6	4.8	3.6	2.4	1.2
Supplier-S2	**Pay-off**	6	4.2	3.6	2.1	1.2
Contractor	**Pay-off**	3.3	5.5	7.7	9.9	11

Option		On Delivery	On Completion of Milestone	On Completion	Bi Weekly	Monthly
Joint-1	**Pay-off**	9.3	10.3	11.3	12.3	12.2
Joint-2	**Pay-off**	9.3	9.7	11.3	12	12.2

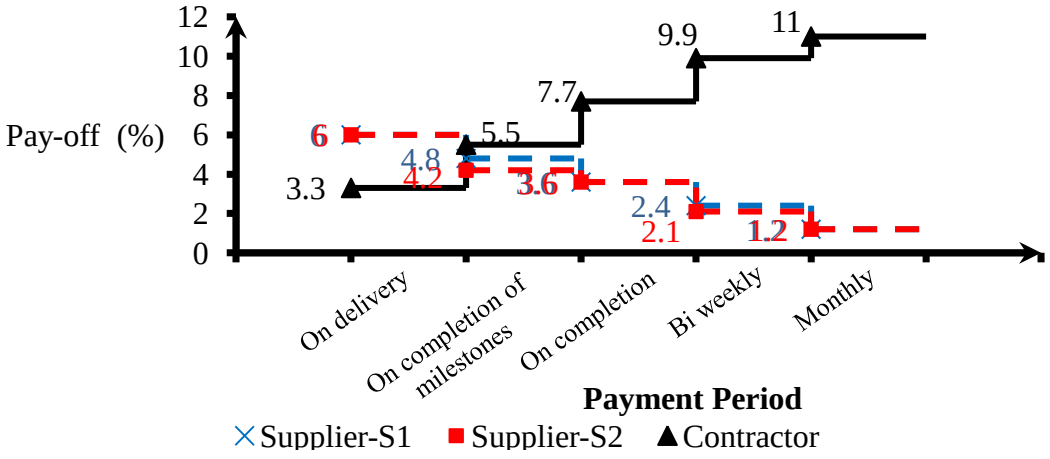


Figure: Payment Period Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	On Delivery	6	3.3	9.3
Supplier-S2	On Delivery	6	3.3	9.3

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Monthly	11	1.2	12.2
Contractor & S2	Monthly	11	1.2	12.2

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	On Completion of Milestone	5.5	4.8	10.3
Both-2	On Completion of Milestone	5.5	4.2	9.7

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Advance Payment Issue

Option		10%	15%	20%	25%	30%
Supplier-S1	**Pay-off**	2	3.5	4	4.5	5
Supplier-S2	**Pay-off**	1.75	3	3.5	4.25	5
Contractor	**Pay-off**	8	7.2	6.4	4.8	2.4

Option		10%	15%	20%	25%	30%
Joint-1	**Pay-off**	10	10.7	10.4	9.3	7.4
Joint-2	**Pay-off**	9.75	10.2	9.9	9.05	7.4

