Decision-making Criteria for Software Requirements Selection: An Empirical Study in China

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Originality Statement

I hereby declare that this submission is my own work and to the best of my knowledge it contains no materials previously published or written by another person, or substantial proportions of material which have been accepted for the award of any other degree or diploma at UNSW or any other educational institution, except where due acknowledgement is made in the thesis. Any contribution made to the research by others, with whom I have worked at UNSW or elsewhere, is explicitly acknowledged in the thesis. I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in the project's design and conception or in style, presentation and linguistic expression is acknowledged.

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Abstract

This study aims to explore the decision-making criteria for requirements selection in market-driven software development projects in China. Requirements selection decisions are made by reconciling the conflicting stakeholders' value propositions into a mutually-agreed set through the negotiation and communication process between stakeholders. Firstly, this study identified decision-making criteria according to different stakeholders' value propositions, and then evaluated the importance of the criteria when making the decisions of requirements selection. Moreover, the study determined the degree to which the stakeholders from business, product, and project perspectives influence the decision-making process. Furthermore, the study explored the communication between major stakeholders in requirements selection process, as a foundation to support and guide the process.

A Delphi survey was applied in this study. Opinions from experienced industrial experts were obtained to achieve reliable consensus among them on the criteria and relative importance of the criteria in requirements selection process. The Delphi survey in this study included four phases of data collection by a series of intensive questionnaires interspersed with controlled opinion feedback and follow-up interviews. 132 Experts from 11 companies were recruited by following the rigid procedure to ensure the validity and reliability of the research.

The study indicated that criteria from the business perspective had a major influence on decision-making of requirements selection, while project- and product-perspective criteria were relatively lower in priority. However, there were some inconsistencies among the opinions of the recruited experts regarding the importance of the criteria. The inconsistencies may result from a number of different factors, for example; different software development projects; different size, culture, organizational structure or maturity level of the companies; or different working positions of the

experts surveyed.

In addition, the study found three different types of communication in requirements selection in the companies surveyed. Further, Chinese culture was believed to have effects on the communication process between stakeholders. While informal communication was highlighted in Chinese context, the Chinese culture of strictly hierarchical communication could lead to problems in the communication process. Further research is recommended to gain deeper insight into these issues.

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1 Introduction

1.1 Preliminary

Many software companies have large databases concerning requirements put on their software products. In order to manage the abundance of requirements, it is essential to select requirements to be actually implemented in a specific software release (Wohlin and Aurum 2005A).

Requirements selection is an important and complex process in software development. The requirements that are selected to be implemented will have a crucial impact on the final value of software product and the satisfaction of stakeholders. Meanwhile, the requirements selection is in itself a complicated decision-making process with numerous uncertainties. First, achievement of one requirement can contribute negatively or positively to the achievements of others (Chung *et al.* 1999), so the interdependency between software requirements should be taken into account in the selection process. Secondly, different stakeholders always have different or even incompatible value propositions with regard to requirements. It is difficult to decide which requirements should be selected based on the various preferences of stakeholders. Communication between stakeholders to elicit and reconcile their value propositions is, therefore, essential for requirements selection. For example, the customer is a major stakeholder as far as software development is concerned. Hence, it is necessary to consider market analysis about what customers need in the requirements selection process (Freire *et al.* 2005). It is generally accepted that business personnel's attention focuses on business strategy and the external market, while technical issues in the software development process constitutes technical personnel's main concern. Thus, communication between business personnel like executives and product managers and technical personnel such as software development group members also plays an important part in the decision-making

process with regard to requirements. Good communication will enable the two groups of personnel to learn from each other's strong points and thus to offset their weak ones.

In practice, people always make their decisions of requirements selection based on their past experience, which may lack valid support (Aurum and Wohlin 2005A). In most cases, the criteria for requirements selection are not officially and explicitly stated, but they are implicitly used by decision-makers. Decisions made without explicit consideration can be damaging to the accuracy and efficiency of selecting requirements. In some international companies, requirements selection decisions are often made by the branches without consulting headquarters (Takeda 1998). The lack of communication between them will lead to unilateral and possibly inaccurate decisions, and may ultimately result in the failure of software development and its market acceptance.

Therefore, for successful requirements selection it is important to understand and support the decision-making process leading up to it. The objective of this research is to investigate the underlying decision-making criteria for including certain software requirements in software development projects. Also under investigation is the communication between business personnel and technical personnel involved in the process. The study is the first step to get a good understanding of the underlying decision-making process to consequently support for requirements selection in the best possible way (Wohlin and Aurum 2005A).

This study concentrates on market-driven software development projects that develop or generalize the software product for a market rather than projects for one or a few particular customers. Market-driven projects always apply iterative and incremental development processes and release several versions of software to advance software delivery to fast-developing markets (Barney *et al.* 2006). Time pressure and lack of access to customers make requirements selection even more complex and essential for

market-driven software.

This study adopted Delphi survey as its research method. The Delphi method was designed to elicit the opinion of industry experts through iteratively controlled feedback. Data was collected from industry experts who were involved in market-driven software development projects in 11 national and international companies in China. The collected data included quantitative data obtained through three-phase questionnaires as well as qualitative data obtained through follow-up interviews.

1.2 Rationale

Software development companies face incredible pressure under the present fierce competition in software industry. In order to achieve and sustain competitive advantage, the companies have to shift their emphases from the software product itself to the value it provides (Aurum and Wohlin, 2005A). This shift leads to the evolution of value-based software engineering (VBSE).

The need for a value-based approach to software development has been emphasized by several researchers (Boehm 2003, Boehm and Sullivan 2000, Favaro *et al.*'s 1998). These researchers introduced the concept of value, which has been discussed in the economics, marketing, and management domains for some time, into software development in their respective research. Marketing researchers find that customers' satisfaction is the core basis for their choice between alternative products from a growing range of suppliers (Kotler 1994). The value and satisfaction level of a product to people depends on the product's attributes, what people pay for the product, and their expectations, which can vary widely between people based on their personal preferences (Besanko *et al.* 2000). The integration of this concept into software development characterizes VBSE, which lays emphasis on the value that software could create. Software development should not only be treated as a technical work,

but also as an investment activity. It must be related to the business goals of software development organizations (Erdogmus *et al*. 2004). With the value-based view, the way for software suppliers to get a competitive advantage is to develop software that can best satisfy stakeholders' needs and expectations.

Value-based requirements engineering (VBRE), as the first element of the VBSE agenda proposed by Boehm (2003), plays a major role in the execution of business strategy and the creation of software value (Favaro 2002). Theory W, which is a core theory in VBSE proposed by Boehm and Ross (1989), suggests that satisfying all the stakeholders with a software product is the only way for a software project to be successful. The software development process, as a complex social process, involves many stakeholders, including developers, customers, and users. Eliciting stakeholders' value propositions and then reconciling them into a mutually-agreed set is an integral element of VBSE (Boehm 2005). In essence, requirements engineering is the process of transforming stakeholders' needs into software requirements which are then implemented into software products (Aurum and Wohlin 2003). The requirements engineering process will directly or indirectly affect the value creation of organizations in which software is developed (Boehm and Sullivan 2000). Therefore, requirements engineering is one of the fundamental activities of value creation in the software development process.

Requirements selection, as a major activity in the requirements selection process, becomes a powerful way of creating and controlling the value of software (Wohlin and Aurum 2005 B). Thus, it is important to discover which requirements should be implemented and which requirements could be postponed to later implementation or even rejected. Regnell *et al.* (2001), Wohlin and Aurum (2005A), Barney (2005), and Barney *et al.* (2006) began to focus on the decision-making criteria for requirements selection and the value created by this process. This study follows their steps to explore the decision-making process of requirements selection in market-driven software companies in China and with a larger data set. To the best of the researcher's

knowledge, no empirical studies had ever been conducted to explore the requirements selection criteria in China. This study aims to fill this gap.

Moreover, many Australian and western software companies aim at the large market that exists in China. These international companies face an enormous challenge. Their target markets, software development teams, and executive level people may be located in different countries. This characteristic of a distributed environment makes the communication between stakeholders more difficult and more important, and sometimes involves cultural and language problems (Takeda 1998). Lack of communication may lead to unilateral decision-making not relevant or useful beyond the immediate environment. Thus, it is important to understand and consequently support the communication process in requirements selection. Similarly, it is difficult for international headquarters to control and understand what happen in branches; because of the physical distance, the different culture, and different backgrounds. Western people and companies interested in Chinese markets need to be aware of what is taking place in the software development process in China, and what the similarities and differences are regarding western practices. Thus, it is valuable to explore the requirements selection process in software development projects in China.

1.3 Research objectives and questions

The main objective of this research is to explore the decision-making criteria for software requirements selection in market-driven software development projects, to enable the projects to add value. This research objective can be divided into the four sub-objectives and corresponding research questions as discussed in the following paragraphs.

First, the research aims to identify the underlying decision-making criteria for selecting requirements to be implemented in market-driven software development projects. These criteria correspond to the value propositions of three types of

stakeholders which are categorized into business, project and product perspectives.

Research Question 1: what are the decision-making criteria used for selecting a requirement to be implemented in market-driven software development projects?

Second, the research aims to evaluate the relative importance of the criteria for the decision-making process of requirements selection. Further, the study is to indicate the differences between the practical situation and the ideal situation in terms of the degree of each criterion's importance for requirements selection.

Research Question 2: which criteria are more important for the decision-making process of requirements selection? How does this differ from the industry perception of the ideal application of the criteria?

Third, the study is going to explore the degree to which the value propositions of stakeholders from different categories influence the decision-making process of requirements selection. There are three major categories of stakeholders involved in the development of software, those from business perspective, project perspective, and product perspective respectively. Additionally, the difference between the practical situation and the ideal situation are determined.

Research Question 3: to what degree do the value propositions of major stakeholders influence the requirements selection process? How does this differ from the industry perception of the ideal application of the criteria?

Finally, the study aims to provide an overview and description of the communication and interaction process between different stakeholders, through which the decisions regarding requirements selection are made.

Research Question 4: how do different stakeholders communicate and interact with

each other in the decision-making process of requirements selection in market-driven software development projects?

1.4 Summary of contribution

The contribution of this study is fourfold.

First, the study filled the gap that no empirical study had ever been conducted to explore the requirements selection criteria in China. Meanwhile, the study was conducted with a larger data set than the previous similar studies.

Second, authoritative criteria for decision-making in requirements selection were developed based on the literature reviewed and a Delphi study in China. The resulting authoritative list of criteria could be used to provide a comprehensive checklist to support the decision making process in requirements selection for software development companies.

Third, the practical and ideal importance of the different criteria for decision-making of requirements selection was revealed through the Delphi survey. The results indicated some criteria were, and should be, more important than others when making decisions for requirements selection. Moreover, it was believed that attaching more importance to some criteria in the future would contribute to more effective decision-making. The findings of the different levels of importance of some criteria over others could provide software development companies with useful guidelines for making the best possible requirements selection decisions. Furthermore, different stakeholders, depending on their perspective, had different opinions regarding the importance of different criteria. This indicated some potential communication problems between stakeholders of different perspectives in the companies. Discovering the problems was the initial step to solving the problems. Thus, the study could provide warnings to software companies about those differing opinions and

could also provide a foundation for further research.

Fourth, the study explored the different influence of stakeholders' value propositions from the business, project, and product perspectives on the decision-making process of requirements selection. The results indicated that business-perspective criteria had a major influence on the decision-making of requirements selection both practically and ideally, while project- and product-perspective criteria were relatively in lower priority. Thus, prioritization of the three perspectives; business, project and product, contributes to better understanding and provides a guide for making better requirements selection decisions in practice. In addition, there were some inconsistent opinions between the stakeholders in some companies regarding the importance of the value propositions of different stakeholder groups. The conflicts may affect the decision-making for requirements selection. The companies could take warning from the potential problems presented in the study.

Finally, the study provided an overall picture of the communication between different stakeholders for decision-making in requirements selection. The study categorized three different types of communication in the requirements selection process in companies. In addition, it highlighted the importance of informal communication as well as formal communication. Moreover, the study revealed problems in the communication process between stakeholders. Scarcity of, or invalid communication was shown to lead to unilateral decision-making and potentially incorrect decisions, and ultimately result in the failure of software development. Companies could heed the potential problems in the communication process presented in the study. Furthermore, the study concluded that the Chinese culture of large power distance could be one reason of the problems in communication process. Further research could be conducted based on the results of this study to gain deeper insight into the issues.

1.5 Outline of the thesis

This thesis is organized in seven chapters:

Chapter 1 – Introduction: introduces the background and rationale of the study, and also briefly presents the research objective, methods, and major contributions of the study.

Chapter 2 – Literature review: covers the literatures related to this study.

Chapter 3 – Methodology: details the research methodology of the study, including research objectives, the research framework, the Delphi method, the questionnaires and interview questions development, and data collection process.

Chapter 4 – Results: describes the results from the Delphi study as well as the validity threats to the findings.

Chapter 5 – Discussion of results: presents the discussion of the findings related to each research objective.

Chapter 6 – Conclusion: presents a summary of the study with the discussion of the opportunity for further research.

1.6 Chapter summary

This chapter provides an introduction to the background, problem domain, rationale, research objectives and questions, and major contribution of this study.

2 Literature Review

2.1 Introduction

This research focused on underlying decision-making criteria for requirements selection in market-driven software development projects in China. This chapter presents a review of the relevant literature of this study, including value-based concepts and approach in economics, marketing, and management domains, value-based software engineering (VBSE), value-based requirements engineering (VBRE), requirements selection, characters of market-driven software development projects, Chinese context, and cultural issues.

In the literature review, the concepts and theories of value in the disciplines of economics, marketing, and management (Section 2.2) are presented respectively. It leads to the discussion of value-based software engineering (Section 2.3). Then literatures are narrowed down to value-based requirements engineering (Section 2.4). Requirements prioritization and selection is discussed in Section 2.5. Moreover, market-driven software development projects are dissertated in Section 2.6; the characters of Chinese software industry are discussed in Section 2.7; and Chinese culture and organizational culture are discussed in Section 2.8. Finally, the chapter is concluded in Section 2.9.

Figure 2.1 graphically presents the outline of the literature review.

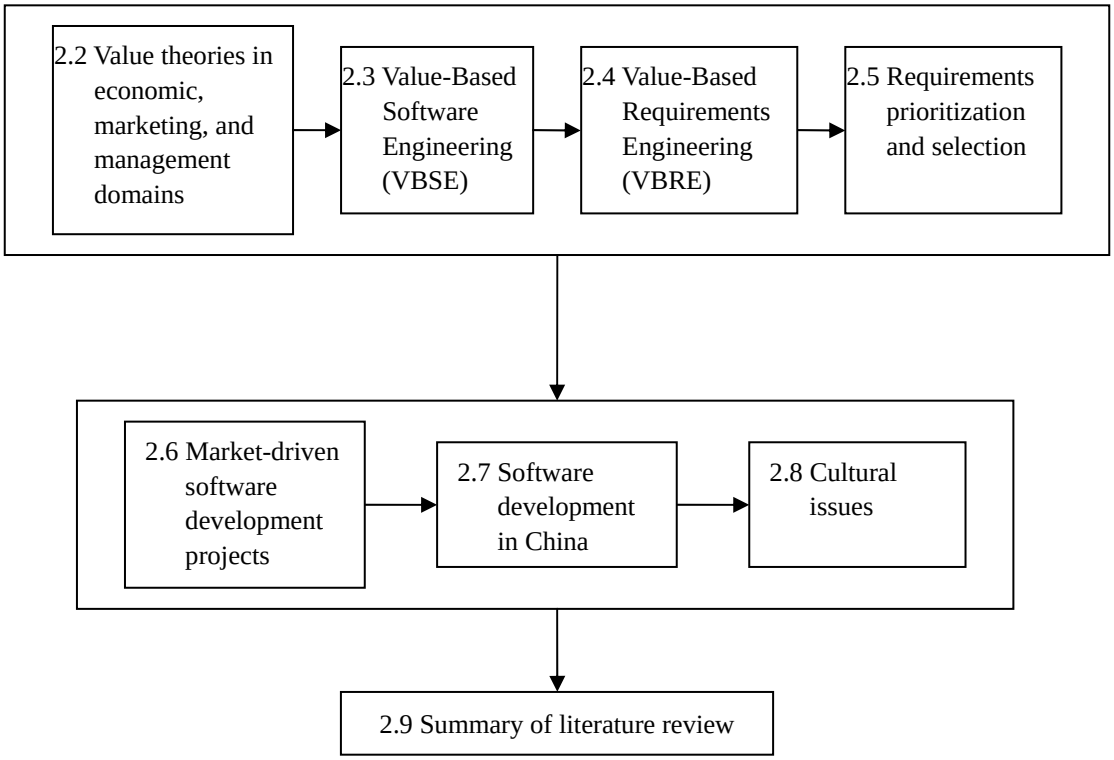

Figure 2.1: Outline of literature review

2.2 The theories of value in economics, marketing, and management

The concept of value is a crucial element in value-based software engineering (VBSE). VBSE adopts this concept from economics, marketing, and management domains into software development discipline (Boehm 2003). Before the discussion of VBSE, value theories in economics, marketing and management are respectively reviewed below.

2.2.1 Economic basis of value

In economists' opinion, economic value is created as goods move along the value chain: as raw materials are converted to components; components are assembled into finished goods; and finished goods are distributed to final consumers. The producer as one part of the vertical chain combines input from previous stages with labor and capital, and exports value-added final products.

In the historical development of value theory in economics, early work-value theory presented by classical economists (for example, Smith 1723-1790, and Marx 1818-1883) has been replaced by utility-value theory, which is the dominant theory currently (Ahmed and Yannou 2003). According to utility-value theory, product value is not necessarily relative to the working time, but depends on the customers' preference and the context of exchange. Product value could vary widely from person to person because of their different preferences for product's attribute, such as performance, reliability, durability, image, as well as the cost of product, such as installing cost, learning cost of how to use, maintaining cost, and transportation cost (Besanko *et al.* 2000). Thus, product value[1] is different from the price of the product, and sometimes even independent of the price. It represents the product's overall capacity to satisfy a particular person's needs, i.e. the person's maximum willingness-to-pay for the product.

Therefore, the total added value, created by the producer, equals to final product value minus the cost what producer spends on payment of labor, capital, and materials or components. The value created in the production process is divided between customer and producer. The portion of the value received by producer is the profit that the price of the product subtracts the cost to manufacture the product, while the portion of the value obtained by customer is represented as "consumer surplus"[2], the difference between the product value to the customer and the product's monetary price (Figure 2.2).

[1] "Product value" is called "perceived benefit" in some books and papers (Besanko *et al.* 2000), but to avoid confusion, it is unified as "product value" in the thesis.

[2] "Consumer surplus" is called "customer-delivered value" (Kotler 1994) and "net buyer benefits" (Ghemawat 1991) in marketing domain, but to avoid confusion, it is unified as "Consumer surplus" in the thesis.

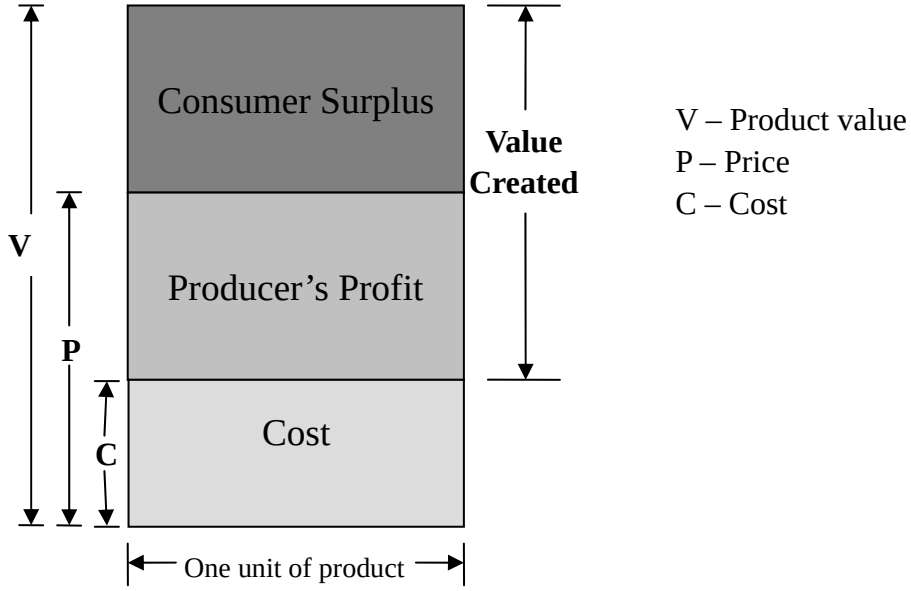

Figure 2.2: Components of value-created (Besanko *et al.* 2000, pg.396

2.2.2 Concept of value in marketing

Marketing plays the role of interface between customer and company (Ahmed and Yannou 2003). When customers face growing range of products from alternative suppliers, customer satisfaction is the core basis for their choice. Customer satisfaction is a marketing terminology, referring to "the level of a person's felt state resulting from comparing a product's perceived performance in relation to the person's expectations" (Kotler 1994, pg.40).

During purchase, customers always choose the product whose potential consumer surplus is larger than other alternatives. Product's potential consumer surplus is estimated by customer's previous experience and affected by other contextual variables, such as statements made by friends, advertisement, and competitors' information. During the consumption, customer satisfaction is evaluated by the disparity between expected consumer surplus and realized consumer surplus of the product. Finally, customer's personal experience is built as an assessment criterion for future purchase. The loop is presented in Figure 2.3.

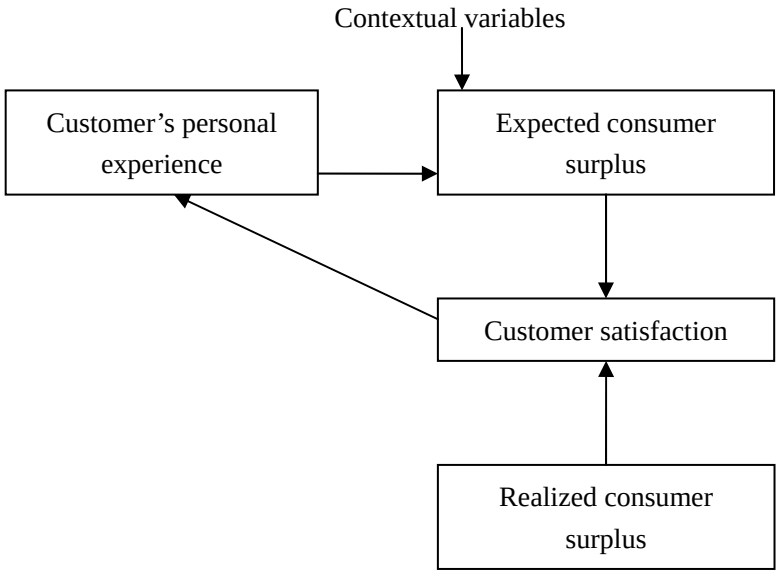

Figure 2.3: Process of purchase and consumption (adapted from Ahmed and Yannou 2003, pg.164)

Customer satisfaction is the best indicator of a future purchase and the company's future profits, because it will result in stronger bonds and loyalty with customers. It always cost much more to attract a new customer than to keep a current customer happy. A satisfied customer will buy more, remain loyal longer, pay less attention to other brands, be less price-sensitive, talk favorably about the company, and offer product ideas to the company (Kotler 1994). Therefore, companies should take customers satisfaction into consideration and deliver desired customer satisfaction.

However, it is a controversial problem as to how to achieve higher customer satisfaction. Although an organization can affect customers' expected consumer surplus of the products through advertisement and propaganda, Kotler (1994) argued that customers' expectations were difficult to be controlled, because their expectations were built on their past buying experience and other contextual variables. Consequently, in order to meet or even exceed customers' expectations of the products and get higher level of customer satisfaction, it is preferable to provide higher perceived consumer surplus by improving the quality of product and service. Thus, the company can get more business and end up with higher profits on the sale.

2.2.3 Concept of value in management

The aim of management is to ensure an organization to be sustainable and achieve the success. Management is an integration of all aspects in an organization, including finance, marketing, human resource management, and so on. Since the objective of organizations is to create more value (Ahmed and Yannou 2003), the traditional product-based management is gradually replaced by value-based management, which aims to create value by aligning the preliminary business management practices with the value-based pillars. Value-based management researchers regard value as the foundation of an organization (Sawhney 2002). Peat (2003) compared some important dimensions between organizations which adopt traditional product mindset and those which adopt value mindset. As presented in Table 2.1, value-based management (i.e. value mindset) is different from product-based management (i.e. product mindset), regarding the strategy they employ, the customers they focus on, the pricing proposition they adopt, the way they organize their sales and marketing, the way they measure and reward success, and the way they track their customers.

Table 2.1: Comparison between product mindset and value mindset (Peat 2003, pg.5)

Dimension	Product mindset	Value mindset
Strategic focus	Winning by launching innovative products and adding features to products	Winning by creating and delivering superior value to customers
Growth driver	Sell broadly to new customers	Sell deeply to existing customers
Pricing strategy	Perpetual license pricing to maximize revenue from transactions	Value-based pricing to align value creation for customers with value capture for the firm through subscription pricing
Sales organization	Product-centric organization with multiple faces to a customer	Customer-centric organization organized around key customer segments, with single face to a customer
Marketing operations	Emphasis on product launches and breadth campaigns to increase reach and influence customer perceptions	Emphasis on ongoing customer engagement and customer value assessment or tracking
Success metrics	Product revenues and product profitability	Customer satisfaction, profitability, and growth
Monitoring and tracking	Periodic surveys of customer satisfaction with products	Ongoing tracking and continuous improvement of the total customer experience

In addition, the idea of satisfying customers in the marketing domain is complemented by management studies. In management researchers' view, it is inadequate to only satisfy customers. Organization should create value for all the stakeholders. Stakeholders can be defined as all those who have a stake in the change of an organization being considered, including customers, shareholders (who take the risk to invest in the company), employees, suppliers, distributors, and other surrounding community. It is difficult for a company to gain high profits unless all stakeholder groups' needs are met, because every stakeholder plays an important role in the process of value creation. For example, organization profits will not be achieved with unhappy employees. Therefore, it is essential to consider all the stakeholders and strive to satisfy their expectations.

However, different types of stakeholders cannot be attached the same degree of importance. According to Ahmed and Yannou (2003), customers have to be placed at the first level, i.e. a high level of customer satisfaction and an acceptable level of satisfaction of other stakeholders. Further, different stakeholders' satisfaction is in a mutually-supplemented relationship. Customer satisfaction will result in satisfying other stakeholders in the long run.

2.2.4 Conclusion of value theories in economics, marketing, and management

In conclusion, a company will not get competitive advantage if it does not have value-based business strategy to satisfy all the stakeholders better than any competitors can. Among all stakeholders, customers have to be placed at the first level (Ahmed and Yannou 2003). A company should provide high product value to customers so as to satisfy customers and meanwhile encourage a purchase (Neap and Celik 1999). Product value is different from monetary price, which is based on customers' preference for product's attribute, such as performance, reliability, durability, and image, as well as the cost of product, such as installing cost, learning cost of how to use, maintaining cost, and transportation cost (Besanko *et al.* 2000). It is crucial for companies to identify and customers' real needs and requirements.

2.3 Value-based software engineering (VBSE)

Many studies on value have been carried out or still in process in economics, marketing, and organizational management (Debreu 1965, Ghemawat 1991, Kotler 1994), which have been discussed in section 2.2 in detail. The value concepts and value-based approaches in these domains are also applicable to the discipline of software development (Boehm 2003). Like other companies, software development companies should also provide high value to their stakeholders, especially their customers, and satisfy them in terms of their needs and requirements.

This section reviews the historical development of VBSE and the major theories concerning it.

2.3.1 Historical development of VBSE

Software development has developed rapidly during the past several decades since the invention of the first true electronic computer, ENIAC (Electronic Numerical Integrator and Computer) in 1945 and the introduction of the term “software” in 1958 (Barrett 2005).

In the very beginning, a value-neutral approach was dominant in the software engineering practice and research, in which each requirement was treated as equally important, people focused on project cost and schedule, and software engineering was limited to turning requirements into verified code (Boehm 2003). With this view, software developers and researchers laid emphasis on software development techniques and methods only. Further, they concern themselves with functional requirements of what the software would do rather than non-functional requirements of how the software would do, such as security and reliability of the software (IEEE 1984).

Since the end of the twentieth century, the rapidly changing competitive environment

has altered this landscape of software industry. It is far from enough to only consider how to transfer customer requirements into codes. First of all, software developers need to keep software development in line with business strategy. It requires that software developers have a very good understanding about business objectives and process (Freire *et al.* 2005, Boehm and Jain 2005). Secondly, product value, which is an economic and marketing concept, should be involved in the software development process to develop software meeting stakeholders' preferences. Thirdly, as suggested by management studies, a company will get competitive advantage only when it can satisfy all stakeholders better than any competitor can (Peat 2003). Similarly, for a software company, software development should also satisfy all stakeholders to get a competitive advantage in software industry.

Some progress has been made recently by integrating value-based view into software engineering domain. Boehm (1981) presented the first significant text to address value considerations instead of cost in software development context. Then, one milestone in VBSE was the research of Favaro (1996). He argued that quality was not the end goal of software development and a balance between quality and cost was more reasonable than merely pursuing quality. The terminology "Value-based" was first used in software development context in Favaro *et al.*'s (1998) article. In 2000, Boehm and Sullivan proposed the first agenda for VBSE, describing how to reach a world that informed software decisions led to more value creation. Three years later, Boehm (2003) presented a formal VBSE agenda, capturing the expanding scope of this budding field. The first formal book of VBSE was published in 2005, which covered all aspects about VBSE, including value-based requirements engineering, value-based architecting, value-based design and development, value-based verification and validation, value-based planning and control, value-based risk management, value-based quality management, value-based people management, and value-based principles and practices (Biffl *et al.* 2005). The following subsection presents some key theories in VBSE.

2.3.2 Key theories of VBSE

Value-based software engineering (VBSE) refers to "integrating value considerations into current and emerging software engineering principles and practices" (Boehm and Huang 2003, pg.33). VBSE theories suggest that software development should not be treated as a technical work but an investment activity. Software development must be related to business objectives of organizations to create maximal value for any given investment (Erdogmus *et al.* 2004). Technical properties, such as satisfaction of a formal specification and possession of a mathematical semantics, are the critical means for increasing value, rather than the end goals (Boehm and Sullivan 2000).

"4+1" theory put forward by Boehm and Jain (2005) provides an overall theoretic framework for VBSE (Figure 2.4). The center is the success-critical stakeholder (SCS) win-win Theory W, which addresses the success condition for a software development organization. The 4 additional theories that support Theory W are dependency theory (which aims to identify the success-critical stakeholder), utility theory (which aims to understand how the SCS want to win), decision theory (which aims to get win-win decisions), and control theory (which aims to control the progress toward SCS win-win realization). This study focuses on decision-making criteria for requirements selection, which is in the province of Theory W, utility theory, and decision theory. The 3 theories are highlighted in Figure 2.4 and discussed below in detail.

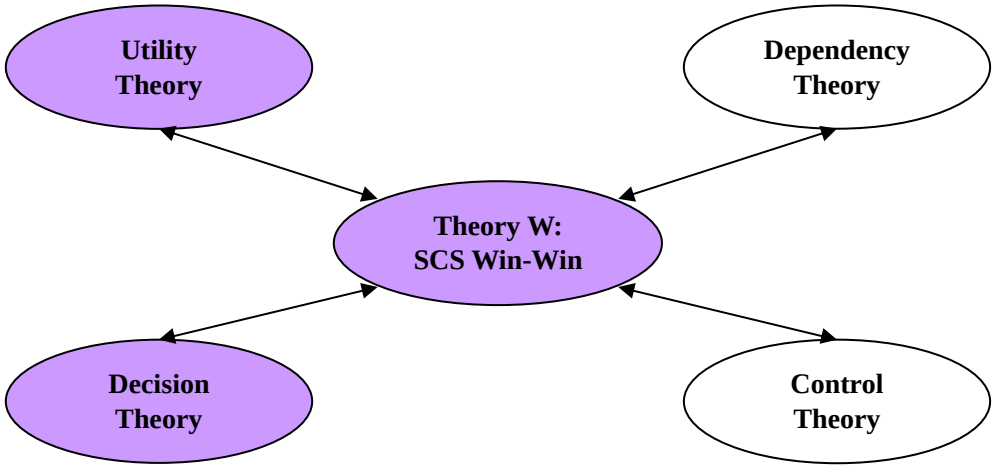

Figure 2.4: The "4+1" theory of VBSE (Boehm and Jain 2005, pg.20)

2.3.2.1 Theory W

Theory W is the central theory of VBSE, which integrates “satisfaction” idea into software engineering. It was proposed by Boehm and Ross (1989), who held that software projects would be fully successful if and only if all success-critical stakeholders (SCS) were satisfied.

SCS refers to a person who will be affected by the software product and who have a direct or indirect influence on the software requirements (Sommerville and Sawyer 1997). The typical SCS include those responsible for software development, those with a financial interest, those responsible for its introduction and maintenance, and those with an interest in its use (Macaulay 1992). It would be convenient if all SCS had compatible value propositions. However, just considering the most frequent value propositions of the most frequent stakeholders shows that conflicts are inevitable and must be reconciled (Boehm 2003). For example, users prefer many software features, while developers prefer ease of meeting budget and schedule. It is obvious that such value conflicts are present in most real-world software development projects.

It seems impossible to satisfy all success-critical stakeholders, and a win-lose situation may be more practical and attractive to the party most likely to win. However, Boehm *et al.* (2001) argued that a win-lose situation would usually turn into a lose-lose one. They presented three classic win-lose situations among three primary stakeholders, including developers, customers, and users, as shown in Table 2.2. The failure to satisfy any critical party would turn the other two “winners” into losers and create risks of compensatory actions that lead to the failure of the whole software development. For example, in the first case, the developer and customer attempt to be satisfied at the expense of the user by reducing time and effort but sacrificing the quality of the software. When the software product is presented to user, the user will refuse to use it. Developer has to redevelop it, inevitably at a higher cost to the customer. So are the other two cases. Therefore, finally nobody will be satisfied in these situations.

Table 2.2: Frequent Software development Win-Lose Patterns (Boehm *et al.* 2001, pg.47)

Proposed solution	"Winner"	Loser
Quickly build a cheap, sloppy product	Developer and customer	User
Add lots "bells and whistles"	Developer and user	Customer
Drive too hard a bargain	Customer and user	Developer

Therefore, it is important to determine the frequently conflicting value propositions of stakeholders and find out how they can be reconciled to optimize the overall value among stakeholders (Grunbacher *et al.* 2005). Barney (2005) explored the stakeholders' conflicting value propositions for requirements selection in his study, which is presented in Section 2.5.2 in detail. In the study, he proposed a conceptual model to illustrate Theory W based on Boehm's (2005) research. In the model, the success-critical stakeholders are identified, their value propositions are elicited, and then conflicting value propositions are reconciled into a mutually-agreed set through negotiation and communication process between stakeholders (Figure 2.5). The research framework of this study is constituted based on this model.

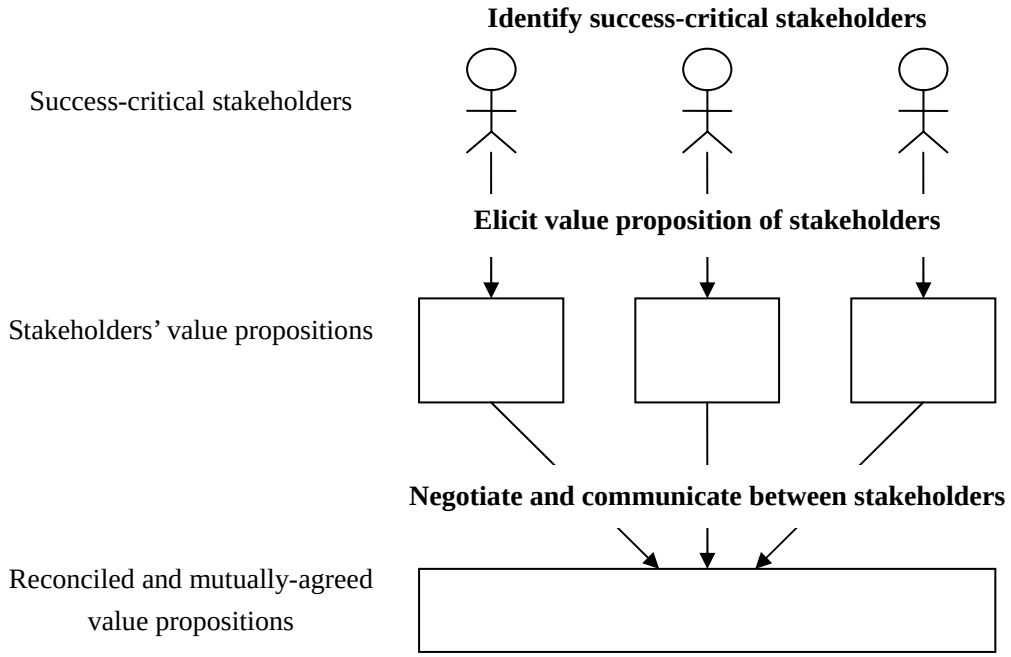

Figure 2.5: Model of Theory W (adapted from Barney 2005, pg.20)

2.3.2.2 Utility theory

Utility theory is adopted in VBSE context as a supporting theory of Theory W to understand how the stakeholders want to win. In other words, utility theory is about understanding value propositions of stakeholders so as to determine how success-critical stakeholders can be satisfied. Customer satisfaction, as presented in marketing studies, is a function of product's value and costs, relative to other software products in the marketplace (Kotler 1994). Software value can be measured by the extent to which the functions and features of the software meet the requirements of the customer, while costs include what customer has paid for the software and any other charges related to the software (Alwis *et al.* 2003). Software value is created through the development process, and it can be increased when organizations provide more satisfying software to meet value propositions of customers. Thus, satisfaction of stakeholders relies on stakeholders' value propositions, which are transformed into software product by requirements engineering process. Requirements engineering has large impact on the value of the final software (Boehm 2005).

2.3.2.3 Decision theory

Decision theory is adopted in VBSE context as another supporting theory of Theory W to understand how to get win-win decisions. Decision theory has many aspects such as negotiation theory, game theory, multi-attribute decision theory, statistical decision theory, real options theory, and the Theory of Justice (Boehm and Jain 2005). These theories provide explanations for the communication process between the success-critical stakeholders to negotiate win-win decisions.

2.4 Value-based requirements engineering (VBRE)

VBRE is the result of combining value concept in economics, marketing and management with requirements engineering. It constitutes one of the most important portions and principal problem areas of VBSE (Sommerville and Sawyer 1997). VBRE highlights the importance of the communication between stakeholders in the

requirements engineering process. Requirements engineering process and value theories in requirements engineering are reviewed in the following two subsections.

2.4.1 Requirements engineering process

Requirements engineering can be defined as the systematic process of developing requirements through an iterative co-operative process, concerned with the real-world goals and constraints for software (Macaulay 1996, Zave 1997). A normal requirements engineering process usually includes a structured set of following activities (Sommerville and Sawyer 1997).

- Requirements elicitation. It is the process of discovering software requirements by communication and consultation with stakeholders, from domain knowledge and market studies, and then documenting the resulting observations in a variety of representation formats. Many studies have been done in requirements elicitation domain (Anton and Potts1998, Sutcliffe *et al.* 1998).
- Requirements prioritization and selection. It is the process of prioritizing and selecting requirements through formal negotiation process with different stakeholders to decide on which requirements should be accepted. This process is the main concern of this research.
- Requirements validation. It is the process of checking the accuracy, consistency, and completeness of requirements to ensure them to follow quality standards.
- Requirements document management. Requirements document is an official statement of software requirements for customers, end-users, and developers. A well-managed requirements document can enhance the communication between different stakeholders and facilitate latter software development.

2.4.2 Value theories in requirements engineering

VBRE is the first element on the VBSE agenda proposed by Boehm (2003). It stands for an approach that integrates value theories in economics, marketing and management into all of the existing and emerging requirements engineering principles

and practices (Gordjin and Akkerman 2003). Boehm (2003) proposed a process for VBRE, consisting of identifying SCS, eliciting their value propositions with respect to the software, and then prioritizing these value propositions to form a mutually-satisfied set of requirements.

Requirements engineering is the starting point where stakeholders' expectations are transformed into codes of software language. Software starting with a poor requirements engineering process cannot meet the satisfaction of stakeholders, despite the efforts made in the stages downstream. Small errors and mistakes made in this phase can lead to enormous loopholes in the final software product. The further the software development evolves, the less opportunity to create stakeholders' satisfaction and reduce costs (Figure 2.6).

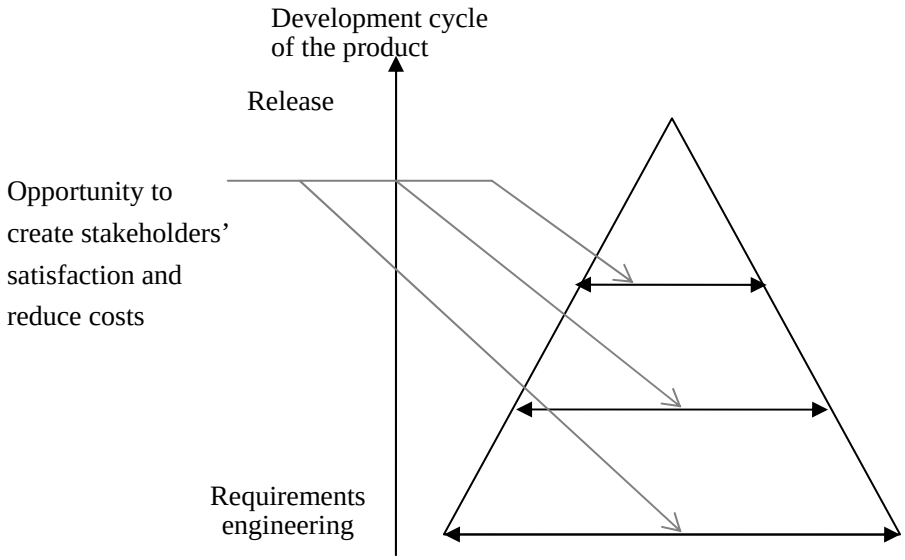

Figure 2.6: Evolution of the opportunity to create stakeholders' satisfaction and reduce costs (adapted from Ahmed and Yannou 2003, pg.166)

It is widely accepted that the process of requirements engineering can be very complex due to a wide range of perspectives taken by various stakeholders (Gordjin and Akkerman 2003). However, VBRE aims to transfer potential inconsistent and conflicting stakeholders' value propositions into a complete set of high quality requirements so as to make the software satisfy all stakeholders (Aurum and Wohlin

2005B). It requires the involvement of various stakeholders and a good communication between them to transform their preferences into a mutually-agreed set when making the decisions in the requirements engineering process (Gordjin and Akkerman 2003, Macaulay 1996).

Aurum and Wohlin (2005B) developed a conceptual model for requirements engineering decisions as presented in Figure 2.7. They categorized the stakeholders into three groups as follows.

- Business-perspective stakeholders mainly include external market and customers. They determine the companies' strategic and business long-term goals in terms of market share and so forth.
- Project-perspective stakeholders include management personnel of the software development project. They concentrate on the management issues about software development project, such as project schedule and budget.
- Product-perspective stakeholders include software development and maintenance personnel in the company. They concern software product itself, such as the complexity to develop and maintain the software and the evolution of the software.

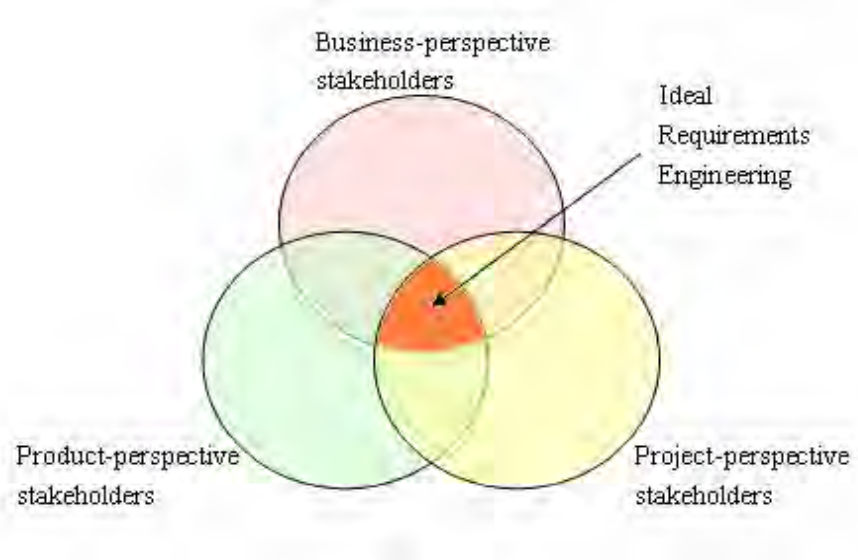

Figure 2.7: Aligning stakeholders from different perspectives for requirements engineering decisions (Aurum and Wohlin 2005B)

The importance of aligning decisions with company's business objectives has widely been accepted in requirements engineering domain (Rosca *et al.* 1997, Aurum and Wohlin 2005B). Contrary to the traditional value-neutral view in requirements engineering which focused on product-perspective and project-perspective stakeholders, Aurum and Wohlin (2005B) suggested that software requirements must be evaluated by business-perspective stakeholders to ensure that the requirements are in line with the goals and strategies of the company. In the decision-making process of requirements engineering, the communication between stakeholders of these three categories becomes especially significant.

This conceptual model as well as the model proposed by Barney (2005) is the foundation of the research framework of this study.

2.5 Requirements prioritization and selection

Requirements prioritization and selection is an important and complex process in requirements engineering. It involves a formal process of compromising value propositions of different stakeholders to decide which requirements are to be selected.

Deciding which requirements are selected to be implemented is a powerful way of creating product value and the satisfaction of stakeholders (Wohlin and Aurum 2005B). It is explained in Theory W and utility theory (Boehm and Ross 1989) that software products will not be successful unless all the success-critical stakeholders are satisfied and software value depends on the degree to which the software meets the expectations of stakeholders. Therefore, the inclusion and exclusion of specific requirements have a crucial impact on software value and the success level of software development.

However, requirements selection is in itself a complicated decision-making process with numerous uncertainties. First of all, there are lots of interdependencies between

requirements (Dahlstedt and Persson 2003). Achievement of one requirement can contribute negatively or positively to the achievement of other requirements (Chung *et al.* 1999), such as efficiency and completeness. Secondly, different stakeholders always have different and even incompatible value propositions of requirements. It is rather difficult to decide which requirements should be selected based on the different preference of the stakeholders. Eliciting stakeholders' conflicting value propositions and reconciling them into an agreed set are essential for requirements selection. For example, it is necessary to combine market analysis with requirements selection process (Freire *et al.* 2005). Thus, the decisions of requirements selection should be made by involving stakeholders from business, project, and product perspectives through comprehensive communication between them (Aurum and Wohlin 2005B).

In practice, most decisions of requirements selection are made subjectively and intuitively (Strigini 1996). People make their decisions of requirements selection based on their past experience, which lacks valid support (Aurum and Wohlin 2005A). The criteria for requirements selection are not officially and explicitly stated, but implicitly used by decision-makers. Decisions made without explicit consideration can be damaging to the accuracy and efficiency of selecting requirements.

Studies on requirements prioritization and selection and studies on the underlying criteria for requirements selection are reviewed in the following subsections.

2.5.1 Research on requirements prioritization and selection

Requirements prioritization and selection has drawn the attention of many scholars and researchers. Here is a review of its major approaches and theories.

In Karlsson and Ryan's (1997) approach for prioritizing requirements, candidate requirements were placed on a cost-value diagram as a conceptual map for selecting requirements to be actually implemented. The relative value of the requirements was assessed by customers and users through analytic hierarchy process (AHP) pairwise

comparison, while the relative cost of implementing each requirement was estimated by experienced software engineers. This approach was limited in that it did not address the interdependence between requirements and when prioritizing a large number of requirements, it took too much time and too many costs.

Boehm *et al.* (2001) proposed a groupware approach based on Theory W (Boehm and Ross 1989), called Easy WinWin, by which the conflicting preferences of different stakeholders could be compromised through negotiation. The approach encouraged and facilitated success-critical stakeholders' participation and collaboration when selecting requirements. In the negotiation process, stakeholders expressed their value propositions as "win conditions". If everyone agreed, the "win conditions" became "agreements", otherwise their conflicts occurred as "issues" and trade-offs should be explored. Equilibrium happened when "agreements" coverd all "win conditions" and no outstanding "issues" existed (Boehm *et al.* 2001). This approach aimed to satisfy all SCS by involving them in the process to prioritize software requirements. As for the weakness of this approach, it is costly and time-consuming, so it would not be cost-effective for some small projects. Besides, it is sometimes impossible to get access to all SCS. For example, for a market-driven software development project, it is almost impossible to involve all customers and users in the negotiation process when they assume the position of SCS.

Ruhe *et al.* (2003) pointed out the subjectivity of measurement in Boehm *et al.*'s approach (2001). They thought Boehm *et al.*'s Easy WinWin (2001) was based on more or less estimates. Ruhe *et al.* (2003) suggested a quantitative approach to provide support for requirements selection. Their method, Quantitative WinWin, provided a quantitative evaluation of requirement alternatives by considering effort, time and quality constraints of each requirement in order to achieve maximum value of requirements selection. However, sometimes quality and effort can not be evaluated numerically. It seems that Ruhe *et al.*'s (2003) research oversimplified the reality. A relatively small set of requirements (only 12) was involved in their case study, and the

result was based on the assumption that all requirements were independent of each other. Besides, similar to Boehm *et al.*'s Easy WinWin (2001), availability of the access to SCS is also necessary for Quantitative WinWin, yet it is hard to ensure in some cases.