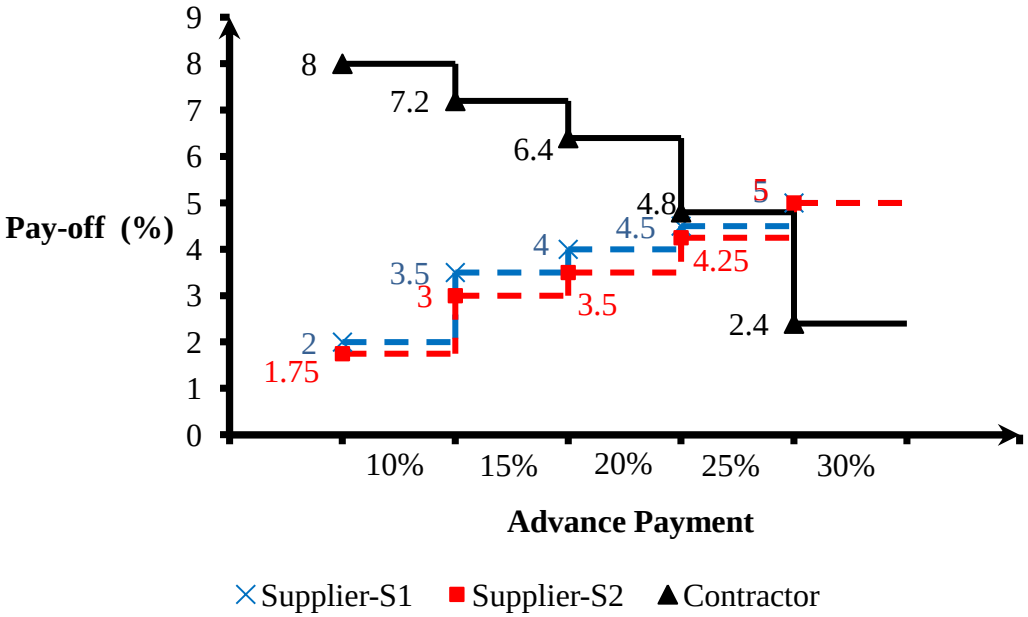


Figure: Advance Payment Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	0.3	5	2.4	7.4
Supplier-S2	0.3	5	2.4	7.4

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	0.1	8	2	10
Contractor & S2	0.1	8	1.75	9.75

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	0.25	4.8	4.5	9.3
Both-2	0.25	4.8	4.25	9.05

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Delivery Issue

Option		Single Delivery	Multiple Delivery	On Call Delivery
Supplier-S1	**Pay-off**	11	6.6	2.2
Supplier-S2	**Pay-off**	12	7.2	1.2
Contractor	**Pay-off**	2.4	4.2	6

Option		Single Delivery	Multiple Delivery	On Call Delivery
Joint-1	**Pay-off**	13.4	10.8	8.2
Joint-2	**Pay-off**	14.4	11.4	7.2

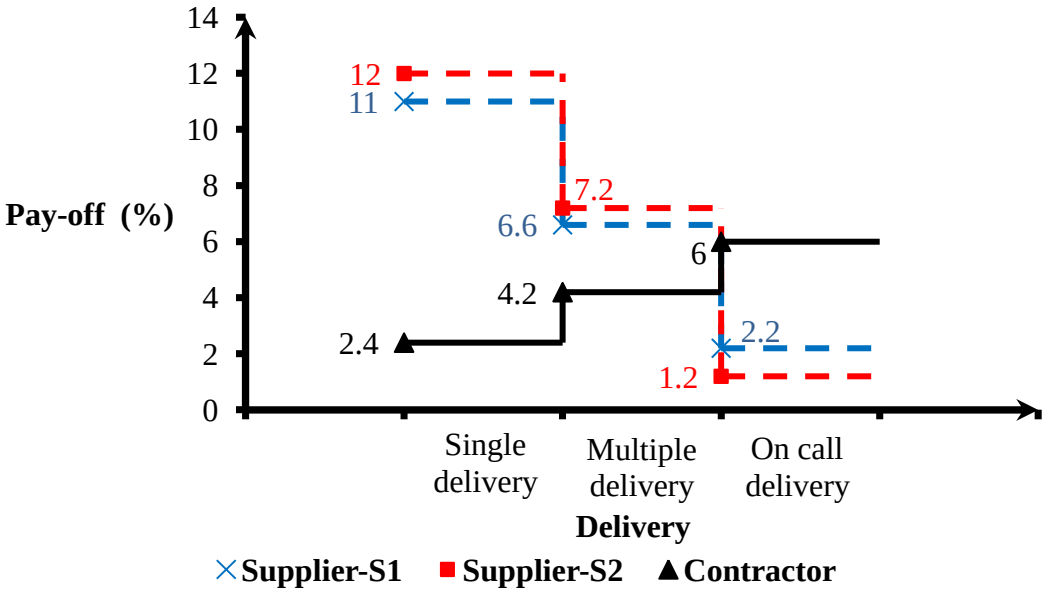


Figure: Delivery Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Single Delivery	11	2.4	13.4
Supplier-S2	Single Delivery	12	2.4	14.4