Apart from the approaches above, there are also some studies, such as the research of Halling *et al.* (2003) and that of Karlsson *et al.* (1998), conducted on requirements prioritization and selection from other perspectives. Halling *et al.* (2003) developed an inspection technique, Negotiation Model Checking, to identify defects of informal and incomplete models in requirements selection methods so as to increase quality of requirements. Karlsson *et al.* (1998) evaluated six different mathematical methods for selecting software requirements, namely AHP, hierarchy AHP, minimal spanning tree, bubblesort, binary search tree, and priority groups. As a result, AHP was found to be the most promising method.

As shown above, studies in this domain have following three limitations. Firstly, approaches or methods they provided are always time-consuming and costly. Secondly, these approaches require availability of the access to all success-critical stakeholders, yet it is hard to ensure in some cases. Thirdly, none of them laid any emphasis on the decision-making criteria for requirements prioritization and selection.

2.5.2 Research on decision-making criteria for requirements selection

The following studies have referred to the decision-making criteria for requirements selection in their research.

Regnell *et al.* (2001) proposed a distributed requirements prioritization process for packaged software in market-driven requirements engineering. Their research focused on gathering and highlighting the differences and similarities in requirements priorities of different market segments, rather than providing an integrated solution of requirements selection. In the case study of the research, respondents were asked to

elicit the most influential criteria when deciding which requirements were important. However, it covered only 10 respondents and 8 criteria, namely, increasing sales, increasing profits, finding new customers, reducing support efforts, dealing competitors, using company skills to the best and technology push, creating complete functions and a truly usable product, and satisfying a key customer. It was obvious that requirements selection criteria were not the focus of their attention. The achievement was more like a by-product of their overall research. Additionally, this study did not reveal the different importance of each criterion either.

Wohlin and Aurum (2005A) presented a survey covering 9 companies and 34 respondents to discover the decision-making criteria for including a specific software requirement into a specific release or development project. They identified 13 criteria covering three different perspectives, namely, competitors, requirement's issuer, stakeholder priority of requirements, and requirement volatility for business-perspective criteria; support for education, development cost-benefit, resources, and delivery date for management-perspective criteria; and system impact, complexity, requirements dependencies, evolution, and maintenance for system-perspective criteria. From the study, they concluded that criteria adopted from business and management perspectives were more important than those from system perspective. The result of the study also showed that although individuals had quite different attitudes, all the 9 companies had similar opinions as to the importance of the criteria for requirements selection.

Following the research of Wohlin and Aurum (2005A), Barney (2005) carried out a similar empirical study in an Australian company and a German company. In his study, 9 semi-structured interviews were conducted and 21 questionnaires were analyzed to explore the relative importance of different criteria applied in requirements selection in a specific release of software and the degree to which major stakeholders were represented in the decision-making process. The study came to a conclusion that the external market of software was the most influential fact in requirements selection.

Important results regarding the two software products in the Australian company were also presented in Barney *et al.*'s (2006) paper.

These studies described above started the empirical study of the decision-making criteria for requirements selection. This study followed their step to further explore the decision-making criteria for requirements selection in China. However, this study has its own particularities. On one hand, these previous studies obtained their conclusions based on a relatively few respondents. This study was conducted with a larger data set. On the other hand, none of these previous studies were conducted in China. To the best of the researcher's knowledge, no similar empirical studies have ever been conducted in China. This study is dedicated to fill the gap. Chinese software industry is under a dramatic developing rate. The specialties of Chinese software industry make the research unique and significant, which are discussed in detail in Section 2.7.

2.6 Market-driven software development projects

There are many different types of software projects even in one organization. This research focuses on one particular type of software development projects: market-driven software development projects. This section reviews the classifications of software development projects, gives the definition of the market-driven projects, and discusses the characteristics of market-driven projects.

2.6.1 Software development projects

Software development projects can be categorized into different types from different perspectives. Table 2.3 presents the classification of Macaulay (1996), Snapshots (2005), and Kotonya and Sommerville (1998) based on relationships between customers and developers, types of software that projects develop, and systems the developed software works for.

Table 2.3: Classification of software development projects

Different types of software development projects	
Based on customer-supplier relationship (Macaulay 1996)	♦ Internal projects (supplier and customer belong to same organization) ♦ External projects (supplier and customer belong to different organizations) --One customer to some potential suppliers --A specific supplier directly to a specific customer --A generic software product to a large number of customers (*Market-Driven*) --Tailoring a generic product for a specific customer
Based on software products (Snapshots 2005)	♦ Software projects that develop application software ♦ Software projects that develop system software ♦ Software projects that develop intermediate link software
Based on systems that software works for (Kotonya and Sommerville 1998)	♦ Projects that develop software working for information systems ♦ Projects that develop software working for embedded systems ♦ Projects that develop software working for command and control systems

2.6.1.1 Classification by customer-supplier relationship

Macaulay (1996) classified software projects by different relationships between customers and information technology suppliers. He first divided software products into internal projects and external projects by judging whether or not the customer and the supplier belong to the same organization. Internal projects stand for the projects where a company develops software for their own company, while external projects stand for the projects where a company develops the software for other companies. Additionally, he subdivided external projects into the following 4 types.

1. Customer-supplier relationship is one to many. In this kind of projects, a customer issues a formal document that represents the customer's own assessment of the requirements to a number of potential suppliers. After competitions between several suppliers, customer will accept one of the proposals and sign the contract with the supplier.
2. Customer-supplier relationship is one to one. A specific supplier is asked directly to respond to a specific customer request to develop a software system. As there is only one customer and one supplier, the two-way communication between

them is efficient, which makes the supplier easily access to customer and users.

3. Customer-supplier relationship is many to one. The kind of projects aims to develop a generic product which meets the needs of a large number of customers. In this case, the supplier always bears high financial risks (Regnell *et al.* 2001). All developments are market-driven, and success is measured in terms of market share. There is always a major pressure on time-to-market, so software product is often offered to a market through recurrent releases. Sometimes different requirements need to be allocated to different releases. This type of software projects is the focus of this study.
4. Customer-supplier relationship is one to one again, but in this kind of projects, a supplier aims to tailor a generic software product developed previously for a specific customer instead of developing entirely new software.

Macaulay (1996) stated that different customer-supplier relationships would lead to different requirements engineering processes. This study focuses on external software development projects with the third customer-supplier relationship.

2.6.1.2 Classification by software product

Another classification of software development projects is according to the nature of the software product that the projects develop. Snapshots (2005) classified software into three different types, i.e. application software, system software, and intermediate link software.

- Application software is the kind of software that enables the sort of work for which computers are brought (Barrett 2005). Application software is always independent programs from operating system, although it is often tailored for specific platforms. Typical examples include office suites and video games.
- System software is the one that sits behind the scenes and makes computer work, including the basic input-output system (often described as firmware rather than software), device drivers, and operating system.

- Intermediate link software is the system software based on the computer hardware and operating systems in support of application software. It provides a standard platform for enterprise-level distributed applications.

In 2004, application software constituted the largest segment of the software market in China as 64.9%, then system software as 28.6% and intermediate link software as 6.5% (Snapshots 2005). The study mainly focuses on application software, but covers other two kinds of software as well.

2.6.1.3 Classification by systems

Although the focus of this research is software requirements engineering, it is impossible to separate software from the system software works for. Besides software, a system may include computer hardware, other types of hardware device, and the operational processes. Kotonya and Sommerville (1998) classified systems into three types, namely, information system, embedded system, and command and control system. This study covers the projects that develop software for all three kinds of systems.

- Information system is primarily concerned with processing information held in database. This kind of system is usually implemented by using standard computer hardware and sometimes built on top of commercial operation systems.
- Embedded system is characterized by using certain software as a controller in some broader hardware system without databases. This kind of system works in a time-critical environment responding to changes in its environment instantly. The correctness of software in these systems depends on the logical results of the computation and the time at which the results are produced (Bennett 1994). Ideally the requirements specification of the software applied in embedded systems should describe the actions for every situation (Allworth and Zobel 1987).
- Command and control system is a combination of several information systems

and embedded systems. The largest and most complex systems, such as military messaging system and railway signaling system, belong to this type.

2.6.2 Definition of market-driven projects

Researchers have given their own definitions of market-driven software development projects in the existing literature. Market-driven software development projects is the project:

- Where a generic software product is developed to meet the needs of a large number of customers (Macaulay 1996);
- Where software is released to a market and not developed specifically for a single customer, so the aim of the software development is to capture the voice of all the customers (Host *et al.* 2000, Yeh 1992);
- Where software is offered off-the-shelf and its requirements are invented for a market segment, so software requirements are invented based on foreseen customers' needs, leading to a software product which can compete on the market (Booth 2001, Regnell *et al.* 1998);
- Where software is developed for more than one actual or potential customers, including developing products for the marketplace and developing a family of similar systems for different customers (Lubars *et al.* 1993).

Most of the researchers defined market-driven software development projects to distinguish it from customer-specific software development ones. The comparison between customer-specific and market-driven software development projects is presented in Table 2.4.

Table 2.4: Comparison of customer-specific and market-driven software development projects (Booth 2001, pg.14)

Customer-specific projects	Market-driven projects
Bespoke project	Commercial off-the-shelf software
A single, well-defined customer	A market with many potential customers
A customized software	A generic software
A contract: the customer decides	No contract: the developer decides

However, the boundary between the customer-specific and market-driven projects is not always very clear in practice. The generic software developed in market-driven projects can be specialized for one particular customer, and then it becomes a customer-specific project. On the other hand, if the company succeeds in several customer-specific projects which develop similar software products, then the software can be generalized for a larger market based on the previous success and it becomes a market-driven project. One company recruited in this study had this kind of project under way.

Therefore, in this study, market-driven software development project indicates the project that develops or generalizes the software product for a market rather than projects for one or a few particular customers.

2.6.3 Characteristics of market-driven projects

Time pressure and unavailable access to customers are the two main characteristics of market-driven software development projects.

On one hand, market-driven projects face great time pressure. Since it pays to be a first-mover in a market, market-driven projects always apply iterative and incremental development process and release several versions of software to reduce development time and to advance software delivery to the market (Barney *et al.* 2006). The software requirements are considered at software release level. A collection of

requirements is elicited and selected for the next version of software in the release planning (Dahlstedt and Persson 2003). However, the interval between two releases becomes shorter and shorter due to the fast-developing market (Rautiainen *et al.* 2002).

On the other hand, market-driven projects have a large number of potential customers. It is impossible to get access to all potential customers. Consequently, instead of directly eliciting customers' requirements, sample surveys, market analyses, and inviting some of representatives are usually employed in the market-driven software development projects. Additionally, the feedback from software's last release is also essential for market-driven projects to obtain customers' needs (Barrett 2005).

These two characteristics make the decisions of requirements selection in market-driven projects more frequent, complicated, and important. Requirements selection for market-driven projects should consider market needs, feedback from previous releases, and market competitors. It is difficult to prioritize them and select appropriate ones to be implemented. Further, the decisions of requirements selection will affect software value to the customer and customer satisfaction (Barrett 2005). Customer satisfactory will have direct impact on companies' reputation, market sharing, and future incoming. Thus, market-driven projects should first aim to satisfy their customers, and meanwhile at least meet the minimum expectations of other stakeholders. This study has taken these characteristics and their implications into full account.

2.7 Software development in China

The empirical study of this research was conducted in China. Software industry in China has its own characteristics different from other countries (Hale and Hale 2003), which makes this research more valuable and unique.

Firstly, although China is a developing country, Chinese software industry is under a dramatic developing rate. Account for one-fourth world population, Chinese software market is very attractive. The compound annual growth rate of Chinese software market for the period 2000-2004 was 18.9% (Snapshots 2005). Snapshots (2005) research forecasted that Chinese software market annual growth rate would remain the same rate in the following five years. As the large market in China, the foreign companies have launched their products into China one after another, and foreign companies have captured about 70 percent of the Chinese software market in 2003 (Hale and Hale 2003). In addition, Chinese domestic companies themselves or collaborated with foreign companies tend to export their software products outside China. Although in 2003 China's software exports only achieved $2 billion compared with India's $12 billion, China is estimated to be able to catch up with India in software exports by 2006, mainly because of government initiatives (Kshetri 2005).

Secondly, most of the companies in Chinese software industry face the same challenge. Their target markets, software development teams, and executive level people may locate in various countries. For instance, foreign companies that launch their products in Chinese market usually have some branches in China and also engage some Chinese employees to get more knowledge about Chinese market. Although their branches in china have their own research and development ability, their policy and business objectives are still under headquarters' control. Communication between branches and headquarter is always complex, sometimes involving cultural and language problems (Takeda 1998). Therefore, it is more interesting to explore communication process between stakeholders in these software companies.

Thirdly, fierce competitions have appeared in Chinese software industry (Xinhuanet 2005). The first cause is the piracy problem of software. Kessler (2004) estimated that over 92 percent of China's software was pirated (Kshetri 2005). The second cause is the increased emphasis on open source software (OSS) development in China under

government initiatives. Although OSS brings many benefits, it also brings the idea of free software. Software value is widely underestimated by Chinese people. Software companies in China have to depress software price to attract more customers, so they have to drive down their development cost. When making the decisions for requirements selection, they have to balance cost and quality of the software.

2.8 Cultural issues

"Culture shapes communication and communication are cultural bond" (Neuliep 2000, p.12). People in different culture make the decisions and communicate with each other differently. Thus, although the research does not focus on the culture impact, some cultural issues should be addressed.

Both national culture and organizational culture do affect the decision-making for requirements selection and the communication process. National culture and organizational culture could be quite different in one company. For example, in a US based international company's branch in China, organizational culture of this branch is affected by western culture, while national culture of this branch is affected by the local Chinese culture.

Chinese culture (national culture in this study) and organizational culture are discussed in the following.

2.8.1 Chinese culture

Hofstede (2001) obtained four dimensions of national culture, which were power distance, individualism-collectivism, masculinity-femininity, and uncertainty avoidance. The Chinese culture is discussed according to these four dimensions as follows.

Power distance refers to the degree of inequality in power between less powerful

members and a more powerful others in the organization (Hofstede 2001). Chinese society has a large power distance which is constructed by a high hierarchical structure and centralized control (Chang and Ding 1995). In a software development project team, the team members have to obey the orders from project manager, who have more power than them. Sometimes, the team members are even deprived of the right to present their opinions. Additionally, in the organizations of hierarchical structure, the only direct link is between subordinates and their immediate superior. Structuring organizations in this way is partly useful because it can reduce the communication overhead by limiting information flow. However,it limits the communication between the subordinates and their other superior except immediate one. For example, it is usually impossible for the software developer to directly communicate with chief information officer in this kind of software development companies.

Individualism versus collectivism refers to the degree to which individuals are integrated into primary groups (Hofstede 2001, Chang and Ding 1995). Chinese is a collectivist society. Chinese people are socially-oriented rather than individually-oriented (Martinsons and Westwood 1997). The personal relationship or connection between people, which is commonly called ‘Guanxi’, is a central concept in Chinese society. Individuals with a high level of collectivism are apt to adopt other’s opinions and take their personal relationships into account when making the decisions for requirements selection (Chang and Ding 1995). Personal relationship may contribute to the decision-making for requirements selection and the communication between stakeholders in this process, while it may also bring some negative effects, like nepotism and cronyism.

Masculinity versus femininity is related to the division of emotional roles between men and women (Hofstede 2001, Goelzer 2003). Chinese society was with a high level of masculinity, while it becomes more and more feministic currently. There are no significant distinctions between gender roles in China. This dimension hardly

affects the decision-making of requirements selection.

Uncertainty avoidance refers to the level of stress in a society when facing the unknown future. Chinese society has relatively low uncertainty avoidance values (Hofstede 2001). However, the tolerance for uncertainty varies considerably from people to people in China (Chang and Ding 1995). People with high uncertainty avoidance tend to pay more attention to volatilities of requirements when making the decisions, while people with low uncertainty avoidance tend to be more confident of coping with changeful requirements.

2.8.2 Organizational culture

Organizational culture refers to the basic assumptions and beliefs that distinguish one organization from another (Hofstede 2001, Sweeney and Hardaker 1994). The organizational culture for an organization is similar to the personality for an individual (Sweeney and Hardaker 1994).

The companies recruited in this study have different types of organizational culture. Typically, the recruited western-based international companies were dominated by western culture as organizational culture, while the recruited Chinese companies were dominated by Chinese culture as organizational culture. Different organizational cultures may result in different types of leadership, different types of power structure, different forms of organizational structure, and consequently different decision-making processes and the communication styles for requirements selection (Sweeney and Hardaker 1994).

2.9 Chapter summary

This chapter reviews the literatures that are related to this study.

As mentioned before, only several studies have been conducted to explore the

decision-making criteria for requirements selection (Regnell *et al.* 2001, Wohlin and Aurum 2005A, Barney 2005, Barney *et al.* 2006). These previous studies obtained their conclusions based on a relatively few respondents, and none of them were conducted in China. This study is dedicated to fill the gap by exploring the underlying decision-making criteria for requirements selection in market-driven software development projects in China with a larger number of participants.

3 Methodology

3.1 Introduction

The main objective of this research is to explore the decision-making criteria for requirements selection in market-driven software development projects in China.

This chapter presents the methodology of this study, dedicated to this research objective. The process of developing the research methodology is outlined in Figure 3.1.

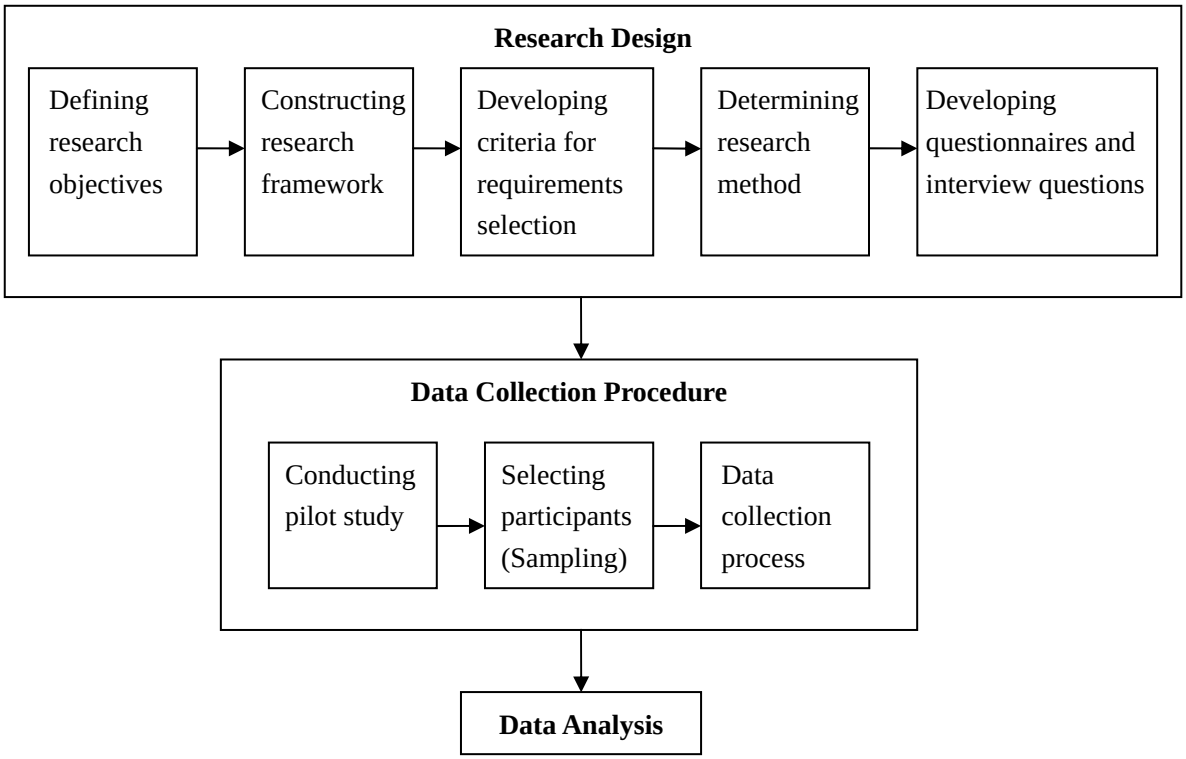

Figure 3.1: Process model of this research

As shown in the process model, the research includes three major parts: the research design before the empirical study, data collection procedure, and data analysis. Each stage within the process is presented in detail in the following sections.

Research design part is constituted by 5 stage:

- The first stage in this study involved defining the research objectives and corresponding research questions (Section 3.2.1).
- Secondly, a research framework was constructed by combining Barney's (2005) model and Aurum and Wohlin's (2005B) conceptual model (Section 3.2.2).
- Thirdly, the initial list of requirements selection criteria were generated from the literatures and linked to the research framework (Section 3.2.3).
- Fourthly, Delphi method was selected as the research method to address the research questions (Section 3.2.4).
- Lastly, questionnaires and potential interview questions were developed for the Delphi survey (Section 3.2.5).

Moreover, data collection procedure includes following stages:

- Firstly, pilot studies were conducted to improve the questionnaires and interview questions (Section 3.3.1).
- Secondly, 11 companies and the participants from these companies were selected and recruited to carry out the Delphi method (Section 3.3.2).
- Thirdly, three-phase survey and follow-up interviews were organized and conducted (Section 3.3.3).
- Additionally, issues about language translation and ethic consideration are presented in Section 3.3.4 and 3.3.5

Furthermore, collected data were analyzed and the findings are presented in Section 4 and discussed in Section 5.

3.2 Research design

This subsection describes the research design before the empirical study, including the research objectives, research framework, development of requirements selection criteria, research method, and questionnaires and interview questions development.

3.2.1 Research objectives

This research aims to explore the decision-making criteria and communication process between stakeholders for requirements selection in market-driven software development projects in China. The research objective can be divided into following four sub-objectives and corresponding research questions.

3.2.1.1 Research objective 1

The first research objective is to identify the underlying decision-making criteria for requirements selection in market-driven software development projects. Identification and explanation of the underlying criteria for requirements selection is the foundation to understand and better support the decision-making processes.

Research Question 1: what are the decision-making criteria used for selecting a requirement to be implemented in market-driven software development projects?

3.2.1.2 Research objective 2

After identifying the criteria for requirements selection, the research aims to evaluate the relative importance of each criterion for the decision-making of requirements selection. The prioritization of the criteria contributes to a good understanding of the decision-making process and provides a guide when conflicts happen between the value propositions of stakeholders.

Besides, the study also indicates the differences between the practical situation and the ideal situation in terms of the degree of each criterion's importance for requirements selection. The practical situation is where the criteria currently affect decision-making of requirements selection in the companies, while the ideal situation is where the stakeholders think that different criteria ought to affect the decision-making of requirements selection, i.e. how stakeholders expect the use of the criteria in the future. What people think that it should be may not necessarily be realized in practice.

Research Question 2: which criteria are more important for the decision-making process of requirements selection? How does this differ from the industry perception of the ideal application of the criteria?

3.2.1.3 Research objective 3

The third research objective is to explore the degree to which the value propositions of stakeholders from different perspectives influenced the decision-making of requirements selection.

There are 3 major categories of stakeholders involved in software development (Aurum and Wohlin 2005B). Customers are the major stakeholders from business perspective, management personnel of the software development project are the major stakeholders from project perspective, and software development and maintenance personnel represent the major stakeholders from product perspective. The criteria are corresponding to the value propositions of stakeholders from these 3 perspectives. The influence of the value propositions of stakeholders from each perspective is indicated by the importance of the criteria from corresponding perspective.

Additionally, the differences between the practical situation and the ideal situation are also determined.

Research Question 3: to what degree do the value propositions of major stakeholders influence the requirements selection process? How does this differ from the industry perception of the ideal application of the criteria?

3.2.1.4 Research objective 4

The fourth research objective is to get an overview of the communication process between different stakeholders when making the decisions of requirements selection.

The decision-making process of requirements selection is the process of combining value propositions of stakeholders from different perspectives, inevitably involving the interaction and collaboration process between them (Aurum and Wohlin 2005B). However, the value propositions from different stakeholders easily collide with each other. Communication between stakeholders is the way to reconcile their conflict value propositions into a mutually agreed set (Boehm 2005).

Research Question 4: how do different stakeholders communicate and interact with each other in the decision-making process of requirements selection in market-driven software development projects?

3.2.2 Research framework

Figure 3.2 presents the research framework of this study. The research framework adopts Barney's (2005) conceptual model, which was developed based on Theory W, into requirements selection context, and also complements Barney's (2005) conceptual model by Aurum and Wohlin's (2005B) conceptual model of requirements engineering decisions. The 3 perspectives proposed by Aurum and Wohlin (2005B), business, project, and product perspectives, are added into Barney's (2005) conceptual model.

Meanwhile, 14 requirements selection criteria are developed according to the reviewed literature, which enriches the research framework. The framework highlights that the decision-making criteria for requirements selection are corresponding to the stakeholders' value proposition from business, project, and product perspectives. In other word, the importance of the criteria from each perspective indicates the influence of the value propositions of stakeholders from this perspective. The detailed descriptions of the requirements selection criteria are presented in Section 3.2.3

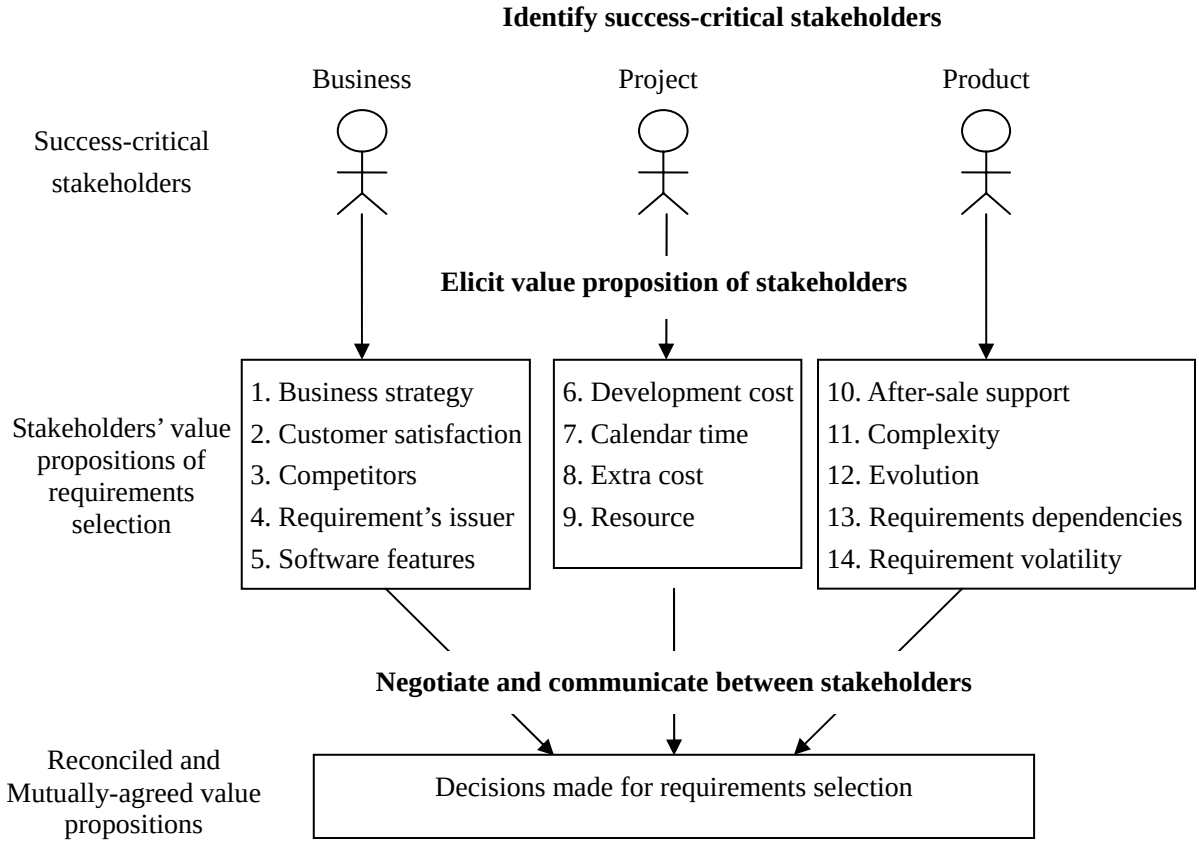

Figure 3.2: Research framework

As presented in the research framework, there are 3 major categories of stakeholders involved in requirements selection process.

- Business-perspective stakeholders mainly include external market and customers. They determine the companies' strategic and business long-term goals in terms of market share and so forth.
- Project-perspective stakeholders include management personnel of the software development project. They concentrate on the management issues about software development project, such as project schedule and budget.
- Product-perspective stakeholders include software development and maintenance personnel in the company. They concern software product itself, such as the complexity to develop and maintain the software and the evolution of the software.

In the process of requirements selection, value propositions of stakeholders from the 3 perspectives are frequently in conflict. The software developers, for instance, tend to select stable requirements to lighten their workload, while the customers prefer high changeable requirements to ensure the flexibility. The requirements selection decisions are made by reconciling the conflicting stakeholders' value propositions into a mutually-agreed set through negotiation and communication process between stakeholders.

3.2.3 Criteria development

A list of decision-making criteria for software requirements selection is summarized from the existing literature. The list of the criteria is tentatively developed by modifying the criteria applied in Wohlin and Aurum's (2005A) study and complementing them with the concepts in some other studies, including Peat's (2003) in management, Ahmed and Yannou's (2003) in economics, Besanko *et al.*'s (2000) in marketing, Regnell *et al.*'s (2001) in requirements engineering.

A summary of requirements selection criteria is listed in Table 3.1. Two principles have been strictly observed when developing the list: first a criterion should be kept at a high level of abstraction; second, as little interdependency between criteria as possible is involved to focus on the importance of each individual criterion (Wohlin and Aurum 2005B). This tentative list of criteria for requirements selection is kept updated through empirical study according to these two principles.

Table 3.1: Summary of requirements selection criteria identified in the literature

Criteria	Explanation	Adopted from
1. Business strategy	The suitability between the requirement and the strategy of the company, including the strategy of attracting customers, pricing strategy, marketing operations, and so forth	Peat 2003
2. Customer satisfaction	The impact of the requirement implementation on the software's overall capacity to satisfy customers – the customers' priority and their expectation to see the requirement met are taken into account	Ahmed and Yannou 2003
3. Competitors	The status of competitors in the market with respect to the requirement – it is taken into account whether a competitor has the implied functionality or not	Wohlin and Aurum 2005A
4. Requirement's issuer	The stakeholder (internal or external) who generated the requirement	Wohlin and Aurum 2005A
5. Software features	The actual features of the software will be brought by implementing the requirement, such as performance, reliability, durability, and so on	Besanko *et al.* 2000
6. Development cost	The cost for implementing the requirement	Wohlin and Aurum 2005A
7. Calendar time	The impact of the requirement implementation on the time to release the software to the market	Wohlin and Aurum 2005A
8. Extra cost	The impact of the requirement implementation on the extra cost customers will spend, such as the cost of software installation, learning how to use it, software maintenance, and so on	Besanko *et al.* 2000
9. Resource	The availability of the resources with the right competencies to implement the requirement	Wohlin and Aurum 2005A
10. After-sale support	The effort of technical, education, and training support that should be provided to customers after the sale with respect to the requirement	Regnell *et al.* 2001
11. Complexity	The estimated complexity of the requirement and associated challenges in implementing it	Wohlin and Aurum 2005A
12. Evolution	The impact of the requirement implementation on the future evolution of the software product	Wohlin and Aurum 2005A
13. Requirements dependencies	The dependencies between the requirement and other requirements, including the requirements already implemented, scheduled to be implemented, or deferred to later release	Wohlin and Aurum 2005A
14. Requirement volatility	This criterion is related to whether the requirement is likely to change or not	Wohlin and Aurum 2005A

The 14 decision-making criteria can be categorized into 3 groups in accordance with the value propositions of stakeholders from each perspective, as shown in the research framework. The importance of the criteria from each perspective indicates the influence of the value propositions of stakeholders from this perspective.

- Business-perspective criteria include ‘business strategy’ (criterion 1), ‘customer satisfaction’ (criterion 2), ‘competitors’ (criterion 3), ‘requirement’s issuer’ (criterion 4), and ‘software features’ (criterion 5);
- Project-perspective criteria include ‘development cost’ (criterion 6), ‘calendar time’ (criterion 7), ‘extra cost’ (criterion 8), and ‘resource’ (criterion 9);
- Product-perspective criteria include ‘after-sale support’ (criterion 10), ‘complexity’ (criterion 11), ‘evolution’ (criterion 12), ‘requirements dependencies’ (criterion 13), and ‘requirement volatility’ (criterion 14).

Identification of underlying criteria for requirements selection is an ideal starting point to understand and support the decision-making process (Aurum and Wohlin 2005B).

3.2.4 Delphi method

This research adopted the Delphi survey method to address the research questions. Delphi method was originated from the practice in Rand Corporation in the 1950s as a means to handle opinions rather than objective facts (Schmidt 1997). It is a way of facilitating anonymous communication between selected experts by corroborating information through several rounds questionnaires (Savchenkova 2003). Delphi survey method is a popular tool in information system (IS) research for identifying and prioritizing issues for decision-making (Schmidt 1997). Several examples that applied the Delphi method in IS domain are presented in Table 3.2.

Table 3.2: Applications of the Delphi method in IS research (adapted from Okoli and Pawlowski 2004)

Examples	**Purpose**
Bacon and Fitzgerald 2001	Develop a framework of the main areas of the IS field
Brancheau *et al.*1987, 1996	Identify the most critical issues IS executives face in the coming 3 to 5 years
Couger 1988	Identify key human resource issues in IS in the 1990s and compare different views from IS executives and human resource executives
Czinkota and Ronkainen 1997	Forecast changes in the international business environment over the next decade and the impact of these changes on corporate practices
Hayne and Pollard 2000	Identify the critical issues in IS in the coming 5 years
Holsapple and Joshi 2002	Develop a descriptive framework of knowledge manipulation activities
Lai and Chung 2002	Identify a prioritized list of international data communications
Nambisan *et al.* 1999	Develop a conceptual taxonomy of organizational design actions
Schmidt *et al.* 2001	Develop a ranked list of common risk factors for software projects as a foundation for theory building about IS project risk management.

This study adopted Delphi survey method for the following reasons.

Firstly, Delphi survey is generally considered as appropriate for exploratory research (Rowe *et al.* 1991). Since there were no systematic theories and not many empirical studies have been conducted about the decision-making criteria for requirements selection, the Delphi method was ideal to this study for exploratory purpose.

Secondly, through a series of linked questionnaire, Delphi allowed the researcher to gather feedback and comments from experts individually without having them physically meet together as a group. For example, the first objective of this study is to identify the decision-making criteria for requirements selection in market-driven projects. Experts' knowledge together with their experience in market-driven software development provides an effective source of requirements selection criteria (Schmidt *et al.* 2001). However, a single expert is not likely to have the experience of all development situations needed to yield a comprehensive list of criteria. With the convenience provided by the Delphi survey, a large number of experts can be enlisted in the study, which ensures the results to be credible and accurate. The comprehensive

list of criteria is the base of the follow-up phases.

Thirdly, the Delphi survey method is flexible in its design and amenable to follow-up interviews, which permits additional insights into the quantitative data obtained by questionnaires (Leedy and Ormrod 2005). Additionally, a basic understanding of the communication process between stakeholders can be obtained through the follow-up interviews so as to get the answer of the fourth research question.

3.2.5 Questionnaires and interview questions development

The Delphi survey in this study was conducted in 4 phases based on Schmidt's (1997) approach:

1. Identifying the key decision-making criteria for requirements selection;
2. Ranking the criteria based on their relative importance;
3. Attaining a consensus on criteria's ideal importance;
4. Exploring the decision-making process of requirements selection.

For the first three phases, industry experts' opinions were collected by 3 connected surveys, while several interviews were conducted in the last phase to get an insight into the rationale behind the data got from the surveys and a basic understanding of the communication process between stakeholders for requirements selection as well.

Three linked questionnaires interspersed with the results from preceding phases were developed for the three connected surveys.

- The first questionnaire was developed for the first-phase survey to identifying the key decision-making criteria for requirements selection. First, the 14 criteria mentioned in Section 3.2.2 were listed with their explanations and motivations in the first questionnaire. The respondents were asked to tick or cross before each criterion to show whether the criterion was relevant to their decision-making of requirements selection or not. Second, the respondents were encouraged to submit

as many extra missing criteria as possible. They were also asked to present the explanation and motivation of new criteria to avoid the confusion when the same criterion was raised by different terms.

- The second questionnaire was developed for the second-phase survey to rank the criteria based on criteria's practical and ideal importance. In the second questionnaire, the criteria validated and updated by the first-phase survey were listed in the first column of the table. The respondents were asked to fill out other two columns beside the list of the criteria. In the two columns, the respondents were asked to provide relative weights regarding the importance of the criteria in terms of value between 0 and 1000 points. A higher number of points meant that a criterion was relatively more important, and the sum of all values in one column should be 1000. The first column asked about the way different criteria were valued practically, while the other one was what the respondents thought it should be in the future. Explanations and motivations of the criteria were provided to respondents in the appendix of the second questionnaire.

- The third questionnaire was developed for the third-phase survey to attain a consensus on criteria's ideal importance among respondents. In the third questionnaire, the criteria identified by the first-phase survey were listed in the first column of the table. The second-phase results regarding the criteria's ideal importance were displayed in the second to five columns of the table, including the mean of all experts' ratings, the mean of all experts' ratings from respondent's company, standard deviation of all experts' ratings, and respondent's personal ratings in the second questionnaire. Respondents were asked to fill out the last column of the table by re-providing relative weights regarding the ideal importance of the criteria in terms of value between 0 and 1000 points according to others' opinion. Explanations and motivations of the criteria were provided to respondents in the appendix of the third questionnaire.

In addition, several interview questions were developed for the fourth-phase interviews. The semi-structured interviews included three parts of interview questions.

- The first-part questions aimed to get basic information about the companies, software development projects, and the interviewee's personal background.

- Through the second-part interview questions, the researcher intended to get the rationale behind the ratings and interviewee's reaction to the results got from the previous questionnaires, such as why they rated the criteria as they did and whether they concurred with other experts' opinions, and if not, the reason for differing. Interviews gave rich information that questionnaires could not cover, and also enhanced the interpretation and understanding of the results obtained by the previous three-phase surveys (Onwuegbuzie and Leech 2004).

- The third-part interview questions focused on the requirements selection process and the communication between stakeholders in this process. The interviewees were asked about the methodologies applied in requirements selection process, the communication between different stakeholders, the problems of the communication, and so forth.

The three questionnaires and the outline of the interview questions are presented in Appendix A.

3.3 Data collection process

The pilot studies, sampling strategy, data collection procedure, language translation issues and ethic consideration of this study are presented in the following subsections.

3.3.1 Pilot study

Questionnaires and interview questions were all pilot-tested and improved to ensure

the clarity and completeness.

3.3.1.1 Pilot study for questionnaires

A three-stage pilot study was conducted for the questionnaires.

Firstly, the researcher's academic supervisor and a researcher who had conducted a similar study reviewed the questionnaires. Based on their suggestions, the second and third questionnaires were modified from Likert-scale ranking to the sum of 1000. The modification highlighted the comparisons between criteria regarding their importance. It could reduce the risk that all criteria would be ranked as very important.

Secondly, the 3 questionnaires were pilot tested in Chinese with 3 graduates who was currently studying in IS domain and an information technology (IT) professional who had a similar background to the selected experts in the study. They were asked to fill in the questionnaires and offer their critiques of the questionnaires. Several suggestions were provided and corresponding changes were made. They suggested that in the first questionnaire, presenting the explanation and motivation of the criteria right after each criterion would be better than listing them in the end.

Thirdly, there is a contact person in each recruited company in this study. The contact persons were given the first questionnaire in advance. They were asked whether they had difficulties understanding any items and whether the constructs had clear definitions. They were invited to comment on the explanation and motivation of the listed criteria regarding the length, wording, and instructions. In general, they were positive in their comments about clarity and readability of the questionnaire. Some changes were subsequently made so as to contribute to the construct validity of the questionnaire.

3.3.1.2 Interview pilot study

The questions developed for follow-up interviews were refined for completeness and

understandability by means of a pilot study. A graduate who was currently studying in IS domain and the IT professional were invited to participate in the pilot study. They were provided the interview schedule and asked a series of potential interview questions. They were asked to figure out any questions that were ambiguous or yield useless responses.

They suggested that the term ‘requirements engineering’ should be avoided, because this term had rarely been introduced in software development in China. Therefore, the terms, like requirements analyses and requirements elicitation, were applied to replace ‘requirements engineering’ in the interviews.

3.3.2 Sampling strategy

Different with traditional survey, Delphi survey does not depend on a statistical sample that attempts to be representative of any population (Okoli and Pawlowski 2004). The goal of Delphi survey is to utilize “expert” opinion. The selection of the qualified experts who have the knowledge of the research problem turns out to be very crucial for the reliability of the results.

The experts were not chosen randomly in this study. This study followed the strict procedure by modifying Delbecq *et al.*’s (1975) approach to solicit qualified experts who have deep understanding of requirements selection in software development.

- Firstly, the researcher got a list of technical companies which were registered in China from Shanghai Administration of Industry and Commerce. More than one thousand companies were listed.

- Secondly, in order to get a reliable result, the companies that had less than 100 staffs were removed from the list. Meanwhile, as this research focuses on requirements selection process in market-driven software development, only the companies that carried out market-driven software development projects were

reserved on the list. After the subtraction, 78 companies were listed.

- Thirdly, based on researcher's personal relationship, 11 out of the 78 companies agreed to participate in this study. The numbers from 1 to 11 were assigned to the 11 companies to replace their names for ethical reason. The detailed information of the 11 companies is presented in Section 4.

- Fourthly, there is a contact person in charge of the contact with the researcher in each of the 11 companies. Every contact person was offered an introduction of the research in advance. The researcher talked to each contact person about the research objective and the desirable experts who would make the best participants. Then, each contact person recommended about 15 industry experts from their companies.

- Finally, the researcher distributed questionnaires to the 168 experts recommended by the contact persons in 11 companies. Of these experts, 132 participated in the first phase of the study; 129 participated in the second-phase survey; 105 participated in the third-phase survey; and 6 of them participated in the follow-up interviews. The recruited experts in this study included companies' executives, product managers, market analyst, project managers, software developer, maintenance engineers, and so on.

3.3.3 Data collection procedure

The data collection procedure of the Delphi study could be divided into four phases as presented in Section 3.2.5: identifying the decision-making criteria for requirements selection, ranking the criteria based on their relative importance, attaining a consensus on their ideal importance, and exploring the decision-making process of requirements selection by follow-up interviews.

3.3.3.1 Phase 1: identification of criteria

In this phase, the industry experts were asked to fill in the first questionnaire to decide whether the criteria identified by the researcher in advance were relevant to their decision-making and present extra missing criteria as well.

As presented in Section 3.3.2, the contact persons in 11 companies selected the experts who they regarded as appropriate to participate in the study. The contact persons in 4 companies chose to distribute the first questionnaire to the participants in their companies by themselves. The researcher offered the electronic copy of the first questionnaire to the contact persons. The contact persons collected participants' responses and then delivered to the researcher. The researcher's contact details were displayed in the questionnaire to ensure that any participant was able to contact the researcher directly. In addition, the questionnaire included a brief introduction of the study to explain the study's motivation and objective.

In the other 7 companies, the researcher distributed the first questionnaire to each of the participants and explained the purpose of the research to them in person, except those who were not in the offices at that moment. For those away from the offices, the contact persons in the companies took charge of the distribution after they came back. All the responses were collected by the contact persons in these companies and then delivered to the researcher.

In total, 132 responses of the first questionnaire were received from the 11 companies out of 168 questionnaires that were sent out.

3.3.3.2 Phase 2: ranking the criteria

In this phase, the experts who participated in the first phase survey were asked to fill in the second questionnaire to provide the ratings regarding the practical and ideal importance of the criteria identified by the first questionnaire.

The second questionnaire was delivered by email to the 132 experts who participated in the first phase survey, and they were asked to return their responses directly to the researcher by email.

The second-phase questionnaire was sent out twice to the experts. After the first delivery, 42 responses were received. Then, the researcher called irresponsive experts individually where their phone numbers were available, and also asked the contact persons to encourage their colleagues to fill in the second questionnaire. All 129 responses were finally received. One expert from Company-3, Company-4, and Company-10 respectively decided not to participate in the study sequentially.

3.3.3.3 Phase 3: consensus on criteria's importance

In this phase, another ranking phase was conducted in order to make the experts reach an acceptable level of consensus. The information summarized from the second-phase survey was a baseline to facilitate their further ranking.

The third questionnaire was delivered by email to the 129 experts who participated in the second phase survey, and they were asked to return their responses directly to the researcher by email.

The third questionnaire was sent out twice to the experts. The contact persons were called and reminded to encourage their colleagues to fill in the third questionnaire. All 105 responses were finally received. One expert from Company-2, 2 from Company-3, 2 from Company-4, 8 from Company-6, 3 from Company-8, 2 from Company-9, 2 from Company-10, and 4 from Company-11 quitted the study.

3.3.3.4 Phase 4: follow-up interviews

In this phase, follow-up interviews were conducted with 6 experts selected from the participants in the anterior three phases. Interviews aim to get some interesting insights into the rationale behind the ratings and collect some responses to the

communication between different stakeholders in the requirements selection process.

Interviewees were chosen by the researcher according to their responses to the 3 questionnaires, their working experience, and their roles in the company. The researchers made the best to distribute interviewees over different companies and different working positions. In all, 22 experts, 2 experts from each company, were invited, but 6 out of the 22 experts were accepted. They were a maintenance engineer and a project manager from Company-3, a software developer from Company-4, a senior consultant from Company-8, a market analyst from Company-10, and a deputy general manager from Company-11

The interviews were conducted with only one participant in attendance. The time to conduct the interview was arranged with each interviewee individually based on his or her convenience. The researcher had a chat with the interviewees before the formal interview. The researcher felt that the casual talk could help the interviewees feel comfortable and friendly with the researcher, and then willing to talk more in the interviews.

Three of the interviews were conducted face-to-face in the meeting room of interviewee's companies. The 3 interviews were conducted with a maintenance engineer and a project manager from Company-3 and a senior consultant from Company-8. The proceedings of the 3 face-to-face interviews were recorded electronically. The other 3 interviews were conducted over the phone. Each interview went for a duration ranging from 20 to 30 minutes.

As Chinese is the first language of both the researcher and participants, all the three-phase survey and follow-up interviews were conducted in Chinese. Table 3.3 presents the number of experts in each company that participated in each phase of the study.

Table 3.3: Number of experts from 11 companies that participated in each phase

	First-phase survey	Second-phase survey	Third-phase survey	Fourth-phase interviews
Company-1	11	11	11	0
Company-2	10	10	9	0
Company-3	12	11	9	2
Company-4	18	17	15	1
Company-5	13	13	13	0
Company-6	12	12	4	0
Company-7	10	10	10	0
Company-8	14	14	11	1
Company-9	11	11	9	0
Company-10	10	9	7	1
Company-11	11	11	7	1
Sum	132	129	105	6

3.3.4 Language translation

As all the data were collected in Chinese in the study, the language translation of the instruments and collected data was a threat to the validity and reliability of the findings. However, strict procedure was followed for the language translation between English and Chinese to lessen the negative effect.

The 3 questionnaires were first translated from English to Chinese by the researcher. Then, two independent specialists of language translation between English and Chinese were asked to review the original questionnaires and the translated versions. One specialist is a professional language translator, and the other one is a college professor specialized in English linguistics. They suggested a few minor changes. The Chinese questionnaires were revised based on their suggestions to ensure that the Chinese versions had the same meanings as the English ones.

Moreover, the data collected by follow-up interviews were transcribed and analyzed in Chinese. However, the researcher translated the interview transcripts from Chinese to English for presentation of the findings and ethics storage. To ensure agreement on

the translation, first, the same 2 independent specialists of language translation mentioned before were invited to review and comment on the translated transcripts. Second, the interviewees were asked to review both the original transcripts and the translated versions. The translated interview records were further modified based on the comments from both sides.

3.3.5 Ethical consideration

This research was approved by UNSW ethics committee. The ethic approval reference number is 056079. Strict ethical procedures were applied throughout the research process. The researcher adhered to ethic codes of UNSW ethics committee. Participants were fully informed of the nature of the research and any relative reportage. The participants' personal information obtained in the study remains confidential and is disclosed only with participants' permission.

3.4 Chapter summary

This chapter details the research methodology of this study, including the research objectives and questions, the research framework, Delphi method, development of questionnaires and interview questions, pilot studies, sampling strategy, data collection procedure, translation issues, and ethic considerations.

4 Data analysis and Results

4.1 Introduction

This chapter, first, introduces the 11 recruited companies in the study respectively. Second, the data analysis processes as well as the results of the four-phase Delphi study are presented according to the 4 research objectives outlined at Section 3.2.1.

4.2 Introduction of companies

Table 4.1 gives overall information about the 11 recruited companies. The scale of company is identified based on the staff number of the company. Ex-large-sized companies have more than 10,000 employees; large-sized companies have less than 10,000 employees but more than 1,000 employees; medium-sized companies have less than 1,000 employees but more than 200 employees, and small-sized companies have less than 200 employees. None of the 11 recruited companies belong to small-sized companies.

Table 4.1: Description of the 11 companies

	Type	Scale	Number of employees	Percentage of IT people	National/ International	Country of origin
Company-1	Telecommunication service provider	Ex-Large	250,000	4%	International	China
Company-2	Software development company	Medium	200	50%	National	China
Company-3	Software development company	Large	5,000	20%	International	China
Company-4	Software development company	Ex-Large	50,000	20%	International	U.S.A.
Company-5	Integrated circuit design company	Medium	250	40%	National	China
Company-6	Telecommunication equipment provider	Ex-Large	60,000	10%	International	Sweden
Company-7	Software development company	Large	2000	30%	International	China
Company-8	Technical value-added service provider	Medium	170	50%	National	China
Company-9	Software development company	Large	2,700	11%	International	China
Company-10	Software development company	Medium	400	30%	National	China
Company-11	Software development company	Medium	350	40%	National	China

4.2.1 Company-1

Company-1 is the leading provider of wire-line telecommunication services in China. Its information services cover the whole country of China and reach each corner of the global. The branches of Company-1 are across all 31 municipalities, provinces and autonomous regions of China as well as the United States and Europe. Software developed in the company works for large command and control systems, including asymmetrical digital subscriber line (ADSL) system, domestic toll free service system, answer system of calling card, and so forth.

Company-1 employs approximately 250,000 staff, of which about 10000 are in IT or IT related roles.

The researcher has a personal contact within Company-1 and gained the approval of the general manger of its Shanghai branch to conduct the study. There were 11 experts recruited from Company-1, who were involved in software development projects. They mainly work in technology department, internet and value-added services department, and Shanghai research institute. They gave their answers based on their overall software development experiences.

4.2.2 Company-2

Company-2 is a software development company that primarily operates in China. Company-2 develops the software applied for waterpower, environmental conservation, electric power, and port transportation. One of its current software development projects in the company is a cooperative project with a German software company to develop a China-customized hydrological water resource information system.

Company-2 is a medium size company, with approximately 200 staff. Most of them have a technical background, and about half are in IT or IT related roles.

The researcher has a personal contact with its general manager and gained his approval to conduct the study. Ten experts were recruited to participate in this study from Company-2, including the general manager himself, marketing analysts, project managers, and software developers. One of them quitted the study in the third-phase survey. They gave their answers mainly based on the hydrological water resource information system project.

4.2.3 Company-3

Company-3 is the second largest providers of management software solutions and service in Asia. It was originally established in China in 1988, and its branches have expanded all over the countries and regions in Asia. Company-3 has been recognized as an outstanding software company in the marketplace due to its quality products and professional service. The company has occupied the No. 1 annual ranking for the management software market in China for five years.

Company-3 employs approximately 5,000 staff, of which about 1000 are in IT or IT related roles.

The researcher got the assistance from the director of maintenance department in Company-3 to conduct the study there. All 12 experts were recruited from this company, but one of them quitted the study in the second-phase survey and other 2 quitted the study in the third-phase survey. They are all involved in one software development project, which develops an integrated software solution for small and medium-sized enterprises based on several successful customer-specific projects. These experts include the department director, project managers, software developers, and engineers for maintenance and customer service. They gave their answers based on this software development project. Two experts from Company-3 participated in the follow-up interviews.

4.2.4 Company-4

Company-4 is one of the largest international enterprise software development companies in the world. The company has its headquarters in the United States and its branches in other 95 countries in the world. It provides database, management, and application software in more than 145 countries.

Company-4 is the first large international software companies entering into Chinese market. The company has two own research and development centers in China for product authentication, software localization, and technical support.

Company-4 employs approximately 50,000 staff all over the world, of which about 10000 are in IT or IT related roles.

The researcher has a personal contact within Company-4 and gained the approval of the manager of its Shanghai branch to conduct the study. There were 18 experts recruited from the company, who were involved in the development and localization of e-business suite software. However, one of them quitted the study in the second-phase survey and other 2 quitted the study in the third-phase survey. The experts include project managers, software developers, marketing analysts, and senior consultants. They gave their answers mainly based on this software development project. One expert from Company-4 participated in the follow-up interview.

4.2.5 Company-5

Company-5 is a medium-sized integrated circuit design company. It provides hardware and software products with mixed-signal processing technologies, which enable new applications in digital entertainment and personal computing. Company-5 was originally founded in China, but solely owned by American side. The company aims at the technical gap of the mixed-signal processing between China and the United States.

Company-5 employs approximately 250 staff, of which about 100 are in IT or IT related roles.

The researcher worked in Company-5 as an intern two years ago. The researcher made direct contact with the technology department manager to conduct the study there. There were 13 experts recruited from this company, including software developers, marketing analysts, project managers. They gave their answers based on their overall software development experiences.

4.2.6 Company-6

Company-6 is a world-leading provider of telecommunication equipments and services of mobile and fixed network. It offers both hardware and software products of telecommunication. Company-6 was originally founded in Sweden. Through more than 100 years development, over 1,000 networks in 140 countries all over the world utilize its network equipments, and 40 percent of all mobile calls are made by its systems.

The company established its branches in China in 1994. China is always treated as the core of the entire world by the company. China has become one of its 3 major product providers since 2002.

Company-6 employs approximately 60,000 worldwide staff, of which about 6,000 are in IT or IT related roles. In China, the company has about 4,000 permanent staff across 34 offices.

The researcher has a personal contact within Company-6. The director of human resource department in its Shanghai branch offered great assistance for conducting the study. The study recruited 12 experts from its China research and development institute in Shanghai, who involved in the project that develop software for three-generation mobile communication network system. They gave their answers

mainly based on this software development project. However, 8 experts quitted the study in the third-phase survey.

4.2.7 Company-7

Company-7 is a Hongkong listed public company, which has been a leading software developer in China for years. It is actively engaged in the development and promotion of software in such areas as e-government, e-business, e-security services and products. In the future decades, the company will lay its emphasis on software outsourcing services in international arena.

Company-7 employs approximately 2000 staff across the branches in China, Japan and, the United States, of which about 600 are in IT or IT related roles.

The researcher has a personal contact with one associate manager of the marketing department in the company. With his help, 10 experts were recruited from the company, who were involved in the inspection system of network in-break development project. They gave their answers mainly based on this project.

4.2.8 Company-8

Company-8 is one major company founded by municipal government in Shanghai as a subsidiary company of Shanghai Pudong Software Park. Its main business is to promote new IT technologies and to provide value-added software products. The company is planning to lay its main emphasis on international software market in the future 5 years.

Company-8 is a medium size company, with approximately 170 staff. Most of them have a technical background, and about half are in IT or IT related roles.

The researcher has a personal contact within the superior company of Company-8, Shanghai Pudong Software Park. There were 14 experts recruited to participate in this

study from the company, but 3 of them quitted the study in the third-phase survey. The recruited experts include department managers, project managers, product managers, and software developers. They are involved in one or several projects among enterprise report system development projects, leader personnel management system development projects, and performance assessment system development projects. They gave the answers based on their overall software development experiences. One expert from the company participated in the follow-up interview.

4.2.9 Company-9

Company-9 is one of the top providers in industry software products as well as automation and intelligent system integration in China. It was established in 2001 as an affiliated company of the largest iron and steel company in China. At the very start, the company developed software for Iron and Steel industry only, but its software products have spread all over metallurgy, power, traffic, finance, retail, media, and medicine. Besides, the company targets at the worldwide market. It mainly exports software to Japan and some Euro-American countries. Currently, the companies have several major software development projects, such as network security, office automation, and city information integration system.

The staff numbers in Company-9 have been multiplied several times from about 200 to 2700 in 4 years. The company has approximately 300 IT or IT related staff at present.

The researcher has a personal contact with the project manager of the network security project. The network security project aims to develop a set of security operation management products for computer local area network, named as eCop. 11 experts were recruited to participate in the study, but 2 of them quitted the study in the third-phase survey. The recruited experts are project managers and software developers in this project. They gave their answers mainly based on this software development project.

4.2.10 Company-10

Company-10 is a joint software development company between Shanghai municipal government and one of the largest international software development companies. The company was established in 2002 in Shanghai. It is an IT service focused software company, extending its business in the fields of technical support, software development, and enterprise services. It strongly promotes China's software industry towards global recognition.

Company-10 employs about 400 staff, of which about 30% are in IT or IT related roles.

The researcher has a personal contact within Company-10 and gained the approval of its chief information officer to conduct the study. The study recruited 10 experts from the company, including department managers, project managers, software developers, maintenance engineers, and marketing analysts. They filled the questionnaires based on their experiences of conformity marketing management system projects, which aims to modify the marketing management systems with Chinese characters so as to meet Chinese small-to-medium companies' requirements. One expert quitted the study in the second-phase survey and other 2 quitted the study in the third-phase survey. Nonetheless, one expert from the company participated in the follow-up interview.

4.2.11 Company-11

Company-11 is a market leader in financial software development and system integration in China. It provides solutions in the fields of online transaction switching and settlement, core banking, credit information management, e-Payment, financial agent business processing, and smart card processing. The company has built up its core competency on online transaction processing by positioning itself as the offshore development center for customers worldwide.

Company-11 employs 350 staff, of which about 140 are in IT or IT related roles.

The researcher has a personal contact with one deputy general manager of Company-11 and gained the approval to conduct the study with her help. The study recruited 11 experts from this company, but 4 of them quitted the study in the third-phase survey. The recruited experts from this company include project managers, senior consultants of software development, after-sale supporters, and software developers. They gave their answers based on their overall development experiences. One expert from the company participated in the follow-up interview.

4.3 Research objective 1

The first research objective is to identify the underlying decision-making criteria for requirements selection in market-driven software development projects.

Research Question 1: what are the decision-making criteria used for selecting a requirement to be implemented in market-driven software development projects?

4.3.1 Data analysis

The first-phase survey with the first questionnaire was conducted to get the answer of this research question. The first questionnaire listed 14 criteria identified by the researcher in advance based on the existing literature. The experts were asked to decide whether the 14 criteria were relevant to their decision-making of requirements selection and encouraged to submit extra missing criteria. The first questionnaire is presented in Appendix A.

Four-step analyses were conducted to interpret the data obtained by the first-phase survey.

First of all, all the responses were analyzed to consolidate into a final list of criteria.

The 14 criteria were sorted based on the experts' opinions of the criteria's relevancy. Additional criteria identified by the experts were listed together and verified whether they had been properly mapped by the existing 14 criteria or they should be added into the following questionnaires.

Secondly, the results of the 11 companies were analyzed individually to compare the differences between them. The experts' opinions of the criteria's relevancy in each company were investigated. Further, experts' opinions from different companies were compared regarding each criterion's relevancy to find out the similarity and differences between the 11 companies.

Thirdly, the results were analyzed based on the different size of the companies. The 11 companies were divided into ex-large, large, and medium size based on their staff numbers as presented in Section 4.2. Company-1, Company-4, and Company-6 belong to ex-large-sized companies; Company-3, Company-7, and Company-9 belong to large-sized companies; and Company-2, Company-5, Company-8, Company-10, and Company-11 belong to medium-sized companies. The opinions of the experts from the different-sized companies were compared regarding each criterion's relevancy so as to find out the similarity and differences between them. It is worth mentioning that all the ex-large companies recruited in this study are international companies, while all the large and medium companies are national companies. The differences of the opinions between different-sized companies also indicated the differences between international and national companies.

Lastly, the responses of the participants from different perspectives were analyzed separately based on their roles in the companies to compare the results between them. General Manager, department manager, product manager, marketing analyst, and senior consultant represent the participants from business perspective; project manager and project coordinator represent the participants from project perspective; software developer, maintenance engineer, service engineer, and after-sale supporter

represent participants from product perspective. The opinions of the experts from different perspectives were compared regarding each criterion's relevancy. The analysis indicated whether there were biases between different-perspective stakeholders regarding the relevancy of the criteria.

The detailed results are presented as follows.

4.3.2 Selection of criteria (all participants)

All 132 experts from the 11 companies were participated in the first-phase Delphi survey to answer whether the 14 criteria were relevant to the decision making of requirements selection or not.

The experts' opinions of the 14 criteria's relevancy are graphically presented in Figure 4.1. The numerical values are presented in Table A.1 in Appendix B.

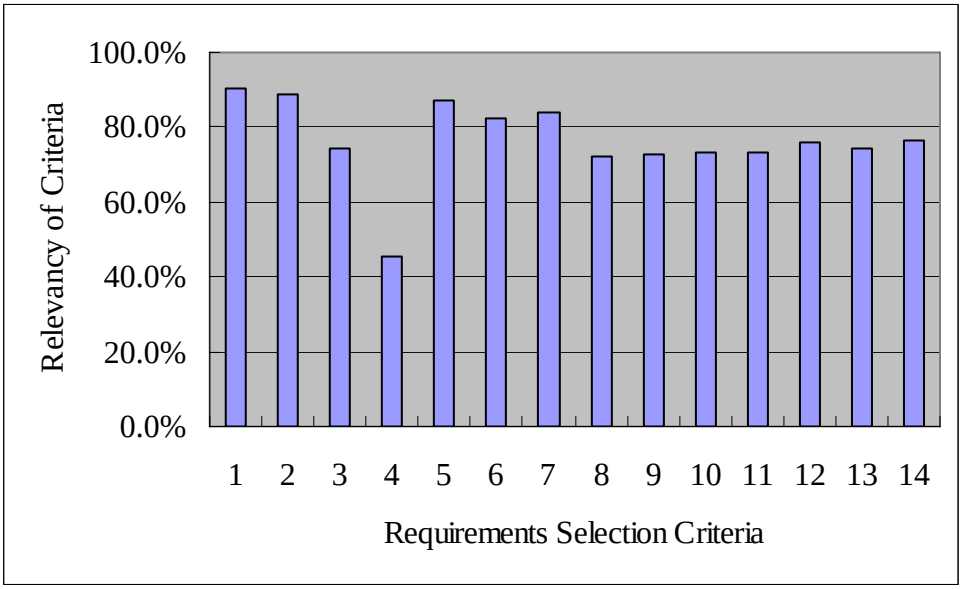

Figure 4.1: Experts' opinions of requirements selection criteria's relevancy

As shown in the figure, more than 80% experts regarded 5 of the 14 criteria as relevant. These 5 criteria were:

- Business strategy (criterion 1)

- Customer satisfaction (criterion 2)
- Software features (criterion 5)
- Development cost (criterion 6)
- Calendar time (criterion 7)

Other 8 criteria were regarded as relevant by more than 70% experts. These were:

- Competitors (criterion 3)
- Extra cost (criterion 8)
- Resources (criterion 9)
- After-sale support (criterion 10)
- Complexity (criterion 11)
- Evolution (criterion 12)
- Requirements dependencies (criterion 13)
- Requirement volatility (criterion 14)

In addition, one criterion was regarded as relevant by less than half experts. Thus, this criterion was removed from the list of criteria in the second and third questionnaires. The least relevant criterion was:

- Requirement's issuer (criterion 4)

It was worth mentioning that 7 additional criteria were proposed by the experts. They are 'relationship with customer', 'total ownership cost', 'business model', 'industy character', 'document management', 'business objective', and 'customer value'. However, the set of criteria identified by the researcher in advance was believed to cover all the additional criteria and provide an exhaustive list of the decision-making criteria for requirements selection. Thus, none of the additional criteria was added into the second or third questionnaires. The detailed definitions and explanations of the extra criteria as well as the reasons why these criteria were not included in the following questionnaires are presented in Appendix C.

4.3.3 Selection of criteria (company-based analysis)

This subsection presented the results based on each company with a comparison between the 11 companies. The experts' opinions of the criteria's relevancy in each company were investigated to indicate whether the criteria were considered or not when making the decisions of requirements selection in the company. Further, experts' opinions from different companies were compared regarding each criterion's relevancy to find out the similarity and differences between the 11 companies.

4.3.3.1 Company-1

All 11 experts from Company-1 were participated in the first-phase Delphi survey. Figure 4.2 presents the opinions of the experts from Company-1 regarding the 14 criteria's relevancy. 5 of the 14 criteria were regarded as relevant by more than 80% experts from Company-1. They were 'customer satisfaction' (criterion 2), 'software features' (criterion 5), 'development cost' (criterion 6), 'calendar time' (criterion 7), and 'resources' (criterion 9). Additionally, less than half experts from Company-1 regarded 'requirement's issuer' (criterion 4), 'extra cost' (criterion 8), and 'after-sale support' (criterion 10) as relevant.

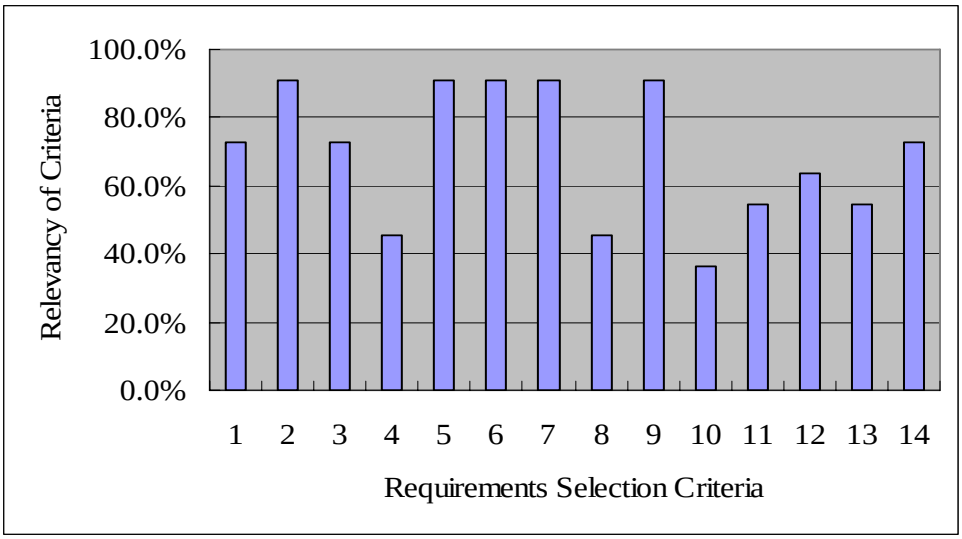

Figure 4.2: Experts' opinions of requirements selection criteria's relevancy in Company-1

4.3.3.2 Company-2

All 10 experts from Company-2 were participated in the first-phase Delphi survey. Figure 4.3 presents the opinions of the experts from Company-3 regarding the 14 criteria's relevancy. 'Business strategy' (criterion 1) and 'calendar time' (criterion 7) were regarded as relevant by all experts from Company-2. Moreover, 4 of the 14 criteria were regarded as relevant by more than 80% experts from Company-2. They were 'customer satisfaction' (criterion 2), 'development cost' (criterion 6), 'extra cost' (criterion 8), 'evolution' (criterion 12). Furthermore, 'competitors' (criterion 3), 'software features' (criterion 5), 'resources' (criterion 9), 'after-sale support' (criterion 10), and 'requirement volatility' (criterion 14) were regarded as relevant by 80% experts from Company-2. However, less than half experts from Company-2 regarded 'requirement's issuer' (criterion 4) as relevant.

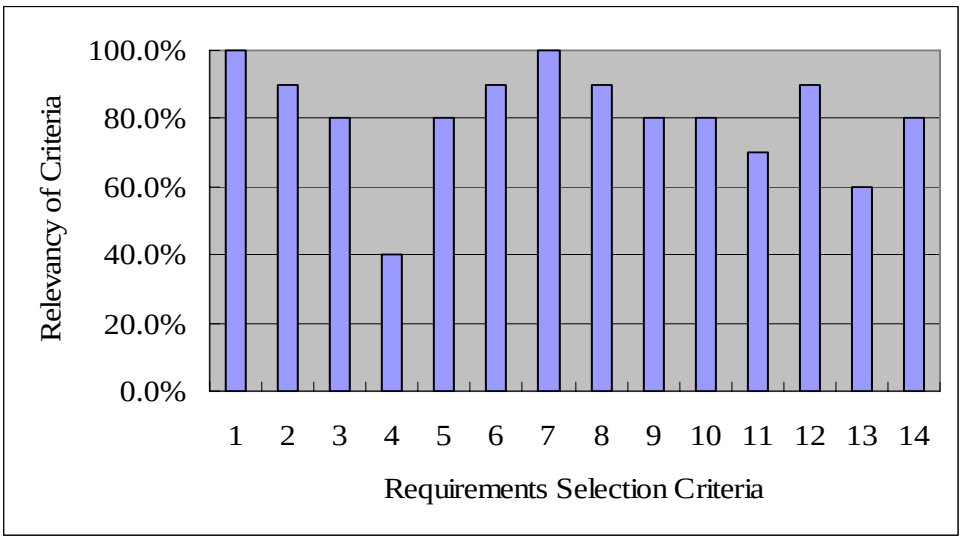

Figure 4.3: Experts' opinions of requirements selection criteria's relevancy in Company-2

4.3.3.3 Company-3

All 12 experts from Company-3 were participated in the first-phase Delphi survey. Figure 4.4 presents the opinions of the experts from Company-3 regarding the 14 criteria's relevancy. 'Business strategy' (criterion 1) and 'after-sale support' (criterion 10) were regarded as relevant by more than 80% experts from Company-3. Additionally, only half experts from Company-2 regarded 'requirement's issuer'

(criterion 4) and ‘development cost’ (criterion 6) as relevant.

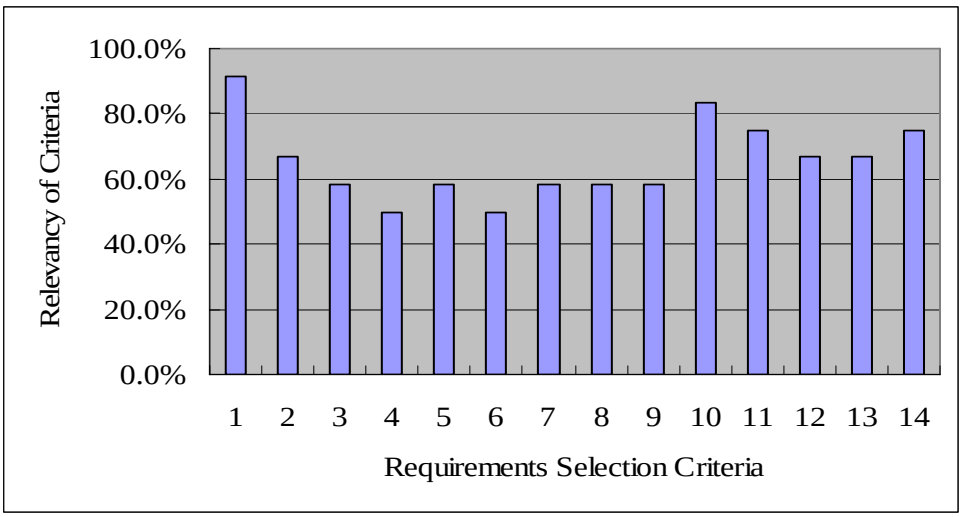

Figure 4.4: Experts’ opinions of requirements selection criteria’s relevancy in Company-3

4.3.3.4 Company-4

All 18 experts from Company-4 were participated in the first-phase Delphi survey. Figure 4.5 presents the opinions of the experts from Company-4 regarding the 14 criteria’s relevancy. ‘Software features’ (criterion 5) was regarded as relevant by all experts from Company-4. Moreover, 4 of the 14 criteria were regarded as relevant by more than 80% experts from Company-4. They were ‘customer satisfaction’ (criterion 2), ‘development cost’ (criterion 6), ‘evolution’ (criterion 12), and ‘requirements dependencies’ (criterion 13). Furthermore, only half experts from Company-4 regarded ‘requirement volatility’ (criterion 14) as relevant.

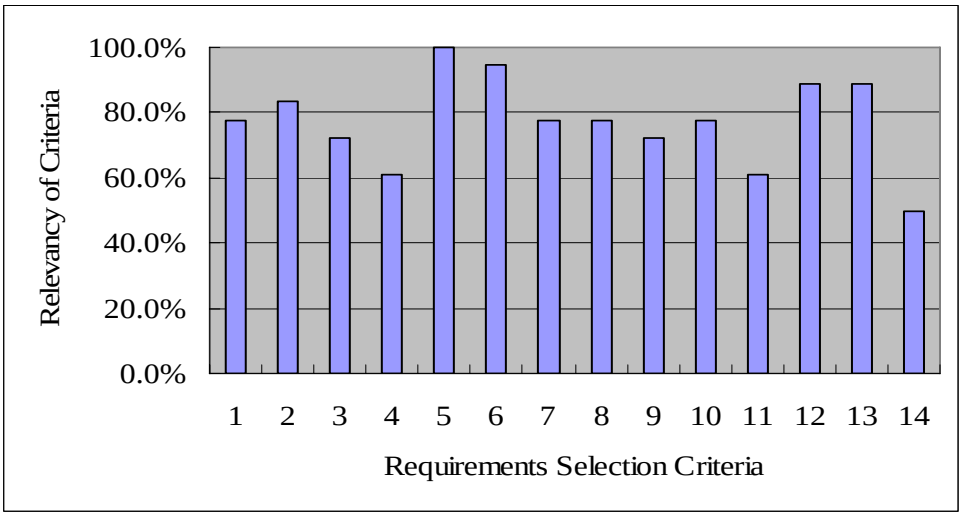

Figure 4.5: Experts' opinions of requirements selection criteria's relevancy in Company-4

4.3.3.5 Company-5

All 13 experts from Company-5 were participated in the first-phase Delphi survey. Figure 4.6 presents the opinions of the experts from Company-5 regarding the 14 criteria's relevancy. 'Business strategy' (criterion 1) was regarded as relevant by all experts from Company-5. Moreover, 3 of the 14 criteria were regarded as relevant by more than 80% experts from Company-5. They were 'customer satisfaction' (criterion 2), 'software features' (criterion 5), and 'complexity' (criterion 11). Furthermore, only about half experts from Company-5 regarded 'requirement's issuer' (criterion 4) and 'after-sale support' (criterion 10) as relevant.

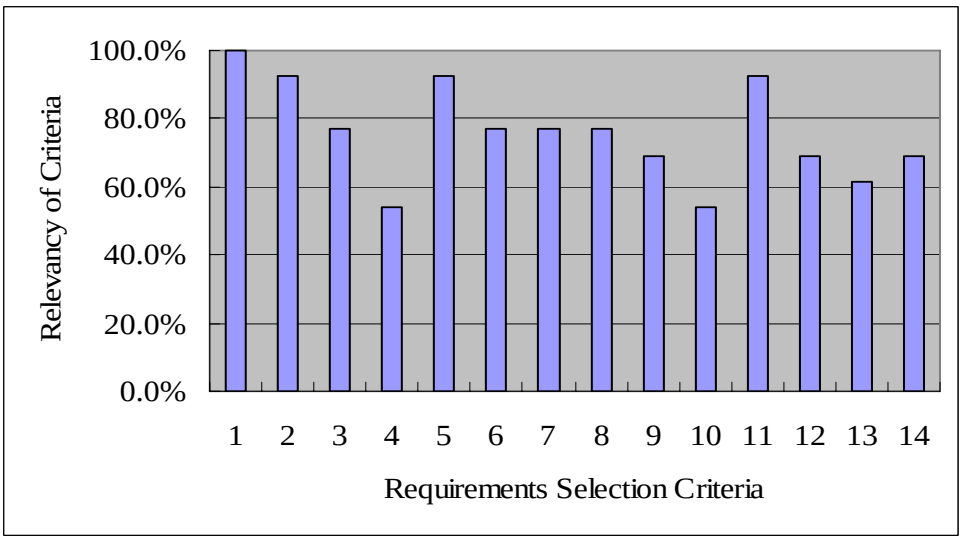

Figure 4.6: Experts' opinions of requirements selection criteria's relevancy in Company-5

4.3.3.6 Company-6

All 12 experts from Company-6 were participated in the first-phase Delphi survey. Figure 4.7 presents the opinions of the experts from Company-6 regarding the 14 criteria's relevancy. 'Business strategy' (criterion 1) was regarded as relevant by all experts from Company-6. Moreover, 7 of the 14 criteria were regarded as relevant by more than 80% experts. They were 'customer satisfaction' (criterion 2), 'competitors' (criterion 3), 'development cost' (criterion 6), 'calendar time' (criterion 7), 'resources' (criterion 9), 'evolution' (criterion 12), and 'requirement volatility' (criterion 14). However, only 30% experts regarded 'requirement's issuer' (criterion 4) as relevant.

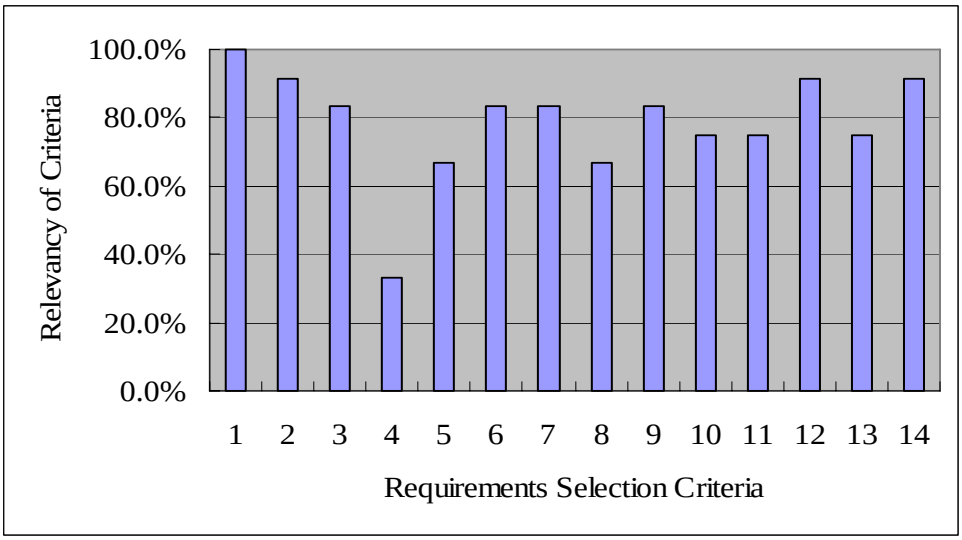

Figure 4.7: Experts' opinions of requirements selection criteria's relevancy in Company-6

4.3.3.7 Company-7

All 10 experts from Company-7 were participated in the first-phase Delphi survey. Figure 4.8 presents the opinions of the experts from Company-7 regarding the 14 criteria's relevancy. 'Competitors' (criterion 3) and 'software features' (criterion 5) were regarded as relevant by all experts from Company-7. Moreover, 9 of the 14 criteria were regarded as relevant by more than 80% experts from Company-2. They were 'business strategy' (criterion 1), 'customer satisfaction' (criterion 2), 'development cost' (criterion 6), 'calendar time' (criterion 7), 'after-sale support' (criterion 10), 'complexity' (criterion 11), 'evolution' (criterion 12), 'requirements

dependencies' (criterion 13), and 'requirement volatility' (criterion 14). Furthermore, less than half experts from Company-7 regarded 'requirement's issuer' (criterion 4) as relevant.

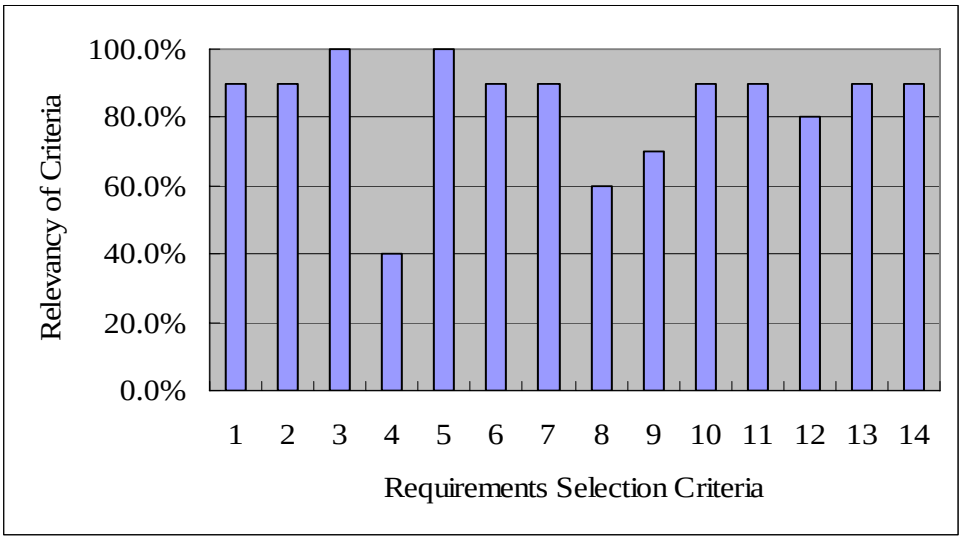

Figure 4.8: Experts' opinions of requirements selection criteria's relevancy in Company-7

4.3.3.8 Company-8

All 14 experts from Company-8 were participated in the first-phase Delphi survey. Figure 4.9 presents the opinions of the experts from Company-8 regarding the 14 criteria's relevancy. More than 80% experts from Company-8 regarded 6 of the 14 criteria as relevant. They were 'business strategy' (criterion 1), 'customer satisfaction' (criterion 2), 'software features' (criterion 5), 'development cost' (criterion 6), 'calendar time' (criterion 7), and 'complexity' (criterion 11). Less than 60% experts from Company-8, however, regarded 'resources' (criterion 9) and 'evolution' (criterion 12) as relevant.

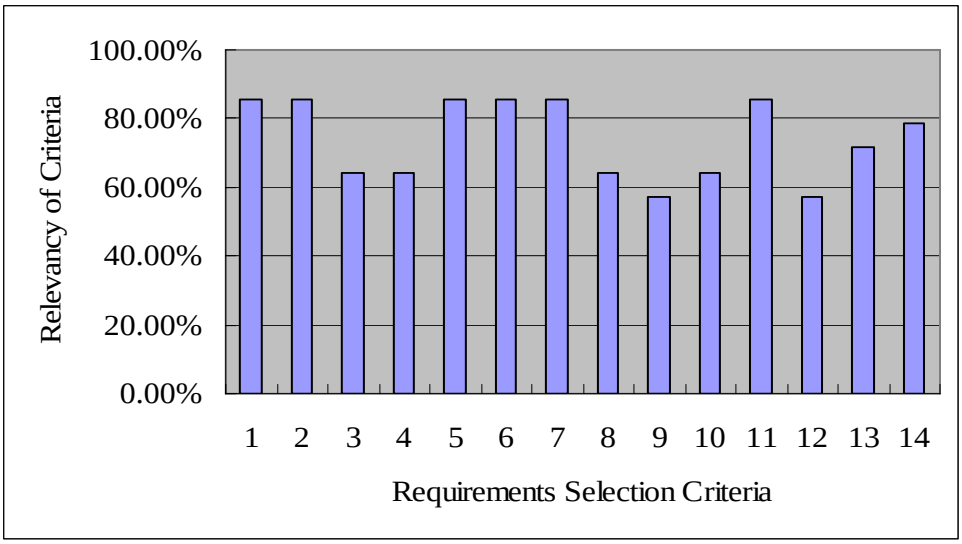

Figure 4.9: Experts' opinions of requirements selection criteria's relevancy in Company-8

4.3.3.9 Company-9

All 11 experts from Company-9 were participated in the first-phase Delphi survey. Figure 4.10 presents the opinions of the experts from Company-9 regarding the 14 criteria's relevancy. 'Business strategy' (criterion 1), 'customer satisfaction' (criterion 2), 'extra cost' (criterion 8), and 'requirement volatility' (criterion 14) were regarded as relevant by all experts from Company-9. Moreover, 5 of the 14 criteria were regarded as relevant by more than 80% experts from the company. They were 'competitors' (criterion 3), 'software features' (criterion 5), 'development cost' (criterion 6), 'calendar time' (criterion 7), 'resources' (criterion 9). Furthermore, less than half experts regarded 'requirement's issuer' (criterion 4) and 'evolution' (criterion 12) as relevant.

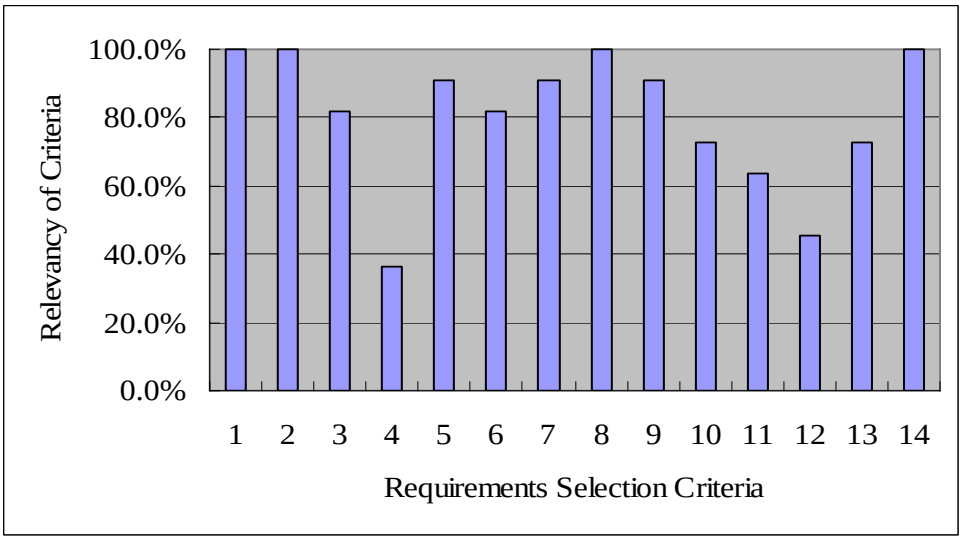

Figure 4.10: Experts' opinions of requirements selection criteria's relevancy in Company-9

4.3.3.10 Company-10

All 10 experts from Company-10 were participated in the first-phase Delphi survey. Figure 4.11 presents the opinions of the experts from Company-10 regarding the 14 criteria's relevancy. 'Business strategy' (criterion 1), 'customer satisfaction' (criterion 2), 'extra cost' (criterion 8), 'resources' (criterion 9), 'complexity' (criterion 10), and 'evolution' (criterion 12) were regarded as relevant by all experts from Company-10. However, only 30% experts from Company-2 regarded 'requirement's issuer' (criterion 4) as relevant.

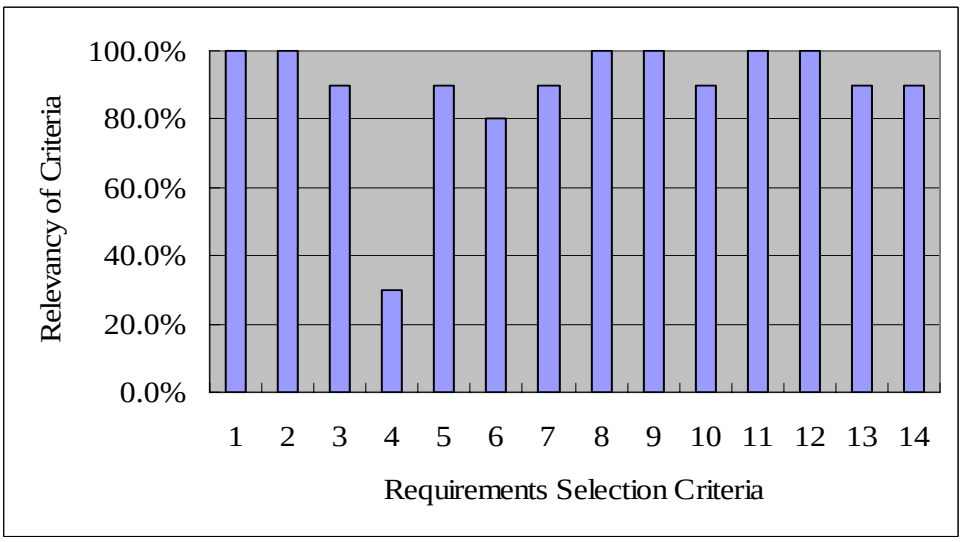

Figure 4.11: Experts' opinions of requirements selection criteria's relevancy in Company-10

4.3.3.11 Company-11

All 11 experts from Company-11 were participated in the first-phase Delphi survey. Figure 4.12 presents the opinions of the experts from Company-11 regarding the 14 criteria's relevancy. 'Software features' (criterion 5) was regarded as relevant by all experts from Company-9. Additionally, 7 of the 14 criteria were regarded as relevant by more than 80% experts from Company-11. They were 'business strategy' (criterion 1), 'customer satisfaction' (criterion 2), 'development cost' (criterion 6), 'calendar time' (criterion 7), 'after-sale support' (criterion 10), 'evolution' (criterion 12), and 'requirements dependencies' (criterion 13). However, less than half experts from Company-11 regarded 'competitors' (criterion 3), 'requirement's issuer' (criterion 4), 'resources' (criterion 9), and 'complexity' (criterion 11) as relevant.

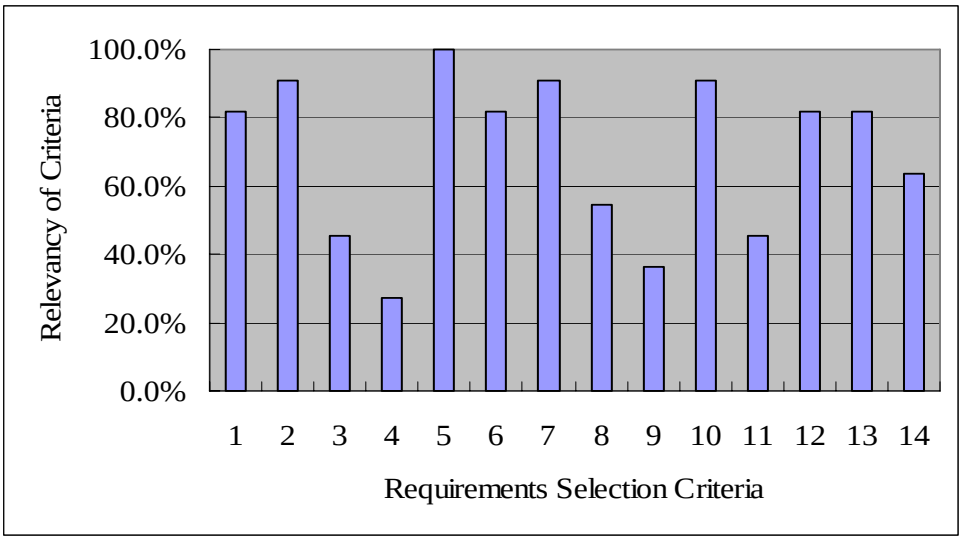

Figure 4.12: Experts' opinions of requirements selection criteria's relevancy in Company-11

4.3.3.12 Comparison between companies regarding each criterion

Experts' opinions from the 11 companies regarding each criterion's relevancy are presented respectively as follows. The analysis is to show the similarity and differences between the companies.

- ‘Business strategy’ (criterion 1)

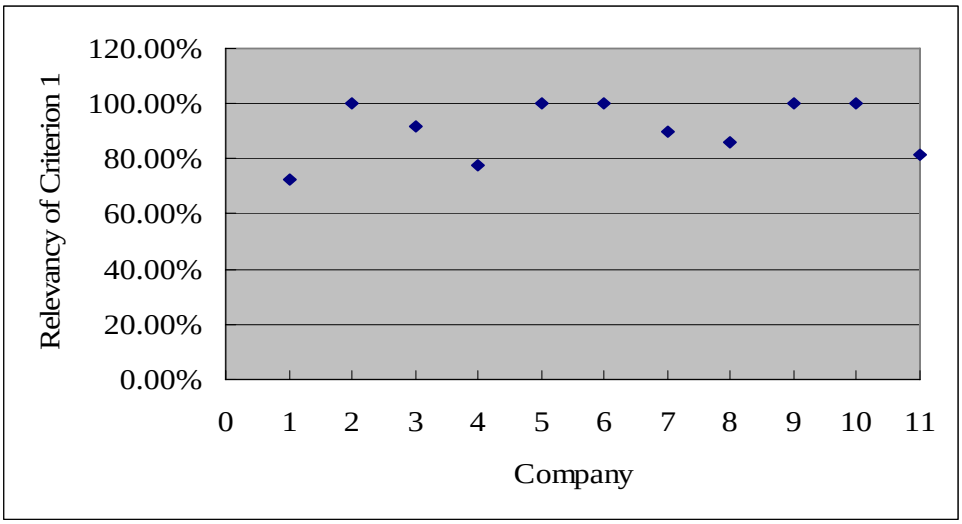

Figure 4.13: Experts’ opinions as to the relevancy of ‘Business Strategy’

As shown in Figure 4.13, the experts’ opinions as to the relevancy of ‘business strategy’ (criterion 1) was quite similar. More than three-quarter experts in all 11 companies felt that this criterion was relevant to their decision making.

- ‘Customer satisfaction’ (criterion 2)

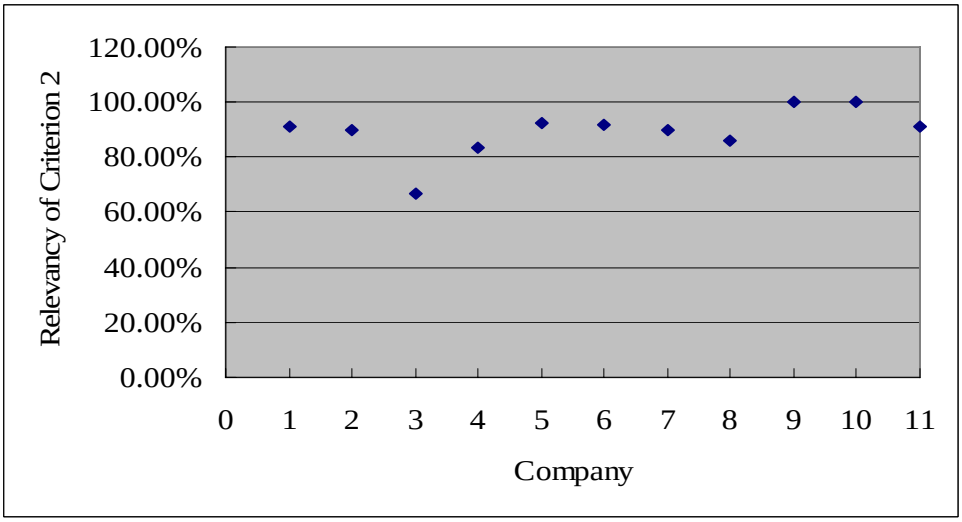

Figure 4.14: Experts’ opinions as to the relevancy of ‘Customer Satisfaction’

As shown in Figure 4.14, the experts from most companies had very similar opinion regarding the relevancy of ‘customer satisfaction’ (criterion 2), except Company-3. More than 83% experts from the other 10 companies considered this criterion as

relevant, while only 66.7% experts from Company-3 felt that this criterion was relevant to their decision-making of requirements selection.

- 'Competitors' (criterion 3)

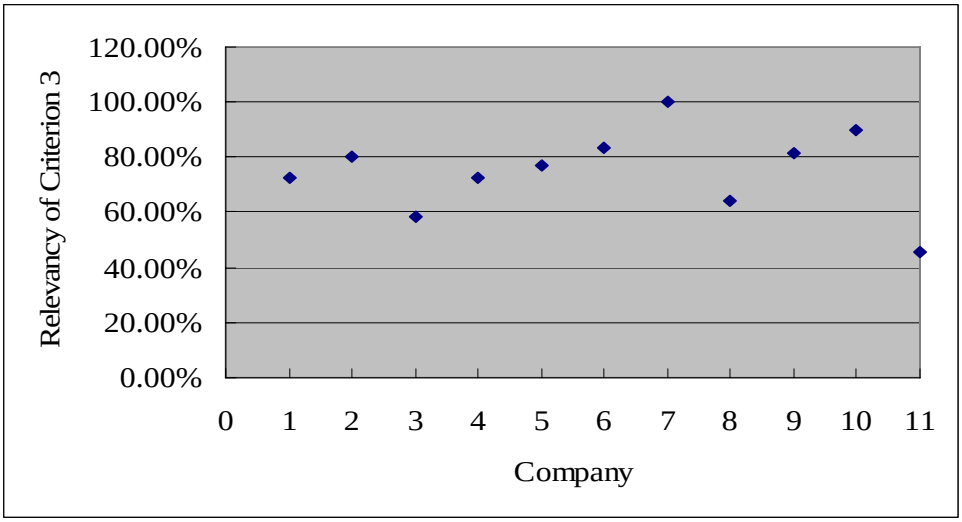

Figure 4.15: Experts' opinions as to the relevancy of 'Competitors'

As shown in Figure 4.15, there was little consistency between the 11 companies regarding the relevancy of 'competitors' (criterion 3). Less than 60% experts from Company-3 and Company-11 consider this criterion as relevant, while all the experts from Company-7 felt that this criterion was relevant to their decision making.

- 'Requirement's issuer' (criterion 4)

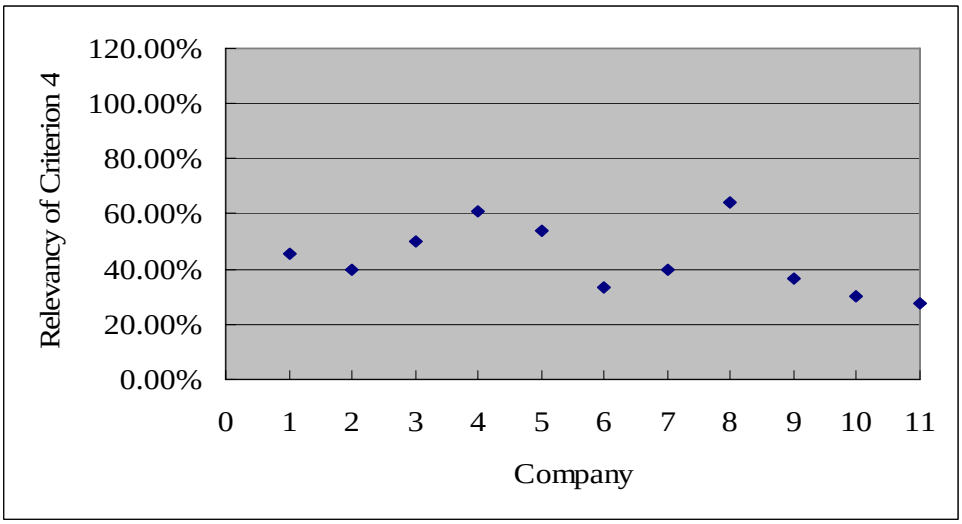

Figure 4.16: Experts' opinions as to the relevancy of 'Requirement's Issuer'

As shown in Figure 4.16, the differences between the companies regarding the relevancy of 'requirement's issuer' (criterion 4) were not large. About 60% experts from Company-4, Company-5, and Company-8 considered this criterion as relevant, while less than half experts from the other 8 companies felt that this criterion was relevant to their decision-making of requirements selection.