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	On Call Delivery	6	2.2	8.2
Contractor & S2	On Call Delivery	6	1.2	7.2

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Multiple Delivery	4.2	6.6	10.8
Both-2	Multiple Delivery	4.2	7.2	11.4

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]:

Freightage Issue

Option		Included	Excluded
Supplier-S1	**Pay-off**	6	15
Supplier-S2	**Pay-off**	5.6	14
Contractor	**Pay-off**	7	1.4

Option		Included	Excluded
Joint-1	**Pay-off**	13	16.4
Joint-2	**Pay-off**	12.6	15.4

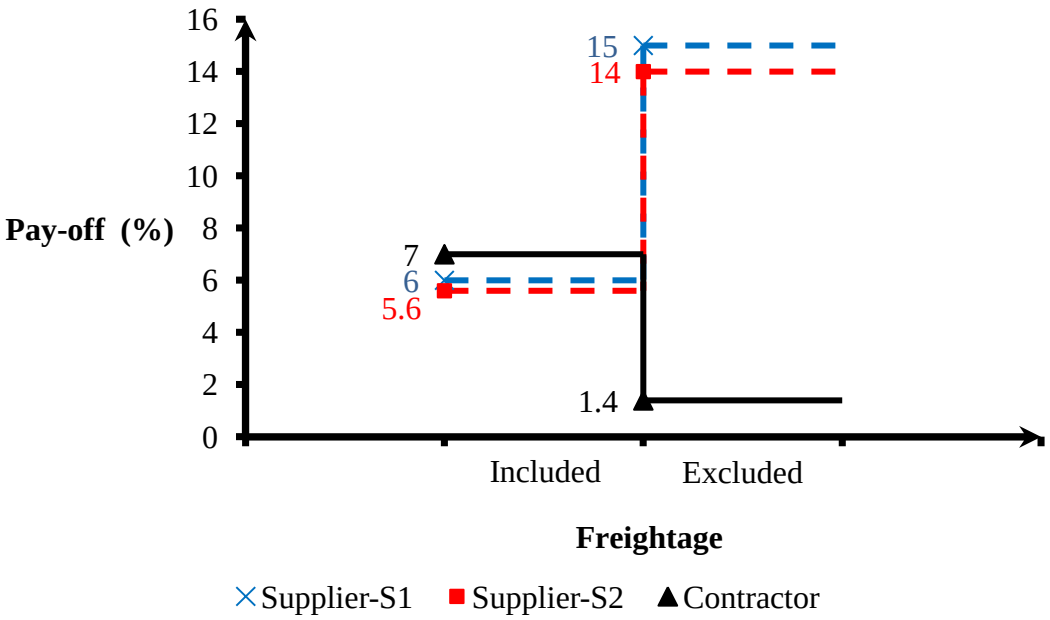


Figure: Freightage Issue

Single Benefit-Supplier

Benefit	Option	Single Pay-off	Contractor	Joint Pay-off
Supplier-S1	Excluded	15	1.4	16.4
Supplier-S2	Excluded	14	1.4	15.4

Single Benefit-Contractor

Benefit	Option	Single Pay-off	Supplier	Joint Pay-off
Contractor & S1	Included	7	6	13
Contractor & S2	Included	7	5.6	12.6

Both benefit

Benefit	Option	Contractor	Supplier	Joint Pay-off
Both-1	Included	7	6	13
Both-2	Included	7	5.6	12.6

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S1
(TOTAL JOIN PAY-OFF)