- 'Software features' (criterion 5)

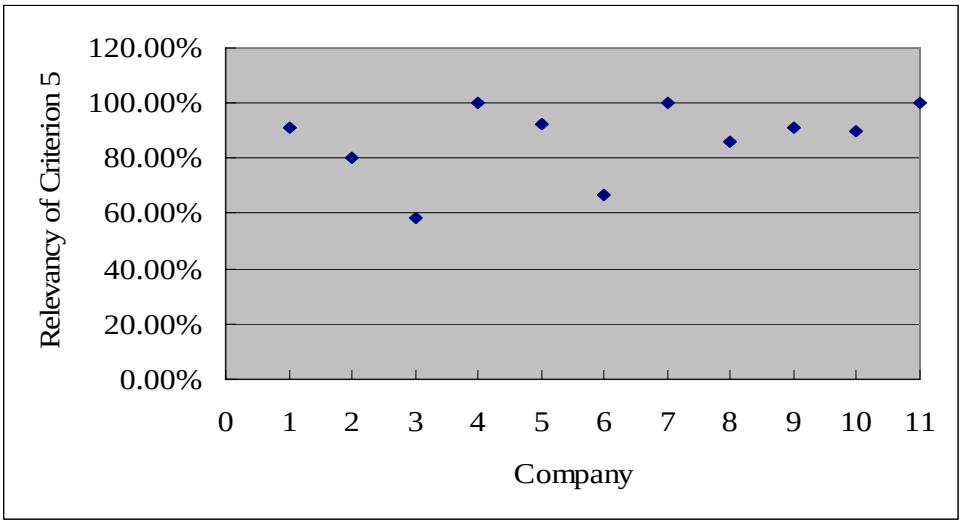

Figure 4.17: Experts' opinions as to the relevancy of 'Software Features'

As shown in Figure 4.17, most companies had similar opinion regarding the relevancy of 'software features' (criterion 5), except Company-3 and Company-6. Approximately 58.3% experts from Company-3 and 66.7% experts from Company-6 felt that this criterion was relevant, while more than 80% experts from the other 9 companies considered this criterion as relevant to their decision-making of requirements selection.

- ‘Development cost’ (criterion 6)

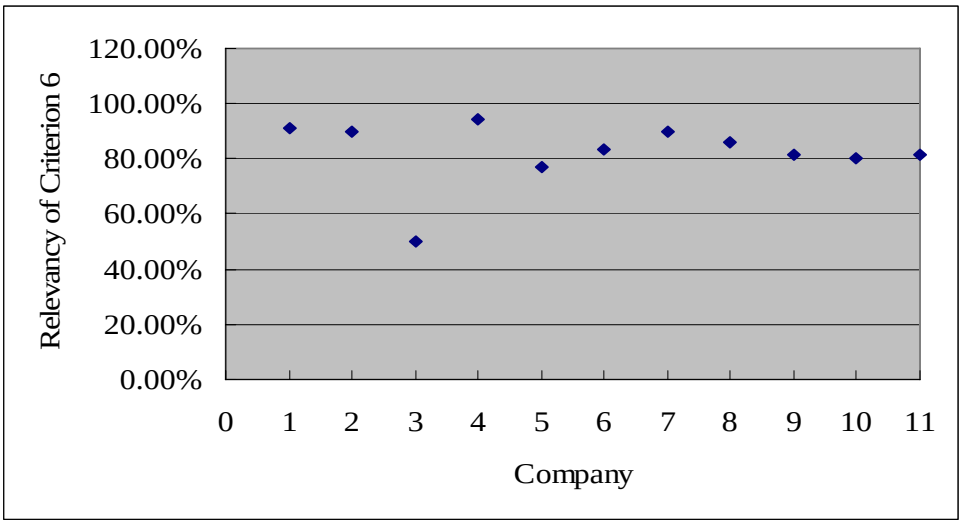

Figure 4.18: Experts’ opinions as to the relevancy of ‘Development Cost’

As shown in Figure 4.18, most companies had very similar opinion regarding the relevancy of ‘development cost’ (criterion 6), except Company-3. Only half of the experts from Company-3 felt that this criterion was relevant. However, the differences between the opinions of the experts from the other 10 companies were relatively small. More than 75% experts from the other 10 companies considered this criterion as relevant to their decision-making of requirements selection.

- ‘Calendar time’ (criterion 7)

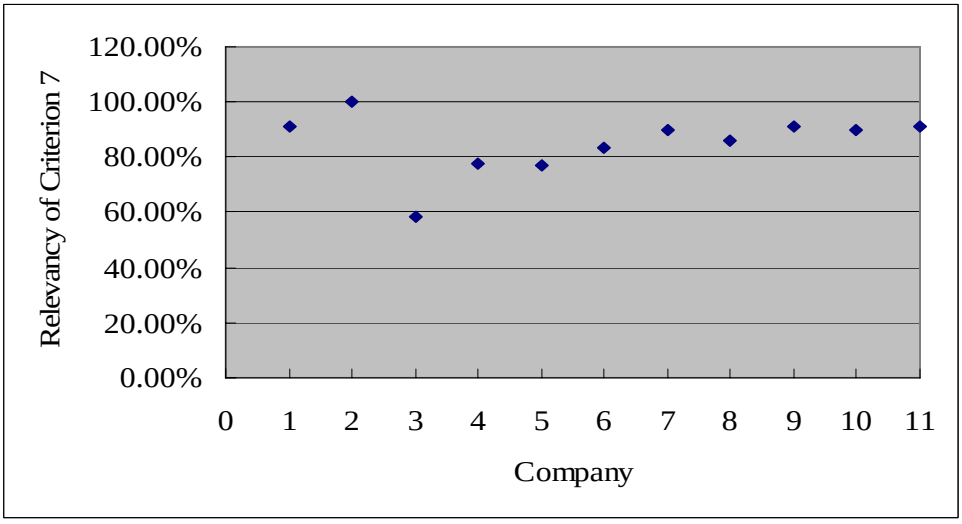

Figure 4.19: Experts’ opinions as to the relevancy of ‘Calendar Time’

As shown in Figure 4.19, the differences between the companies were not large regarding the relevancy of 'calendar time' (criterion 7), except Company-2 and Company-3. Only about half of the experts from Company-3 felt that this criterion was relevant, while all the experts from Company-2 felt that this criterion was relevant. However, the other 9 companies had very similar opinion about the relevancy of this criterion. More than 75% but less than 91% experts from these 9 companies considered this criterion as relevant to their decision making.

- 'Extra cost' (criterion 8)

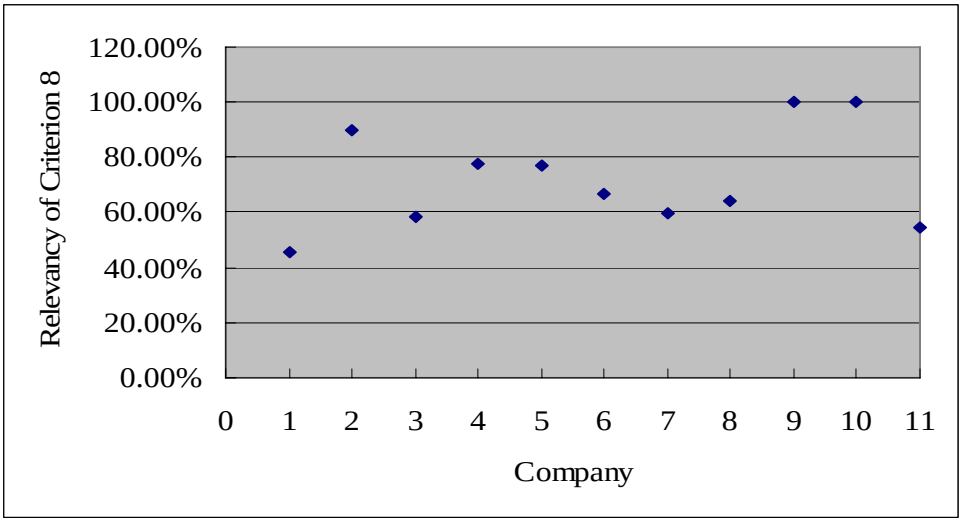

Figure 4.20: Experts' opinions as to the relevancy of 'Extra Cost'

As shown in Figure 4.20, there was little consistency between the 11 companies as to the relevancy of this criterion. The differences between the companies regarding this criterion were not small. All the experts from Company-9 and Company-10 and 90% experts from Company-2 felt that this criterion was relevant, while only 45% experts from Company-1 and 60% experts from Company-3 and Company-11 felt that this criterion was relevant to their decision-making of requirements selection.

- ‘Resources’ (criterion 9)

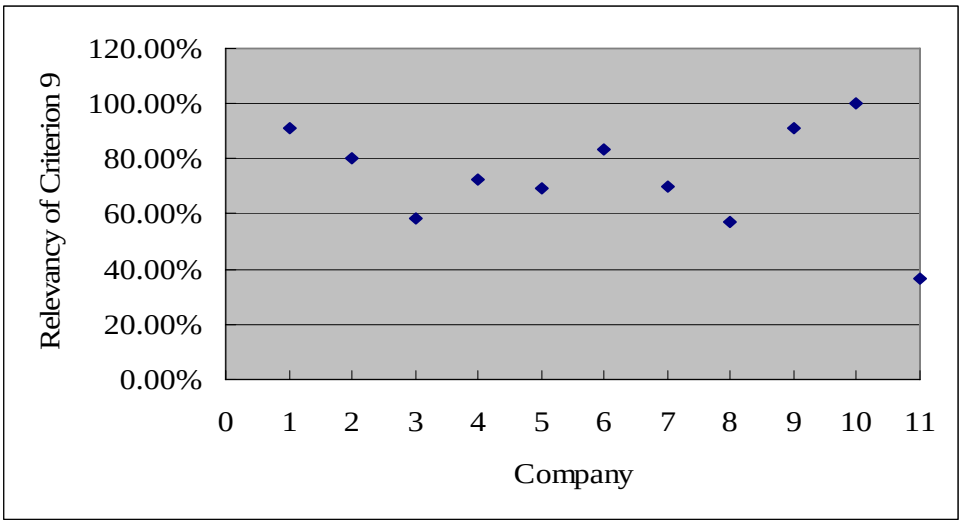

Figure 4.21: Experts’ opinions as to the relevancy of ‘Resources’

As shown in Figure 4.21, the differences between the companies regarding the relevancy of this criterion were quite large. All experts from Company-10 and about 90% experts from Company-1 and Company-9 felt that this criterion was relevant, while less than 40% experts from Company-11 and about 60% experts from Company-3 and Company-8 felt that this criterion was relevant to their decision making.

- ‘After-sale support’ (criterion 10)

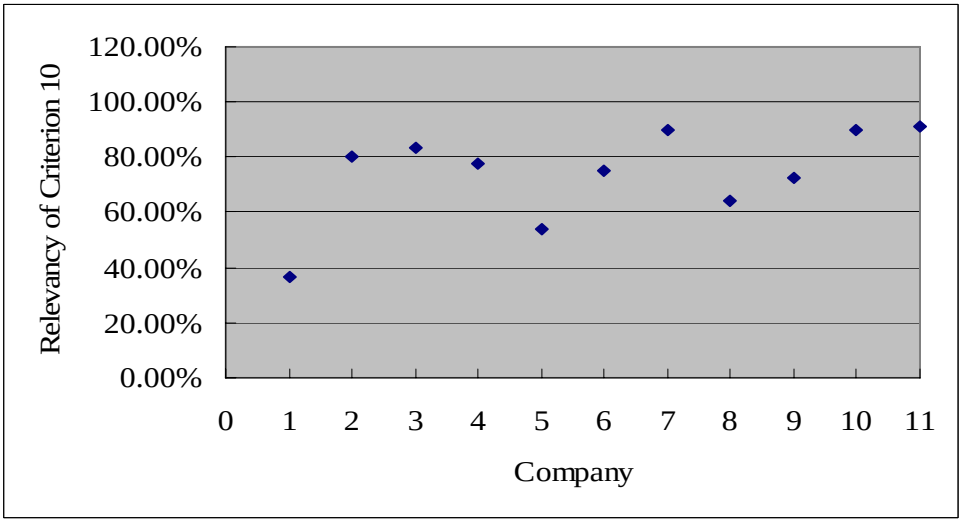

Figure 4.22: Experts’ opinions as to the relevancy of ‘After-sale support’

As shown in Figure 4.22, there was little consistency between the 11 companies as to the relevancy of 'after-sale support' (criterion 10). The differences between the companies regarding the relevancy of this criterion were large. About 90% experts from Company-7, Company-10, and Company-11 felt that this criterion was relevant, while only about 35% experts from Company-1 and about 55% experts from Company-5 felt that this criterion was relevant to their decision-making of requirements selection.

- 'Complexity' (criterion 11)

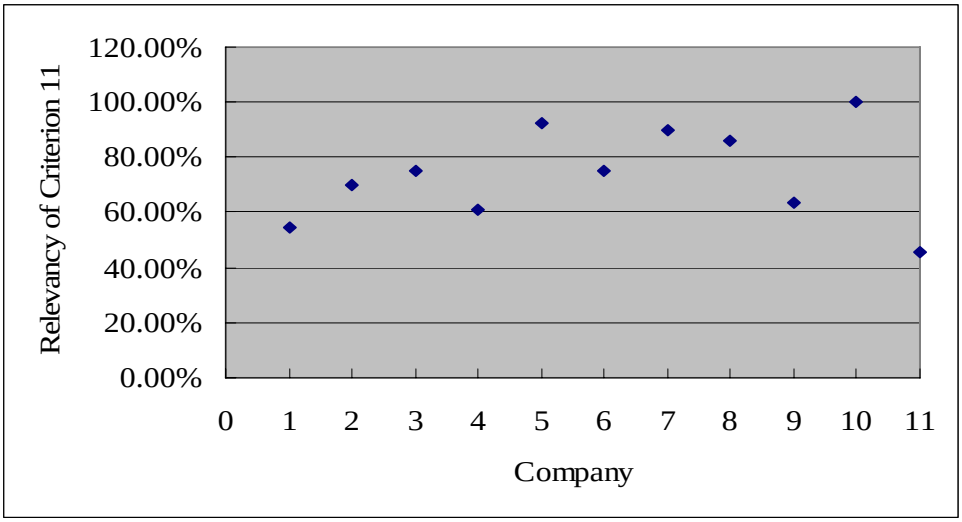

Figure 4.23: Experts' opinions as to the relevancy of 'Complexity'

As shown in Figure 4.23, the differences between the companies regarding the relevancy of 'complexity' (criterion 11) were relatively large. All the experts from Company-10 and about 90% experts from Company-5, Company-7, and Company-8 regarded this criterion as relevant, while only about half experts from Company-1 and Company-11 felt that this criterion was relevant to their decision-making of requirements selection.

- ‘Evolution’ (criterion 12)

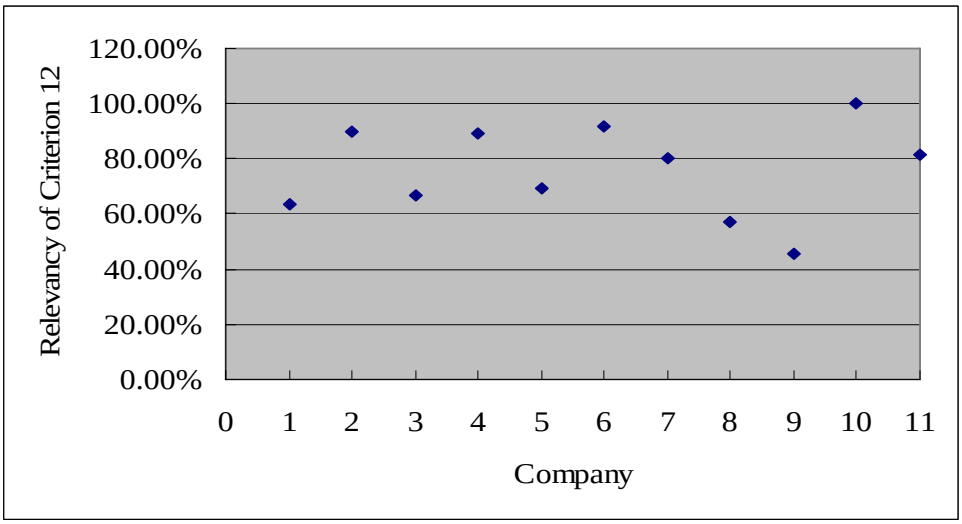

Figure 4.24: Experts’ opinions as to the relevancy of ‘Evolution’

As shown in Figure 4.24, the differences between the companies regarding the relevancy of ‘evolution’ (criterion 12) were large. All the experts from Company-10 and about 90% experts from Company-2, Company-4, and Company-6 felt that this criterion was relevant, while less than 60% experts from Company-8 and Company-9 felt that this criterion was relevant to their decision making.

- ‘Requirements dependencies’ (criterion 13)

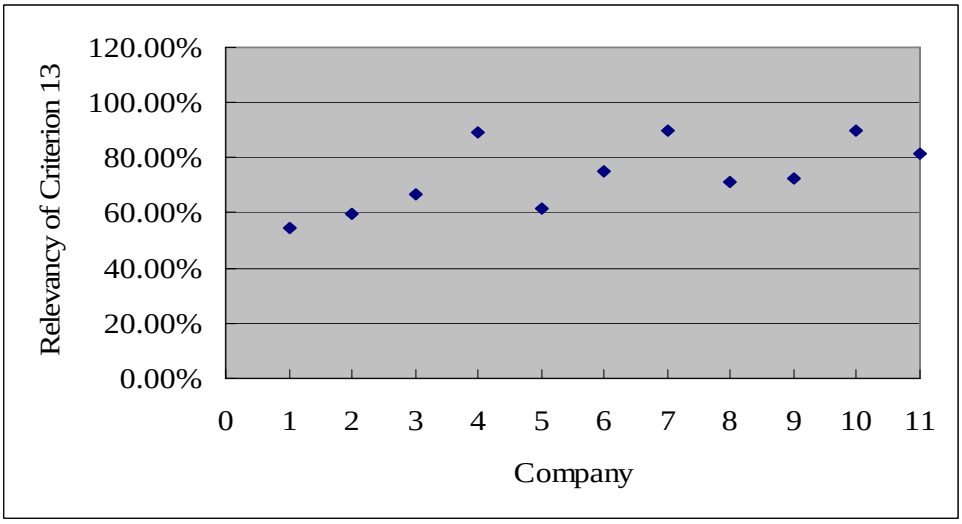

Figure 4.25: Experts’ opinions as to the relevancy of ‘Requirements Dependencies’

As shown in Figure 4.25, the differences between the companies regarding the relevancy of 'requirements dependencies' (criterion 13) were relatively small, compared with the other product-perspective criteria. About 90% experts from Company-4, Company-7, and Company-10 felt that this criterion was relevant, while less than 60% experts from Company-1 considered this criterion as relevant.

- 'Requirement volatility' (criterion 14)

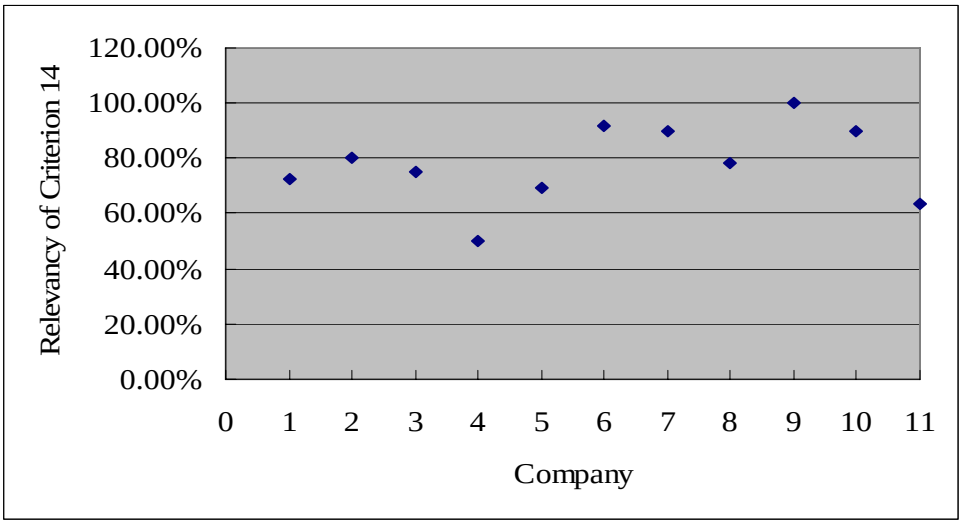

Figure 4.26: Experts' opinions as to the relevancy of 'Requirement Volatility'

As shown in Figure 4.26, the differences between the companies regarding the relevancy of 'requirement volatility' (criterion 14) were not small. All the experts from Company-9 and about 90% experts from Company-6, Company-7, and Company-10 felt that this criterion was relevant, while only half of the experts from Company-4 felt that this criterion was relevant to their decision-making of requirements selection.

In conclusion, there was little consistency between the companies regarding the relevancy of 'competitors' (criterion 3), 'extra cost' (criterion 8), 'resources' (criterion 9), 'after-sale support' (criterion 10), 'complexity' (criterion 11), 'evolution' (criterion 12), and 'requirements volatility' (criterion 14). However, there were not many differences between most of the companies regarding the relevancy of the other 7 criteria. It was worth mentioning that there was little consistency between the

companies regarding the relevancy of most product-perspective criteria. The detailed numerical values are presented in Table A.2 in Appendix B.

4.3.4 Selection of criteria (company-size-based analysis)

The 11 companies were divided into three different size based on the number of their staff. There were 41 experts from ex-large companies, 33 experts from large companies, and 58 experts from medium companies participating in the first-phase Delphi survey. This subsection presented the comparisons of the opinions of the experts from different-sized companies regarding each criterion's relevancy. This analysis, meanwhile, indicated the differences between international and national companies regarding the relevancy of the criteria.

Figure 4.27 graphically presents the opinions of the experts from different-sized companies regarding the relevancy of each criterion. The numerical values are presented in Table A.3 in Appendix B.

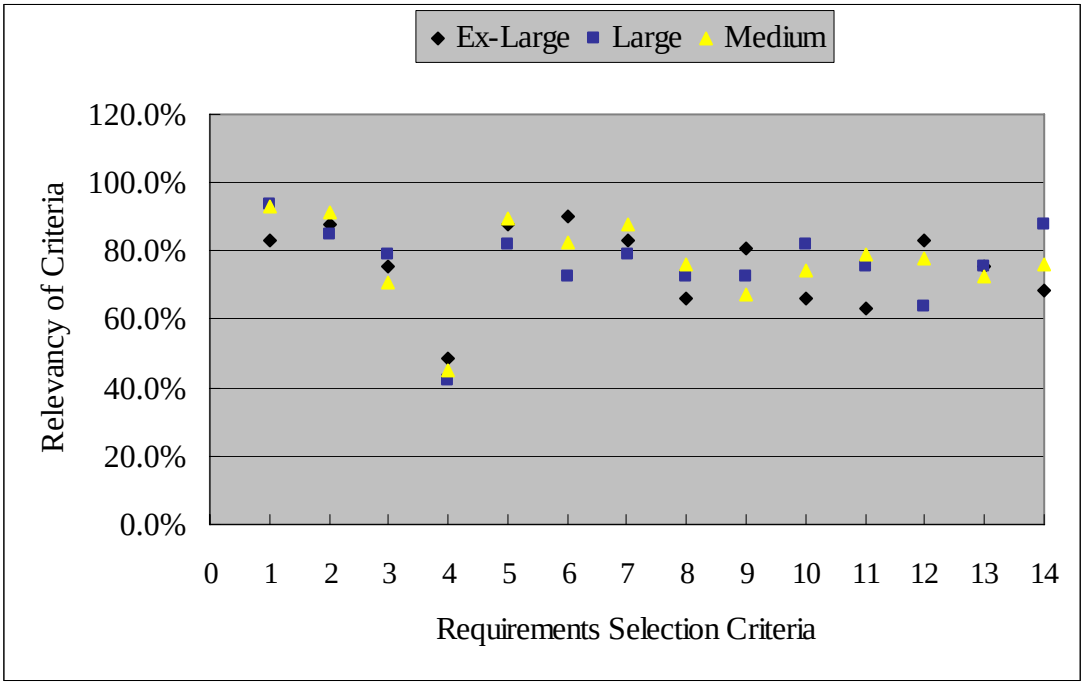

Figure 4.27: Opinions of the experts from different-sized companies as to criteria's relevancy

As shown in the figure, there were much consistency between the experts from ex-large-sized, large-sized, and medium-sized companies as to the relevancy of ‘customer satisfaction’ (criterion 2), ‘competitors’ (criterion 3), ‘requirement’s issuer’ (criterion 4), ‘software features’ (criterion 5), ‘calendar time’ (criterion 7), and ‘requirements dependencies’ (criterion 13). The experts from different-sized companies had similar opinions regarding the relevancy of these 6 criteria.

However, the experts from different-sized companies had relatively different opinions regarding the relevancy of the other 8 criteria. The experts from ex-large-sized companies always had quite different opinions from large-sized and medium-sized companies regarding the relevancy of the 8 criteria. Smaller portion of the experts from ex-large-sized than large-sized and medium-sized companies considered ‘business strategy’ (criterion 1), ‘extra cost’ (criterion 8), ‘after-sale support’ (criterion 10), ‘complexity’ (criterion 11), and ‘requirements volatility’ (criterion 14) as relevant, while larger portion considered ‘development cost’ (criterion 6), ‘resources’ (criterion 9), and ‘evolution’ (criterion 12) as relevant. It showed the differences of the opinions between the experts from international and national companies regarding the relevancy of the 8 criteria.

4.3.5 Selection of criteria (perspective-based analysis)

The 132 participants were divided into 3 perspectives based on their different working positions. There were 36 experts from business perspective, 33 experts from project perspective, and 63 experts from product perspective participating in the first-phase Delphi survey. This subsection presented the comparisons of the opinions of the experts from different perspectives regarding each criterion’s relevancy. This analysis aimed to discover whether there were biases between different-perspective stakeholders regarding the relevancy of the criteria.

Figure 4.28 graphically presents the opinions of the experts from different perspectives regarding the relevancy of each criterion. The numerical values are

presented in Table A.4 in Appendix B.

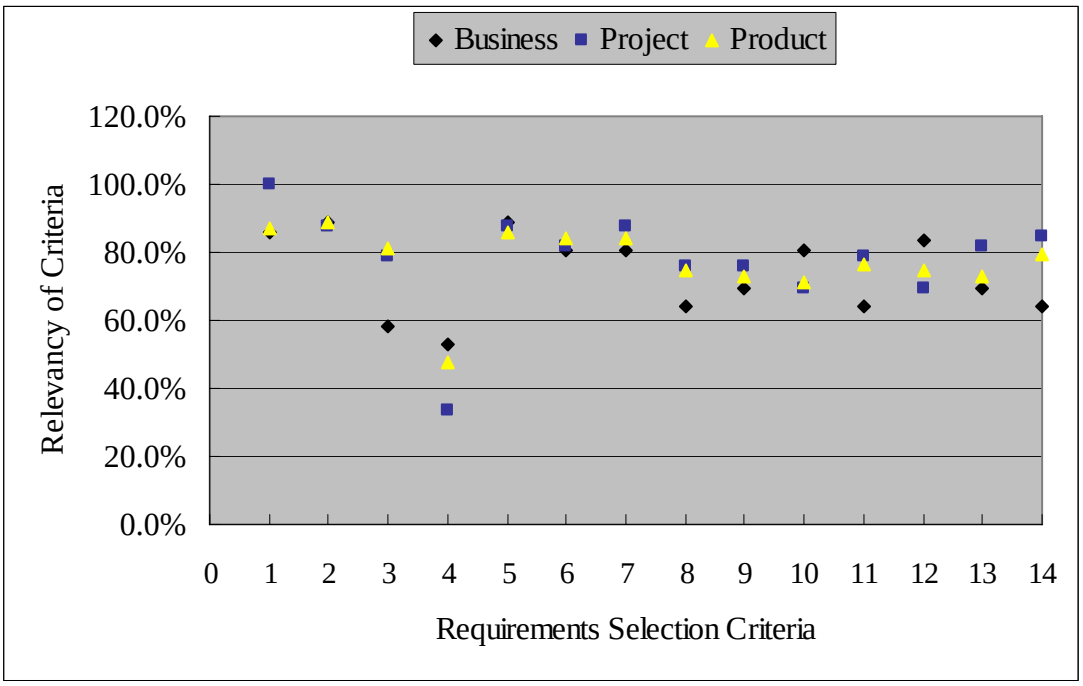

Figure 4.28: Opinions of different-perspective stakeholders as to criteria's relevancy

As shown in the figure, there were much consistency between the experts from business, project, and product perspectives as to the relevancy of 'customer satisfaction' (criterion 2), 'software features' (criterion 5), 'development cost' (criterion 6), 'calendar time' (criterion 7), and 'resources' (criterion 9). The experts from different perspectives had similar opinions regarding the relevancy of these 5 criteria.

However, the experts from different perspective had relatively different opinions regarding the relevancy of the other 9 criteria.

Firstly, the experts from project and product perspective had quite similar opinions as to the relevancy of project- and product-perspective criteria, while the experts from business perspective had different opinions from project- and product-perspective experts. For example, smaller portion of the experts from business perspective than project and product perspectives considered 'extra cost' (criterion 8), 'complexity'

(criterion 11), ‘requirements volatility’ (criterion 14) as relevant, while larger portion considered ‘after-sale support’ (criterion 10) and ‘evolution’ (criterion 12) as relevant. It showed the differences of the opinions between the experts from business perspective and the other 2 perspectives regarding the relevancy of project- and product-perspective criteria.

Secondly, regarding the relevancy of business-perspective criteria, the situation was more complex. Compared with project and product perspective, smaller portion of the experts from business perspective considered ‘competitors’ (criterion 3) when making the decisions of requirements selection. Nonetheless, as to the relevancy of ‘business strategy’ (criterion 1) and ‘requirement’s issuer’ (criterion 4), the experts from project perspective had different opinions with the experts from business and product perspectives. Smaller portion of the experts from project perspectives than the other 2 perspectives considered ‘requirement’s issuer’ (criterion 4) as relevant, while larger portion considered ‘business strategy’ (criterion 1) as relevant.

4.4 Research objective 2

After identifying the criteria for requirements selection, the second objective of the study is to evaluate the relative importance of each criterion for the decision-making of requirements selection. Besides, the study also aims to indicate the differences between the practical and ideal situation in terms of each criterion’s importance for requirements selection. The practical situation is where criteria currently affect decision-making of requirements selection in the companies, while the ideal situation is where the stakeholders think that different criteria ought to affect the decision-making of requirements selection.

Research Question 2: which criteria are more important for the decision-making process of requirements selection? How does this differ from the industry perception of the ideal application of the criteria?

4.4.1 Data analysis

The answers of this research question were obtained by the second and third phase of the Delphi study. In the 132 first-phase participants, three decided not to take part in the second-phase survey. 129 experts from the 11 companies were participated in the second-phase Delphi survey to evaluate both practical and ideal importance of the criteria. One of the 129 experts provided incomplete response, so his answer was excluded from the analysis. Besides, the third-phase survey was conducted to make the experts reach an acceptable level of consensus on the ideal importance of the criteria. 105 responses of the third questionnaire were finally received. Thus, the analyses were conducted based on the 128 responses of the second questionnaire and the 105 responses of the third questionnaire.

As ‘requirement’s issuer’ (criterion 4) was removed from the list in the second and third questionnaires, the experts were asked to provide relative weights regarding the importance of the 13 criteria in terms of value between 0 and 1000 points. The second and third-phase questionnaires are presented in Appendix A.

Before the analyses, the values were scaled to 1000 by the researcher, where three participants failed to assign points for the importance of the criteria to 1000. In addition, the same number is applied to each criterion in the latter phase analyses as the first phase to avoid the confusion.

The data were analyzed separately for practical and ideal situation, followed by the comparison between these two situations.

For the practical situation, four-step data analyses were conducted based on the data collected by the second-phase survey.

- Firstly, all participants’ responses to criteria’s practical importance were analyzed as an integrated one. The practical importance of each criterion was analyzed by

taking the sum of the points provided by each respondent and then normalizing the sum to a percentage figure. The importance values in percentage revealed the proportion that the criteria contributed to the requirements selection decisions (Wohlin and Aurum 2005A). The criteria were ranked from the most important one to the least important one according to their importance values. Moreover, Friedman test was conducted to explore whether there were statistical differences between the rankings of the criteria.

- Secondly, the results were analyzed for each company individually by taking the sum of the points provided by the respondents from the same company and then normalizing the sum to a percentage figure to show the different practical importance of the 13 criteria in each company. Moreover, the analyses were also conducted to compare each criterion's different importance in different companies. It indicated whether the different companies had different preferences of the criteria applied for requirements selection. Furthermore, the absolute dispersions of the importance values between the 11 companies were obtained for each criterion to discover of which criteria the 11 companies had the most similar or different opinions.

- Thirdly, the results were analyzed based on the different size of the companies. As the data analysis that conducted for the first research objective, the 11 companies were divided into ex-large, large, and medium size based on their staff numbers. The data were normalized to a percentage figure for different-sized companies to show the differences between them as to the criteria's practical importance. Besides, kolmogorov-smirnov tests were applied to find out the distribution of the data in order to find out the suitable statistical techniques, because some statistical techniques had a strict assumption of data distribution. As the results of kolmogorov-smirnov tests indicated that the data collected by second-phase survey were not near normal distribution, the Kruskal-Wallis tests were applied to further point out the differences between different-sized companies regarding

criteria's practical importance. If a significant difference was identified by the Kruskal-Wallis tests, then one-way analysis of variance (ANOVA) tests with post-hoc tests were applied to confirm the results of Kruskal-Wallis tests and identify between which two sizes there were significant differences. However, ANOVA tests had a strict assumption of data distribution, so homogeneity of variance tests were conducted before ANOVA tests to ensure that the data were suitable to apply ANOVA tests. The same measure was also taken for each of the following ANOVA tests. A significance level of 0.05 was used in all statistical tests in this study. The analysis could reveal whether there were significant differences between different-sized companies. Company size not only indicates the scale of the company but also related to the maturity level of the company.

- Lastly, the results were analyzed to compare the responses of the participants from different perspectives. As the data analysis that conducted for the first research objective, the recruited experts were divided into business, project, and product perspectives based on their working positions. The data were normalized to a percentage figure for different-perspective experts to show the differences between them as to the criteria's practical importance. Moreover, the Kruskal-Wallis tests were applied to further discover the differences of criteria's practical importance between different-perspective experts. If a significant difference was identified by the Kruskal-Wallis tests, then homogeneity of variance tests and ANOVA tests with post-hoc tests were also applied. Furthermore, the Kruskal-Wallis tests were applied to compare the ratings between the three-perspective experts regarding criteria's practical importance in each company. If a significant difference was identified by the Kruskal-Wallis tests, then homogeneity of variance tests and ANOVA tests with post-hoc tests were also applied to identify between which two-perspective experts in the company there were significant differences. The analysis revealed the inconsistency between the stakeholders from different perspectives regarding the practical importance of the criteria in the companies.

Moreover, for the ideal situation, several-step data analyses were conducted based on the data collected by the second- and third-phase survey.

- First of all, the ratings of ideal importance obtained by second-phase survey were analyzed by descriptive statistics, including the mean of all experts' ratings, the mean of all experts' ratings from respondent's company, and standard deviation of all experts' ratings. These results were offered to the participants in the third questionnaire as a baseline for their reevaluation. These detailed results are presented in Table A.8 in Appendix B.

- Secondly, all participants' responses of criteria's ideal importance obtained by both second-phase and third-phase survey were analyzed by taking the sum of the points provided by each respondent and then normalizing the sum to a percentage figure. The importance values in percentage revealed the degree to which the stakeholders thought the criteria should contribute to the requirements selection decisions ideally. Meanwhile, the degree of consensus among the experts as to the criteria's ideal importance was measured by Kendall's coefficient of concordance W (Kendall 1975).

- Thirdly, several same analyses were conducted for ideal situation as the practical one. These analyses were conducted according to the responses obtained by the third-phase survey, because it was believed that the results of experts' re-evaluation were more valid and reliable (Schmidt 1997). The data were analyzed based on different companies, different-sized companies, and different-perspective experts. Kolmogorov-smirnov tests were applied to find out the distribution of the data obtained by the third-phase survey, and the results came out that the data collected by the third-phase were not near normal distribution either. Thus, the same statistic analyses were conducted for the ideal situation as the practical situation.

Furthermore, the analyses were conducted to compare criteria's practical importance to their ideal importance.

- First of all, the criteria were ranked based on their ideal importance obtained by the third-phase survey, compared with the criteria's rankings regarding their practical importance. The analyses pointed out the shifts in priorities of the criteria that could contribute to the decision-making of requirements selection.

- Secondly, the practical and ideal importance values were compared for each criterion. The findings indicated stakeholders the changes of criteria's application that could improve the decision-making of requirements selection.

- Lastly, Wilcoxon tests were applied for each criterion to indicate whether the differences between its practical and ideal importance were significant or not. Wilcoxon tests could further prove the findings by the descriptive analyses.

The detailed analysis results are presented as follows.

4.4.2 Practical importance of criteria

In this subsection, the findings regarding the practical importance of the 13 criteria are reported.

4.4.2.1 Practical importance of criteria (all participants)

As presented in Section 4.4.1, the practical importance of each criterion was analyzed by taking the sum of the points provided by all respondents and then normalizing the sum to a percentage figure. The 13 criteria's importance values in percentage are graphically presented in Figure 4.29, and the criteria were ranked from the most to the least important one in Table 4.2.

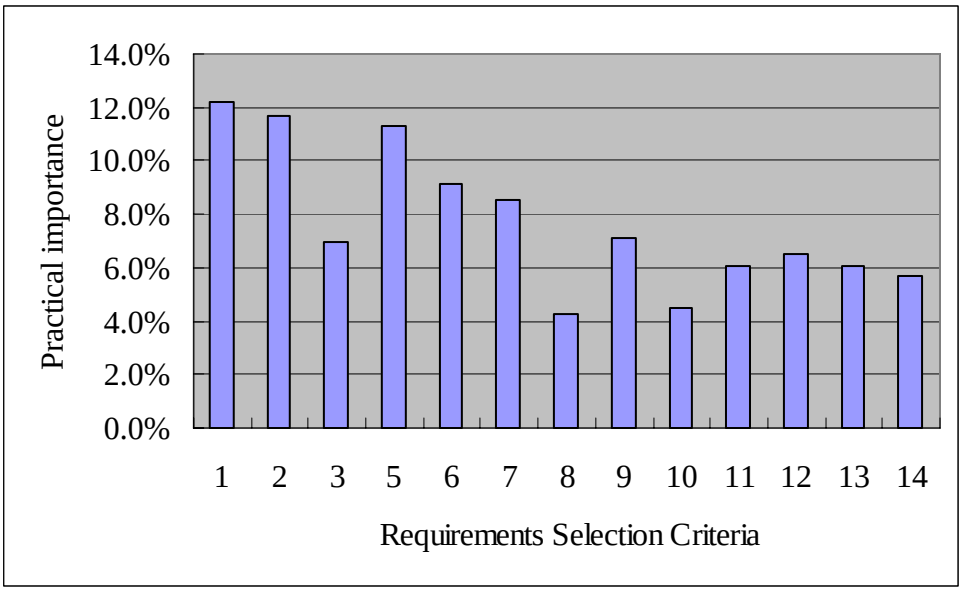

Figure 4.29: Practical importance of different criteria for all participants

Table 4.2: Practical importance of different criteria for all participants

Criteria		
1	Business strategy	12.2%
2	Customer satisfaction	11.7%
5	Software features	11.3%
6	Development cost	9.1%
7	Calendar time	8.5%
9	Resources	7.1%
3	Competitors	7%
12	Evolution	6.5%
11	Complexity	6.1%
13	Requirements dependencies	6.1%
14	Requirement volatility	5.7%
10	After-sale support	4.5%
8	Extra cost	4.3%

Meanwhile, Friedman test, which was conducted to explore whether there were statistical differences between the rankings of the criteria, came out that the

significance level was less than 0.001. In other word, the rankings of the 13 criteria had statistically significant differences.

The results indicated that some criteria were more important than others when practically making the decisions of requirements selection in software development process. The 3 most important criteria were (in order): ‘business strategy’ (criterion 1), ‘customer satisfaction’ (criterion 2), and ‘software features’ (criterion 5). They had importance values above 10%, which meant that the 3 criteria contributed more than 10% to the decision-making of requirements selection practically. However, ‘extra cost’ (criterion 8) and ‘after-sale support’ (criterion 10) were the least and second least important criteria with importance values below 5%. It pointed out that these 2 criteria did not contribute much to the decision-making.

The 3 most important criteria all represented business-perspective criteria, which indicated that business-perspective criteria had the most significant influence on the requirements selection practically. However, ‘competitors’ (criterion 3) had a relatively lower importance value, compared with the other 3 business-perspective criteria.

Moreover, some project-perspective criteria were considered more important than the others. ‘Development cost’ (criterion 6), ‘calendar time’ (criterion 7), and ‘resources’ (criterion 9) had importance values above 7%, while ‘extra cost’ (criterion 8) were the least important criteria among all the 13 criteria with an importance value below 4.5%.

Furthermore, most product-perspective criteria were considered of approximately equal importance. They clustered together with importance values between 5.7% and 6.5%, except ‘after-sale support’ (criterion 10) which had importance values about 4.5%.

The different importance of the criteria from different perspectives gave some indications of what could be expected when analyzing the importance of the 3 perspectives for the third research question.

4.4.2.2 Practical importance of criteria (company-based analysis)

Table 4.3 presents each company's practical importance of each criterion. One list represents the results from one company. It was analyzed by taking the sum of the points provided by the respondents from the same company and then normalizing the sum to a percentage figure.

Table 4.3: Practical importance of different criteria for the 11 companies

	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11
1. Business strategy	14.3%	9.2%	12.0%	14.6%	11.6%	15.1%	11.0%	12.4%	8.4%	15.1%	9.3%
2. Customer satisfaction	14.8%	10.8%	13.2%	9.8%	9.5%	13.8%	12.9%	11.1%	10.3%	11.5%	12.7%
3. Competitors	6.9%	8.9%	4.6%	7.3%	5.8%	6.9%	6.2%	7.8%	7.8%	5.9%	8.8%
5. Software features	10.7%	13.7%	13.1%	9.9%	12.8%	11.0%	11.9%	10.8%	10.2%	12.4%	8.4%
6. Development cost	9.0%	9.5%	11.9%	10.1%	8.1%	7.3%	10.0%	9.1%	9.2%	7.3%	8.3%
7. Calendar time	8.4%	12.1%	9.0%	9.3%	9.3%	7.9%	7.1%	7.7%	5.3%	8.3%	8.5%
8. Extra cost	2.9%	3.5%	3.5%	4.4%	5.8%	4.2%	5.2%	4.0%	4.4%	3.8%	5.5%
9. Resources	5.3%	7.2%	7.9%	6.3%	6.9%	6.6%	6.3%	7.9%	6.2%	9.3%	8.8%
10. After-sale support	3.0%	4.1%	3.0%	3.3%	4.0%	3.0%	8.4%	4.2%	8.9%	3.8%	4.5%
11. Complexity	7.0%	6.3%	4.9%	6.8%	7.5%	4.2%	5.1%	6.1%	7.4%	5.1%	5.9%
12. Evolution	4.5%	5.6%	5.3%	6.0%	5.8%	9.1%	7.8%	6.7%	7.5%	7.6%	6.4%
13. Requirements dependencies	5.7%	5.1%	4.9%	7.7%	5.3%	4.9%	6.1%	6.6%	7.3%	5.6%	6.5%
14. Requirement volatility	7.5%	3.9%	6.6%	4.6%	7.7%	6.2%	2.0%	5.7%	7.1%	4.3%	6.5%

Where importance values of the criteria are above 10% in each company are highlighted in Table 4.3. As shown in the table, the most important criteria regarded by the 11 companies concentrated on 'business strategy' (criterion 1), 'customer satisfaction' (criterion 2), 'software features' (criterion 5), 'development cost' (criterion 6), and 'calendar time' (criterion 7). The findings indicated that business-perspective criteria, except 'competitors' (Criterion 3), were considered as very important by most of the companies, meanwhile traditional project issues such as development cost and time were also very important when making the decisions of requirements selection in some companies.

In addition, the practical importance of each criterion was compared between 11 companies to figure out the consistency or inconsistency. The opinions of the 11 companies regarding the practical importance of each criterion are presented respectively as follows.

- 'Business strategy' (criterion 1)

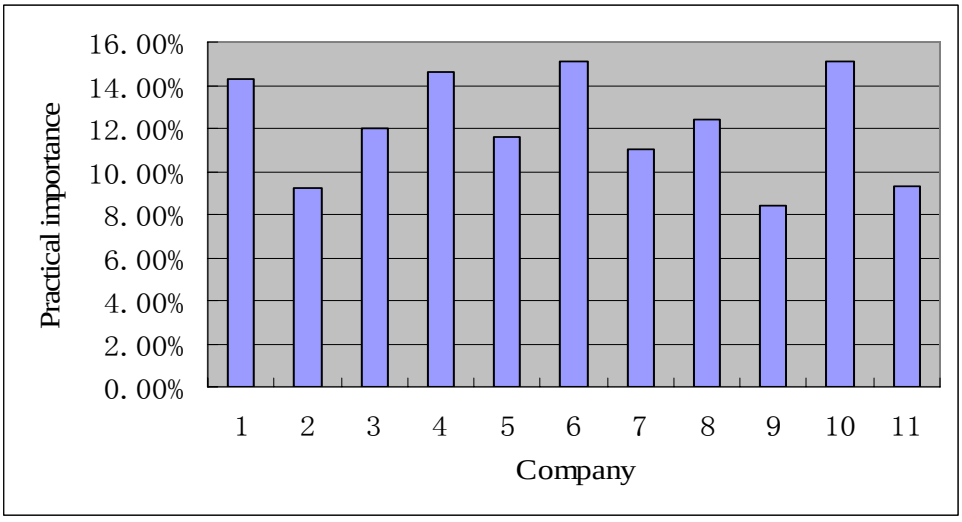

Figure 4.30: Practical importance of 'Business Strategy'

As shown in Figure 4.30, the 11 companies had quite different opinions regarding the practical importance of 'business strategy' (criterion 1). The importance values of this criterion ranged from 8.4% to 15.1% in the 11 companies, with a dispersion of 6.7%.

In Company-1, 4, 6, and 10, ‘business strategy’ contributed more than 14% to the requirements selection decisions, while in Company-2 and 9, the importance values of this criterion were less than 10%.

- ‘Customer satisfaction’ (criterion 2)

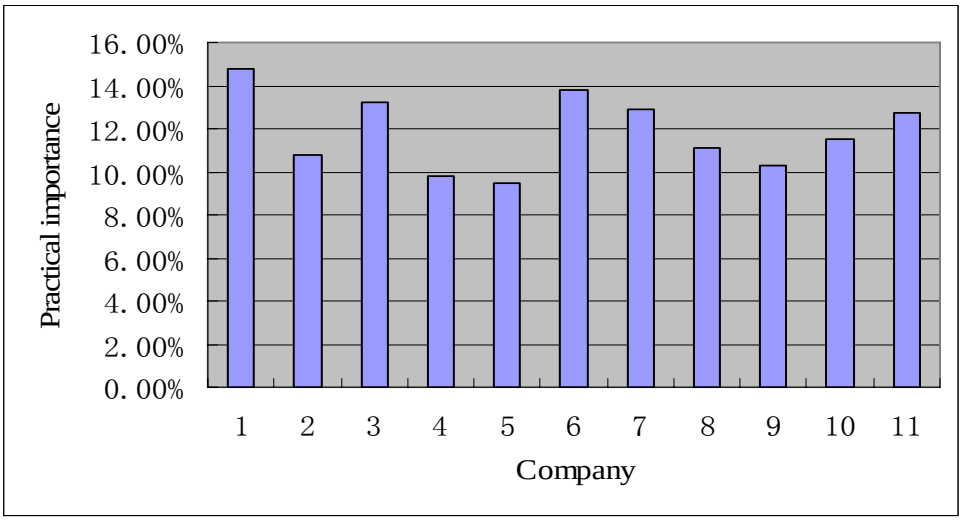

Figure 4.31: Practical importance of ‘Customer Satisfaction’

As shown in Figure 4.31, companies did not have very similar opinions regarding the practical importance of ‘customer satisfaction’ (criterion 2). The importance values of this criterion ranged from 9.5% to 14.8% in the 11 companies, with a dispersion of 5.3%. In Company-1, ‘customer satisfaction’ contributed more than 14% to the requirements selection decisions, while in Company-4 and 5, the importance values of this criterion were less than 10%.