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	66.21	19.5	12.2	10	8.2	13	129.11
Both	49.76	19.5	12.2	10	8.2	13	112.66
Supplier	46.47	19.5	12.2	10	8.2	13	109.37

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	66.21	16.2	10.3	9.3	10.8	13	125.81
Both	49.76	16.2	10.3	9.3	10.8	13	109.36
Supplier	46.47	16.2	10.3	9.3	10.8	13	106.07

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	66.21	13.5	9.3	7.4	13.4	16.4	126.21
Both	49.76	13.5	9.3	7.4	13.4	16.4	109.76
Supplier	46.47	13.5	9.3	7.4	13.4	16.4	106.47

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S1
(TOTAL SINGLE PAY-OFF)

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	16.50	4.5	1.2	2	2.2	6	32.40
Contractor & S1	49.71	15	11	8	6	7	96.71
Supplier-S1	24.88	4.5	1.2	2	2.2	6	40.78
Contractor & S1	24.88	15	11	8	6	7	71.88
Supplier-S1	25.67	4.5	1.2	2	2.2	6	41.57
Contractor & S1	20.80	15	11	8	6	7	67.80

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	16.50	7.2	4.8	4.5	6.6	6	45.60
Contractor & S1	49.71	9	5.5	4.8	4.2	7	80.21
Supplier-S1	24.88	7.2	4.8	4.5	6.6	6	53.98
Contractor & S1	24.88	9	5.5	4.8	4.2	7	55.38
Supplier-S1	25.67	7.2	4.8	4.5	6.6	6	54.77
Contractor & S1	20.80	9	5.5	4.8	4.2	7	51.30

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	16.50	9	6	5	11	15	62.50
Contractor & S1	49.71	4.5	3.3	2.4	2.4	1.4	63.71
Supplier-S1	24.88	9	6	5	11	15	70.88
Contractor & S1	24.88	4.5	3.3	2.4	2.4	1.4	38.88
Supplier-S1	25.67	9	6	5	11	15	71.67
Contractor & S1	20.80	4.5	3.3	2.4	2.4	1.4	34.80

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S1
(OPTION JOIN PAY-OFF)

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	205.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	209.57	30-day check	On Completion of Milestone	0.25	Multiple Delivery	Included
Supplier	210.00	Cash	On Delivery	0.3	Single Delivery	Excluded

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S2
(TOTAL JOIN PAY-OFF)

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	71.46	19	12.2	9.75	7.2	12.6	132.21
Both	55.64	19	12.2	9.75	7.2	12.6	116.39
Supplier	49.49	19	12.2	9.75	7.2	12.6	110.24

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	71.46	18	9.7	9.05	11.4	12.6	132.21
Both	55.64	18	9.7	9.05	11.4	12.6	116.39
Supplier	49.49	18	9.7	9.05	11.4	12.6	110.24

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Joint Pay-off
Contractor	71.46	14.5	9.3	7.4	14.4	15.4	132.46
Both	55.64	14.5	9.3	7.4	14.4	15.4	116.64
Supplier	49.49	14.5	9.3	7.4	14.4	15.4	110.49

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S2
(TOTAL SINGLE PAY-OFF)

Price Benefit to		Contractor Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	21.60	4	1.2	1.75	1.2	5.6	35.35
Contractor & S2	49.86	15	11	8	6	7	96.86
Supplier-S2	27.82	4	1.2	1.75	1.2	5.6	41.57
Contractor & S2	27.82	15	11	8	6	7	74.82
Supplier-S2	28.69	4	1.2	1.75	1.2	5.6	42.44
Contractor & S2	20.80	15	11	8	6	7	67.80

Price Benefit to		Both Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	21.60	9	4.2	4.25	7.2	5.6	51.85
Contractor & S2	49.86	9	5.5	4.8	4.2	7	80.36
Supplier-S2	27.82	9	4.2	4.25	7.2	5.6	58.07
Contractor & S2	27.82	9	5.5	4.8	4.2	7	58.32
Supplier-S2	28.69	9	4.2	4.25	7.2	5.6	58.94
Contractor & S2	20.80	9	5.5	4.8	4.2	7	51.30