- ‘Competitors’ (criterion 3)

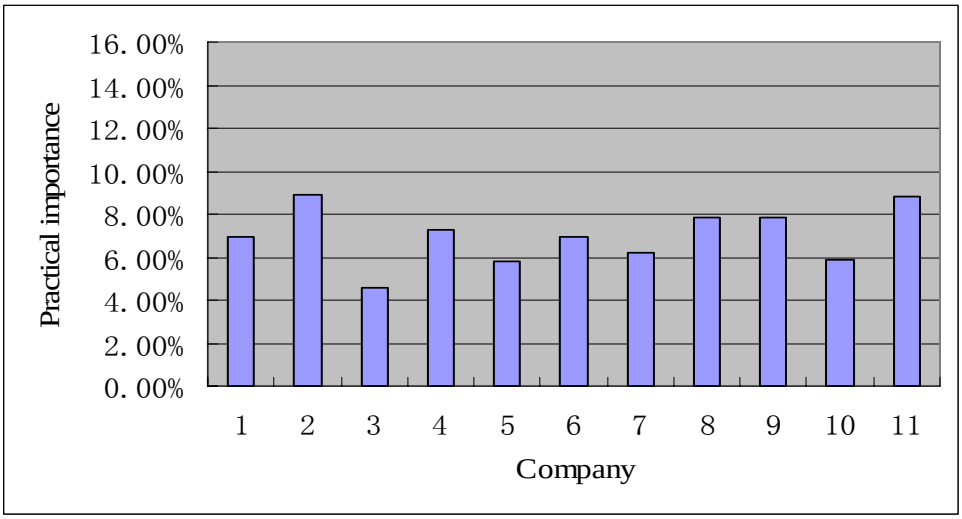

Figure 4.32: Practical importance of ‘Competitors’

As shown in Figure 4.32, there was little inconsistency between the companies regarding the practical importance of ‘competitors’ (criterion 3), except Company-3. The importance values of this criterion ranged from 5.8% to 8.9% in the other 10 companies, with a dispersion of 3.1% only, while in company-3, the importance value of ‘competitors’ was only 4.6%.

- ‘Software features’ (criterion 5)

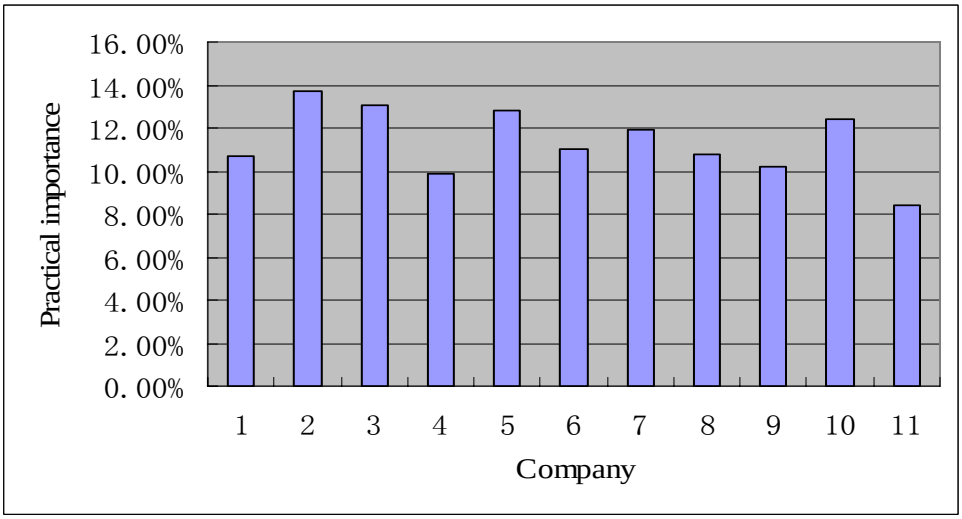

Figure 4.33: Practical importance of ‘Software Feature’

As shown in Figure 4.33, the importance values of ‘software features’ (criterion 5) were above 10% in most of the companies, except Company-11. This criterion only contributed 8.4% to the requirements selection decisions in Company-11, while the importance values of this criterion ranged from 10% to 13.7% in the other 10 companies.

- ‘Development cost’ (criterion 6)

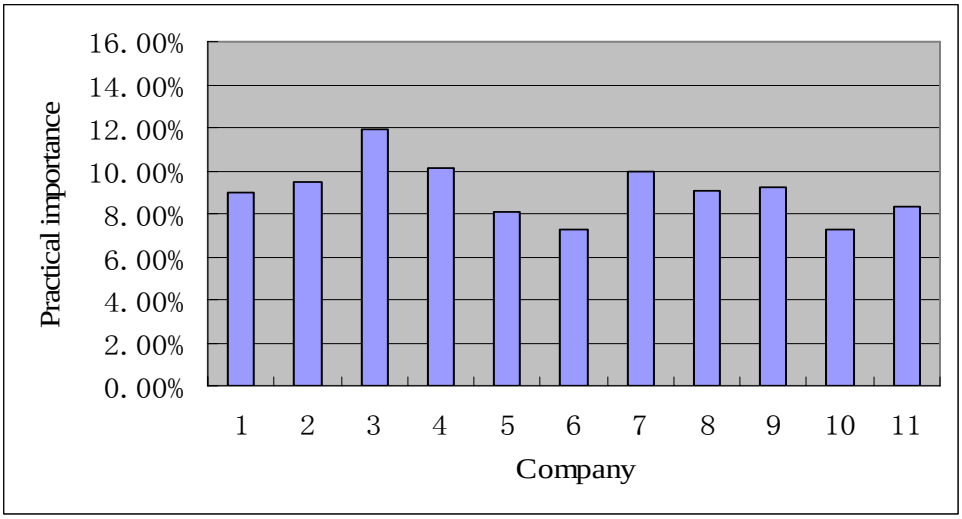

Figure 4.34: Practical importance of ‘Development Cost’

As shown in Figure 4.34, most companies had very similar opinions regarding the practical importance of ‘development cost’ (criterion 6), except Company-3. The results indicated that ‘development cost’ was more important in Company-3 than the other companies. The importance values of this criterion ranged from 7.3% to 10.1% in the other 10 companies, while the importance value was 11.9% in Company-3.

- ‘Calendar time’ (criterion 7)

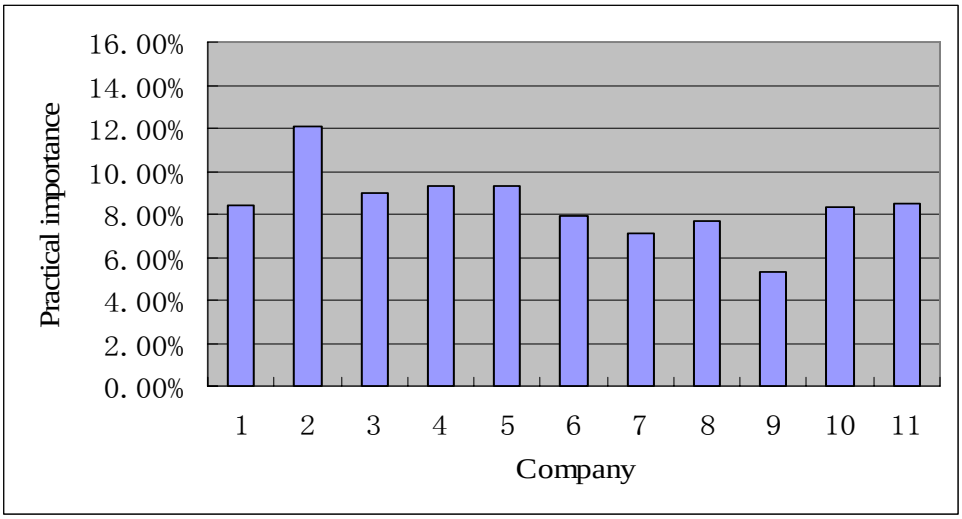

Figure 4.35: Practical importance of ‘Calendar Time’

As shown in Figure 4.35, the differences between most companies were small regarding the practical importance of ‘calendar time’ (criterion 7), except Company-2 and 9. The importance values of this criterion ranged from 7.1% to 9.3% in the other 9 companies, with a dispersion of 2.2%. However, the results indicated that ‘calendar time’ was more important in Company-2 than the other companies, while ‘calendar time’ was less important in Company-9.

- ‘Extra cost’ (criterion 8)

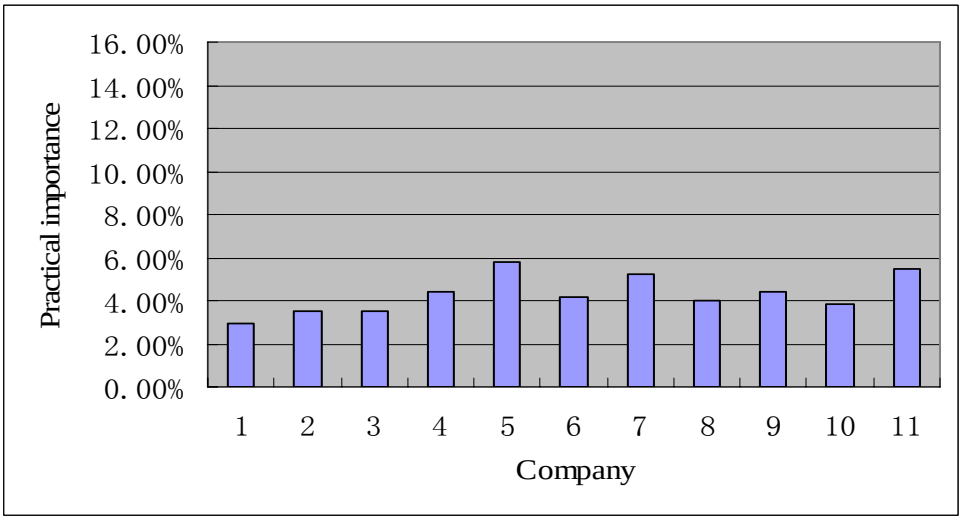

Figure 4.36: Practical importance of ‘Extra Cost’

As shown in Figure 4.36, there was little inconsistency between the 11 companies as to the practical importance of ‘extra cost’ (criterion 8). The importance values of ‘extra cost’ were relative low in all the 11 companies, ranging from 2.9% to 5.8% with a dispersion of 2.9%.

- ‘Resources’ (criterion 9)

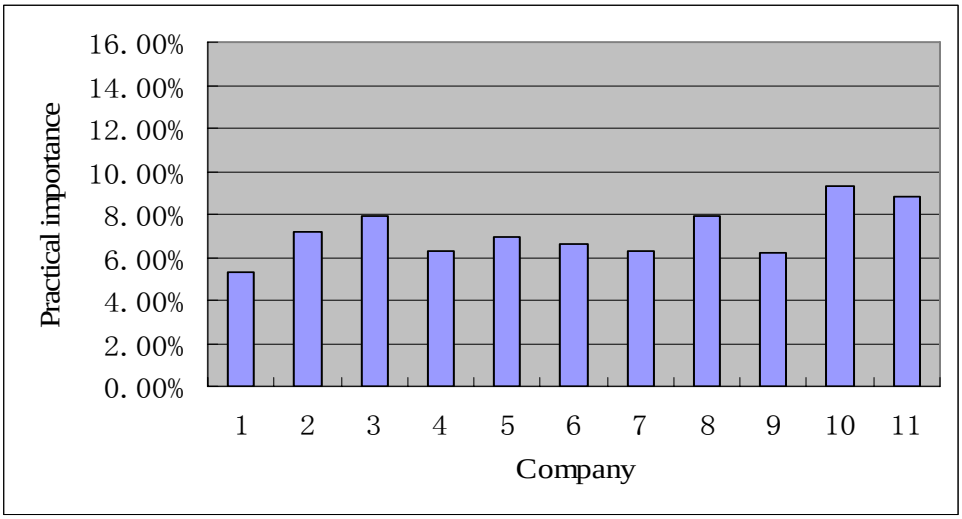

Figure 4.37: Practical importance of ‘Resources’

As shown in Figure 4.37, the differences between the companies were not small regarding the practical importance of ‘resources’ (criterion 9). The importance values of this criterion ranged from 5.3% to 9.3% in the 11 companies, with a dispersion of 4%. The importance values of ‘resources’ in Company-10 and 11 were about 9%, while it was only about 5% in Company-1.

- ‘After-sale support’ (criterion 10)

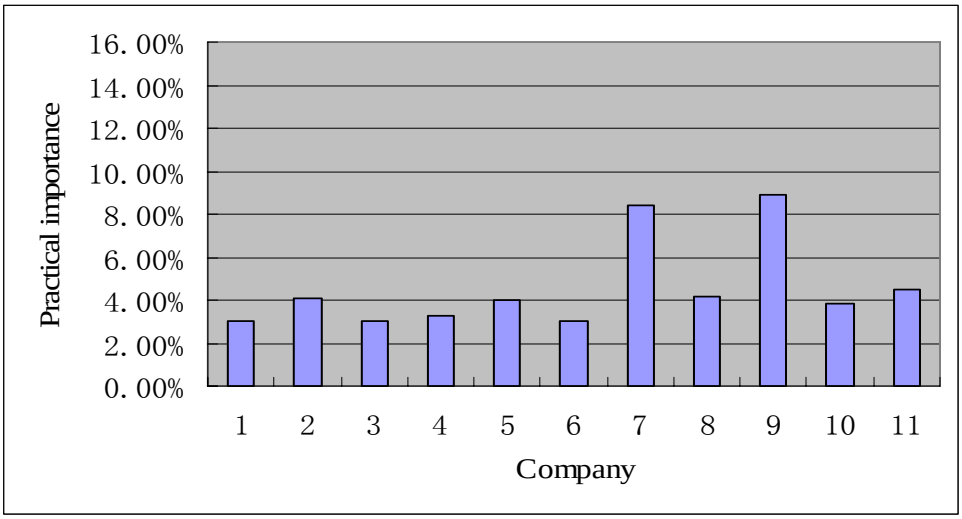

Figure 4.38: Practical importance of ‘After-sale Support’

As shown in Figure 4.38, there was little consistency between the 11 companies as to the practical importance of ‘after-sale support’ (criterion 8). The differences between the companies were very large regarding the practical importance this criterion. The importance values of this criterion ranged from 3% to 8.9% in the 11 companies, with a dispersion of 5.9%. The importance values of ‘after-sale support’ in Company-7 and 9 were above 8%, while the importance values ranged from 3% to 4% in the other 9 companies.

- ‘Complexity’ (criterion 11)

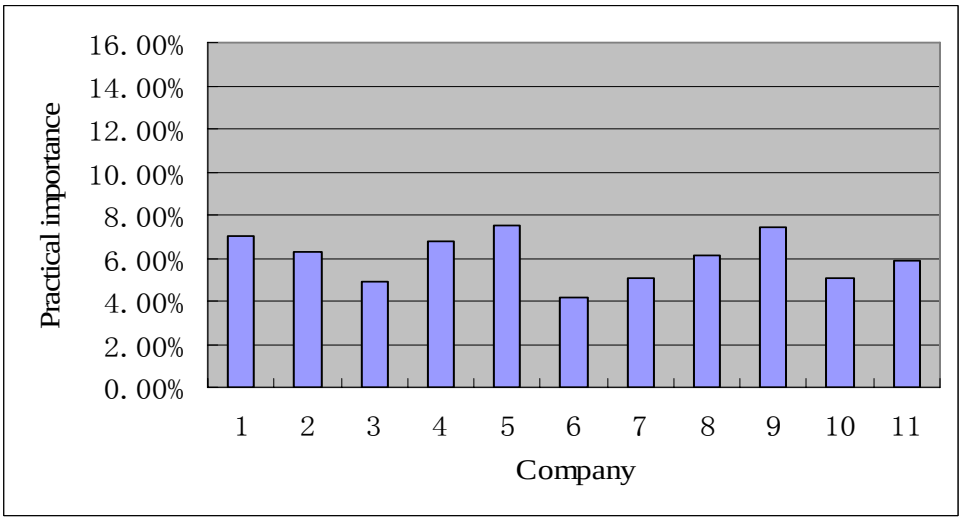

Figure 4.39: Practical importance of ‘Complexity’

As shown in Figure 4.39, the differences between the companies were not large regarding the practical importance of ‘complexity’ (criterion 11). The importance values of this criterion ranged from 4.2% to 7.5% in the 11 companies, with a dispersion of 3.3% only.

- ‘Evolution’ (criterion 12)

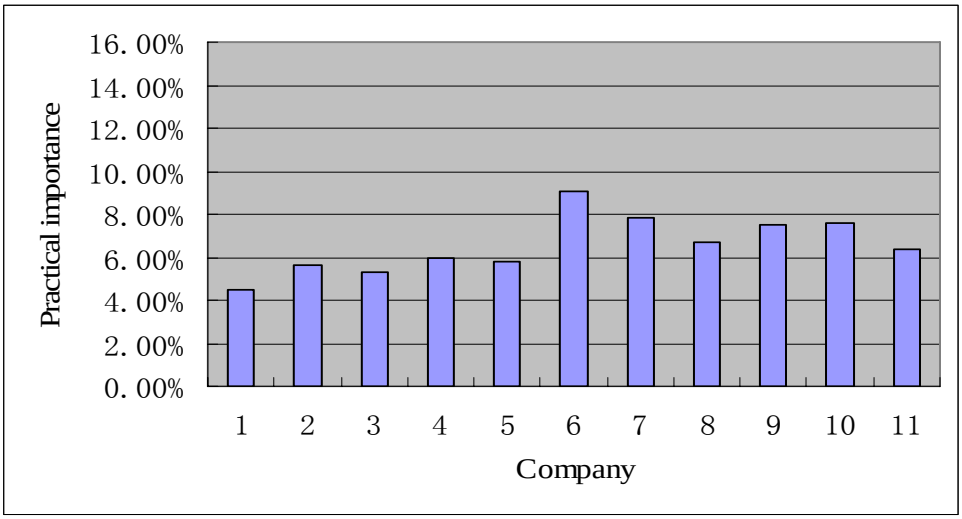

Figure 4.40: Practical importance of ‘Evolution’

As shown in Figure 4.40, the differences between the 11 companies were relatively large regarding the practical importance of ‘evolution’ (criterion 12). The importance values of this criterion ranged from 4.5% to 9.1% in the 11 companies, with a dispersion of 4.6%. In Company-6, the importance value of the criterion was above 9%, while it was only about 4.5% in Company-1.

- ‘Requirements dependencies’ (criterion 13)

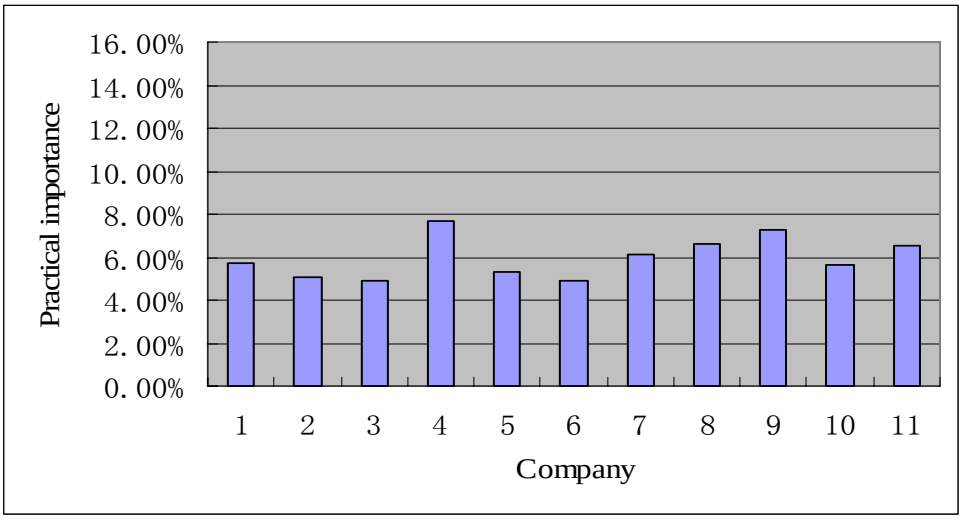

Figure 4.41: Practical importance of ‘Requirements Dependencies’

As shown in Figure 4.41, the differences between the companies were relatively small regarding the practical importance of ‘requirements dependencies’ (criterion 13). The importance values of this criterion ranged from 4.9% to 7.7% in the 11 companies, with a dispersion of 2.8% only.

- ‘Requirement volatility’ (criterion 14)

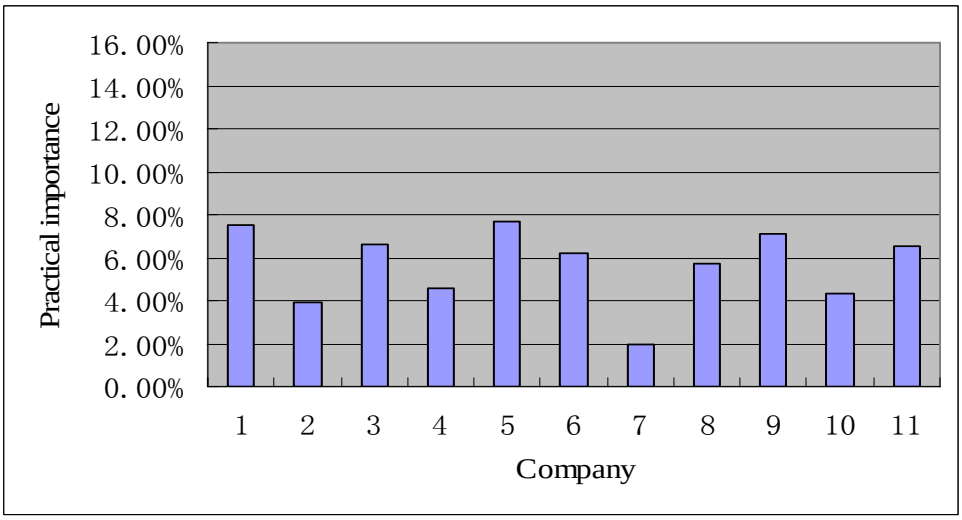

Figure 4.42: Practical importance of ‘Requirement Volatility’

As shown in Figure 4.42, the differences between the companies were quite large regarding the practical importance of ‘requirement volatility’ (criterion 14). The

importance values of this criterion ranged from 2% to 7.7% in the 11 companies, with a dispersion of 5.7%. In Company-7, this criterion only contributed 2% to the requirements selection decisions, while in Company-1, 5, and 9, it contributed more than 7% to the decision making.

To sum up, as shown in Figure 4.43, the absolute dispersions of the ratings between the experts from the 11 companies regarding the practical importance of the 13 criteria ranged from 2.8 to 6.8 percentage points. The numerical values of the dispersions between the 11 companies are presented in Table A.5 in Appendix B. Among the 13 criteria, the experts from the 11 companies had the most different opinions regarding the practical importance of 'business strategy' (criterion 1) and 'calendar time' (criterion 7), while the 11 companies had relatively similar opinions regarding the practical importance of 'extra cost' (criterion 8) and 'requirements dependencies' (criterion 13).

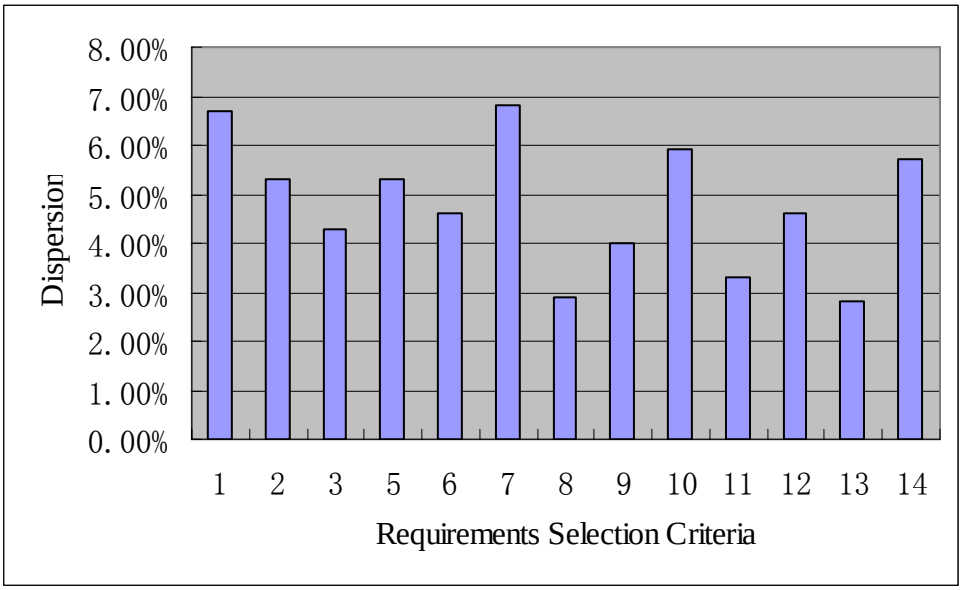

Figure 4.43: Dispersions of the practical importance between the 11 companies

4.4.2.3 Practical importance of criteria (company-size--based analysis)

As the analyses for the first research objective, further analyses were conducted to compare the applications of the 13 criteria between different-sized companies. There were 39 experts from ex-large-sized companies, 32 experts from large-sized companies, and 57 experts from medium-sized companies who participated in the second-phase survey.

The data were normalized to a percentage figure for different-sized companies to display the differences of the criteria's practical importance in different-sized companies. Figure 4.44 graphically presents the importance values of each criterion in ex-large-sized, large-sized, and medium-sized companies. The numerical values are presented in Table A.6 in Appendix B.

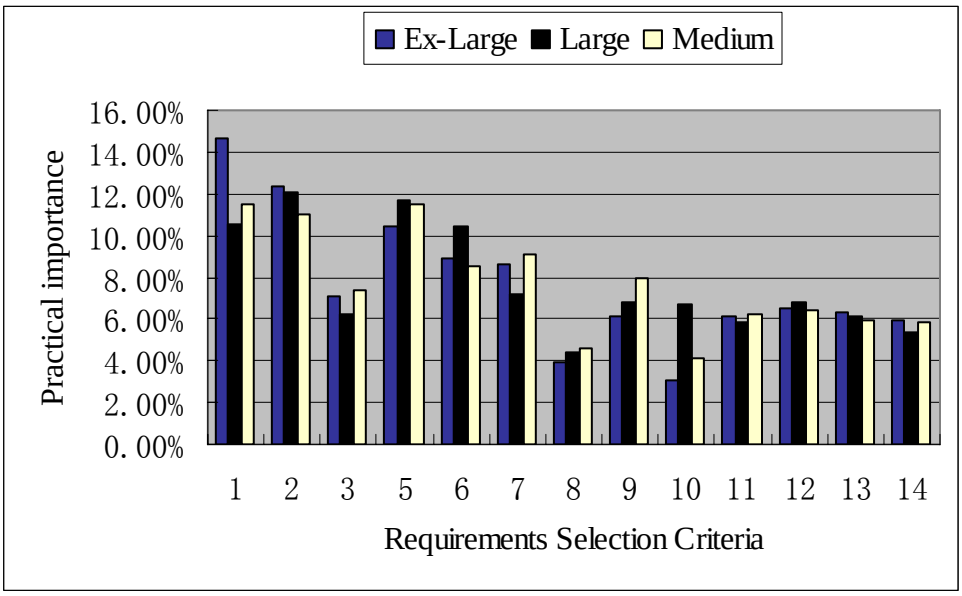

Figure 4.44: Practical importance of different criteria for different-sized companies

It was not surprising that the 3 most important criteria regarded by different-sized companies were still 'business strategy' (criterion 1), 'customer satisfaction' (criterion 2), and 'software features' (criterion 5). However, there were some shifts of the order between different-sized companies regarding the practical importance of the 3 criteria. For instance, 'business strategy' (criterion 1) was regarded as the most important

criterion in ex-large-sized companies, while this criterion was less important than ‘customer satisfaction’ (criterion 2) and ‘software features’ (criterion 5) in large-sized and medium-sized companies.

On the other hand, different-sized companies had relatively different opinions as to the least important criteria. ‘After-sale support’ (criterion 10) was considered as the least important criterion when making the decision of requirements selection in ex-large-sized and medium-sized companies, but it was more much important in large-sized companies.

To further discover the differences between different-sized companies, a series of statistical analyses were conduced as follows. A significance level of 0.05 was used in all the statistical tests in this study.

First, kolmogorov-smirnov tests were applied to find out the distribution of the data collected by the second-phase survey. The kolmogorov-smirnov tests came out that the significance was below 0.05 for all criteria. It indicated that the data collected by second-phase survey were not near normal distribution.

Moreover, according to the results of kolmogorov-smirnov tests, Kruskal-Wallis tests were applied to compare the ratings of criteria’s practical importance between participants from different-sized companies. As highlighted in Table 4.4, the Kruskal-Wallis tests came out that the significance levels of ‘business strategy’ (criterion 1), ‘development cost’ (criterion 6), ‘calendar time’ (criterion 7), and ‘after-sale support’ (criterion 10) were less than 0.05, while significance levels of the other 9 criteria were above 0.05. The results suggested that there were statistically significant differences between different-sized companies regarding the practical importance of ‘business strategy’ (criterion 1), ‘development cost’ (criterion 6), ‘calendar time’ (criterion 7), and ‘after-sale support’ (criterion 10).

Table 4.4: the results of Kruskal-Wallis test for different-sized companies

	Significance
1. Business strategy	0. 031
2. Customer satisfaction	0. 347
3. Competitors	0. 216
5. Software features	0. 703
6. Development cost	0. 015
7. Calendar time	0. 018
8. Extra cost	0. 569
9. Resources	0. 086
10. After-sale support	0. 000
11. Complexity	0. 720
12. Evolution	0. 788
13. Requirements dependencies	0. 967
14. Requirement volatility	0. 721

Kruskal-Wallis tests could only tell that there were differences between the 3 groups, but it could not tell which 2 of them were different from each other. Therefore, ANOVA tests with post-hoc test were applied to confirm the results got by Kruskal-Wallis tests and identify between which 2 of the 3 groups there were significant differences. Before ANOVA tests, homogeneity of variance tests were conducted and the results ensured that the data were suitable to apply ANOVA tests. As can be expected, the results from the ANOVA tests also indicated that there were significant differences between different-sized companies regarding the practical importance of these 4 criteria. The post-hoc test identified which 2 groups were different from each other.

- Regarding the practical importance of ‘business strategy’ (criterion 1), there were statistical significant differences between ex-large-sized and large-sized as well as ex-large-sized and medium-sized companies, but there was no significant difference between large-sized and medium-sized companies.
- Regarding the practical importance of ‘development cost’ (criterion 6), there were statistical significant differences between large-sized and medium-sized companies, but there was no significant difference between ex-large-sized and

large-sized as well as ex-large-sized and medium-sized companies.

- Regarding the practical importance of 'calendar time' (criterion 7), there were statistical significant differences between ex-large-sized and large-sized as well as large-sized and medium-sized companies, but there was no significant difference between ex-large-sized and medium-sized companies.
- 'After-sale support' (criterion 10) had the same results as 'calendar time'.

4.4.2.4 Practical importance of criteria (perspective-based analysis)

As the analyses for the first research objective, the participants were divided into three perspectives based on their different roles in the companies. There were 36 experts from business perspective, 33 experts from project perspective, and 59 experts from product perspective participating in the second-phase survey.

The ratings of criteria's practical importance by the experts from business, project, and product perspectives are graphically presented in Figure 4.45. The numerical values are presented in Table A.7 in Appendix B.

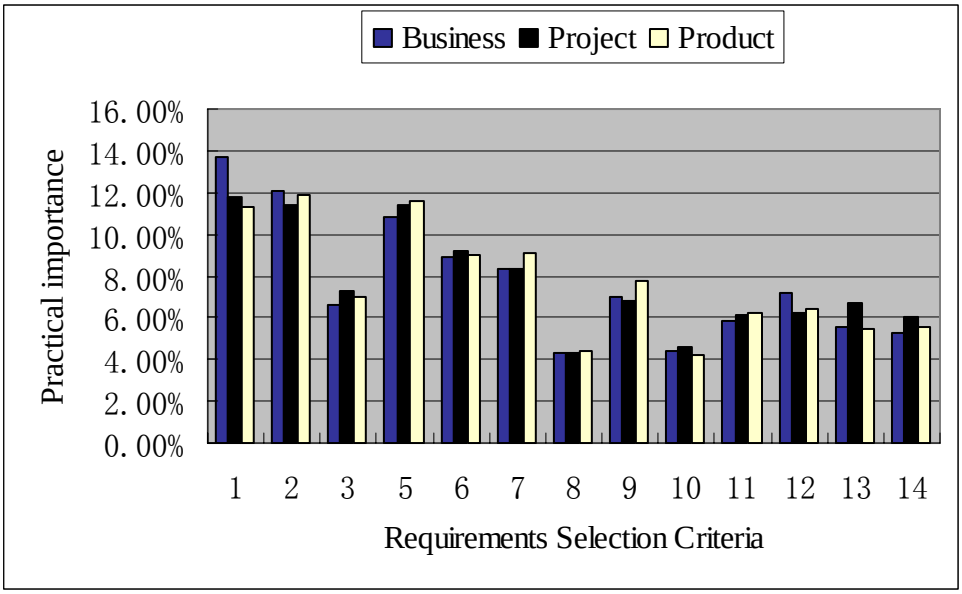

Figure 4.45: Practical importance of different criteria for different-perspective stakeholders

It was worth noting that the differences between the experts from different

perspectives as to the practical importance of the 13 criteria were not large. ‘Business strategy’ (criterion 1), ‘customer satisfaction’ (criterion 2), and ‘software features’ (criterion 5) were regarded as the 3 most important criteria by the experts from all 3 perspectives. ‘Extra cost’ (criterion 8) and ‘after-sale support’ (criterion 10) were considered as the least and second least important criteria by the experts from all 3 perspectives.

To shed further light on the similarities between the ratings by participants from different perspectives, Kruskal-Wallis tests were conducted to compare the ratings between the three-perspective experts regarding the practical importance of the 13 criteria. As shown in Table 4.5, the tests came out that the significance levels were above 0.05 for all 13 criteria. The results suggested that there was no statistical significance to indicate that the three-perspective experts had different opinions of the criteria’s practical importance.

Table 4.5: the results of Kruskal-Wallis test for different perspectives

	Significance
1. Business strategy	0. 861
2. Customer satisfaction	0. 744
3. Competitors	0. 809
5. Software features	0. 652
6. Development cost	0. 779
7. Calendar time	0. 400
8. Extra cost	0. 995
9. Resources	0. 383
10. After-sale support	0. 840
11. Complexity	0. 879
12. Evolution	0. 243
13. Requirements dependencies	0. 395
14. Requirement volatility	0. 601

Furthermore, Kruskal-Wallis tests were applied to compare the ratings between the three-perspective experts in each company as to the practical importance of the criteria. Table 4.6 presents the results of Kruskal-Wallis tests for the 11 companies.

Where the significance level was below 0.05 were highlighted in the table.

The Kruskal-Wallis tests came out that the significance levels of 'customer satisfaction' (criterion 2) in Company-1, 'resources' (criterion 9) in Company-7, and 'calendar time' (criterion 7) in Company-8 were less than 0.05. The results indicated that there were statistically significant differences between the ratings of the different-perspective experts in Company-1 regarding the practical importance of 'customer satisfaction' (criterion 2), in Company-7 regarding the practical importance of 'resources' (criterion 9), and in Company-8 regarding the practical importance of 'calendar time' (criterion 7).

Table 4.6: the results of Kruskal-Wallis tests for different perspectives in the 11 companies

	C-1	**C-2**	**C-3**	**C-4**	**C-5**	**C-6**	**C-7**	**C-8**	**C-9**	**C-10**	**C-11**
1. Business strategy	0.053	0.249	0.746	0.706	0.679	0.315	0.070	0.592	0.495	0.925	0.683
2. Customer satisfaction	0.035	0.803	0.343	0.109	0.626	0.843	0.641	0.909	0.890	0.264	0.339
3. Competitors	0.827	0.508	0.623	0.597	0.231	0.136	0.321	0.238	0.736	0.133	0.735
5. Software features	0.444	0.696	0.223	0.811	0.145	0.081	0.573	0.635	0.197	0.977	0.836
6. Development cost	0.329	0.696	0.431	0.660	0.415	0.216	0.521	0.120	0.737	0.533	0.541
7. Calendar time	0.766	0.951	0.108	0.751	0.102	0.760	0.834	0.027	0.728	0.452	0.552
8. Extra cost	0.084	0.211	0.808	0.708	0.360	0.295	0.830	0.904	0.473	0.465	0.663
9. Resources	0.086	0.978	0.243	0.259	0.860	0.912	0.047	0.519	0.761	0.321	0.185
10. After-sale support	0.171	0.925	0.780	0.612	0.566	0.559	0.433	0.372	0.106	0.635	0.299
11. Complexity	0.348	0.273	0.323	0.715	0.182	0.489	0.826	0.574	0.918	0.708	0.152
12. Evolution	0.360	0.446	0.217	0.421	0.612	0.261	0.503	0.447	0.877	0.214	0.680
13. Requirements dependencies	0.070	0.501	0.478	0.820	0.634	0.080	0.270	0.512	0.447	0.209	0.448
14. Requirement volatility	0.343	0.108	0.253	0.682	0.859	0.744	0.230	0.770	0.917	0.155	0.681

As mentioned before, Kruskal-Wallis tests could only indicate that there were differences between the experts from the 3 perspectives in these 3 companies, but it could not point out the experts from which 2 perspectives had different opinions from each other. Thus, to further analysis, homogeneity of variance tests and ANOVA tests with post-hoc tests were applied for Company-1, 7, and 8 to confirm the results got by Kruskal-Wallis tests and identify between which 2 of the 3 perspectives there were significant differences.

- In Company-1, regarding the practical importance of ‘customer satisfaction’ (criterion 2), there were statistical significant differences between the ratings of experts from business and project perspectives as well as business and product perspectives, but there was no significant difference between the ratings of experts from project and product perspectives.

- In Company-7, regarding the practical importance of ‘resources’ (criterion 9), there were statistical significant differences between the ratings of experts from business and project perspectives as well as project and product perspectives, but there was no significant difference between the ratings of experts from business and product perspectives.

- In Company-8, regarding the practical importance of ‘calendar time’ (criterion 7), there were statistical significant differences between the ratings of experts from business and project perspectives as well as project and product perspectives, but there was no significant difference between the ratings of experts from business and product perspectives.

4.4.3 Ideal importance of criteria

In this subsection, the findings regarding the ideal importance of the 13 criteria are reported according to the data collected by second-phase and third-phase survey. Criteria's ideal importance indicated that how the stakeholders thought the criteria should be ideally applied for the decision-making of requirements selection

In the third-phase survey, the experts were asked to re-rate the ideal importance of the criteria according to others' opinion, including the mean of all experts' ratings, the mean of all experts' ratings from respondent's company, standard deviation of all experts' ratings, and respondent's personal ratings in the second questionnaire. These results are presented in Table A.8 in Appendix B. The objective of the third-phase survey was to obtain a reasonable consensus between the experts on the ideal importance of the 13 criteria.

4.4.3.1 Ideal importance of criteria (all participants)

The ideal importance of the criteria is presented in Figure 4.46 based on all 128 responses obtained by the second-phase survey and 105 responses obtained by the third-phase survey. The numerical values are presented in Table A.9 in Appendix B.

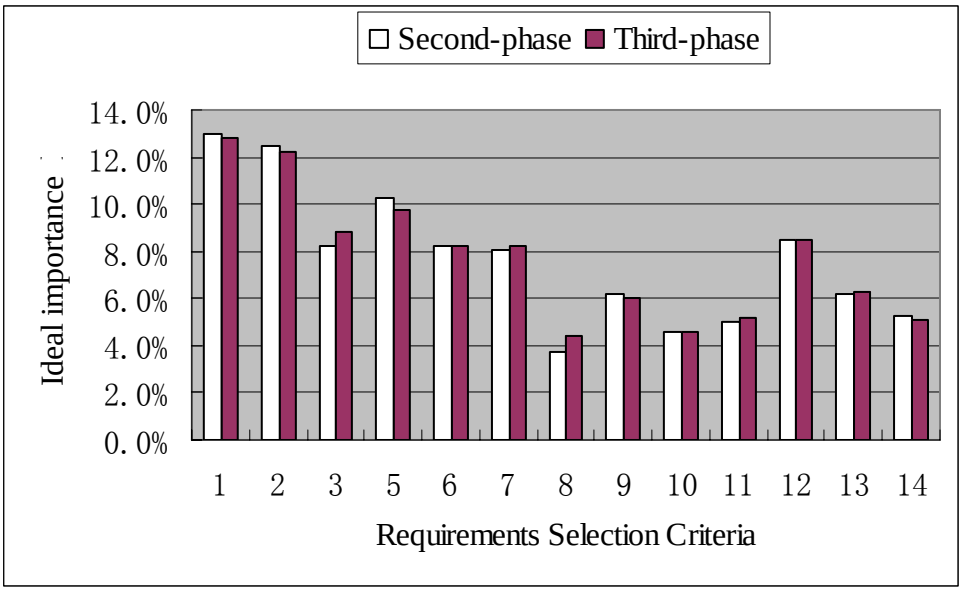

Figure 4.46: Ideal importance of the 13 criteria for all participants (second- and third-phase)

The results implied that there was no major shift in priorities of the criteria between the second-phase and third-phase responses. The order of the criteria in terms of their ideal importance is close to the same, except that 3 pairs of the criteria swapped place from the second-phase to third-phase responses. The ideal importance of ‘competitors’ (criterion 3) overtook the ideal importance of ‘evolution’ (criterion 12); ‘requirements dependencies’ (criterion 13) overtook ‘resources’ (criterion 9); and ‘complexity’ (criterion 11) overtook ‘requirements volatility’ (criterion 14).

Moreover, the most important criteria that experts wanted to see in the future remained the same as the practical situation. As shown in Figure 4.46, ‘business strategy’ (criterion 1) was still regarded as the most important criterion, while ‘customer satisfaction’ (criterion 2) and ‘software features’ (criterion 5) should still be the second and third important criteria in the future.

Furthermore, ‘competitors’ (criterion 3), ‘development cost’ (criterion 6), ‘calendar time’ (criterion 7), and ‘evolution’ (criterion 12) had ideal importance values over 8%. It indicated that experts thought these 4 criteria should also be taken into account when making the decisions. It was worth mentioning that all 4 business-perspective criteria appeared in the first 5 places regarding their ideal importance. In other words, the experts agreed that business-perspective criteria should remain the most significant influence on the decision-making of requirements selection in the ideal situation as the practical one.

However, on the other hand, ‘extra cost’ (criterion 8) and ‘after-sale support’ (criterion 10) were still considered as the least and second least important criteria, with ideal importance values below 5%.

4.4.3.2 Consensus on ideal importance

The degree of consensus between the experts on the criteria's ideal importance was measured by Kendall's coefficient of concordance W (Kendall 1975), which has been used in many Delphi studies (Couger 1988, Schmidt *et al.* 2001).

The coefficient of concordance W of the second-phase responses was 0.479 regarding the ideal importance of the 13 criteria, while the coefficient of concordance W of the third-phase responses was 0.674. The results indicated that the degree of consensus between the experts on the ideal importance increased through two-phase ratings. The coefficient of concordance W of the third-phase responses was near 0.7, so it showed a reasonable level of consensus between the experts.

The detailed analyses as to criteria's ideal importance were conducted according to the results of the third-phase survey. It was believed that the results of experts' re-evaluation were more valid and reliable (Schmidt 1997).

4.4.3.3 Ideal importance of criteria (company-based analysis)

Table 4.7 presents the ideal importance of each criterion in each company. One list represents the results from one company. It was analyzed by taking the sum of the points provided by the respondents from the same company and then normalizing the sum to a percentage figure.

Table 4.7: Ideal importance of different criteria for the 11 companies

	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11
1. Business strategy	14.6%	12.7%	11.9%	14.2%	11.8%	13.8%	11.9%	13.2%	11.3%	14.0%	10.9%
2. Customer satisfaction	13.7%	11.6%	12.3%	12.9%	10.8%	14.0%	12.1%	12.9%	11.1%	12.6%	11.1%
3. Competitors	7.5%	9.6%	7.2%	9.3%	8.9%	8.1%	8.9%	8.7%	9.4%	9.7%	8.7%
5. Software features	9.5%	11.1%	6.6%	10.1%	9.5%	11.0%	11.8%	9.3%	9.8%	10.0%	9.6%
6. Development cost	8.2%	9.9%	9.4%	8.5%	7.8%	7.1%	8.6%	7.1%	7.6%	6.0%	8.7%
7. Calendar time	7.7%	10.3%	9.6%	8.9%	8.2%	7.9%	8.8%	6.4%	6.2%	7.4%	8.7%
8. Extra cost	4.2%	4.1%	8.8%	3.0%	4.6%	5.0%	3.6%	4.5%	3.6%	3.4%	4.1%
9. Resources	5.3%	4.7%	8.8%	4.8%	6.0%	5.5%	5.5%	7.0%	5.0%	6.3%	8.4%
10. After-sale support	4.6%	4.8%	3.7%	4.1%	4.3%	2.6%	5.0%	4.6%	6.4%	5.3%	4.3%
11. Complexity	5.9%	4.8%	6.9%	4.3%	5.3%	5.0%	5.2%	4.9%	5.4%	5.0%	5.4%
12. Evolution	6.2%	6.3%	4.6%	8.4%	9.5%	10.5%	10.1%	9.6%	11.0%	9.7%	8.0%
13. Requirements dependencies	6.9%	5.2%	5.5%	6.7%	6.7%	5.0%	5.2%	6.6%	8.1%	5.6%	5.6%
14. Requirement volatility	5.6%	4.9%	4.5%	4.7%	6.5%	4.5%	3.4%	5.1%	5.1%	5.0%	6.4%

Where ideal importance values of the criteria are above 10% in each company are highlighted in Table 4.7. As shown in the table, ‘business strategy’ (criterion 1) and ‘customer satisfaction’ (criterion 2) were regarded as the 2 most important criteria by all 11 companies. In other words, all the companies had the same opinion that these 2 criteria should be the 2 most important ones driving the decision-making of requirements selection.

In addition, the ideal importance of each criterion was compared between 11 companies to figure out the consistency or inconsistency. The opinions of the 11

companies regarding the ideal importance of each criterion are presented respectively as follows.

- ‘Business strategy’ (criterion 1)

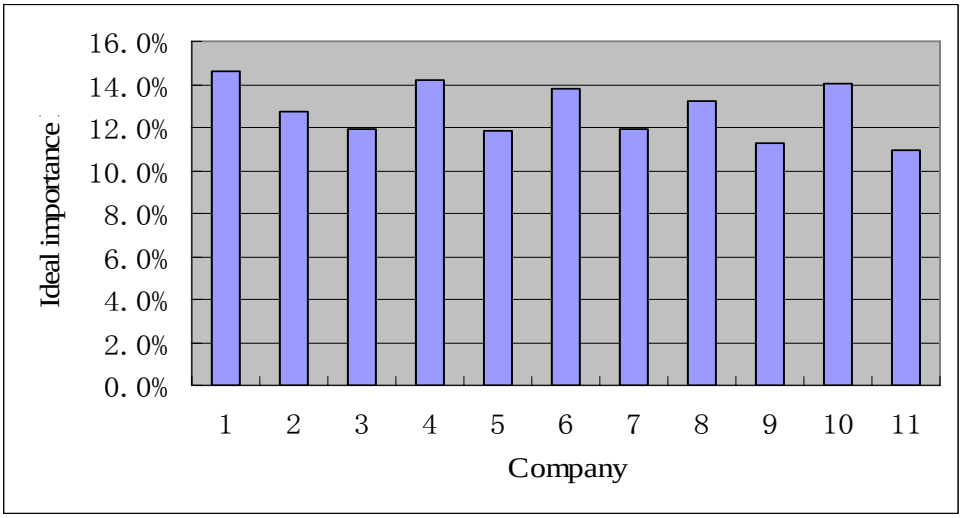

Figure 4.47: Ideal importance of ‘Business Strategy’

As shown in Figure 4.47, the 11 companies did not have very different opinions regarding the ideal importance of ‘business strategy’ (criterion 1). In all the 11 companies, the ideal importance values of this criterion were above 10%, ranging from 10.9% to 14.6%.

- ‘Customer satisfaction’ (criterion 2)

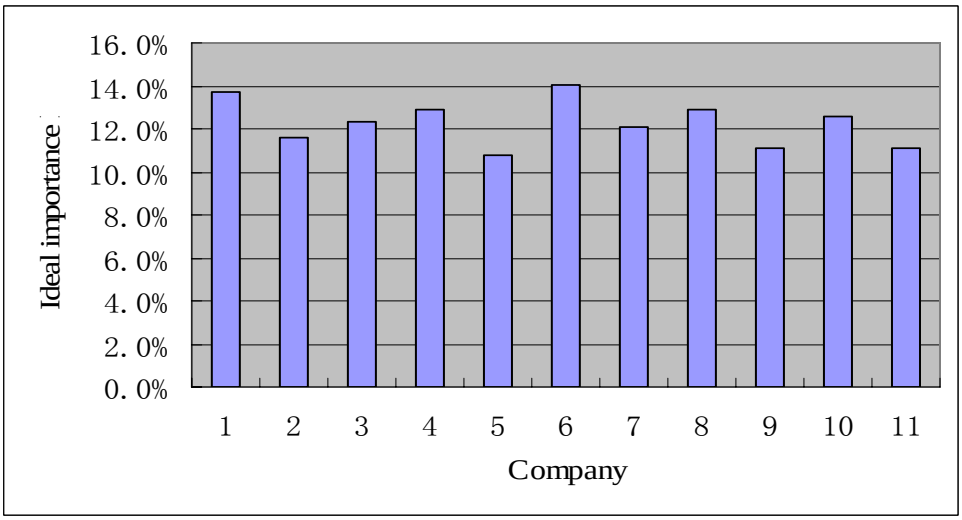

Figure 4.48: Ideal importance of ‘Customer Satisfaction’

As shown in Figure 4.48, the 11 companies had relatively similar opinions regarding the ideal importance of ‘customer satisfaction’ (criterion 2). The ideal importance values of ‘customer satisfaction’ were above 10% in all the 11 companies, ranging from 10.8% to 14%.