Price Benefit to		Supplier Benefit					
		Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	21.60	10	6	5	12	14	68.60
Contractor & S2	49.86	4.5	3.3	2.4	2.4	1.4	63.86
Supplier-S2	27.82	10	6	5	12	14	74.82
Contractor & S2	27.82	4.5	3.3	2.4	2.4	1.4	41.82
Supplier-S2	28.69	10	6	5	12	14	75.69
Contractor & S2	20.80	4.5	3.3	2.4	2.4	1.4	34.80

READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S2
(OPTION JOIN PAY-OFF)

Benefit for	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor	204.00	60-day check	Monthly	0.1	On Call Delivery	Included
Both	209.26	30-day check	On Completion of Milestone	0.25	Multiple Delivery	Included
Supplier	210.00	Cash	On Delivery	0.3	Single Delivery	Excluded

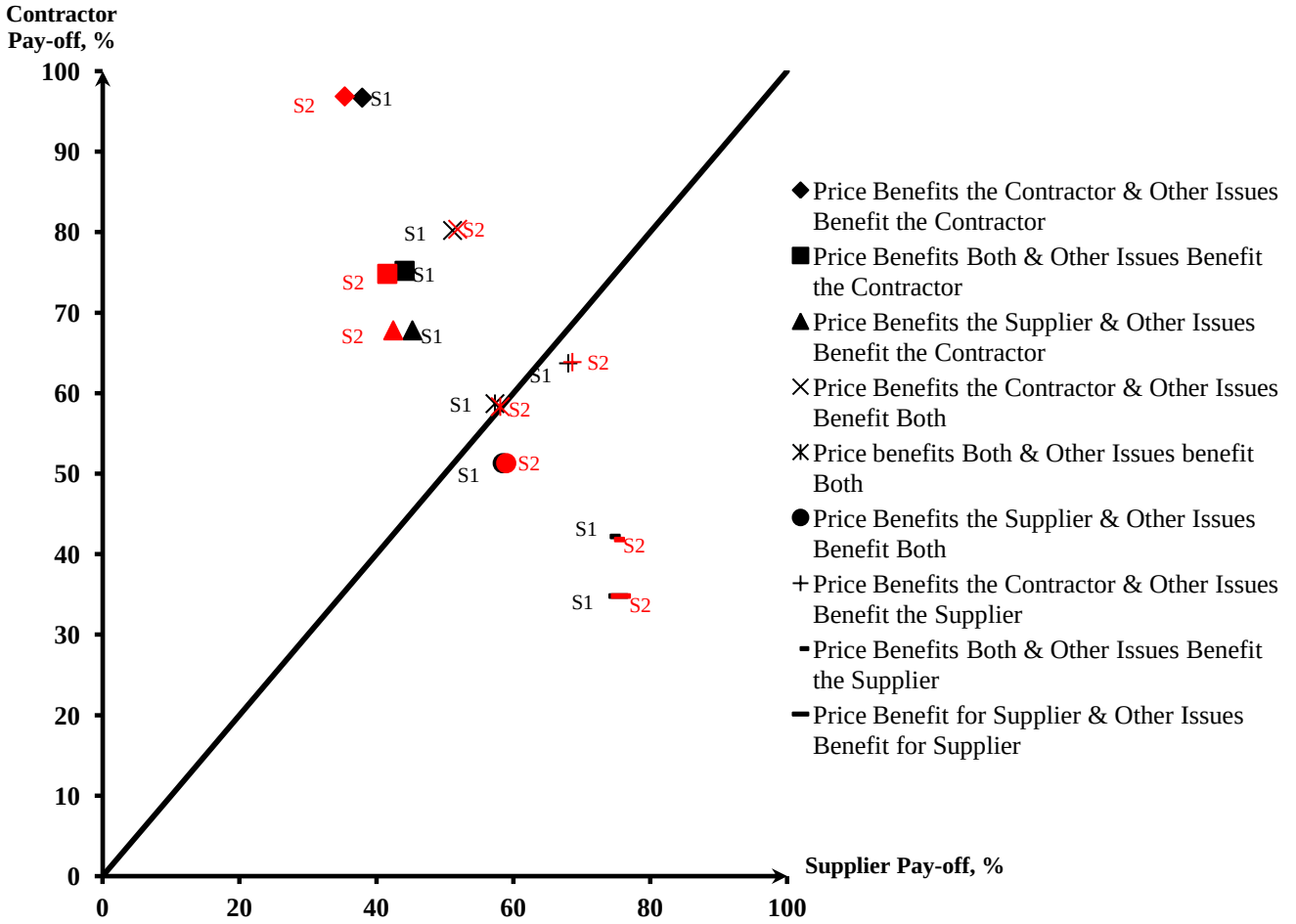


Figure: Optimization Joint Pay-off–(READY MIX CONCRETE [Normal Mix - Grade 35, Granite])

ACTUAL: READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S1 (TOTAL SINGLE PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Single Pay-off/6
Supplier-S1	53.33	75	60	70	60	40	358.33	59.72
Contractor & S1	40.00	80	70	90	70	100	450.00	75.00

ACTUAL: READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S1 (OPTION JOIN PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S1	210.00	45-day check	On Completion	0.15	Multiple Delivery	Included

ACTUAL: READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S2 (TOTAL SINGLE PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off	Total Single Pay-off/6
Supplier-S2	53.13	70	60	60	60	40	343.13	57.19
Contractor & S2	40.00	80	70	90	70	100	450.00	75.00

ACTUAL: READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S2 (OPTION JOIN PAY-OFF) – Without weight

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S2	210.00	45-day check	On Completion	0.15	Multiple Delivery	Included