- ‘Competitors’ (criterion 3)

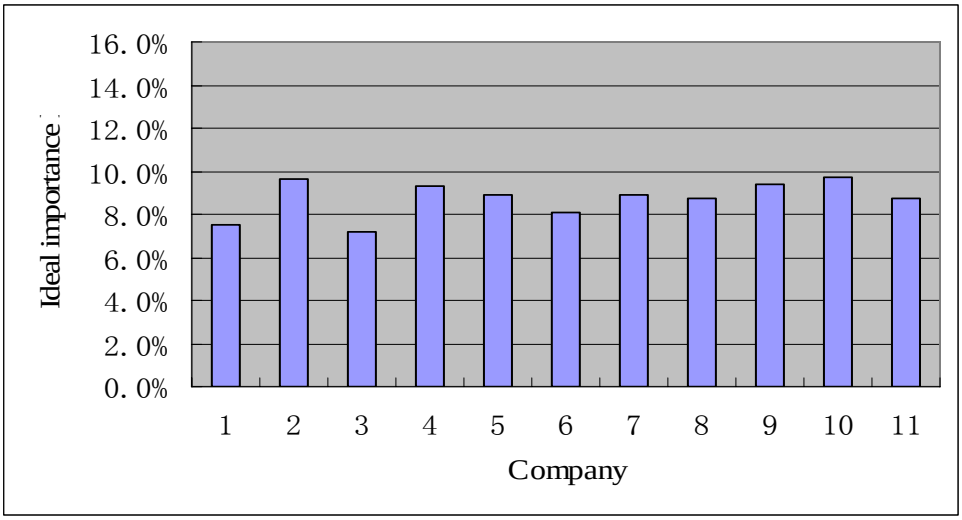

Figure 4.49: Ideal importance of ‘Competitors’

As shown in Figure 4.49, there was much consistency between most companies regarding the ideal importance of ‘competitors’ (criterion 3). The ideal importance values of this criterion ranged from 7.2% to 9.7% in the 11 companies, with a dispersion of 2.5% only. It was worth noting that the importance value of this criterion in Company-3 was relatively lower than the other companies.

- ‘Software features’ (criterion 5)

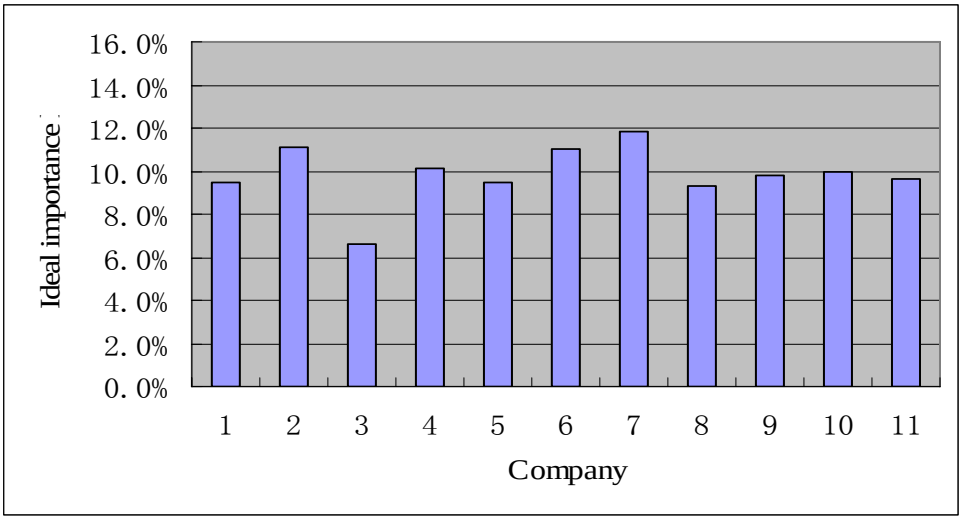

Figure 4.50: Ideal importance of ‘Software Feature’

As shown in Figure 4.50, there was some inconsistency between the companies regarding the ideal importance of ‘software features’ (criterion 5). Especially in Company-3, the experts though that ‘software features’ should only contribute 6.6% to the requirements selection decisions in the future, while the ideal importance values of this criterion ranged from 9.3% to 11.8% in the other companies.

- ‘Development cost’ (criterion 6)

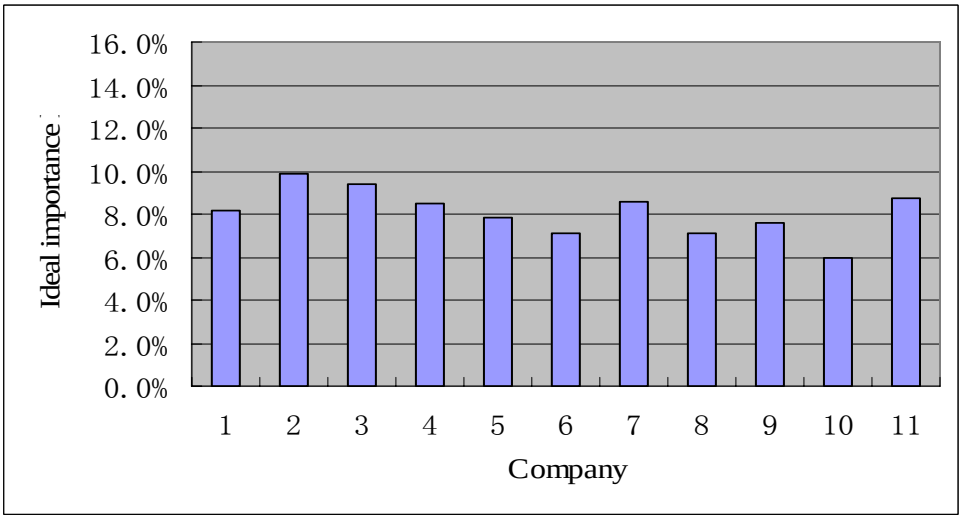

Figure 4.51: Ideal importance of ‘Development Cost’

As shown in Figure 4.51, most companies had similar opinions regarding the ideal importance of ‘development cost’ (criterion 6), except Company-10. The ideal importance values of this criterion in the other 10 companies ranged from 7.1% to 9.9%, while it was only 6% in Company-10. The results indicated that the experts from Company-10 thought that ‘development cost’ should be less important than the experts from the other 10 companies thought.

- ‘Calendar time’ (criterion 7)

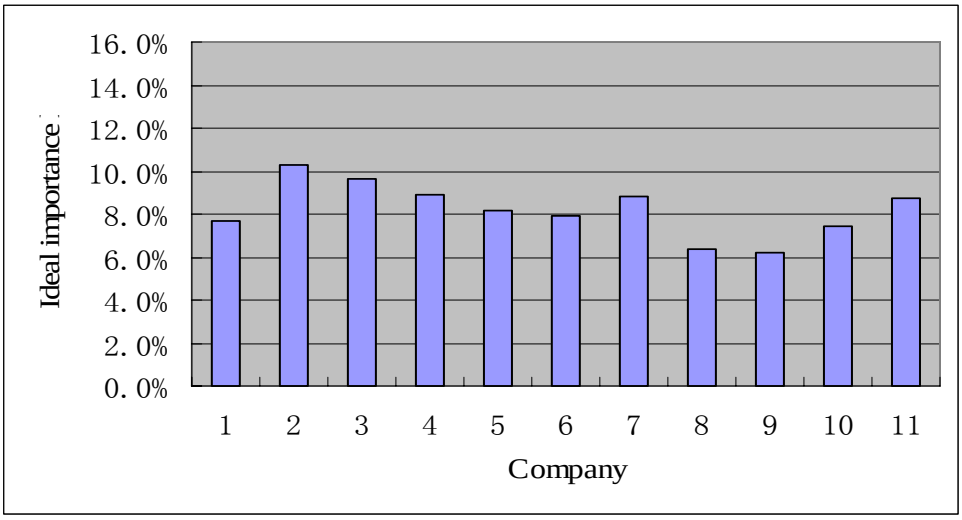

Figure 4.52: Ideal importance of ‘Calendar Time’

As shown in Figure 4.52, the differences between the companies were not very large regarding the ideal importance of ‘calendar time’ (criterion 7), except Company-8 and Company-9. The ideal importance values of this criterion in Company-8 and Company-9 were a little lower than the ones in the other 9 companies. The ideal importance values of this criterion in the other 9 companies ranged from 7.4% to 10.3%, with a dispersion of 2.9%, while the importance values were only 6.4% and 6.2% in Company-8 and Company-9.

- ‘Extra cost’ (criterion 8)

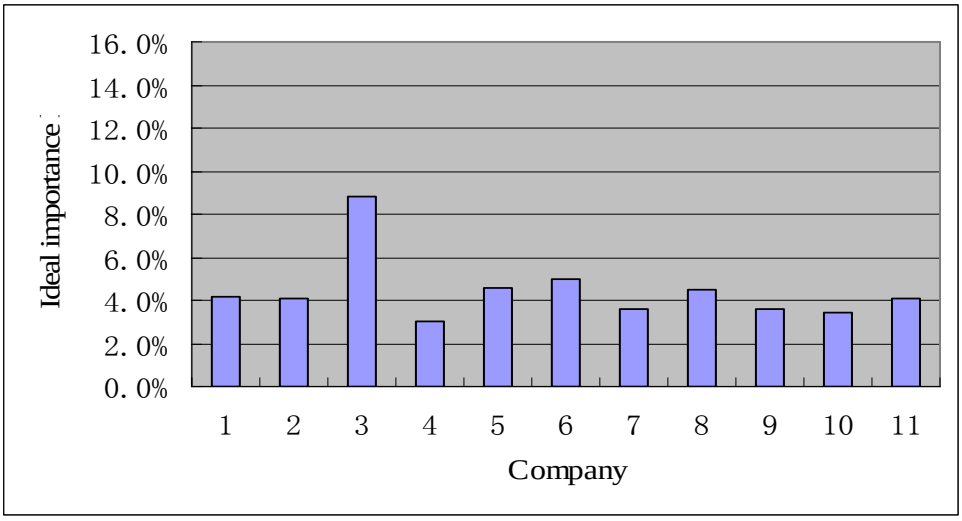

Figure 4.53: Ideal importance of ‘Extra Cost’

As shown in Figure 4.53, there was little inconsistency between most companies as to the ideal importance of ‘extra cost’ (criterion 8), except Company-3. The ideal importance values of ‘extra cost’ ranged from 3% to 5% in the other 10 companies, with a dispersion of 2% only, while it was about 8.8% in Company-3.

- ‘Resources’ (criterion 9)

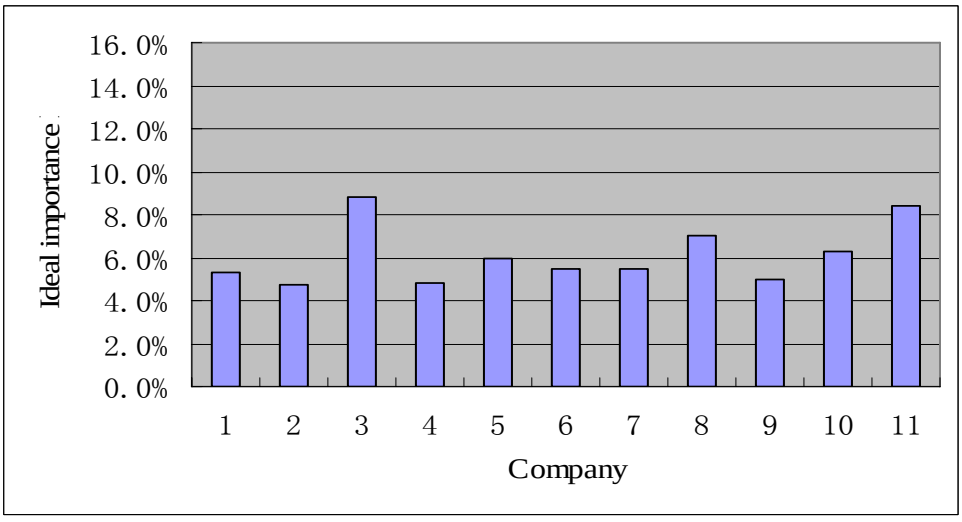

Figure 4.54: Ideal importance of ‘Resources’

As shown in Figure 4.54, the differences between the companies were not small regarding the ideal importance of ‘resources’ (criterion 9). The ideal importance

values of this criterion ranged from 4.7% to 8.8% in the 11 companies, with a dispersion of 4.1%. The ideal importance values of 'resources' in Company-3 and Company-11 were above 8%, while the importance values were only about 5% in Company-2, Company-4, and Company-9.

- 'After-sale support' (criterion 10)

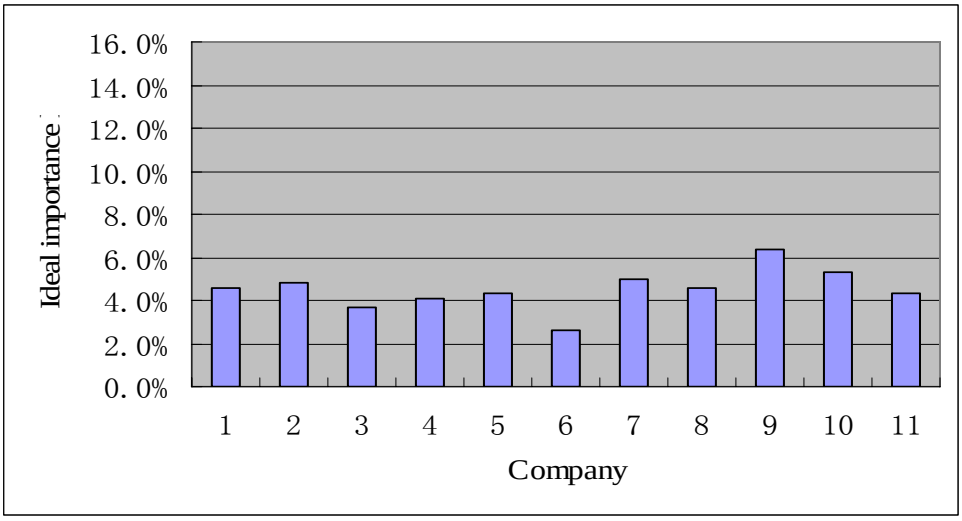

Figure 4.55: Ideal importance of 'After-sale Support'

As shown in Figure 4.55, there was little inconsistency between most companies as to the ideal importance of 'after-sale support' (criterion 8), except Company-6. The ideal importance values of this criterion ranged from 3.7% to 6.4% in the other 10 companies, with a dispersion of 2.7% only. However, the ideal importance value of 'after-sale support' in Company-6 was relatively lower than the other companies, which is only 2.6%.

- ‘Complexity’ (criterion 11)

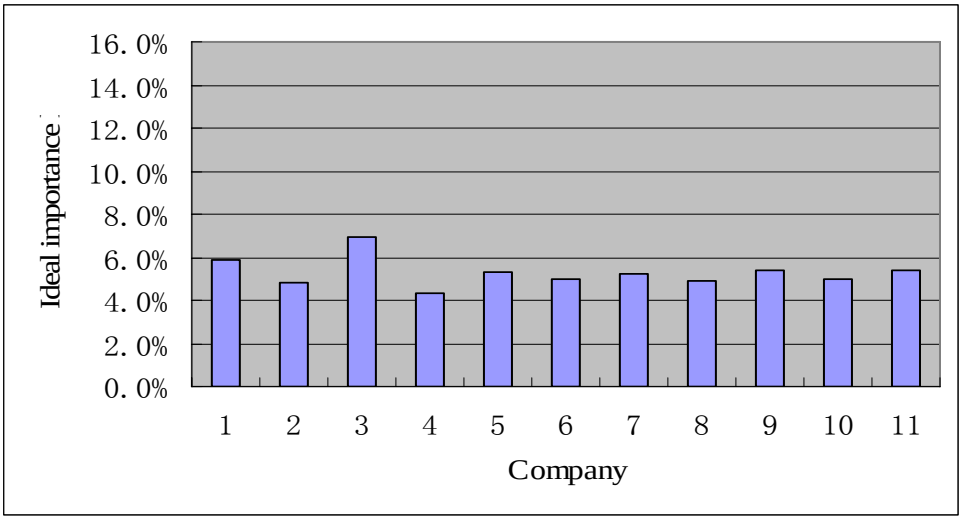

Figure 4.56: Ideal importance of ‘Complexity’

As shown in Figure 4.56, the differences between the companies were small regarding the ideal importance of ‘complexity’ (criterion 11). The ideal importance values of this criterion ranged from 4.3% to 6.9% in the 11 companies, with a dispersion of 2.6% only.

- ‘Evolution’ (criterion 12)

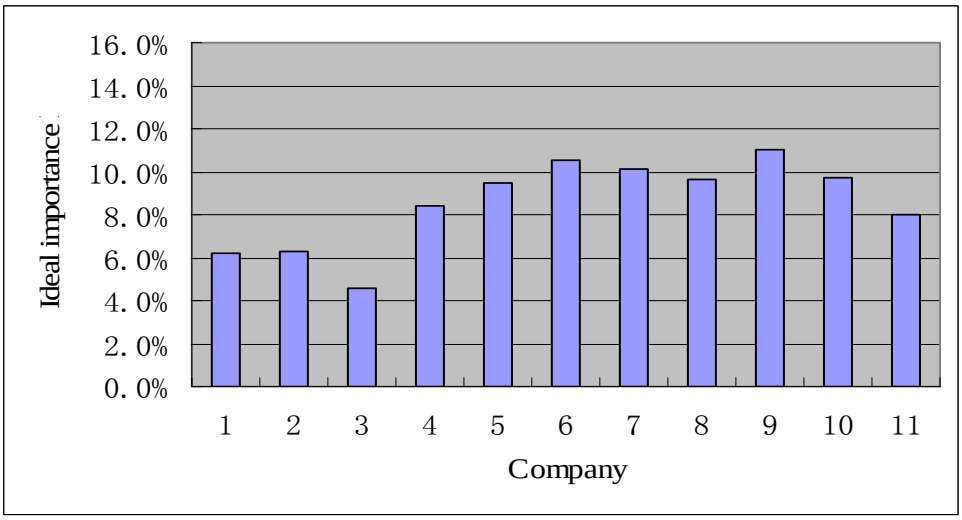

Figure 4.57: Ideal importance of ‘Evolution’

As shown in Figure 4.57, the differences between the companies were quite large regarding the ideal importance of ‘evolution’ (criterion 12). The ideal importance

values of this criterion ranged from 4.6% to 11% in the 11 companies, with a dispersion of 6.4%. In Company-1, Company-2, and Company-3, the ideal importance values of 'evolution' were below 6.5%. Especially in Company-3, the percentage value of this criterion was only 5%. However, the ideal importance value of this criterion was 11% in Company-9.

- 'Requirements dependencies' (criterion 13)

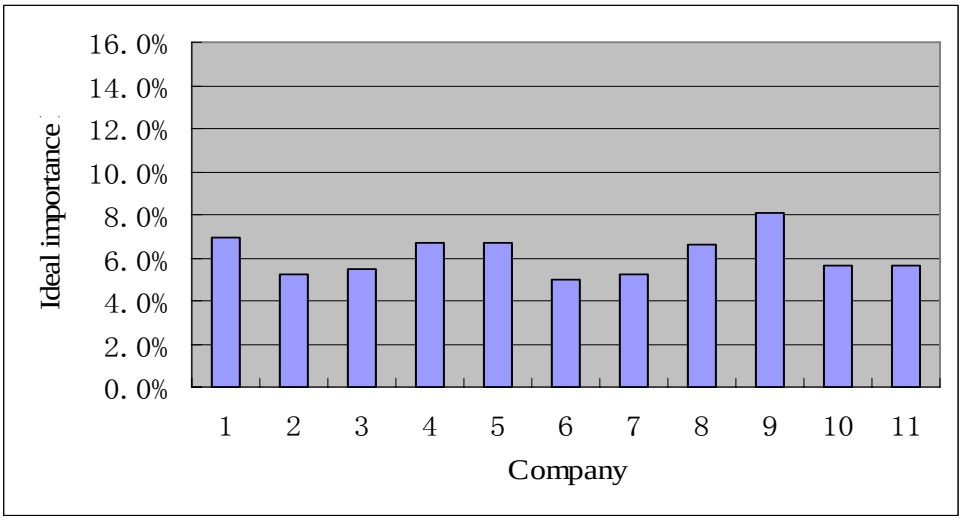

Figure 4.58: Ideal importance of 'Requirements Dependencies'

As shown in Figure 4.58, the differences between the companies were relatively small regarding the ideal importance of 'requirements dependencies' (criterion 13). The ideal importance values of this criterion ranged from 5% to 8.1% in the 11 companies, with a dispersion of 3.1%. It was worth mentioning the experts from Company-9 thought that 'requirements dependencies' should be more important than the experts from the other companies thought.

- ‘Requirement volatility’ (criterion 14)

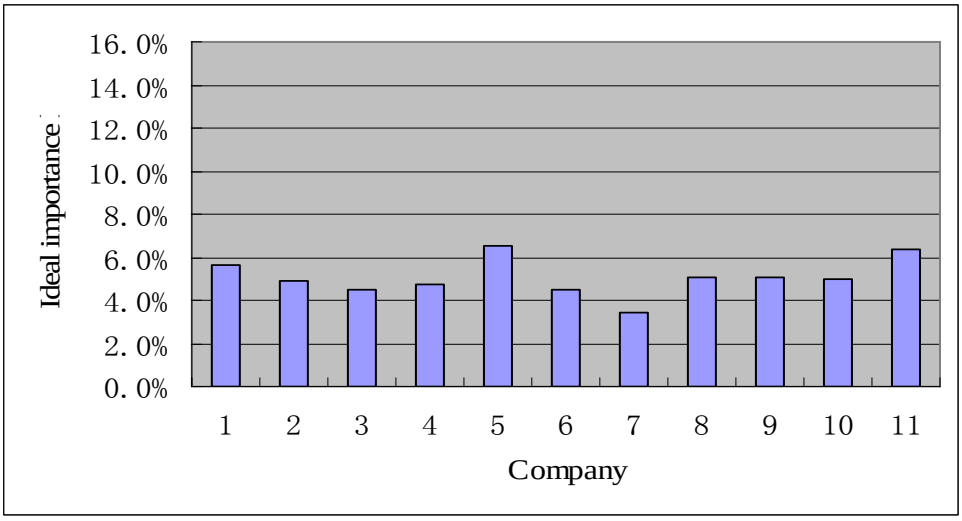

Figure 4.59: Ideal importance of ‘Requirement Volatility’

As shown in Figure 4.59, the differences between the companies were not large regarding the ideal importance of ‘requirement volatility’ (criterion 14). The ideal importance values of this criterion ranged from 3.4% to 6.5% in the 11 companies, with a dispersion of 3.1%.

To sum up, the experts from Company-3 always had different opinions from the other 10 companies regarding the ideal importance of the criteria. The experts from Company-3 thought ‘software features’ (criterion 5) and ‘evolution’ (criterion 12) should be much less important than the experts from the other 10 companies thought, while the experts from Company-3 thought ‘extra cost’ (criterion 8) and ‘resources’ (criterion 9) should be much more important than the experts from the other companies thought.

Furthermore, Figure 4.60 presents the absolute dispersions between the 11 companies regarding the ideal importance of the 13 criteria. The numerical values are presented in Table A.10 in Appendix B. The dispersions ranged from 2.6% to 6.4%. As shown in the figure, the differences between the companies were relatively large regarding the ideal importance of ‘software features’ (criterion 5), ‘extra cost’ (criterion 8), and

‘evolution’ (criterion 12).

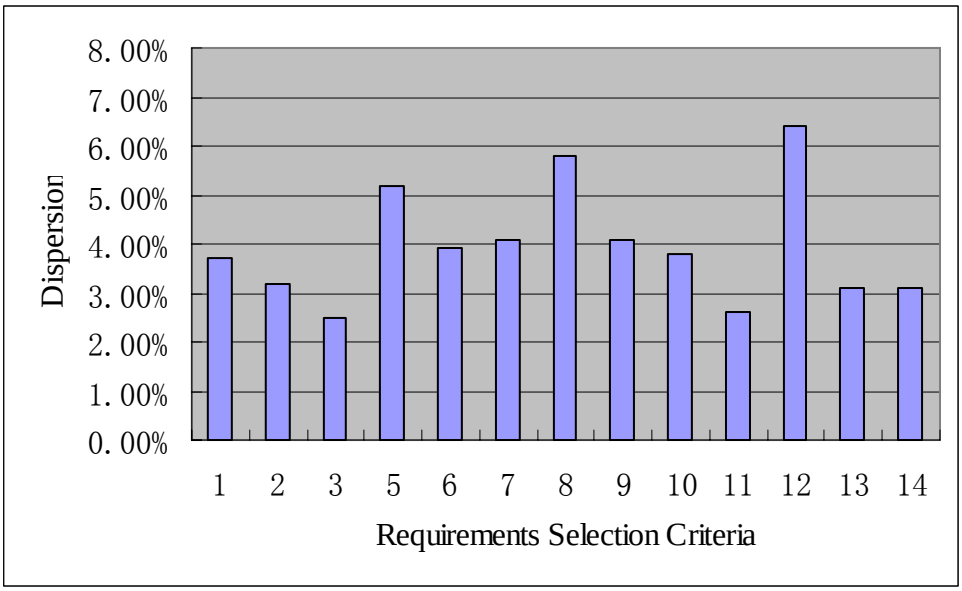

Figure 4.60: Dispersions of the ideal importance between the 11 companies

4.4.3.4 Ideal importance of criteria (company-size-based analysis)

As the analyses for criteria’s practical importance, the 11 companies were divided into 3 groups based on their different sizes. There were 30 experts from ex-large-sized companies, 28 experts from large-sized companies, and 47 experts from medium-sized companies participating in the third-phase survey.

The data were normalized to a percentage figure for different-sized companies to display the differences of the criteria’s ideal importance in different-sized companies. Figure 4.61 presents ideal importance of each criterion in ex-large-sized, large-sized, and medium-sized companies. The numerical values are presented in Table A.11 in Appendix B.

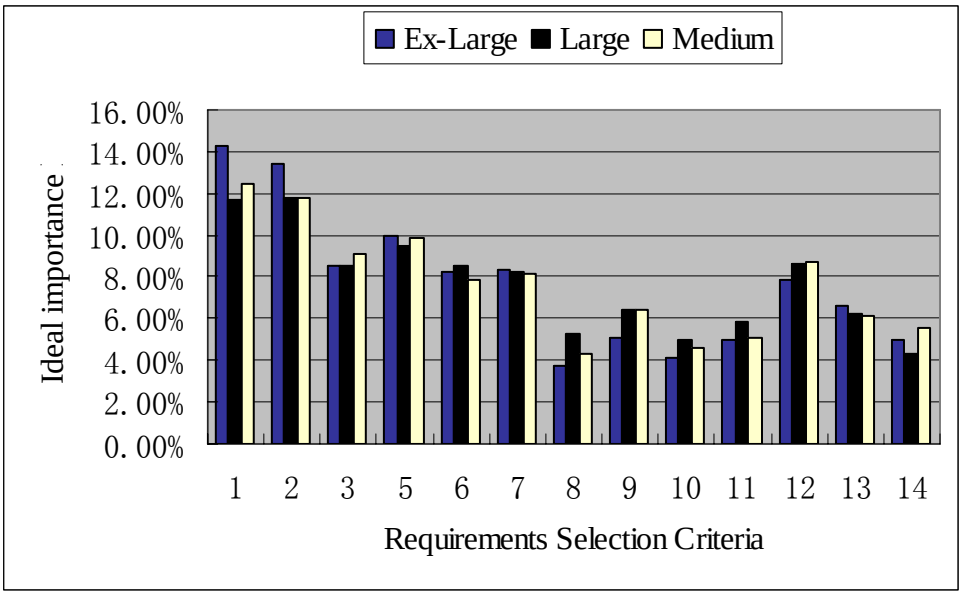

Figure 4.61: Ideal importance of different criteria for different-sized companies

The differences between different-sized companies regarding the ideal importance of the criteria were not as many as the practical importance. However, there were some differences in existence. First of all, the experts from ex-large-sized companies thought that 'business strategy' (criterion 1) and 'customer satisfaction' (criterion 2) should be more important than the experts from large-sized and medium-sized companies thought. Moreover, in ex-large-sized and medium-sized companies, 'extra cost' (criterion 8) and 'after-sale support' (criterion 10) were regarded as the least and second least important criteria, while in medium-sized companies these 2 criteria should be more important than 'requirements volatility' (criterion 14) when making the decisions for requirements selection.

To further discover the differences between different-sized companies, statistical analyses were conduced as the practical situation.

Firstly, kolmogorov-smirnov tests were applied to find out the distribution of the data collected by the third-phase survey. The kolmogorov-smirnov tests came out that the significance was below 0.05 for all criteria. It indicated that the data collected by third-phase survey were not near normal distribution.

Secondly, according to the results of kolmogorov-smirnov tests, Kruskal-Wallis tests were applied to compare the ratings of criteria's ideal importance between participants from different-sized companies. As highlighted in Table 4.8, the Kruskal-Wallis tests came out that the significance levels of 'business strategy' (criterion 1), 'customer satisfaction' (criterion 2), 'resources' (criterion 9), and 'requirements volatility' (criterion 14) were less than 0.05, while significance levels of the other 9 criteria were above 0.05. The results suggested that there were statistically significant differences between different-sized companies regarding the ideal importance of 'business strategy' (criterion 1), 'customer satisfaction' (criterion 2), 'resources' (criterion 9), and 'requirements volatility' (criterion 14).

Table 4.8: the results of Kruskal-Wallis test for different-sized companies

	Significance
1. Business strategy	0. 002
2. Customer satisfaction	0. 001
3. Competitors	0. 452
5. Software features	0. 594
6. Development cost	0. 274
7. Calendar time	0. 923
8. Extra cost	0. 507
9. Resources	0. 015
10. After-sale support	0. 235
11. Complexity	0. 113
12. Evolution	0. 121
13. Requirements dependencies	0. 531
14. Requirement volatility	0. 004

Lastly, homogeneity of variance tests and ANOVA tests with post-hoc tests were applied to confirm the results got by Kruskal-Wallis tests and identify between which 2 of the 3 groups there were significant differences. As can be expected, the results from the ANOVA tests also indicated that there were significant differences between different-sized companies for the ideal importance regarding the ideal importance of these 4 criteria. The post-hoc tests identified which 2 groups were different from each other.

- Regarding the ideal importance of ‘business strategy’ (criterion 1), there were statistical significant differences between ex-large-sized and large-sized as well as ex-large-sized and medium-sized companies, but there was no significant difference between large-sized and medium-sized companies.
- ‘Customer satisfaction’ (criterion 2) had the same results as ‘business strategy’.
- ‘Resources’ (criterion 9) also had the same results as ‘business strategy’.
- Regarding the ideal importance of ‘requirements volatility’ (criterion 14), there were statistical significant differences between large-sized and medium-sized companies, but there was no significant difference between ex-large-sized and large-sized as well as ex-large-sized and medium-sized companies.

The results indicated that the differences existed between ex-large-sized and the other two sizes regarding the ideal importance of ‘business strategy’ (criterion 1), ‘customer satisfaction’ (criterion 2), and ‘resources’ (criterion 9). The differences might indicate the differences between international and national companies. In addition, the experts from large-sized and medium-sized companies had different opinions as to the ideal importance of ‘requirements volatility’ (criterion 14), but there were little inconsistency between ex-large-sized and the other two sizes as to the ideal importance of this criterion.

4.4.3.5 Ideal importance (perspective-based analysis)

As the analyses for criteria’s practical importance, the experts were divided into 3 perspectives based on their different roles in the companies. There were 28 experts from business perspective, 27 experts from project perspective, and 50 experts from product perspective participating in the third-phase survey.

The opinions of the experts from business, project, and product perspectives regarding criteria’s ideal importance are graphically presented in Figure 4.62. The numerical values are presented in Table A.12 in Appendix B.

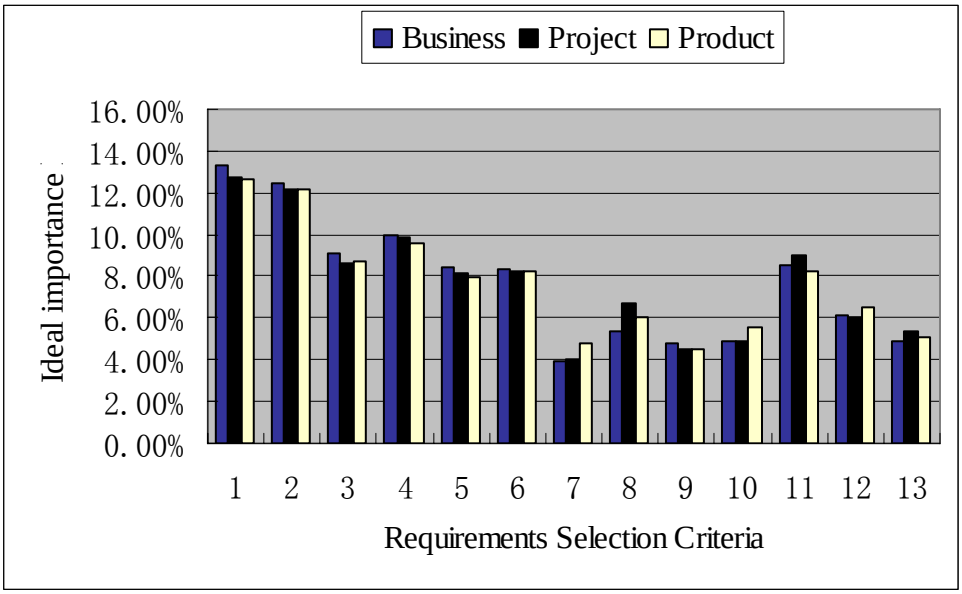

Figure 4.62: Ideal importance of different criteria for different-perspective stakeholders

As shown in the figure, there were not many differences between the experts from different perspectives regarding the ideal importance of the 13 criteria. The experts from business, project, and product perspectives had similar opinions about how the 13 criteria should be applied in the future. The absolute dispersions of the ratings between different-perspective experts were less than 1.5% as to criteria's ideal importance.

Kruskal-Wallis tests were applied to compare the ratings between the three-perspective experts as to criteria's ideal importance. As shown in Table 4.9, the tests came out that significance levels were above 0.05 for all the 13 criteria. The results suggested that there was no statistical significance to indicate that the experts from different perspectives had different opinions regarding the ideal importance of the criteria.

Table 4.9: the results of Kruskal-Wallis test for different perspective

	Significance
1. Business strategy	0.921
2. Customer satisfaction	0.725
3. Competitors	0.588
5. Software features	0.658
6. Development cost	0.550
7. Calendar time	0.891
8. Extra cost	0.302
9. Resources	0.174
10. After-sale support	0.905
11. Complexity	0.112
12. Evolution	0.553
13. Requirements dependencies	0.379
14. Requirement volatility	0.558

Furthermore, Kruskal-Wallis tests were applied to compare the ratings between the three-perspective participants in each company as to criteria's ideal importance. As some participants quitted in the third-phase Delphi study, the experts from Company-3 and Company-6 were from project and product perspectives only. Thus, the Kruskal-Wallis tests applied to compare the ratings between the three-perspective experts actually compared the ratings between the experts from project and product perspectives only in Company-3 and Company-6.

Table 4.10 presents the results of Kruskal-Wallis tests for the 11 companies. Where the significance level was below 0.05 were highlighted in the table. The Kruskal-Wallis tests came out that the significance level of 'customer satisfaction' (criterion 2) in Company-1 was less than 0.05. The results indicated that there were statistically significant differences between the ratings of the experts from different perspectives in Company-1 regarding the ideal importance of 'customer satisfaction' (criterion 2).

Table 4.10: the results of Kruskal-Wallis tests for different perspectives in the 11 companies

	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11
1. Business strategy	0.175	0.515	1.000	0.782	0.695	0.439	0.544	0.752	1.000	0.422	0.570
2. Customer satisfaction	0.037	0.290	1.000	0.204	0.535	0.102	0.442	0.401	0.535	0.862	0.169
3. Competitors	0.432	0.518	0.692	0.972	0.204	0.121	0.668	0.114	0.438	0.837	0.687
5. Software features	0.472	0.947	0.845	0.750	0.480	0.317	0.382	0.845	0.565	1.000	0.185
6. Development cost	0.289	0.670	0.596	0.398	0.629	0.439	0.356	0.480	0.717	0.760	0.687
7. Calendar time	0.618	0.670	0.818	0.849	0.220	0.317	0.093	0.304	0.314	0.513	0.207
8. Extra cost	0.202	0.825	0.818	0.774	0.322	0.683	0.890	0.883	0.457	0.292	0.080
9. Resources	0.368	0.350	0.391	0.141	0.166	0.317	0.565	0.949	1.000	0.334	0.558
10. After-sale support	0.648	0.518	0.522	0.782	0.175	1.000	0.610	0.845	0.361	0.135	0.207
11. Complexity	0.115	0.208	0.114	0.851	0.184	1.000	0.223	0.105	0.476	1.000	0.687
12. Evolution	0.489	0.964	0.840	0.997	0.170	0.317	0.083	0.883	0.710	0.819	0.565
13. Requirements dependencies	0.162	0.565	0.724	0.505	0.183	0.221	0.269	0.527	0.569	0.801	0.377
14. Requirement volatility	0.068	0.132	1.000	0.668	0.416	0.221	0.826	0.736	0.497	1.000	0.071

To further analysis, ANOVA tests with post-hoc tests were conducted for Company-1 to identify between which 2 of the 3 perspectives there were significant differences.

- In Company-1, regarding the ideal importance of ‘customer satisfaction’ (criterion 2), there were statistical significant differences between the ratings of experts from business and project perspectives as well as business and product perspectives, but there was no significant difference between the ratings of experts from project and product perspectives.

4.4.4 Comparison between practical and ideal situation

This subsection compares the practical situation and ideal situation, regarding the

importance of the 13 criteria to the decision-making of requirements selection. The objective is to capture what would ideally be a better balance between the 13 criteria than the practical situation. The results of the practical situation are based on the second-phase survey, while the results of the ideal situation are according to the third-phase results.

4.4.4.1 Comparison between practical and ideal rankings of criteria

Table 4.11 presents the rankings of the 13 criteria regarding their ideal importance as well as the differences between the rankings of the criteria as to their practical and ideal importance.

Table 4.11: Rankings of criteria regarding their ideal and practical importance

Criteria			**Movement (compare to practical situation)**
1	Business strategy	12.8%	−
2	Customer satisfaction	12.2%	−
5	Software features	9.8%	−
3	Competitors	8.8%	+3
12	Evolution	8.5%	+3
6	Development cost	8.2%	−2
7	Calendar time	8.2%	−2
13	Requirements dependencies	6.3%	+2
9	Resources	6%	−3
11	Complexity	5.2%	−1
14	Requirement volatility	5.1%	−
10	After-sale support	4.6%	−
8	Extra cost	4.4%	−

As shown in the table, the experts considered that the 3 most and least important criteria in the ideal situation should remain the same as the practical situation.

However, there were some shifts in priorities of the criteria in the middle part. Comparing to the practical situation, the ideal importance of ‘competitors’ (criterion 3) and ‘evolution’ (criterion 12) raised 3 places in the ranking, while ‘development cost’

(criterion 6) and ‘calendar time’ (criterion 7) fell 2 places instead. The experts considered that more emphases should be put on ‘competitors’ and ‘evolution’ of the software rather than the traditional project issues such as development cost and time. Additionally, the experts preferred to see that the impact of ‘requirements dependencies’ (criterion 13) on requirements selection decisions overtook the one of ‘resources’ (criterion 9) and ‘complexity’ (criterion 11). The experts believed that these shifts would contribute to better requirements selection decisions.

4.4.4.2 Comparison between practical and ideal importance value of criteria

The changes between criteria’s practical and ideal importance value are presented in Table 4.12. The results are graphically presented in Figure 4.63 to make the findings more visual.

Table 4.12: Practical and ideal importance of the criteria for all participants

	Practical	Ideal	Difference
1. Business strategy	12.2%	12.8%	+0.6%
2. Customer satisfaction	11.7%	12.2%	+0.5%
3. Competitors	7%	8.8%	+1.8%
5. Software features	11.3%	9.8%	-1.5%
6. Development cost	9.1%	8.2%	-0.9%
7. Calendar time	8.5%	8.2%	-0.3%
8. Extra cost	4.3%	4.4%	+0.1%
9. Resources	7.1%	6%	-1.1%
10. After-sale support	4.5%	4.6%	+0.1%
11. Complexity	6.1%	5.2%	-0.9%
12. Evolution	6.5%	8.5%	+2.0%
13. Requirements dependencies	6.1%	6.3%	+0.2%
14. Requirement volatility	5.7%	5.1%	-0.6%

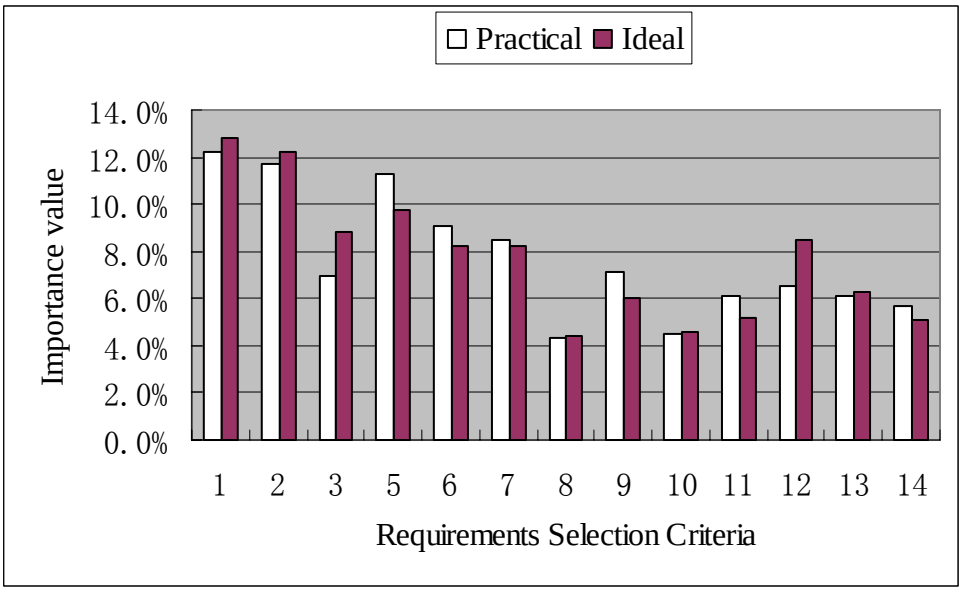

Figure 4.63: Practical and ideal importance of the criteria for all participants

As shown in the table and figure, there were some differences between how the criteria were practically applied and how the experts thought that the criteria should be ideally applied when making the decisions for requirements selection.

First of all, there were large differences between the practical and ideal importance of 'evolution' (criterion 12) as well as 'competitors' (criterion 3), about 2% and 1.8% respectively. The experts believed that ideally these 2 criteria should be much more important on requirements selection decisions than the practical situation.

Moreover, the experts considered that 'software features' (criterion 5), 'development cost' (criterion 6), and 'complexity' (criterion 11) were 3 criteria to which had been paid too much attention in practice. They should be less important in the ideal situation than the practical situation.

Furthermore, the 13 criteria had a tighter distribution when applied practically than ideally. The criteria were distributed over 7.9 percentage points in practical situation, while they were distributed over 8.4 percentage points in ideal situation.

4.4.4.3 Statistical tests to compare criteria's practical and ideal importance

Wilcoxon tests were conducted to further analysis what changes should be made to gain the benefits, compared with the practical situation.

A Wilcoxon test is a nonparametric test to compare the 2 members of paired data. Wilcoxon tests were applied for each criterion to compare its practical and ideal importance. The practical importance of the criteria was based on the second-phase ratings by the 105 experts who had participated in all three-phase survey, while the ideal importance was based on the 105 experts' ratings in the third-phase survey.

The tests came out that 8 criteria's significance levels were below 0.05, as highlighted in Table 4.13. They were 'business strategy' (criterion 1), 'customer satisfaction' (criterion 2), 'competitors' (criterion 3), 'software features' (criterion 5), 'development cost' (criterion 6), 'resources' (criterion 9), 'complexity' (criterion 11), and 'evolution' (criterion 12). The results suggested that there was statistical significance to indicate the differences between these 8 criteria's practical and ideal importance. In other words, the experts considered that the 8 criteria should ideally be applied differently with the practical situation to gain the benefits when making the decisions for requirements selection.

It was worth noting that all of the 4 business-perspective criteria had statistically significance to indicate the differences between their practical and ideal importance. The statistical analysis supported and validated the observed findings.

Table 4.13: the results of Wilcoxon tests to compare practical and ideal situation

	Significance
1. Business strategy	0. 019
2. Customer satisfaction	0. 005
3. Competitors	0. 000
5. Software features	0. 002
6. Development cost	0. 000
7. Calendar time	0. 060
8. Extra cost	0. 461
9. Resources	0. 001
10. After-sale support	0. 532
11. Complexity	0. 000
12. Evolution	0. 000
13. Requirements dependencies	0. 674
14. Requirement volatility	0. 081

4.5 Research objective 3

The third research objective is to explore the degree to which the value propositions of stakeholders from different perspectives influenced the decision-making process of requirements selection. The 13 criteria for requirements selection are divided into 3 groups in accordance with the value propositions of stakeholders from the 3 perspectives.

- Business-perspective criteria include: 'Business strategy' (criterion 1), 'customer satisfaction' (criterion 2), 'competitors' (criterion 3), and 'software features' (criterion 5)
- Project-perspective criteria include: 'development cost' (criterion 6), 'calendar time' (criterion 7), 'extra cost' (criterion 8), and 'resources' (criterion 9)
- Product-perspective criteria include: 'after-sale support' (criterion 10), 'complexity' (criterion 11), 'evolution' (criterion 12), 'requirements dependencies' (criterion 13), and 'requirements volatility' (criterion 14).

Additionally, the differences between the practical and the ideal situation are determined

Research Question 3: to what degree do the value propositions of major stakeholders influence the requirements selection process? How does this differ from the industry perception of the ideal application of the criteria?

4.5.1 Data analysis

The findings of this research objective were obtained by the second-phase and third-phase Delphi study. The results of the practical situation were based on the 128 responses of the second-phase questionnaires, while the results of the ideal situation were based on 105 responses of the third-phase questionnaires. Five-step data analyses were conducted for this research objective.

- Firstly, all participants' responses were analyzed as a whole. Both practical and ideal importance of each perspective was analyzed by taking the sum of the points of each perspective and then normalizing the sum to a percentage figure. The importance values in percentage revealed the degree to which the value propositions of stakeholders from each perspective contributed to the decision-making of requirements selection practically and ideally. Meanwhile, Kruskal-Wallis tests were conducted to find out whether there were significant differences between the 3 perspectives regarding their importance. If a significant difference was identified by the Kruskal-Wallis tests, then homogeneity of variance tests and ANOVA tests with post-hoc tests were applied to identify between which 2 perspectives there were significant differences.

- Secondly, the results of each company were analyzed individually to imply the practical and ideal importance of the 3 perspectives in the company. They were also analyzed by taking the sum of the points of each perspective provided by the respondents from the same company and then normalizing the sum to a percentage figure. The findings were twofold. On one hand, it indicated the different importance of different perspectives in each company. On the other hand, it indicated different importance of each perspective in different companies.

- Thirdly, the results were analyzed for different-sized companies to show the differences between different-sized companies regarding the practical and ideal importance of the 3 perspectives. Kruskal-Wallis tests were applied to further point out whether there were significant differences between different-sized companies. If a significant difference was identified by the Kruskal-Wallis tests, then ANOVA tests with post-hoc tests were applied to identify between which two sizes there were significant differences.

- Fourthly, the results were analyzed to compare the ratings by business-perspective, project-perspective, and product-perspective stakeholders regarding the practical and ideal importance of the three-perspective criteria. Kruskal-Wallis tests were applied to further discover whether there were significant differences between the responses of the experts from different perspectives. If a significant difference was identified by the Kruskal-Wallis tests, then ANOVA tests with post-hoc tests were applied. In addition, the Kruskal-Wallis tests were applied to compare the responses of the experts from different perspectives in each company regarding the importance of the three-perspective criteria. If a significant difference was identified by the Kruskal-Wallis tests, then ANOVA tests with post-hoc tests were applied to identify between the responses of which two-perspective stakeholders in the company there were significant differences. The analysis revealed the inconsistency between the stakeholders from different perspectives regarding the importance of different-perspective criteria in the companies.

- Lastly, the comparison was conducted between the practical and ideal importance of the 3 perspectives. Wilcoxon tests were applied for each perspective to reveal whether there were significant differences between its practical and ideal influence on the decision-making of requirements selection.

The detailed findings are presented as follows.

4.5.2 Influence of three perspectives (all participants)

As mentioned in Section 4.5.1, the importance of each perspective was analyzed by taking the sum of the points of each perspective and then normalizing the sum to a percentage figure. The results are presented in Table 4.14 and Figure 4.64.

Table 4.14: Importance of three-perspective criteria on requirements selection

	Practical situation	Ideal situation
Business-perspective criteria	42.2%	43.6%
Project-perspective criteria	29.0%	26.8%
Product-perspective criteria	28.8%	29.7%

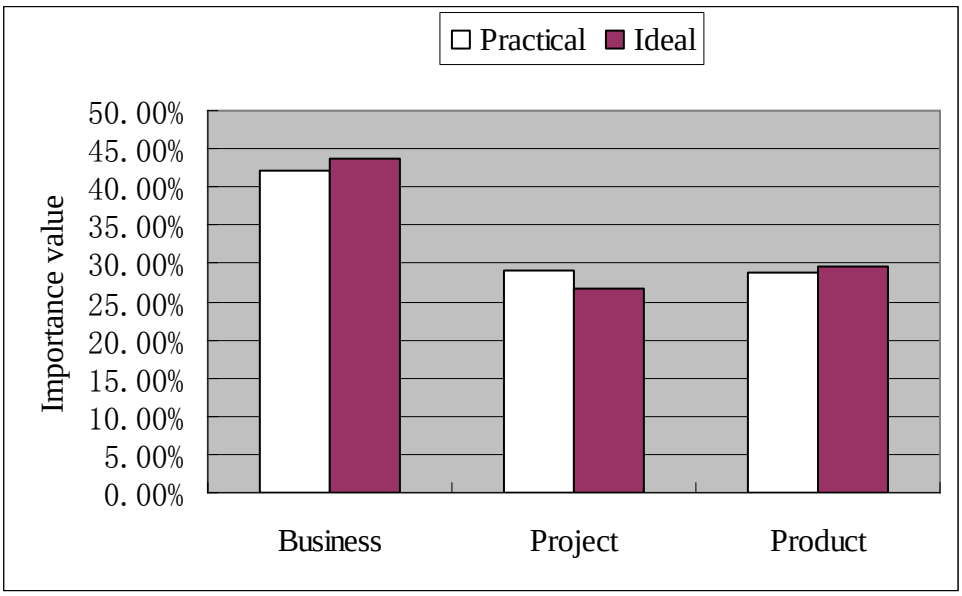

Figure 4.64: Importance of three-perspective criteria on requirements selection

In the practical situation, the results clearly indicated that the value propositions of stakeholders from business perspective had the major influence upon the decision-making of requirements selection. However, project and product perspective were of similar smaller importance. The value propositions of stakeholders from project perspective were second important to decision-making of requirements selection, while product perspective was least important.

In the ideal situation, the experts believed that the business-perspective criteria should still be the most important ones to requirements selection decisions. Nevertheless, the experts felt that ideally the product-perspective criteria should be more important than project-perspective ones. They considered that better requirements selection decisions would be made with a decrease in the influence of the project-perspective criteria and an increase in the influence of the product-perspective criteria.

Kruskal-Wallis tests were applied to further identify significant differences between the 3 perspectives' importance. The statistical analyses were conducted based on the second-phase and third-phase responses of the 105 experts who had participated in all three-phase survey. The analyses were conducted for both practical and ideal situation. The Kruskal-Wallis tests for both practical and ideal situation came out with very low significance levels (less than 0.0005). The results suggested that there were statistical significance differences between the three-perspective criteria as to their practical and ideal importance to the decision-making of requirements selection.

To further analysis, ANOVA tests with post-hoc tests were applied to confirm the results got by Kruskal-Wallis tests and identify between which 2 of the 3 perspectives there were significant differences. As can be expected, the results from the ANOVA tests also indicated that there were significant differences between the 3 perspectives regarding their practical and ideal importance, with very low significance levels (less than 0.0005). Besides, the post-hoc tests identified which 2 perspectives were different from each other.

- Regarding the practical importance, there were statistical significant differences between business and project perspectives, business and product perspectives, as well as project and product perspectives. In other words, the differences between any 2 of the 3 perspectives were highly significant.
- It turned out to be the same results for the ideal situation.

4.5.3 Influence of three perspectives (company-based analysis)

Figure 4.65 and Figure 4.66 present the practical and ideal importance of different perspectives in the 11 company. The numerical values are presented in Table A.13 in Appendix B.

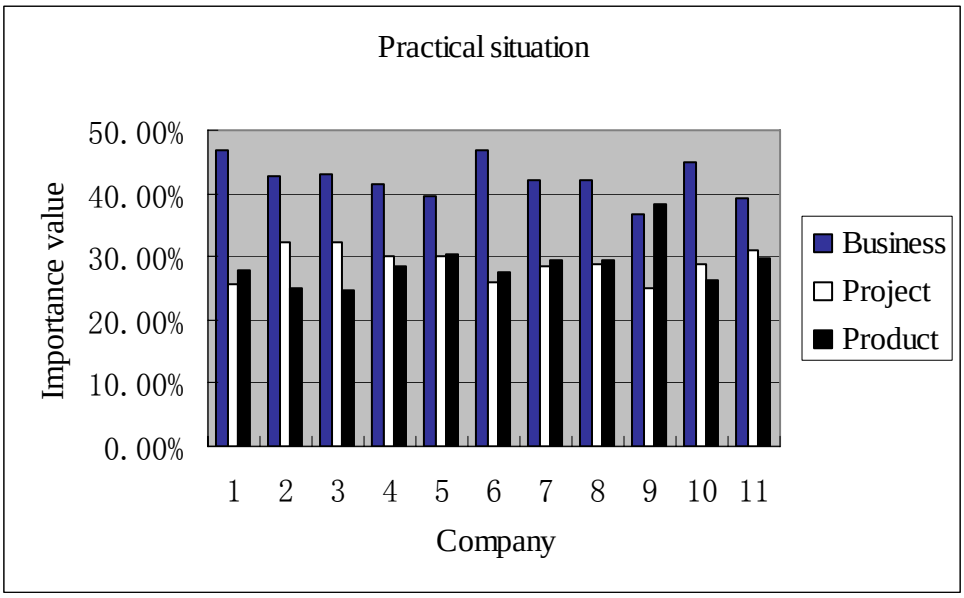

Figure 4.65: Practical importance of three perspective

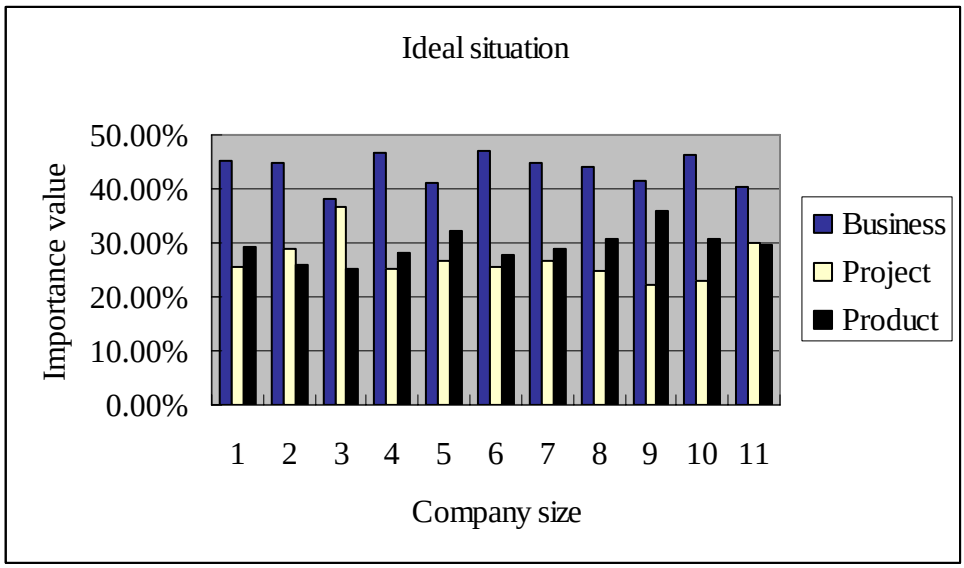

Figure 4.66: Ideal importance of three perspective

As shown in the figures, practically business-perspective criteria contributed most to the decision-making of requirements selection in most companies, except Company-9. Company-9 was the only company in which business perspective was not regarded as

the most important one, but less important than product perspective. Ideally, the experts in all the 11 companies believed that business perspective should be the most important one. However, it was also worth mentioning that the experts from Company-3 felt that ideally project perspective should have similar large influence on the requirements selection decisions as business perspective.

Moreover, the 11 companies had different opinions regarding the importance of project-perspective and product-perspective criteria. In the practical situation, project-perspective criteria were more important in Company-2, Company-3, Company-4, Company-10, and Company-11, while product-perspective criteria were more important in the other companies. In the ideal situation, the experts from Company 2, Company-3, and Company-11 felt that project perspective should be more important, while the experts from the other companies had the opposite opinions.

Furthermore, the experts from most companies thought that ideally business perspective should be valued higher than they were practically, except Company-1 and Company-3. Besides, the experts from most companies had a general opinion that project perspective should be valued lower than they were practically, except Company-3.

4.5.4 Influence of three perspectives (company-size-based analysis)

Figure 4.67 and Figure 4.68 present the practical and ideal importance of the 3 perspectives in ex-large-sized, large-sized, and medium-sized companies. The numerical values are presented in Table A.14 in Appendix B.

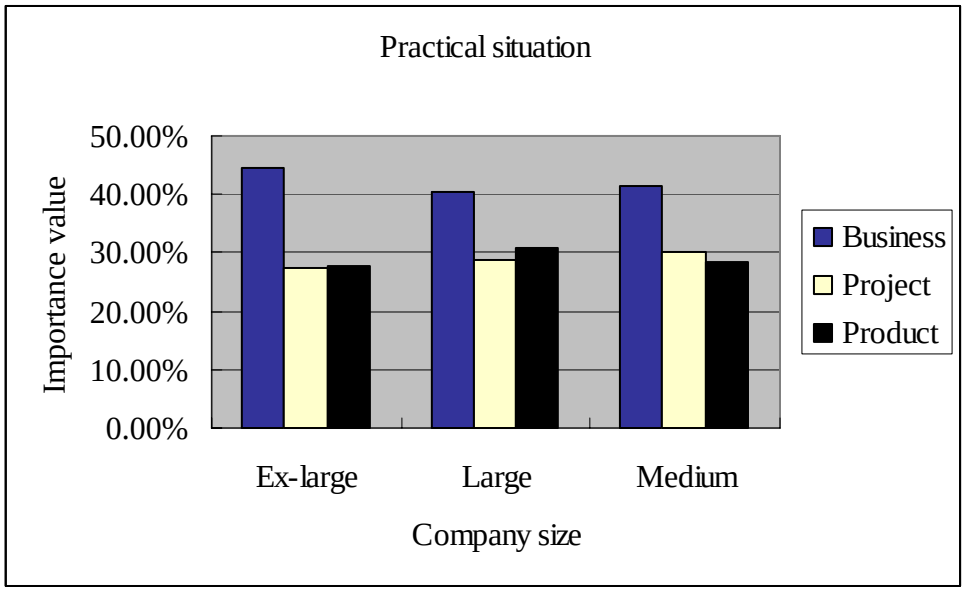

Figure 4.67: Practical importance of three-perspective criteria for different-sized companies

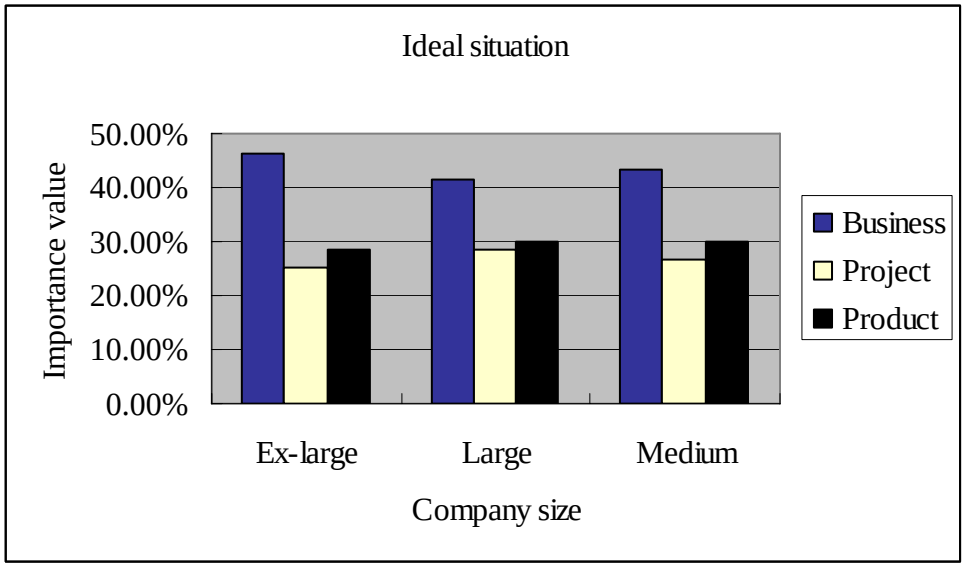

Figure 4.68: Ideal importance of three-perspective criteria for different-sized companies

As shown in the figures, there was not much disagreement between different-sized companies as to the importance of different perspectives. Ex-large-sized, large-sized, and medium-sized companies all felt that business perspective was the most important one both practically and ideally. Besides, ideally product perspective should be the second important one and project perspective should be the least important one considered by the experts from the companies of all sizes. However, practically product perspective was more important than project perspective in ex-large-sized and

large-sized companies, while medium-sized companies had contrary situations.

Different-sized companies agreed that ideally business-perspective criteria should be valued higher and project-perspective criteria should be valued lower than they were practically. However, the experts from ex-large-sized and medium-sized companies thought that product-perspective criteria should be valued higher than they were practically, while the experts from large-sized companies had opposite opinions.

Kruskal-Wallis tests were applied to further discover the differences between different-sized companies. The statistical analyses were based on the second-phase and third-phase responses of the 105 experts who had participated in all three-phase survey. As shown in Table 4.15, the Kruskal-Wallis tests came out that the significance levels of the 3 perspectives were all above 0.05, both practically and ideally. Thus, there was no significant difference between different-sized companies regarding the practical and ideal importance of the 3 perspectives.

Table 4.15: The results of Kruskal-Wallis test for different-sized companies

		Significance
Practical	Business-perspective criteria	0. 300
	Project-perspective criteria	0. 454
	Product-perspective criteria	0. 277
Ideal	Business-perspective criteria	0. 060
	Project-perspective criteria	0. 110
	Product-perspective criteria	0. 704

4.5.5 Influence of three perspectives (perspective-based analysis)

This subsection presents the differences between the ratings of the stakeholders from business, project, and product perspectives regarding the practical and ideal importance of different-perspective criteria. The analyses were conducted for all participants and within each company.

4.5.5.1 Perspective-based analysis for all participants

Figure 4.69 and Figure 4.70 present the importance of the 3 perspectives rated by the stakeholders from different perspectives, according to the 128 responses obtained by the second-phase survey and the 105 responses obtained by the third-phase survey. The numerical values are presented in Table A.15 in Appendix B.

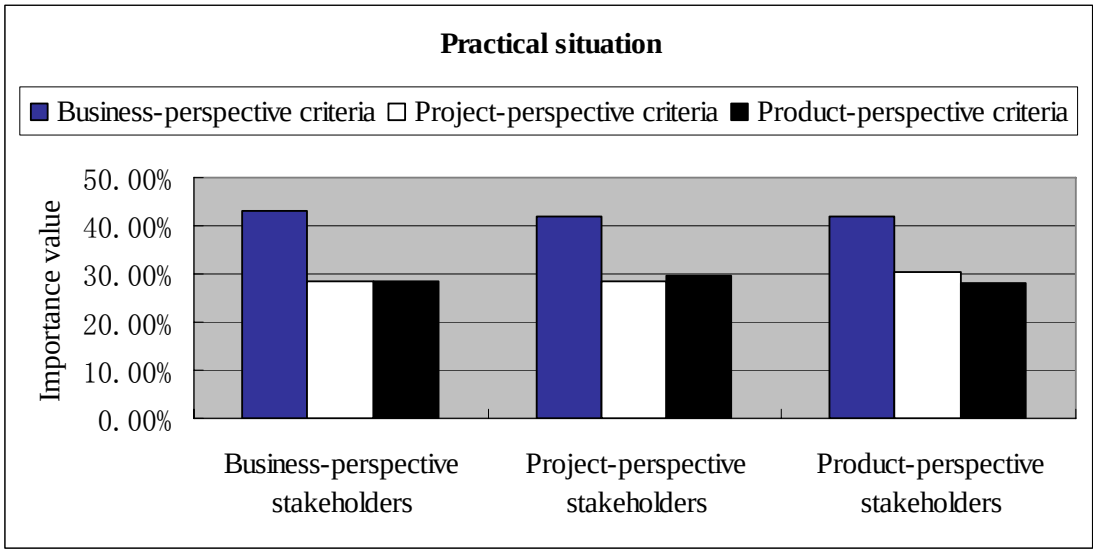

Figure 4.69: Practical importance of three-perspective criteria rated by different-perspective stakeholders

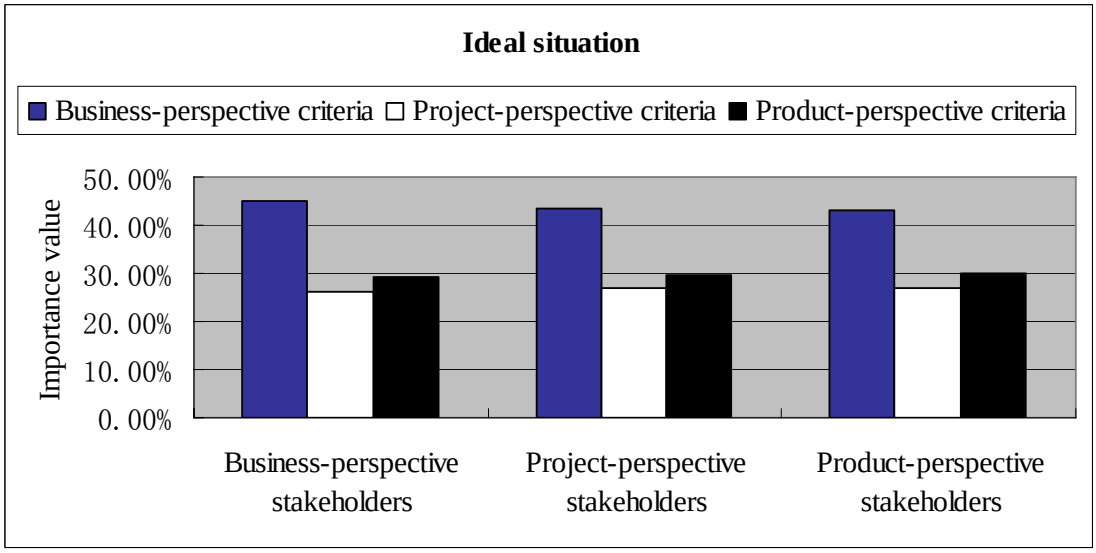

Figure 4.70: Ideal importance of three-perspective criteria rated by different-perspective stakeholders

As shown in the figures, there was much consistency between the ratings of stakeholders from different perspectives as to the importance of different-perspective criteria. Business-perspective criteria were regarded as the most important ones by stakeholders from different perspectives, both practically and ideally. Besides, ideally product-perspective and project-perspective criteria should be the second and least important considered by all different-perspective stakeholders. However, the stakeholders from business and product perspectives felt that practically project-perspective criteria were more important than product-perspective criteria, while project-perspective stakeholders had contrary opinions.

Additionally, the stakeholders from different perspectives all agreed that ideally business-perspective criteria should be valued higher, project-perspective criteria should be valued lower, and product-perspective criteria should be valued higher than they were practically.

Kruskal-Wallis tests were applied to further discover whether there were significant differences among the ratings of the stakeholders from different perspectives. The statistical analyses were based on the second-phase and third-phase responses of the 105 experts who had participated in all three-phase survey. As shown in Table 4.16, the Kruskal-Wallis tests came out that the significance level of the 3 perspectives were all above 0.05, both practically and ideally. Thus, there was no significant difference between the ratings of different-perspective stakeholders regarding the practical and ideal importance of the 3 perspectives.

Table 4.16: the results of Kruskal-Wallis test for stakeholders from different perspectives

		Significance
Practical	Business-perspective criteria	0. 988
	Project-perspective criteria	0. 235
	Product-perspective criteria	0. 816
Ideal	Business-perspective criteria	0. 590
	Project-perspective criteria	0. 670
	Product-perspective criteria	0. 697

4.5.5.2 Perspective-based analysis for each company

Kruskal-Wallis tests were applied to find out whether there were significant differences among the ratings of three-perspective stakeholders in each company regarding the practical and ideal importance of three-perspective criteria. The statistical analyses were based on the second-phase and third-phase responses of the 105 experts who had participated in all three-phase survey. The respondents from Company-3 and 6 were from project and product perspectives only, so the Kruskal-Wallis tests that were applied in Company-3 and 6 actually compared the ratings between the stakeholders from project and product perspectives only.

Table 4.17 presents the results of the Kruskal-Wallis tests for the 11 companies. Where the significance level was below 0.05 were highlighted in the table.

Table 4.17: The results of Kruskal-Wallis tests for stakeholders from different perspectives in the 11 companies

	C-1	**C-2**	**C-3**	**C-4**	**C-5**	**C-6**	**C-7**	**C-8**	**C-9**	**C-10**	**C-11**
Business (Practical)	0.040	0.576	0.243	0.299	0.033	0.683	0.049	0.867	1.000	0.930	0.450
Business (Ideal)	0.040	0.302	0.697	0.546	0.638	0.439	0.566	0.916	0.659	0.982	0.378
Project (Practical)	0.024	0.871	1.000	0.891	0.100	1.000	0.911	0.107	0.453	0.559	0.300
Project (Ideal)	0.156	0.586	0.544	0.244	0.165	0.439	0.111	0.568	0.112	0.513	0.826
Product (Practical)	0.075	0.665	0.245	0.878	0.370	0.683	0.358	0.171	0.837	0.264	0.312
Project (Ideal)	0.042	0.277	0.435	0.944	0.832	1.000	0.249	0.379	0.361	0.368	0.600

The Kruskal-Wallis tests came out that in Company-1 the significance levels of business-perspective criteria in both practical and ideal situation, project-perspective criteria in practical situation, and product-perspective criteria in ideal situation were less than 0.05. In other words, there were significant differences between the ratings of different-perapective stakeholders in Company-1 regarding the practical and ideal

importance of business-perspective criteria, the practical importance of project-perspective criteria, and the ideal importance of product-perspective criteria. Moreover, the significance levels of business-perspective criteria in practical situation in Company-5 and Company-7 were less than 0.05. The results indicated that there were significant differences between the ratings of different-perspective stakeholders in Company-5 and Company-7 regarding the practical importance of business-perspective criteria..

To further analysis, ANOVA tests with post-hoc tests were applied for Company-1, Company-5, and Company-7 to identify between which 2 of the three-perspective stakeholders there were significant differences.

- In Company-1, regarding the practical importance of business-perspective criteria, there were significant differences between the ratings of stakeholders from business and project perspectives as well as business and product perspectives, but there was no significant difference between the ratings of stakeholders from project and product perspectives.

  Regarding the ideal importance of business-perspective criteria, there were significant differences between the ratings of stakeholders from business and project perspectives, but there was no significant difference between the ratings of experts from business and product perspectives or project and product perspectives.

  Regarding the practical importance of project-perspective criteria, there were significant differences between the ratings of stakeholders from business and project perspectives as well as project and product perspectives, but there was no significant difference between the ratings of experts from business and product perspectives.

Regarding the ideal importance of product-perspective criteria, there were significant differences between the ratings of stakeholders from business and product perspectives, but there was no significant difference between the ratings of experts from business and project perspectives or project and product perspectives.

- In Company-5, regarding the practical importance of business-perspective criteria, there were significant differences between the ratings of stakeholders from business and product perspectives as well as project and product perspectives, but there was no significant difference between the ratings of experts from business and project perspectives.

- In Company-7, regarding the practical importance of business-perspective criteria, there were significant differences between the ratings of stakeholders from business and project perspectives as well as project and product perspectives, but there was no significant difference between the ratings of experts from business and product perspectives.

4.5.6 Comparison between practical and ideal situation

As presented in the previous several subsections, there were some differences between the practical and ideal importance of the three-perspective criteria. To shed further light on the differences, Wilcoxon tests were conducted for each perspective to compare its practical and ideal importance. The analyses were based on the second-phase and third-phase responses of the 105 experts who had participated in all three-phase survey.

As shown in Table 4.18, the tests came out that significance levels of business and project perspectives were below 0.05, while the significance level of product perspective was above 0.05. As the results suggested, there was statistical significance to indicate the difference between the practical and ideal importance of business and project perspective. In other words, the experts thought that business-perspective and

project-perspective criteria should be applied differently in the future to gain the benefits to the decision-making of requirements selection.

Table 4.18: the results of Wilcoxon tests to compare practical and ideal situation

	Significance
Business-perspective criteria	0. 000
Project-perspective criteria	0. 000
Product-perspective criteria	0. 206

4.6 Research objective 4

The fourth research objective is to get an overview of requirements selection process in the software development projects and the communication among different stakeholders within the process.

Research Question 4: how do different stakeholders communicate and interact with each other in the decision-making process of requirements selection in market-driven software development projects?

4.6.1 Data analysis

This research question was answered based on the follow-up interviews with 6 experts from 5 companies. In all, 22 experts, 2 experts from each company, were invited to attend the interview according to their responses to the 3 questionnaires, their working experience, and their roles in the company, but 6 out of the 22 experts were accepted. They were a maintenance engineer and a project manager from Company-3, a software developer from Company-4, a senior consultant from Company-8, a market analyst from Company-10, and a deputy general manager from Company-11. As to the interviews, 3 were conducted face-to-face and the other 3 were conducted over the phone. The 3 face-to-face interviews were transcribed verbatim from the recording, while the 3 telephone interviews were transcribed right after the interviews to ensure that the contents were lost as few as possible. The interviews were analyzed in Chinese to make it possible for the researcher to take advantage of the language.

The data collected by the interviews were divided into two categories so as to analyze the data into meaningful groups (Leedy and Ormrod 2005). They were ‘requirements selection process in the software development projects’ and ‘the communication process among stakeholders in the process’. Besides, each category was divided into several sub-categories for analysis. These categories include:

Requirements selection

- Requirements engineer
- The person in charge of requirements selection
- Requirements selection process

Communication between stakeholders

- Communication process
- Communication with oversea headquarters or branches in international companies
- Communication media
- Problems in the communication

The detailed findings are presented as follows.

4.6.2 Requirements selection

This sub-section presents the findings about the issues of the requirements selection.

4.6.2.1 Requirements engineer

There was a position called requirements analyst in Company-4, according to the interviewee from this company:

> *We have a requirements analyst, who is to facilitate requirements elicitation and selection process as well as manage requirements documents.*

However, the role of requirements engineer was not clearly defined in Company-3,

Company-8, Company-10, and Company-11. Although there was no specific position as requirements engineer, the interviewees from the 4 companies all indicated that one or several persons from each software development project team would be assigned to fulfill this role, as expressed by the interviewee from Company-8:

> *There isn't such a special position (requirements engineer or analyst) in our company, but in every project team some software developers do play the role of what you call requirements engineer. In my project team, a software engineer fulfills this role.*

4.6.2.2 The person in charge of requirements selection

It was worth noting that the so-called requirements engineer did not make their decisions of requirements selection alone, but only facilitated the process and managed requirements documents. The reasons why the decisions could not be made by requirements engineer only were explained by the interviewee from Company-4:

> *The requirements analyst is formerly a technician in software development, who is not experienced in purchase, marketing, and finance. The requirements analyst probably doesn't understand what is really happening to a client enterprise. If we start the development without any knowledge of these aspects, the software product can hardly satisfy our customers.*

Many people should be involved in the decision-making process of requirements selection. According to interviewees' responses, different persons were in charge of the decision-making of requirements selection in different companies.

In Company-3, the decisions were made by the software development project team members together:

> *The project team, including project manager and technicians (were involved in*

the decision-making process of requirements selection). It (whether market analysts or product managers would join the discussion) depends on whether our standardized software can meet the requirements. Generally, we don't need other professionals' participation or help.

Interviewees from Company-4 presented that software development project team members should be involved in and responsible for the decision-making process:

All project team members need to be interested in requirements analysis and to be responsible for the decision-making process and results.

The key persons of the software development project team were in charge of the requirements selection in Company-8:

Generally, the key persons of the project team, including the project manager, requirement analyst, several senior engineers and I (senior consultant), are involved in this process (decision-making process of requirements selection). We make the decisions together based on leaders' requests, time control, and market feedback concerning the previous software versions. The requirements analyst is responsible for summarizing and keeping the results on file.

The project manager and marketing persons made the decisions of requirements selection in Company-10:

The project manager and the personnel from marketing department make it (the decisions of requirements selection) out together. The former one decides product vision and functional spaces, while the latter one checks market opportunity and define customers' requirements based on market analysis.

Software development project team was responsible for the decision-making of

requirements selection with the assistance of other staffs in Company-11:

> *They (executive people, marketing analyst, project manager, product manager, and software developer) will assist the decision-making of requirements selection, but the decisions were still made by the software project team.*

4.6.2.3 Requirements selection process

First of all, requirements selection was attached different importance in different companies. The interviewee from Company-4 figured out that the importance of the requirements analysis and selection had been realized by the company:

> *We have reached a consensus that requirements analysis lays the groundwork of a project and its management. We must make the decision of requirement selection on a solid basis to ensure an excellent software product; otherwise, there will be many potential threats.*

Nonetheless, the interviewee from Company-8 thought that requirements selection had not obtained due attention in the Chinese software industry:

> *Most companies do not want to spend too much material or labor on it (requirements selection).*

Besides, one interviewee from Company-3 expressed that requirements elicitation and collection was attached more importance than requirements selection in the company:

> *We usually communicate with the representatives of the customers first. They always put forward some generalized requirements rather than specific ones, so there are not so many requirements as you imagined and they are mainly abstract ones. It is significant to collect requirements at first.*

Secondly, the requirements selection process in the software development was described by the interviewees. As expressed by the interviewee from Company-10, requirements selection is conducted in the first phase of the software development:

> *We adopt a risk-driven spiral model of three phases to develop software. The three phases are planning, developing, and stabilizing. Requirements selection is conducted in the phase of planning, according to the analysis of competitors, the plan for future versions, the problems of the previous version, and the functions to be added.*

The interviewee from Company-11 presented how requirements selection was conducted in the company:

> *There are a few steps for the decision-making of requirements selection. Firstly, categorize project types. There are many different project types that out company can take part into, such as system integration and service consulting. Secondly, analyze the business background. Our company is taking a leading IT position in a few selected areas. Our core business includes financial banking, payment, and switches segments. We prefer to participate into these areas. Certainly we will also consider the project in other business sectors if it suits company's market strategy. Thirdly, analyze the scale of the project. The decisions (of requirements selection) were made based on the time frame, available resources, and the influence of this project.*

One interviewee from Company-3 presented more concrete process of requirements selection:

> *It (requirements selection) mainly depends on clients' requirements and we also take feasibility into consideration. According to their requirements, we list all the compulsory requirements which we must meet in the product. Apart from that, we*

will consider those unnecessary requirements which can contribute to customers' satisfaction, such as providing many forms of a report.

Besides, cost-benefit analysis was the most favorite methodology the companies applied to select the requirements.

Lastly, both of the interviewees from Company-3 indicated that requirements selection was not conducted as an explicitly stated stage in their company, but within the stage of requirements analysis.

4.6.3 Communication between stakeholders

The importance of communication in requirements selection has been realized:

We always make many suppositions about what customers need based on market feedback (in requirements selection process), but these suppositions are sometimes not in line with reality. What we consider as necessary may not be needed by customers, and vise versa. Thus, customers' satisfaction doesn't solely rely on the technology. The communication is also important in this respect, sometimes even more important than technology itself.

This sub-section presents the communication process between different stakeholders in the companies for requirements selection.

4.6.3.1 Communication process

The communication process between stakeholders for requirements selection in the 5 companies could be divided into 3 different types.

First, the communications were mainly restricted within the software development project team. Other stakeholders would only give some assistance to the decision-making of requirements selection by means of written documents or reports.

Company-8 belongs to this type:

> *We don't have this kind of meetings (the meetings with marketing personnel or superiors). We usually hold discussions three times to make the decisions inside our project team. The marketing people provide information for us by a written report, and the superiors made some general orders to us.*

Second, project manager acted as a medium of the communications. In this case, project manager was the person to communicate with stakeholders outside the project team, including the customers, executive people of the company, marketing personnel, and so forth. Meanwhile, project manager was the communication coordinator within the project team. Therefore, project manager turned out to be the most essential one for the efficient and effective communications. Company-3 and Company-10 belong to this type. The project manger from Company-3 explained as follows:

> *It is I (project manager) who play this role (communicate with outside). I am in charge of the communications with the company to gain more resources and attention on the project. I will also ask for advice from those who have conducted similar projects in order to make good use of outside resources.*

The interviewee from Company-10 presented that:

> *Executive people such as product managers do not take part in a specific decision-making of requirements selection, and they do not attend the discussions or meetings with project team either. The main task of a product manager is to control the entire process of product development. However, our project manager frequently discusses with them and asks for their advices.*

Third, the communications between all related stakeholders were conducted for the decision-making of requirements selection in Company-4, and Company-11,

according to the interviewee from Company-4:

> *All related staffs, including requirements analyst, project manager, developers, marketing people, and product manager, will give their opinions. We have regular meetings to collect these people together and discuss with each other.*

According to the interviewee from Company-11:

> *In the decision-making process for requirements selection, the responsible personnel will organize all the meetings and carry on the procedures by certain tools and methods. The related departments and personnel will take part into accordingly.*

4.6.3.2 Communication with oversea headquarters or branches

The interviewee from Company-4 mentioned the communication between the branches in China and the headquarters. It is impossible to communicate with the headquarters for each particular project, as explained by the interviewee:

> *Usually, it is the people at the manager level who are in charge of the communication with the headquarters. Companies in China, either solely foreign-owned or jointly invested, are affected by Chinese culture. Due to a strict hierarchy culture, we always report to our immediate superiors. Sometimes we have some training programs that send some Chinese employees to the headquarters, but in a specific project the direct communication is not realistic.*

The project that the interviewee from Company-4 participated in was a localization project of e-business suite software. The e-business suite software had been developed and launched into the market in other countries before. The project aimed to localize the software to suit the Chinese market. Thus, it is important for the Chinese project team to communicate with oversea branches who had developed this software before.

The communications were conducted by inviting a foreign technician who had many experiences in developing this software as a senior consultant in China:

> *We try to put the system in accordance with the reality of China. We have a technician from a foreign branch in our project team. We can consult him about any problems in the software development process.*

4.6.3.3 Communication media

Phone, email, meetings, open forum, and workshop were the most favorable medium for the communications between stakeholders in the companies. Company-11 had also established an intranet for communications. In each phase of the requirements selection process, "*the procedures and outcomes are specified clearly*" on the intranet.

Different communication medium had their strongpoint and weakness. Face-to-face discussion as open forum and workshop could result in more sufficient communications between the attendants than phone and email. According to the project manager from Company-3:

> *I organized an open forum once. We invited some superiors and customer representatives to participate in the discussion. It proved a valuable try. We found that some of our ideas went against the ones of customers and some were not in line with the business strategy of the company. It enabled us to solve these problems in the stage of requirements analysis and thus to avoid the enormous mending job after the software was developed.*

However, face-to-face discussion always cost more than other tools. The project manager from Company-3 also indicated that:

> *Discussion of this kind (the open forum) costs much and no one can see the immediate returns from it. The aim of a company is to maximize its profits. Thus,*

currently, not too much cost would be put on it (communication).

Besides, the interviewee from Company-4 agreed with this point:

Meeting is very effective but costs much. People such as marketing personnel and product manager are engaged in more than one project at the same time, so the meetings can not be frequently conducted with them.

Therefore, it is not practical to hold face-to-face discussions all the time, "*at most once or twice for small projects*". Email and phone were more usually used. Company-4 had a trade-off way for the communication between stakeholders:

At the stage of requirements selection, the requirements analyst marks those requirements of which he cannot make the decisions alone with "to-be-decided". Then, we will hold a workshop within the project team and discuss those "to-be-decided". If still there are problems, we will consult the related experts and even conduct a workshop at higher level with our superiors.

Moreover, phone, email, and face-to-face discussion were described as formal communication medium by the interviewees from Company-3 and Company-10. They figured out that informal communications, such as the communication through comfortable working environment and relaxed organizational culture, were also important for the decision-making of requirements selection. As expressed by one interviewee from Company-3:

What is more important, I think, is informal communication. All members of the project team work together. I (project manager) try hard to create a relaxed environment in which they can communicate with each other more effectively and efficiently. It seems that every one can work well and the efficiency has been increased in this way.

According to the interviewee from Company-10:

> *We have a relaxed environment due to the organizational culture I mentioned, so we can freely talk to each other at work or at spare time.*

4.6.3.4 Problems in the communication

Most of the interviewees thought that the communications in their companies were going well and effectively. However, some interviewees indicated there were potential problems in the communications. The interviewee from Company-10 presented an unsuccessful communication case and gave his own understanding of the cause:

> *For example, there was an unsuccessful project because of the problems in the communications between the project manager and developers. The project manager didn't believe developers' ability and took some repulsive measures to strictly control developers' activities. Some developers resisted the supervisions by advocating "digital heroism". It leaded to the serious communication problems, which resulted in the failure of the software development.*

> *I think that some problems may result from the power distance between managers and developers, which excluded developers' opinions from the decision-making of requirements selection.*

Additionally, the interviewee from Company-3 explained that the possible reasons for ineffective communications might be the typical Chinese human relationships:

> *Many projects failed because of the complicated human relationships in China. Managers and developers should cooperate and communicate with each other to tackle the problems in the development process, but this situation cannot be realized due to their unequal compulsive relationships. Developers have to accept their superiors' advice and suggestions. I am strongly opposed to power*

centralization which deprives the developers of the right to present their opinions.

Moreover, the interviewee from Company-11 felt that there were more problems of communications in a small project which only had 10 people or less:

In contrast with big projects, small projects are characterized by relatively few software functions, small personnel, and short development time. It appears that small projects can gain success easily, yet some details can be neglected. Developers tend to think that communications are not so necessary now that there are only several people. Sometimes they find the disharmony between different software modules only when they each finish their part.

4.7 Chapter summary

This chapter presents the data analysis process for the 4 research questions and the corresponding findings as well.

5 Discussion of Results

5.1 Introduction

This chapter presents a discussion of the important findings obtained by the Delphi study.

This chapter is divided into 4 parts based on the 4 research objectives: relevant criteria for decision-making of requirements selection (Section 5.2), practical and ideal importance of these criteria to requirements selection (Section 5.3), practical and ideal influence of the value propositions of stakeholders from different perspectives on requirements selection (Section 5.4), and communication process between stakeholders for requirements selection (Section 5.5).

5.2 Research objective 1

The 132 experts from the 11 companies were asked to answer whether the 14 criteria identified by the researcher in advance were relevant to their decision-making or not. Based on their answers, most of the criteria were regarded as relevant by more than 70% experts, except ‘requirement’s issuer’ (criterion 4).

5.2.1 Selection of criteria (all participants)

The 14 criteria for requirements selection was in accordance with the value propositions of stakeholders from business, project, and product perspectives. This subsection discusses the results of the first research question according to the 3 perspectives.

Business-perspective criteria include ‘business strategy’ (criterion 1), ‘customer satisfaction’ (criterion 2), ‘competitors’ (criterion 3), ‘requirement’s issuer’ (criterion 4), and ‘software features’ (criterion 5). ‘Business strategy’ (criterion 1), ‘customer

satisfaction' (criterion 2), and 'software features' (criterion 5) were regarded as relevant by most experts. It showed that these 3 criteria were always considered when making the decisions of requirements selection. It was a little surprising that 'competitors' (criterion 3) was not regarded as relevant by as many experts as other 3 criteria. Nonetheless, it may result from the special environment of Chinese software industry. Chinese software industry is a monopolistic competition market. There are many software providers in the market, but their target customers and their products have large differentiation. Especially, most of the 11 companies recruited in this study were market leaders. Therefore, sometimes they may not concern their competitors when making the decisions for requirements selection. However, less than half experts regarded 'requirement's issuer' (criterion 4) as relevant. The detailed discussions of this criterion are presented in Section 5.2.2.

Project-perspective criteria include 'development cost' (criterion 6), 'calendar time' (criterion 7), 'extra cost' (criterion 8), and 'resource' (criterion 9). It is interesting to find out that these 4 criteria could be divided into 2 groups based on their relevancy. 'Development cost' (criterion 6) and 'calendar time' (criterion 7) were considered as relevant by about 83% experts, while 'extra cost' (criterion 8) and 'resource' (criterion 9) were considered as relevant by about 72% experts. However, this finding is not surprising. Development cost and time are two crucial points for a software development project, but the extra cost for software installing and learning as well as the resources to implement the requirement can be fixed or provided later.

Product-perspective criteria include 'after-sale support' (criterion 10), 'complexity' (criterion 11), 'evolution' (criterion 12), 'requirements dependencies' (criterion 13), and 'requirement volatility' (criterion 14). All of the 5 criteria were considered as relevant by three-quarter experts.

5.2.2 Requirement's issuer (criterion 4)

Less than half of the experts from the 11 companies considered 'requirement's issuer'

(criterion 4) as relevant. This criterion was removed from the second and third questionnaires.

This result was different from Wohlin and Aurum's (2005A) study and Barney's (2005) study, which conducted similar studies in Sweden, Germany, and Australia to explore the decision-making criteria for requirements selection. In Wohlin and Aurum's (2005A) study, more than 88% participants considered this criterion as being relevant. In Barney's (2005) study, only one of the 21 participants felt that 'requirement's issuer' was not relevant to their decision making.

The potential reasons of the difference between this study and two former studies could be twofold.

- Software development in China

  The typical character of Chinese software industry could be one reason. When the interviewees were asked about the rationale behind this result during the follow-up interviews, two interviewees figured that "*the software industry in china was still in its initial stage and the customers were not mature*". The customers were unaware of what they want before the development. One interviewee presented that "*in most cases, the issuers of the software requirements were software developers themselves based on their past development experiences*". In other words, the requirement was issued by the software development company instead of the important customers or market representative. Additionally, another interviewee argued that "*no matter which internal stakeholders generated the requirements, they all represented the company*". Therefore, the requirement's issuer was seldom taken into account when making the decisions for requirements selection in China.

- Design of the questionnaire

  The expression of the questionnaire could be another reason of the difference. In this study, the relevancy of the criteria was asked in a separated questionnaire, while

the respondents were asked to tick the relevant criteria and evaluate the importance of the criteria in the same questionnaire in Wohlin and Aurum's (2005A) study and Barney's (2005) study. Combining criteria's relevancy and importance into one questionnaire made the respondents easier to agree that the criteria were relevant, because it implied that the researchers regarded these criteria as relevant. However, in this study, the respondents could feel free to say "yes" or "no" to the criteria in a separate questionnaire.

5.2.3 Selection of criteria (company-based analysis)

There was not much consistency between the 11 companies as to the relevancy of the criteria, especially the product-perspective criteria. Different scales, different maturity levels, different cultures, and different target market segments of the companies may also be the reasons for the differences between the companies regarding the relevancy of the criteria.

It was worth mentioning that Company-3 always had different opinions from the other 10 companies. In particular, much smaller portions of the experts from Company-3 than the other 10 companies regarded 'customer satisfaction' (criterion 2) 'software features' (criterion 5), 'development cost' (criterion 6), and 'calendar time' (criterion 7) as relevant.

The differences between Company-3 and the other companies might result from the typical type of the software development project in Company-3. The objective of the project was to develop a software system for small-sized and medium-sized companies by integrating enterprise resource planning, human resource, and customer relationship management. This project originated from several successful customer-specific projects that developed integrated software systems for several particular customers based on their specific requirements. This project aimed to generalize the integrated software systems for large market.

The requirements of the software system were mainly adapted from the anterior customer-specific projects, rather than the market analysis or software functions. Additionally, as the integrated software system was not developed from very beginning, the cost and time to implement a requirement could be well estimated beforehand. Therefore, ‘customer satisfaction’ (criterion 2), ‘software features’ (criterion 5), ‘development cost’ (criterion 6), and ‘calendar time’ (criterion 7) might be neglected sometimes when making the decisions for requirements selection in Company-3.

However, in practice, many software development projects are the same as the one in Company-3, instead of developing a software product from very beginning. The findings of Company-3 represented another type of software development projects, compared with the other 10 companies.

5.2.4 Selection of criteria (company-size-based analysis)

The experts from ex-large-sized companies always had quite different opinions from large-sized and medium-sized companies regarding the relevancy of the criteria. The differences might result from their different organizational culture as well as their different scales.

As mentioned in Section 4.3.1, all the ex-large companies recruited in this study are international companies, while all the large and medium companies are national companies. The differences between ex-large-sized companies and the other two sizes might also show the differences between international and national companies. The international and national companies had different organizational cultures. The international companies recruited in this study were dominated by western culture or mixed culture as organizational culture, while the recruited national companies were dominated by Chinese culture as organizational culture. Different organizational cultures would lead to different types of leadership, different types of power structure, different forms of organizational structure, and consequently different

decision-making criteria for requirements selection (Sweeney and Hardaker 1994). Therefore, the different organizational culture between international and national companies, i.e. ex-large-sized companies and the other two sizes might be the reason for their different opinions regarding the relevancy of the criteria. For instance, the inconsistency of the results regarding the relevancy of 'resources' (criterion 9) can be explained by the differences in organizational culture. The study showed that smaller portion of the experts from large and medium-sized companies than ex-large size considered 'resources' (criterion 9) as relevant when making the decisions for requirements selection. The results went against the general belief that smaller companies laid more emphases on resources for their lack of them. The inconsistency might result from the differences of the companies' organizational culture, which was dominated by the broad Chinese, western or mixed culture.

5.2.5 Selection of criteria (perspective-based analysis)

The stakeholders from business, project, and product perspectives had relatively similar opinions regarding the relevancy of 'customer satisfaction' (criterion 2), 'software features' (criterion 5), 'development cost' (criterion 6), 'calendar time' (criterion 7), and 'resources' (criterion 9), while they had different opinions regarding the relevancy of the other criteria.

It was a little surprising that smaller portion of the stakeholders from business perspective regarded 'competitors' (criterion 3) as relevant than project and product perspectives. However, as mentioned in Section 5.2.1, most of the 11 companies recruited in this study were market leaders. Business-perspective stakeholders, such as general managers, market analysts, and department managers, might have a better understanding of their companies' status in the market. Therefore, they might consider that it was unnecessary to concern their competitors when making the decisions for requirements selection in some cases.

It was expectable that the stakeholders from project and product perspectives had

similar opinions, but the business-perspective stakeholders had different opinions as to the relevancy of project-perspective and product-perspective criteria. The 14 criteria were developed in accordance with the value propositions of stakeholders from the 3 perspectives. It was natural that the business-perspective stakeholders did not have the same opinions as the stakeholders from project and product perspectives regarding project-perspective and product-perspective issues.

5.3 Research objective 2

The second research objective is to evaluate the practical and ideal importance of the criteria when making the decisions for requirements selection. The findings of this research objective were based on the 128 responses obtained by the second-phase survey and 105 responses obtained by the third-phase survey. 'Requirement's issuer' (criterion 4) was removed from the list of the criteria based on the results of the first-phase survey. The discussions as to the practical and ideal importance of the 13 criteria are presented as follows.

5.3.1 Practical importance of criteria

The findings regarding the practical importance of the criteria are discussed in this section.

5.3.1.1 Practical importance of criteria (all participants)

'Business strategy' (criterion 1), 'customer satisfaction' (criterion 2), and 'software features' (criterion 5) were the 3 most important criteria to the decision-making of requirements selection practically. The results were expectable. A company would get competitive advantage only if it had value-based business strategy so as to satisfy its customers (Ahmed and Yannou 2003). Interviewees presented in the follow-up interview that "*the products should first be in line with company's business strategy*" and "*customer satisfaction was the ultimate goal of a company*". Besides, the features of a software product were the foundation to satisfy the customers.

However, ‘extra cost’ (criterion 8) and ‘after-sale support’ (criterion 10) were the least and second least important criteria among the 13 criteria. These 2 criteria were both related to the issues after the purchase of the software product. As the results indicated, if some conflicts happened between the 2 criteria and the other criteria, the decisions of requirements selection would be made based on the other criteria rather than ‘extra cost’ and ‘after-sale support’. However, the installing, training, or supporting of the software were usually considered and provided later.

5.3.1.2 Practical importance of criteria (company-based analysis)

There was little consistency between the 11 companies as to the practical importance of the criteria, especially ‘business strategy’ (criterion 1) and ‘calendar time’ (criterion 7).

Different companies had quite different opinions regarding the practical importance of ‘business strategy’. ‘Business strategy’ was the most important criterion when making the decisions for requirements selection in most companies. However, in some other companies, customers’ satisfaction, the function of the software, or traditional project management issues such as development cost and time were more important than ‘business strategy’ because of their different focuses.

Moreover, it was understandable that different companies attached different importance to the development time of the software. Different companies had different software development projects with different emphases. For example, if the company aimed to be a first-mover in the market, ‘calendar time’ would be one of the most important issues in the software development process. It could be the major reason why ‘calendar time’ was more important than ‘business strategy’ in Company-2.

Furthermore, the differences between the companies as to the practical importance of the criteria might also result from the different maturity levels of these companies. In

an immature company, software development process is generally improvised during a project, so that the developers are usually focused on solving immediate crises (Paulk *et al.* 1993). Hence, development schedules and budgets are routinely exceeded because of unpractical estimations. As a company matures, the software process becomes better defined and more consistently implemented throughout the company (Paulk *et al.* 1993). Therefore, the companies with different maturity levels have different emphases when developing the software. Consequently, they would regard the importance of the criteria differently when making the decisions for requirements selection.