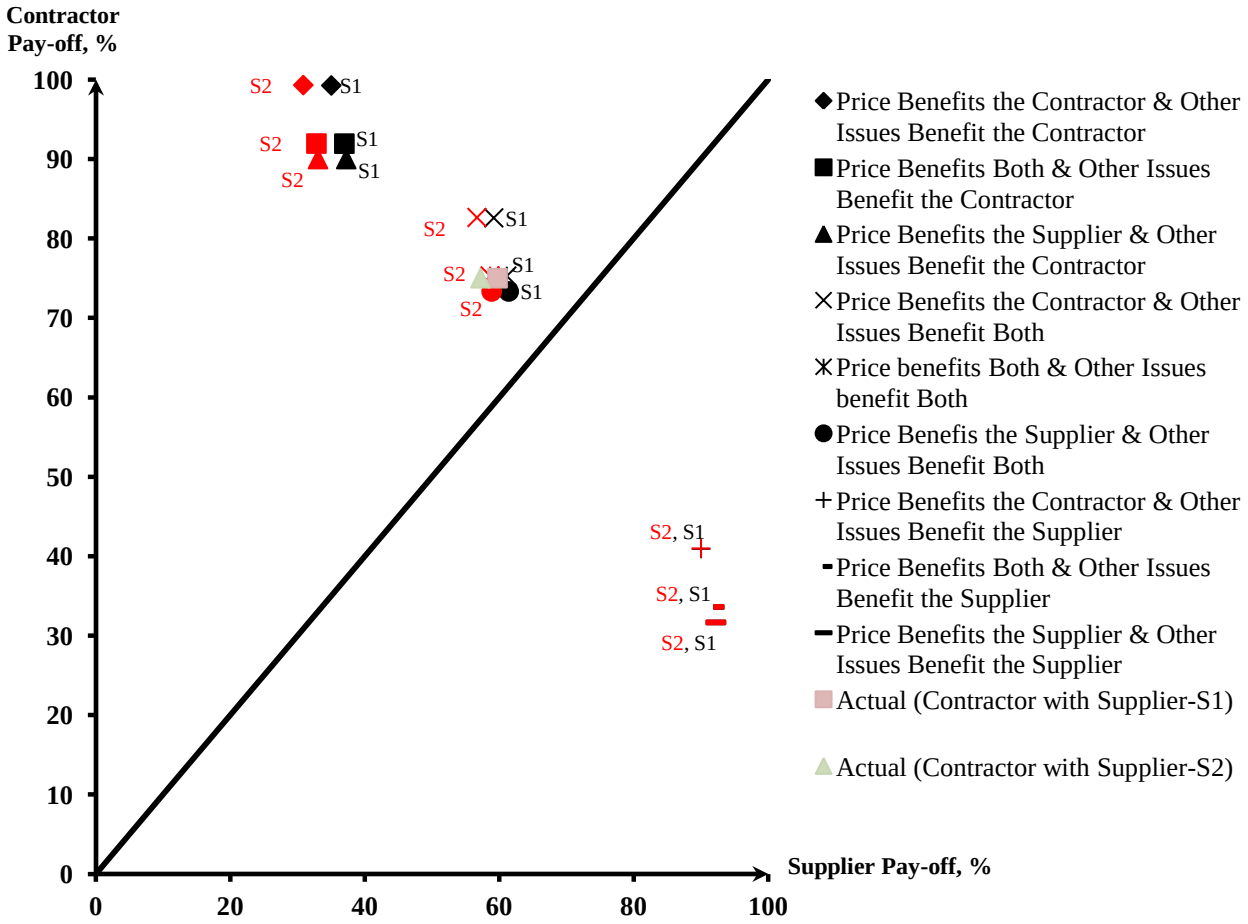


Figure: Actual Optimization Joint Pay-off – (READY MIX CONCRETE [Normal Mix - Grade 35, Granite]) – Without weig

ACTUAL: READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S1 (TOTAL SINGLE PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S1	29.33	6.75	3.6	3.5	6.6	6	55.78
Contractor & S1	20.80	12	7.7	7.2	4.2	7	58.90

ACTUAL: READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S1 (OPTION JOIN PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S1	210.00	45-day check	On Completion	0.15	Multiple Delivery	Included

ACTUAL: READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S2 (TOTAL SINGLE PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage	Total Single Pay-off
Supplier-S2	28.69	7	3.6	3	7.2	5.6	55.09
Contractor & S2	20.80	12	7.7	7.2	4.2	7	58.90

ACTUAL: READY MIX CONCRETE [Normal Mix - Grade 35, Granite]
Summary Contractor and Supplier-S2 (OPTION JOIN PAY-OFF)

Party	Price	Payment Term	Payment Period	Advance Payment	Delivery	Freightage
Contractor & S2	210.00	45-day check	On Completion	0.15	Multiple Delivery	Included

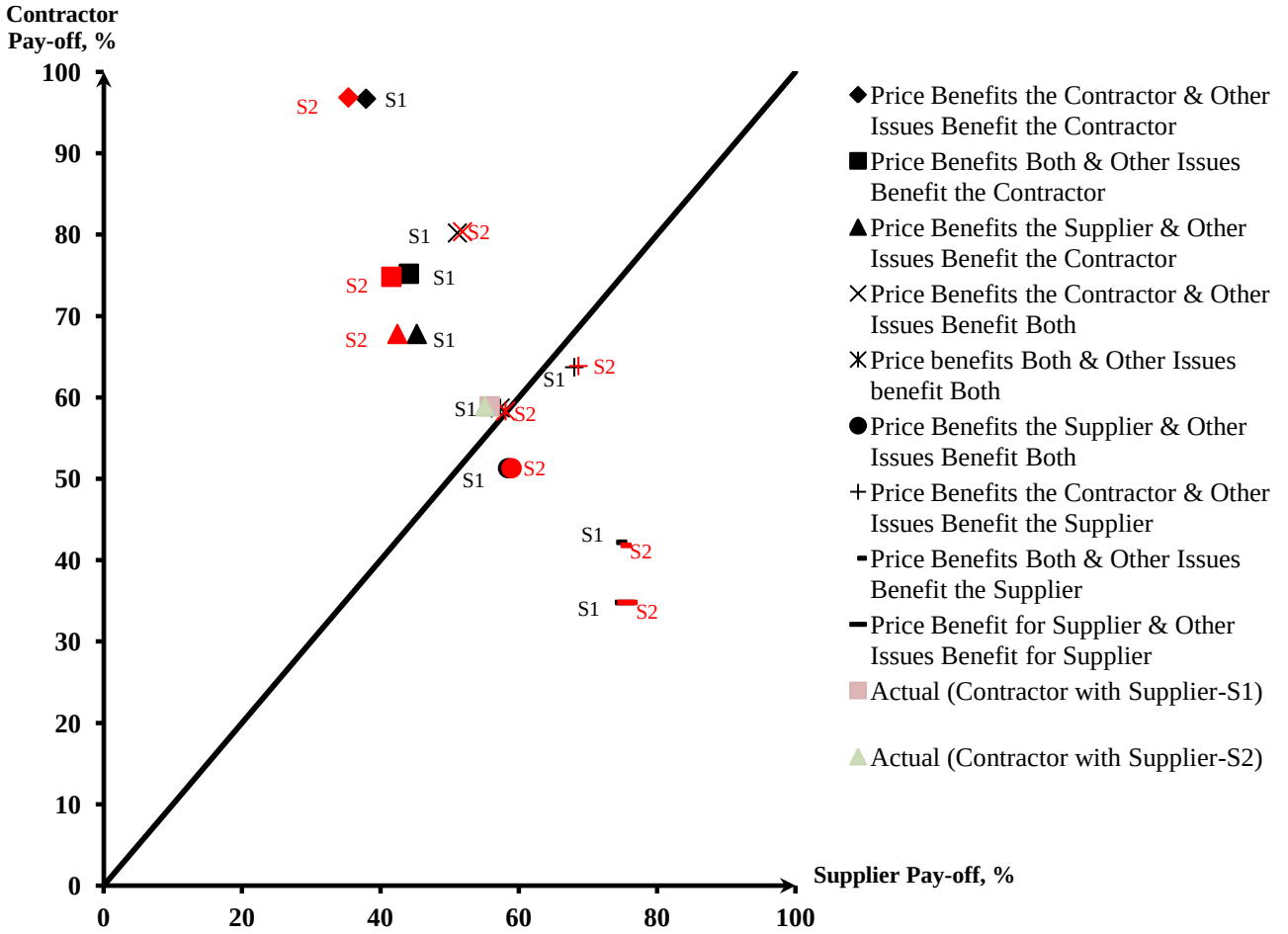


Figure: Actual Optimization Joint Pay-off – (READY MIX CONCRETE [Normal Mix - Grade 35, Granite])

BIOGRAPHY

Rafiuddin was born in 1988 in state of Perak, Malaysia. He finished high school in 2005 at MARA Junior Science College in Penang state. In the same year, he continues his study to Kolej Matrikulasi Perak and passed the entrance exam to pursue his study at the Universiti Sains Malaysia where he earned his Bachelor of Civil Engineering in 2011. He studied in School of Civil Engineering, Universiti Sains Malaysia. Soon after he graduated, he was awarded AUN/SEED-Net scholarship to continue his Master's study in field of construction engineering and management, Department of Civil Engineering, Faculty of Engineering, Chulalongkorn University, Thailand in 2011. Upon graduation, he would like to improve the material procurement in Malaysia construction industry. The mission is to make sure each party such as the contractor and the supplier could work efficiently in the construction project.