5.3.1.3 Practical importance of criteria (company-size-based analysis)

Different-sized companies had quite different opinions as to the practical importance of 'business strategy' (criterion 1) and 'after-sale support' (criterion 10). 'Business strategy' (criterion 1) was the most important criterion in ex-large-sized companies, but not in large-sized and medium-sized companies. It indicated that more attention had been paid to 'business strategy' in ex-large-sized companies than large-sized and medium-sized companies. In addition, 'after-sale support' (criterion 10) was the least important criterion in ex-large-sized and medium-sized companies, but not in large-sized companies. It indicated that more attention had been paid to 'after-sale support' in large-sized companies than ex-large-sized and medium-sized companies.

The scale of the companies may be or may not be the most influential factor for these differences. The scale of the companies is related to the maturity level of the companies. Usually, a larger company has a longer history and consequently a relatively higher maturity level. Different maturity levels could be another reason for the differences. Further research should be conducted to find out the rationale behind the differences between different-sized companies.

5.3.1.4 Practical importance of criteria (perspective-based analysis)

There were some differences between the opinions of the stakeholders from different

perspectives in Company-1, Company-7, and Company-8 regarding the practical importance of the criteria.

In Company-1, the stakeholders from business perspective had different opinions with the stakeholders from project and product perspectives regarding the practical importance of ‘customer satisfaction’ (criterion 2). The stakeholders from business perspective thought ‘customer satisfaction’ was more important than the stakeholders from the other 2 perspectives thought. It may show some communication gaps between the stakeholders from business perspective and the other two perspectives. As presented by the interviewees in the follow-up interviews, project-perspective stakeholders made the decisions of requirements selection in the most cases, while business strategy and business objectives of the companies were established by business-perspective stakeholders. The stakeholders who actually made the decisions did not regard ‘customer satisfaction’ as important as business-perspective stakeholders thought. The differences would lead to the problems in the software development process.

In Company-7, the stakeholders from project perspective had different opinions with the stakeholders from business and product perspectives regarding the practical important of ‘resources’ (criterion 9). The stakeholders from project perspective thought ‘resources’ was more important than the stakeholders from the other 2 perspectives thought. As Company-1, it might show the understanding or communication gaps between the stakeholders from project perspective and the other 2 perspectives. On the other hand, project-perspective stakeholders usually paid more attention to the right people and competencies to implement the requirement. It was understandable that the stakeholders from project perspective had different opinions regarding the importance of ‘resources’ to the requirements selection decisions.

In Company-8, the stakeholders from project perspective had different opinions with the stakeholders from business and product perspectives regarding the practical

important of ‘calendar time’ (criterion 7). The situation in Company-8 was similar to the one in Company-7.

5.3.2 Ideal importance of criteria

The findings regarding the ideal importance of the criteria are discussed in this section.

5.3.2.1 Ideal importance of criteria (all participants)

‘Business strategy’ (criterion 1), ‘customer satisfaction’ (criterion 2), and ‘software features’ (criterion 5) should still be the 3 most important criteria in the future, while ‘extra cost’ (criterion 8) and ‘after-sale support’ (criterion 10) should still be the least and second least important criteria. The results indicated that the experts were satisfied with the practical application of these criteria.

It was worth mentioning that the experts believed that ideally all the 4 business-perspective criteria should have significant influence on the decision-making for requirements selection. In other words, it could be expected that in the future business-perspective criteria would dominate the decision-making.

5.3.2.2 Ideal importance of criteria (company-based analysis)

Different companies had relatively similar opinions as to the ideal importance of each criterion, due to the re-rating phase. In the re-rating phase, the experts were provided with the average ratings of all experts as to criteria’s ideal importance in the anterior phase.

However, the experts from Company-3 had different opinions from the other 10 companies regarding the ideal importance of ‘software features’ (criterion 5), ‘extra cost’ (criterion 8), ‘resources’ (criterion 9), and ‘evolution’ (criterion 12). As mentioned in Section 5.2.3, the experts from Company-3 focused on a particular type of software development project. This project aims to generalize an integrated

software system for large market based on the several successful customer-specific projects. The software development project in Company-3 was maturer than the ones in the other 10 companies. It was not surprising that the experts from Company-3 found out that their emphases should not be software features or system evolution, but the extra cost for software installing and maintenance and the right resources to develop the system.

5.3.2.3 Ideal importance of criteria (company-size-based analysis)

Ex-large-sized companies had different opinions with large-sized and medium-sized companies, regarding the ideal importance of 'business strategy' (criterion 1), 'customer satisfaction' (criterion 2), and 'resources' (criterion 9).

The experts from ex-large-sized companies thought that 'business strategy' and 'customer satisfaction' should be more important and 'resources' should be less important than large-sized and medium-sized companies thought. The results were comprehensible. Because of the large scale, recourse was not as scarce as smaller companies in ex-large-sized companies. One of the interviewees from a ex-large-sized company pointed out that they had sufficient resources in their company and resources were not their major concerns. Companies' strategy and customers were the most important issues for ex-large-sized companies.

5.3.2.4 Ideal importance of criteria (perspective-based analysis)

Inconsistency emerged between the three-perspective stakeholders in Company-1, regarding the ideal importance of 'customer satisfaction' (criterion 2). The stakeholders from business perspective had different opinions with the stakeholders from project and product perspectives in Company-1. The stakeholders from business perspective in Company-1 thought 'customer satisfaction' should be more important than the stakeholders from the other 2 perspectives thought. The results highlighted the understanding and communication gaps between the stakeholders from business perspective and the other 2 perspectives in Company-1.

Different-perspective stakeholders did not have significantly different opinions as to criteria's ideal importance in the other 10 companies. It might show the good communications between the stakeholders from different perspectives in these companies. However, it might also result from the re-rating phase.

5.3.3 Comparison between practical and ideal importance

There were some differences between how the criteria were practically applied and how the criteria should ideally be applied for requirements selection decisions.

First of all, experts thought 'evolution' (criterion 12) should be much more important to requirements selection decisions in the ideal situation than practical situation. The findings pointed out that the importance of evolution had been realized by the experts in Chinese software industry. Evolution determined the future of the software, and in turn the future of the company. Therefore, it was expectable that the long-term evolution should occupy a crucial position when making the decisions for requirements selection.

Secondly, experts considered that more emphasis should be laid on 'competitors' (criterion 3) in the future. The results were understandable. As mentioned in Section 5.2.1, Chinese software industry is a monopolistic competition market and most of the 11 companies recruited in this study are market leaders. Therefore, in the practical situation, they may not attach much importance to their competitors. Nonetheless, the potential competitors had appeared, as presented by an interviewee during the follow-up interview. If the competitors were always ignored, the company would inevitably be exceeded in the future.

Thirdly, experts considered that less attention should be paid to 'software features' (criterion 5) in the future. The finding was a little surprising. 'Software features' were the basic foundation of the software. However, the results did not indicate that features and functions of the software were not crucial, but the experts though that too

much importance had been attached to this criterion when making the decisions for requirements selection in practice.

Lastly, experts believed that ‘development cost’ (criterion 6) and ‘complexity’ (criterion 11) should be less important in the ideal situation than the practical situation. ‘Development cost’ and ‘complexity’ were enslaved to the software development technology. Thus, it could be expected that these 2 criteria would be less important to requirements selection decisions with the development of the technology.

5.4 Research objective 3

The third research objective is to explore the degree to which the value propositions of stakeholders from business, project, and product perspectives influence requirements selection decisions. The findings of this research objective were also according to 128 responses obtained by the second-phase survey and 105 responses obtained by the third-phase survey. The discussions as to the practical and ideal importance of the 3 perspectives are presented as follows.

5.4.1 Influence of three perspectives (all participants)

Business-perspective stakeholders’ value propositions had a major influence on the decision-making of requirements selection both practically and ideally. The results were expectable. Target market and customers were the most critical driving forces for the companies to create software value (Barney 2005). However, the experts felt that project-perspective and product-perspective criteria did not have a major influence on the decision-making of requirements selection both practically and ideally. Thus, the decisions were made mainly based on non-technical criteria rather than technical criteria, which could result in a big challenge for the software developers. The software developers had to cope with the technical issues in latter process instead.

Further, the results were different with Wohlin and Aurum’s (2005A) study, which

conducted a similar study in Sweden. In their study, business-perspective and project-perspective criteria were much more important than product-perspective criteria both practically and ideally. Thus, compared with the companies in Sweden, not much importance had been attached to the project management issues when practically making the decision for requirements selection in the companies in China. Nonetheless, less importance would be attached to project-perspective criteria in the future in the companies in China.

5.4.2 Influence of three perspectives (company-based analysis)

There were not many differences between the 11 companies as to the influence of business, project, and product perspectives. However, 2 companies should be mentioned.

Business perspective was the most important one to requirements selection decisions regarded by most companies, except Company-9. In Company-9, product perspective was more important than business perspective when making the decisions of requirements selection practically. The findings were understandable. The recruited experts from Company-9 were involved in a network security project, which aimed to develop a set of security management software for computer local area network. This project was cooperated with Shanghai municipal government, and the customers were guaranteed by the government. Therefore, the market and customers were not the major concerns in Company-9. They focused on the complexity to develop and maintain the software, the evolution of the software, and so forth.

In addition, it was worth noting that Company-3 had some different opinions from other companies too. First, the experts from Company-3 felt that ideally project perspective should be as important as business perspective. It showed that the experts from Company-3 had discovered the weakness to handle these project management issues as part of the posterior development process. They believed that considering these issues in requirements selection process would provide benefits to software

development. Second, the experts from Company-3 thought that business perspective should be less important ideally than practically, while most companies disagreed. The experts from Company-3 found out that business perspective had stifled product-perspective and project-perspective issues and negatively affected software value. As mentioned in Section 5.3.3, the differences between Company-3 and other companies probably resulted from the particular type of software development project in Company-3.

5.4.3 Influence of three perspectives (size-based analysis)

Both observations and statistical analyses indicated that there was little inconsistency between different-sized companies as to the practical and ideal importance of different perspectives. Thus, size might not be the influential factor in the different opinions regarding the influence of the 3 perspectives.

5.4.4 Influence of three perspectives (perspective-based analysis)

One interesting finding was that the stakeholders from product perspective felt that practically project-perspective criteria were more important than product-perspective criteria, while project-perspective stakeholders had contrary opinions. Stakeholders from each perspective would focus on the value propositions from their own perspective more than others, but always felt that other perspectives had been better addressed. Thus, it could be understood why the stakeholders from product perspective thought that more emphases had been laid on project perspective rather than product perspective. Product-perspective stakeholders were inclined to consider that product-perspective criteria were stifled by other perspectives, and vice versa.

Moreover, three-perspective stakeholders had different opinions regarding the practical and ideal importance of the criteria from different perspectives in Company-1, Company-5, and Company-7.

In Company-1, the stakeholders from each perspective thought that the criteria from

their perspective were more important than other stakeholders thought. For example, business-perspective criteria were more important regarded by business-perspective stakeholders than project-perspective and product-perspective stakeholders. The results reflected serious communication problems between the stakeholders from different perspectives in Company-1. There was much inconsistency between the stakeholders in the company. The conflicts would negatively affect the decision-making of requirements selection.

In Company-5, the stakeholders from product perspective thought business-perspective criteria were more important than the stakeholders from other perspectives thought, while in Company-7, the stakeholders from project perspective thought business-perspective criteria were more important than the stakeholders from other perspectives thought. The results seemed to be a little surprising. On the other hand, as mentioned before, stakeholders from each perspective would focus on the value propositions from their own perspective more than others, but always felt that other perspectives had been better addressed. It might be the reason of the inconsistency in Company-5 and Company-7.

5.4.5 Comparison between practical and ideal situation

Inadequate importance had been attached to the value propositions of stakeholders from business perspective, when making the decisions for requirements selection practically. The stakeholders felt that ideally business-perspective criteria should be more dominant in the decision-making process.

Moreover, requirements selection decisions would be made more effectively with a decrease in the influence of project-perspective criteria. The results could be expected. As more standard and common development tools were applied in software development, development cost and time would be more predictable and fewer resources would be required. Thus, project perspective would be less important in the future.

Furthermore, ideally the influence of product perspective should be enhanced, and product perspective should exceed project perspective. The stakeholders had realized that product-perspective issues should partly be considered in the requirements selection stage so as to lighten the pressure on the latter process. Thus, requirements selection decisions would be made more effectively with an increase in the influence of product-perspective criteria.

5.5 Research objective 4

The fourth research objective is to get a basic understanding of the communication process between stakeholders for requirements selection. The findings were obtained by the interviews with 6 experts from 5 companies.

5.5.1 Requirements selection

The importance of requirements selection has been realized in Companie-4, but still ignored in Company-3 and Company-8, as presented by the interviewees from these companies. However, most interviewees themselves agreed that requirements selection should play an essential role in the entire process of software development. It might show the tendency to lay more emphases on requirements selection in the future. Nonetheless, the interviewees were inclined to agree with the researcher, as they knew that this study focused on requirements selection and the researcher regarded requirements selection as very important.

Further, except Company-4, there was no stable working position as requirements engineer in the other 4 companies. Instead, the project team members were assigned to fulfill the role. The dynamic assignment could contribute to lower cost and more flexible project management. Nonetheless, the temporary assigned personnel might not be as professional as the requirements engineer who specialized in requirements analysis for software development.

However, requirements selection decisions were not made by the requirements engineer or the person assigned to perform this role only. In Company-10, the decisions were made by project manager and marketing personnel, while in the other 4 companies, the key persons in the project team or the whole project team made the decisions. As the decisions were not made by one person, this situation highlighted the importance of the effective communication between these decision makers.

5.5.2 Communication between stakeholders

This sub-section discussed the issues related to the communication process between different stakeholders in the companies for requirements selection.

5.5.2.1 Communication process

As mentioned in Section 4.6.3, there were 3 different types of communications in the 5 companies.

The first type had the most limited stakeholders to communicate with each other in requirements selection process. The communications were restricted within the project team itself. Although others would provide information by written documents, communications were incomprehensive for requirements selection. Value propositions of stakeholders from project perspective would be fully considered, while value propositions of stakeholders from business and product perspectives would easily be neglected.

In the second type, project manager was the center of the communication process. Project manager was the person who was in charge of communications outside as well as inside the project team and reacted to any conflicts and contradictions in the communication process. This type of communications depended too much on the personal communication skills of project manager. Thus, an unskillful project manager would lead to ineffectual communications and consequently improper

decisions for requirements selection.

The third type of communications was the most sufficient one. It involved all related stakeholders, including project manager, software developers, marketing personnel, product manager, and so forth. This communication type made it possible to combine and reconcile different value propositions of different stakeholders for decision-making of requirements selection. Nevertheless, this type of communications always cost much more than the other 2 types.

5.5.2.2 Communication with oversea headquarters

Communications with headquarters were always infrequent, as presented by the interviewee from Company-4

As mentioned in Section 2.9.1, Chinese society has a large power distance which is constructed by a high hierarchical structure and centralized control (Chang and Ding 1995). Because of the Chinese strict hierarchy culture, people always took orders from their immediate superiors only. Thus, it was impossible for the software developers or project manager to communicate with the executives in the headquarters directly. Instead, the communications were conducted between the manager of the branch and the headquarters. It restricted the communications between the underlings, who practically made the decisions for requirements selection, and the executives, who was in charge of business objective and strategy of the company.

5.5.2.3 Communication media

The communication medium could be divided into two types, face-to-face and none-face-to-face. Face-to-face communication medium included meeting, open forum, and workshop. They were efficient and effective, but with expenses of time and cost. None-face-to-face medium included phone, email, and so on. They were not time-consuming or costly, but not so efficient either. Thus, the selection of proper communication medium was a kind of balance between efficiency and cost.

In addition, the interviewees pointed out the importance of informal communications through comfortable working environment, due to the Chinese relationship-oriented culture. Chinese societies are based on networks of personal relationships (Martinsons and Westwood 1997). The information exchanges between stakeholders in China might depend more on informal and personal communications than the formal ones. Thus, comfortable working environment and relaxed organizational culture turned out to be very essential to efficient and effective communications in the companies in China.

5.5.2.4 Problems in communication process

The problems of communications in the companies in China mainly resulted from Chinese culture of power distance. Superiors rarely adopted the suggestions from their subordinates, while subordinates dare not express their opinions to their superiors. Thus, sometimes requirements selection decisions seemed to be made by all project team members, but the decisions were actually made by project managers themselves. Nonetheless, project managers were usually not very familiar with technical issues especially detailed ones. If project managers made the decisions for requirements selection subjectively, then the problems would inevitably appear in the latter development process.

5.6 Validity threats

The validity threats have to be carefully controlled to ensure that statistical significance could be obtained in the data analysis, meaningful information could be learnt from the data, and conclusions drawn from the study are truly warranted by the data (Leedy and Ormrod 2005).

Validity threats of the findings can be divided into 4 types, conclusion validity, internal validity, construct validity, and external validity (Wohlin *et al.* 2000). The

followings present the 4 kinds of validity threats to this research respectively. These threats highlight the need to replicate this study.

5.6.1 Conclusion validity

There were some potential threats to the conclusion validity of this study.

Firstly, the data collected in this study were not near normal distribution, as kolmogorov-smirnov tests came out. It would lead to a potential threat to the conclusion validity, because some statistical techniques, such as ANOVA tests, had a strict assumption of data distribution. However, most of the statistical tests applied in this study are nonparametric statistical tests which are suitable for non-normal distribution data, such as Kruskal-Wallis tests and Wilcoxon tests. ANOVA tests were conducted after Kruskal-Wallis tests only to confirm the results of Kruskal-Wallis tests. Besides, homogeneity of variance tests were conducted before ANOVA tests to ensure that the data were suitable to apply ANOVA tests.

Second, the scale of the 11 recruited companies was quite different and the participants were from different perspectives, which might threaten the conclusion validity of the findings. Although the data size was relatively large in this study, data points may not be enough to support the findings for each size of the companies and participants from each perspective. It would lead to better conclusion validity if recruiting same-sized companies and same-perspective participants.

Third, the data points for each company were not large enough. It was a potential threat to the conclusion validity of the findings for each company. Besides, Company-3 had a different type of software development project from the other companies. It might also be a potential threat to the conclusion validity of the results.

Fourth, the previous similar studies (Wohlin and Aurum 2005A, Barney 2005) were all conducted in western countries, but this study was conducted in China, a typical

eastern country. It would lead to a potential threat to the conclusion validity when comparing the results of this study with the previous studies. However, cultural issues had been considered when interpreting the data. It could contribute to better conclusion validity of this study.

5.6.2 Internal validity

Potential threats to the internal validity were related to the questionnaires.

Firstly, it is always difficult to know whether the participants have understood the questions as intended or not.
Secondly, it is also difficult to predict whether the participants have a similar conception of 1000 or not.

However, these threats to the internal validity were somewhat addressed by the follow-up interviews when providing the results of the first three-phase survey to the interviewees and discussing the rationale behind the results with them.

5.6.3 Construct validity

There is a potential threat to the construct validity. The participants of the study might try to figure out the researcher's opinions and the purpose of the study, and sometimes subconsciously they would tend to agree with the researcher. Thus, it is easier for the participants to agree with the set of criteria identified by the researcher in advance than disagree, because they knew that the researcher considered the criteria on the list as relevant. Additionally, in the follow-up interviews, the interviewees knew that the researcher felt the communications between stakeholders were very important to requirements selection, and they would rather agree with the researcher.

Another threat to the construct validity is that it is easier to stick to the stated criteria than proposing new criteria. No new criteria were added to the second and third questionnaires. This means that important criteria may be missing.

5.6.4 External validity

The potential threat to the external validity is related to what the 11 recruited companies in this study represent in terms of population (Wohlin and Aurum 2005A).

The 11 companies have several issues in common. They all have market-driven software development projects; they all have more than 150 employees; and they are all in china. Caution should be taken when generalizing the results obtained from this study away from the characteristics of the companies.

5.7 Chapter summary

This chapter discusses the important findings obtained by the Delphi study as well as the underlying rationale behind the findings. In addition, the validity threats of the findings are also discussed in the end of this chapter.

6 Conclusion

6.1 Introduction

The objective of this research is to explore the decision-making criteria for software requirements selection and the communications among stakeholders in market-driven software development projects in China.

Four-phase Delphi survey was applied in this study. Experienced industry experts' opinions of requirements selection criteria were obtained by three-phase survey through three questionnaires interspersed with controlled feedback. Meanwhile, a basic understanding of the communications between stakeholders for requirements selection was obtained by the follow-up interviews.

To the best of the researcher's knowledge, no such empirical studies had ever been conducted in China, and no systematical theory was available to explain the decision-making process of requirements selection. The study filled the gap in the existing literatures.

This chapter summarizes the findings for the 4 research objectives and several opportunities based on this study that warrant further investigations.

6.2 Research objective 1

The first research objective of this study is to identify the underlying decision-making criteria for requirements selection in market-driven software development project in China. The industry experts were asked to decide whether the 14 criteria identified by the researcher in advance were relevant to their decision-making or not and also encouraged to submit extra missing criteria in the first-phase Delphi survey.

13 criteria were regarded as relevant by more than 70% experts, while 'requirement's

issuer' (criterion 4) were regarded as relevant by less than 50% experts. Thus, 'requirement's issuer' was removed from the list of the criteria in the second and third questionnaires.

Several additional criteria were identified by the experts. However, the set of criteria identified by the researcher in advance was believed to cover all the additional criteria proposed by the experts, so no new criteria was added into the second and third questionnaires. The detailed discussions of the extra criteria are presented in Appendix C.

It was worth noting that Company-3 always had different opinions with other companies, probably due to the typical type of software development project in Company-3.

6.3 Research objective 2

The second research objective is to evaluate both practical and ideal importance of the criteria for the decision-making of requirements selection. The results of this objective were based on the second-phase and third-phase survey. The experts assessed both practical and ideal importance of the criteria in the second-phase survey, and re-assessed the ideal importance in the third-phase survey according to the results from the second phase.

The findings showed that some criteria were more important than others when practically making the decisions for requirements selection. 'Business strategy' (criterion 1) and 'customer satisfaction' (criterion 1) were the most and second most influential criteria for requirements selection decisions. However, different-sized companies had different opinions as to the importance of some criteria, and the stakeholders from different perspectives had different opinions regarding criteria's importance in Company-1, Company-7, and Company-8.

The experts felt that benefits would be obtained by applying the criteria differently from the practical situation. More emphases should be laid on ‘Evolution’ (criterion 12) and ‘competitors’ (criterion 3), while less importance should be attached to ‘software features’ (criterion 5), ‘development cost’ (criterion 6), ‘resources’ (criterion 9) and ‘complexity’ (criterion 11) in the future.

6.4 Research objective 3

The third research objective is to explore the degree to which the value propositions of stakeholders from business, project, and product perspectives influence the decision-making of requirements selection. The results of this research objective were also based on the second-phase and third-phase survey.

The results indicated that business perspective had the most significant influence on the decision-making of requirements selection. Further, more emphases should be laid on business-perspective criteria in the future. Company’s objective and external market were the most critical driving forces for the company to create software value. However, project and product perspectives did not have a major influence on the decision-making of requirements selection.

Moreover, business perspective was the most important perspective in most companies, except Company-9. Product perspective was more important than business perspective in Company-9. Additionally, it was worth noting that again the experts from Company-3 had different opinions from the other 10 companies regarding to the importance of different perspectives.

Furthermore, the stakeholders from product perspective felt that project-perspective criteria were more important than product-perspective criteria, while project-perspective stakeholders had contrary opinions. In addition, different-perspective stakeholders had different opinions regarding the importance of

the three-perspective criteria in Company-1, Company-5, and Company-7.

6.5 Research objective 4

The last research objective is to get an overview of requirements selection process and the communications between different stakeholders in the process. The findings of this objective were obtained by 6 follow-up interviews.

Stable working position as requirements engineer was not prevalent in the companies, but some persons would be assigned to fulfill this role in each software development project.

The importance of requirements selection and the communications in the process was gradually realized by the software company. Requirements selection was the process to reconcile the value propositions from different perspectives into a mutually agreed set through communications between stakeholders.

Usually, software development project team made the decisions for requirements selection in the companies. The project team became the critical part of the communications between stakeholders. Project manager, as the leader of the team, played a significant role in the decision-making as well as the communications for requirements selection.

Moreover, both formal and informal communications were important to requirements selection. Informal communications were highlighted by the typical Chinese culture of human relationship.

Furthermore, Chinese hierarchy culture might lead to the problems in the communication process between staffs and their superiors as well as the problems in the communication process between project teams and the headquarters.

6.6 Further research

Several opportunities of further research are presented as follows. Due to the scope and time restraints, they were unable to be addressed in this study.

Firstly, the findings of this study emphasize the differences between different companies and different-sized companies as to the importance of the criteria. The differences may result from different organizational cultures, different maturity levels, different scales, or different target market segments of the companies. However, the data sizes for each company and the companies of each scale are not large enough. Further research is required to determine whether the differences result from these factors or not. For example, a further study can be conducted by combining capability maturity model (CMM), which aims to assess a company's software process maturity, into the research. The CMM is organized into five maturity levels, including initial level, repeatable level, defined level, managed level, and optimizing level (Herbsleb *et al.* 1997). In the further study, companies with different maturity levels can be recruited to discover the differences between these companies as to the importance of the criteria to the decision-making of requirements selection.

Secondly, the experts from Company-3 always had different opinions from the other 10 companies, probably due to the different software project in Company-3. The software project in Company-3 aims to generalize the software product from the anterior successful customer-specific projects for the large market. However, in practice, a majority of the software development projects are similar to the project in Company-3. Further research can be conducted to recruit the experts who are involved in this kind of projects. Some interesting findings will be obtained by comparing these two types of market-driven projects regarding the importance of the criteria.

Thirdly, the study indicated that different-perspective stakeholders had divergent opinions of criteria's importance in some companies. It might result from some

understanding and communication gaps between the stakeholders from different perspectives in these companies. Nonetheless, the data sizes for different-perspective stakeholders from each company are not large enough to fully support this conclusion. Further research should be conducted to prove the findings.

Lastly, this study is conducted in Chinese environment, which contributes to a good understanding of the Chinese software industry. Additionally, some typical Chinese culture, such as large power distance and collectivist culture, will affect the decision-making for requirements selection and the communications between the stakeholders in the process. However, culture is not the main focus of this study. The implication of Chinese culture on requirements selection and the communications between the stakeholders in the process is an interesting topic for the further research.

6.7 Chapter summary

In this chapter, the major findings as well as the possible areas for future research are summarized.

References

Ahmed W.B., and Yannou B., 2003, 'Polysemy of values or conflict of interests: a multi-disciplinary analysis', *International Journal of Value-Based Management*, Vol.16, No.2, pp.153-179

Allworth S.T., and Zobel R.N., 1987, *Introduction to real-time software design*, Macmillan Education, London, Second Edition

Alwis D., Hlupic V., and Fitzgerald G., 2003, 'Intellectual capital factors that impact of value creation', *25th International Conference Information Technology Interfaces*, 16th June -19th June, Cavtat, Croatia, pp.411-416

Anton A.L., and Potts C., 1998, 'The use of goals to surface requirements for evolving systems', *IEEE Computer Society*, International Conference on Software Engineering, Colorado Springs, Colorado, USA, pp.157-166

Aurum A., and Wohlin C., 2003, 'The fundamental nature of requirements engineering activities as a decision-making process', *Information and Software Technology*, Vol. 45, pp.945-954

Aurum A., and Wohlin C., 2005A, *Engineering and managing software requirements*, Springer

Aurum A., and Wohlin C., 2005B, 'Aligning requirements with business objectives: a framework for requirements engineering decisions', *Workshop on Requirements Engineering Decision Support (REDEC'05)*, 29th Aug- 2nd Sept, Paris, France

Bacon C.J., and Fitzgerald B., 2001, 'A systemic framework for the field of information system', *The Data Base for Advances in Information Systems*, Vol.32, No.2, pp.46-67

Barney S., 2005, *Quest for a silver bullet: creating software product value through requirements selection*, Thesis for Bachelor of Science in Business Information Technology, The University of New South Wales, Australia

Barney S., Aurum A., and Wohlin C., 2006 'Quest for a silver bullet: creating software product value through requirements selection', *32nd EUROMICRO Conference*

on Software Engineering and Advanced Applications (SEAA), Track on Value Based Software Engineering, August 28, September 1, 2006, Cavtat/Dubrovnik.

Barrett R., 2005, *Management, labour process and software development: reality bytes*, Routledge, London

Bennett S., 1994, *Real-time computer control: an introduction*, Prentice Hall International (UK), Second Edition

Besanko D., Dranove D., and Shanley M., 2000, *Economics of strategy*, John Wiley & Sons, New York, 2nd Edition

Biffl S., Aurum A., Boehm B., Erdogmus H., and Grunbacher P., 2005, *Value-based software engineering*, Springer, Germany

Boehm B.W., 1981, *Software engineering economics*, Prentice-Hall

Boehm B.W., and Ross R., 1989, 'Theory-W software project management: principles and examples', *IEEE Transaction on Software Engineering*, Vol.15, No.7, pp.902-916

Boehm B.W., and Sullivan K., 2000, 'Software economics: a roadmap', *the future of software economics (ACM press)*, pp.319-343

Boehm B.W., Grunbacher P., and Briggs R.O., 2001, 'Developing groupware for requirements negotiation: lessons learned', *IEEE Software*, Vol.18, No.3, pp46-55

Boehm B.W., 2003, 'Value-based software engineering', ACM SIGSOFT, *Software Engineering Notes*, Vol.28, No.2, pp.1-12

Boehm B.W., and Huang L.G., 2003, 'Value-based software engineering: a case study', *IEEE Computer Society*, March, pp.33-41

Boehm B.W., 2005, 'Value-based software engineering: Overview and agenda', in *Value-based Software Engineering*, Edited by Biffl S., Aurum A., Boehm B., Erdogmus H., Grunbacher P., Chapter 1, Springer, Germany

Boehm B.W., and Jain A., 2005, 'An initial theory of value-based software engineering', in *Value-based Software Engineering*, Edited by Biffl S., Aurum A., Boehm B., Erdogmus H., Grunbacher P., Chapter 2, Springer, Germany

Booth R., 2001, *Market-driven requirements engineering: an industrial case study of*

the requirements management function at the Swedish CASE-tool vendor, Telelogic AB, Thesis for Bachelor of Science in Business Information Technology, The University of New South Wales, Australia

Brancheau J.C. and Wetherbe J.C., 1987, 'Key issues in information systems management', *MIS Quarterly*, Vol.11, No.1, pp.23-45

Brancheau J.C. Janz B.D., and Wetherbe J.C., 1996, 'Key issues in information systems management: 1994-95 SIM Delphi results', *MIS Quarterly,* Vol.20, No.2, pp.225-242

Chang K, and Ding C.G., 1995, 'The influence of culture on industrial buying selection criteria in Taiwan and Mainland China', *Industrial Marketing Management*, Vol.24, pp.277-284

Chung L., Nixon B.A., Yu E., and Mylopoulos J., 1999, *Non-functional requirements in software engineering*, Kluwer Academic Publishers

Couger J.D., 1988, 'Key human resource issues in IS in the 1990s: views of IS executives versus human resource executives', *Information & Management*, Vol.14, pp.161-174

Czinkota M.R., and Ronkainen L.A., 1997, 'International business and trade in the next decade: report from a Delphi study', *Journal of International Business Studies,* Vol.28, No.4, pp.827-844

Dahlstedt A., and Persson A., 2003, 'Requirements interdependencies - moulding the state of research into a research agenda', *Proceedings Ninth International Workshop on Requirements Engineering (REFSQ '03),* Klagenfurt / Velden, Austria, pp.71-80

Debreu G., 1965, *Theory of value: an axiomatic analysis of economic equilibrium*, Cowles Foundation for Research in Economics at Yale University, John Wiley & Sons, New York, 3rd Printing

Delbecq A.L., Van de Ven A.H., Gustafson D.H., 1975, *Group techniques for program planning: a guide to nominal group and Delphi processes*, Scott, Foresman and Company, Glenview, Illinois

Erdogmus H., Favaro J., and Strigel W., 2004, 'Return on investment', *IEEE Software*,

pp.18-22

Favaro J., 1996, ‘When the pursuit of quality destroys value’, *IEEE Software*, pp.93-95

Favaro J., Favaro K.R., and Favaro P.F., 1998, ‘Value-based reuse investment’, *Annals of Software Engineering*, Vol.5, pp.5-52

Favaro J., 2002, ‘Managing requirements for business value’, *IEEE Software*, Vol.19, No.2, pp.15-17

Freire E.H.F., Abdelouahab Z., Rocha S.V., 2005, ‘Applying value concepts to organizational modelling’, *1st International Workshop on Requirements Engineering for Business Need and IT Alignment (REBNITA Proceedings)*

Ghemawat P., 1991, *Commitment: the dynamic of strategy,* The Free Press, New York

Goelzer P.G., 2003, *Effects of national culture on organizational culture*, Thesis for Doctor of Philosophy in Organization Development, Benedictine University, United States

Gordjin J., and Akkerman J. M., 2003, ‘Value-based requirements engineering: Exploring innovative e-commerce ideas’, *Requirements Engineering*, Vol.8, No.2, pp.114-134

Grunbacher P, Koszegi S., and Biffl S., 2005, ‘Stakeholder value proposition elicitation and reconciliation’, in *Value-based Software Engineering*, Edited by Biffl S., Aurum A., Boehm B., Erdogmus H., Grunbacher P., Chapter 2, Springer, Germany

Hale D., and Hale L.H., 2003, ‘China takes off’, *Foreign Affairs*, Vol.82, No.6, pp.36-54

Halling M., Biffl S. and Grunbacher P., 2003, ‘An economic approach for improving requirements negotiation models with inspection’, *Requirements Engineering*, Vol.8, pp.236-247

Hayne S., and Pollard C., 2000, ‘A comparative analysis of critical issues facing Canadian information systems personnel: a national and global perspective’, *Information & Management,* Vol.38, No.2, pp. 73–86

Herbsleb J., Zubrow D., Goldenson D., Hayes W., and Paulk M., 1997, ‘Software

quality and the capability maturity model', Association for Computing Machinery, *Communications of the ACM*, Vol.40, No.6, pp.30-40

Hofstede G., 2001, *Culture's consequences: comparing values, behaviors, institutions and organizations across nations*, USA, SAGE, 2nd Edition

Holsapple P., and Joshi K., 2002, 'Knowledge manipulation activities: results of a Delphi study', *Information & Management*, Vol.39, No.6, pp. 477–490

Host M., Regnell B., Natt och Dag J., Nedstam J., Nyberg C., 2000, 'Exploring bottlenecks in market-driven requirements management processes with discrete event simulation', *Proceedings of Software Process Simulation Modeling Workshop (PROSIM2000)*, London

IEEE, 1984, 'IEEE guide to software requirements specifications', *IEEE Standard 830*, the Institution of Electrical and Electronics Engineers, New York

Karlsson J., and Ryan K., 1997, 'A cost-value approach for prioritizing requirements', *IEEE Software*, September-October, pp.67-74

Karlsson J., Wohlin C., and Regnell B., 1998, 'An evaluation of methods for prioritizing software requirements', *Information and Software Technology*, Vol.39, pp.939-947

Kendall M., 1975, *Rank correlation methods*, Charles Griffin & Company LTD, London and High Wycombe, 4th Edition

Kessler M., 2004, 'US firms: doing business in China tough, but critical', *USA Today*, 17th Aug, pg.801

Kotler P., 1994, *Marketing management: analysis, planning, implementation, and control*, Prentice Hall, 8th Edition

Kotonya G.. and Sommerville I., 1998, *Requirements engineering: processes and techniques*, John Wiley & Sons

Kshetri N., 2005, 'Structural shifts in the Chinese software industry', *IEEE Computer Society*, August, pp.86-93

Lai V., and Chung W., 2002, 'Managing international data communications', *Information & Management*, Vol.45, No.3, pp.89-93

Leedy P.D., and Ormrod J.E., 2005, *Practical research: planning and design*, Prentice

Hall, New Jersey, 8th Edition

Lubars M, Potts C., and Richter C., 1993, 'A review of the state of the practice in requirements modeling', *Proceedings of First IEEE International Symposium on Requirements Engineering (RE'93)*, San Diego, USA, pp.2-14

Macaulay L., 1992, 'Requirements capture as a cooperative activity', *the First International Symposium on Requirements Engineering*, San Diego, IEEE Press, pp.174-181

Macaulay L., 1996, *Requirement Engineering*, Springer-Verlag, London

Martinsons M.G., and Westwood R.I., 1997, "Management information systems in the Chinese business culture: as explanatory theory", *Information & Management*, Vol.32, pp.215-228

Marx K.(1818-1883), 1990, *Capital : a critique of political economy, Introduced by Mandel E.*, Translated by Fowkes B., Harmondsworth, Penguin in association with New Left Review

Nambisan S., Agarwal R., and Tanniru M., 1999, 'Organizational mechanisms for enhancing user innovation in information technology', *MIS Quarterly*, Vol.23, No.3, pp.365-395

Neap H.S., and Celik T., 1999, 'Value of a product: a definition', *International Journal of value-based management*, Vol.12, No.2, pp.181-191

Neuliep, J.W., 2000, *Intercultural communication: A contextual approach*, USA, Houghton Miffin

Okoli C., and Pawlowski S.D., 2004, 'The Delphi method as a research tool: an example, design considerations and applications', *Information & Management*, Vol.42, pp.15-29

Onwuegbuzie A.J., and Leech N.L., 2004, 'Enhancing the interpretation of "significant" findings: the role of mixed methods research', *The Qualitative Report*, Vol.9, No.4, pp.770-792

Paulk M.C., Curtis B., Chrissis M.B., and Weber C.V., 1993, 'Capability maturity model version 1.1', *Software IEEE*, Vol.10, No.4, pp. 18-27

Peat R., 2003, 'Value drive value', *University of Auckland Business Review*, Vol.5,

No.2, pp.1-11

Rautiainen K., Lassenius C., and Sulonen R., 2002, '4CC: a framework for management software product development', *Engineering Management Journal*, Vol.14, No.2, pp.27-32

Regnell B., Beremark P., Eklundh O., 1998, 'A market-driven requirements engineering process: results from an industry process improvement programe', *Proceedings of Conference on European Industrial Requirements Engineering (CEIRE' 98),* London

Regnell B., Host M., Natt och Dag J., Beremark P., and Hjelm T., 2001, 'An industrial case study on distributed prioritisation in market-driven requirements engineering for packaged software', *Requirements Engineering*, Vol.6, pp.51-62

Rosca D., Greenspant S., Feblowitzt M., and Wild C., 1997, 'A decision making methodology in support of the business rules', *Proceedings of IEEE Requirements Engineering Conference*, pp.236-246

Rowe G., Wright G., and Bolger F., 1991, 'Delphi: a re-evaluation of research and theory', *Technological Forecasting and Social Change*, Vol.39, pp.345-355

Ruhe G., Eberlein A., and Prahl D., 2003, 'Trade-off analysis for requirements selection', *International Journal of Software Engineering*, Vol.13, No.4, pp.345-366

Savchenkova V.B., 2003, *Evaluation criteria for language teaching software: a Delphi study of professional perspectives*, Thesis for Doctor of Philosophy Degree, The University of Tennessee, Knoxville

Sawhney M., 2002, 'Create value from values: the purpose of business is greater than profits', *CIO*, Vol.16, No.4, pp.1-3

Schmidt R.C., 1997, 'Management Delphi surveys using nonparametric statistical techniques', *Decision Sciences*, Vol.28, No.3, pp.763-774

Schmidt R.C., Lyytinen K., Keil M., and Cule P., 2001, 'Identifying software project risks: an international Delphi study', *Journal of Management Information System*, Vol.17, No.4, pp.5-36

Smith A. (1723-1790), 1937, *Wealth of nations: an inquiry into the nature and causes*

of the wealth of nations, Edited by Cannon E., New York

Snapshots, 2005, 'China Software 2005', *Snapshots International Ltd.*, http://dx.doi.org/10.1337/cn200165, viewed 15 October 2005

Sommerville L., and Sawyer P., 1997, *Requirements engineering: a good practice guide*, John Wiley & Sons, England

Strigini L., 1996, 'Limiting the dangers of intuitive decision making**',** *IEEE Software*, Vol.13, No.1, pp.101-103

Sutcliffe A.G., Maiden N.A.M., Minocha S., and Manuel D., 1998, 'Supporting scenario-based requirements engineering', *IEEE Transactions on Software Engineering*, Vol.24, No.12, pp.1072-1088

Sweeney E.P., and Hardaker G., 1994, 'The importance of organizational and national culture", *European Business Review*, Vol.94, No.5, pp.3-14

Takeda M.B., 1998, *The impact of human resource management identity on strategic intent in international organizations*, Thesis for Doctor of Philosophy, University of Pittsburgh, the United States

Wohlin C., Runeson P., Host M., Ohlsson M.C., Regnell B., Wesslen A., 2000, *Experimentation in software engineering: an introduction*, Kluwer Academic Publishers, Boston, USA

Wohlin C., and Aurum A., 2005A, 'What is important when deciding to include a software requirement in a project or release', *the Fourth International Symposium on Empirical Software Engineering Conference*, Noosa Heads, Queensland, Australia, November

Wohlin C., and Aurum A., 2005B, 'Criteria for selecting software requirements to create product value: an industrial empirical study', in *Value-based Software Engineering*, Edited by Biffl S., Aurum A., Boehm B., Erdogmus H., Grunbacher P., Chapter 9, Springer, Germany

Xinhuanet, 2005, *Vicious price competition has appeared in Chinese software industry,* http://news.xinhuanet.com/it/2005-08/24/content_3396618.htm, Viewed 26 October 2005

Yeh A. 1992, 'REQUirements Engineering Support Technique (REQUEST) a market

driven requirements management process', *Proceedings of Second Symposium of Assessment of Quality Software Development Tools*, New Orleans, USA, pp.211-223

Zave P., 1997, 'Classification of research efforts in requirements engineering', *ACM Computing Surveys*, Vol.29, No.4, pp.313-314

Appendices

Appendix A: Questionnaires and interview questions

First-phase questionnaire

Research Background:

The rapid changing competitive environment of software industry is altering the landscape of software industry. Software development should satisfy all the stakeholders better than any other competitor can to get a competitive advantage in software industry. Software development is far from enough by transferring customer requirements into codes, so it is not sufficient to make the decision in the software development process based on technical reasons only.

Research Objective:

This research focuses on software requirements selection in software development process. I hope to investigate the underlying reasons when you are deciding to include a software requirement in market-driven software projects by the questionnaires. You are asked to identify what governs the decisions for requirements selection and the different importance of the underlying criteria.

Survey process:

You will be asked to fulfill the questionnaire three times. In the first questionnaire, you will be asked to judge whether the identified criteria are relevant to requirements selection or not and provide other missing criteria. An authority list of criteria will be conducted in the second questionnaire by analyzing the results from first phase. You should identify the importance of each criterion for both practical and ideal situation in the second questionnaire. In the third questionnaire, you will be asked to re-rate the ideal importance of each criterion based on others rating in the last questionnaire, including average rating and standard variation of all the participants as well as average rating from your organization.

Confidential assurance:

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission, except as required by law. All the personal information will be kept secretly and no data in the analysis will be connected to specific individuals.

Personal Information:

Name:
Company:
Organizational unit: (such as development, testing, marketing, and etc.)
Your role within the organization: (such as product manager, project manager, developer, and etc.)
Numbers of years work experience:
Number of years at this company:
The project you involved: (if your answer is based on your overall experience, write no specific project)
The software product developed in the project: (if your answer is based on your overall experience, write no specific product)
Email address:

Followings are identified criteria from the literature or previous studies. If you think the criterion is related to the decision-making of the requirements prioritization and selection in market-driven software development process, then "☑" before the criterion, otherwise then "☒". If you think any additional related criteria are missing, please feel free to add them on the next page and give the explanation and motivation of the criteria.

❑**1. Business strategy**

Explanation: the suitability between the requirements and the strategy of the company, including the strategy of attracting customers, pricing strategy, marketing operations, and so forth.

Motivation: we may not want to include a requirement if it conflicts with company's business strategy or has negative impact on achieving company's objective.

❑**2. Customer satisfaction**

Explanation: the impact of the requirements implementation on the software's overall capacity to satisfy customers – the customers' priority and their expectation to see the requirement met are taken into account.

Motivation: we may want to include a requirement if it will bring high product value to customer, in other words, our customers think that the requirement is of high importance and meet their expectations.

❑**3. Competitors**

Explanation: the status of competitors in the market with respect to the requirement – it is taken into account whether a competitor has the implied functionality or not.

Motivation: we may feel forced to include a requirement if our competitors have the functionality, or we may want to implement something that is considered to be leading edge functionality in the market, which others do not have.

❑**4. Requirement's issuer**

Explanation: the stakeholder (internal or external) who generated the requirement

Motivation: we may judge some issuers more important than others, for example representative of a key market or CEO of the company.

❑**5. Software features and benefits**

Explanation: the actual features of the software will be brought by implementing the requirement, such as performance, reliability, durability, and so on.

Motivation: we may want to include a requirement if the implementation of the requirement will bring high expected features and benefits.

❑**6. Development cost**

Explanation: the cost for implementing the requirement.

Motivation: we may not want to include a requirement if the implementation

cost is judged to high.

❑**7. Calendar time**

Expectation: the impact of the requirement implementation on the time to release the software to the market.

Motivation: we may not want to introduce a requirement that may affect the time for the software to the market negatively.

❑**8. Extra cost**

Explanation: the impact of the requirement implementation on the extra cost customers will spend, such as the cost of software installation, learning how to use it, software maintenance, and so on.

Motivation: we may not want to implement a requirement if it is believed that the requirement may cause many extra costs to customers.

❑**9. Resources**

Explanation: the availability of the resources with the right competencies to implement the requirement.

Motivation: we may not want to implement a requirement unless we are sure that we have the right people available for the job

❑**10. After-sale support**

Explanation: the effort of technical support, education support, and training support that should be provided to customers after the sale with respect to the requirement.

Motivation: we may not want to implement the requirement if the requirement will bring technical, education, and training support effort we can not provide or do not want to provide.

❑**11. Complexity**

Explanation: the estimated complexity of the requirement and the associated challenges in implementing it.

Motivation: we may not want to include a requirement that is judged to be very complex to implement and as a consequence the risk of failure as too high.

❑**12. Evolution**

Explanation: the impact of the requirement implementation on the future evolution of the software product.

Motivation: we may not want to implement a requirement if it is believed to make long-term evolution of the software product more complicated.

❑**13. Requirements dependencies**

Explanation: the dependencies between the requirement and other requirements, including the requirements already implemented, scheduled to be implemented, or deferred to later release.

Motivation: the dependencies to other requirements may affect out decision regarding the current specific requirement.

❑**14.Requirement volatility**

Explanation: whether the requirement is easily to change or not is taken into account.

Motivation: we may want to handle highly volatile requirements differently.

If you think any additional related criteria are missing, please add them following. (Please feel free to add more):

15._____

Explanation:_____
_____
_____

Motivation:_____
_____
_____

16._____

Explanation:_____
_____
_____

Motivation:_____
_____
_____

17._____

Explanation:_____
_____
_____

Motivation:_____
_____
_____

18._____

Explanation:_____
_____
_____

Motivation:_____
_____
_____

19._____

Explanation:_____
_____
_____

Motivation:_____
_____
_____

Second-phase questionnaire

Thank you for your participation. This questionnaire aims to find out which criteria are more important and should be more important when deciding the requirements to be implemented in a release in market-driven software development process.

The following criteria have been listed based on results of last questionnaires. As less than half participants thought that ‘requirements issuer’ (criterion 4) as irrelevant, this criterion has been removed from the list. The explanation and motivation of the criteria is presented in the appendix.

Please rate the relative weights in both *Practical* and *Ideal* column, regarding the importance of the 13 criteria in terms of value between 0 and 1000 points. A higher number of points mean that a criterion is relatively more important for requirements selection. For example, if one criterion is twice as important as another one, the value should be twice as large. The sum of all values in one column should be 1000.

- The *Practical* column represents the situation today. In other words, how you value the importance of these criteria in practice today.
- The *Ideal* column represents how you think it ought to be in the future.

Please try to distribute your rating scores across as much of the rating scale as you feel is appropriate

	Criteria	Practical	Ideal
1	Business strategy		
2	Customer satisfaction		
3	Competitors		
5	software features		
6	Development cost		
7	Calendar time		
8	Extra cost		
9	Resource		
10	After-sale support		
11	Complexity		
12	Evolution		
13	Requirements dependencies		
14	Requirement volatility		
	SUM	**1000**	**1000**

Third-phase questionnaire

Thank you for your participation. The following criteria have been listed in descending order from most important to least important based on the average rating of the criteria's ideal importance from all the participants received by last round questionnaires. The explanation and motivation of the criteria are presented in the appendix.

For your convenience, the mean of all experts' ratings, the mean of all experts' ratings from your company, standard deviation of all experts' ratings, and your personal ratings for the ideal importance of the criteria from the last-round survey are listed next to criterion. Please re-rate the ideal importance of the criteria when deciding the requirements to be implemented in market-driven software development project. After considering others opinion, please write your new rating in the space provided.

Please re-rate the relative weights regarding the ideal importance of the criteria in terms of value between 0 and 1000 points. As before, a higher number of points mean that a criterion is relatively more important when deciding to include a software requirement in a release. For example, if one criterion is twice as important as another one, the value should be twice as large. The sum of all values in one column should be 1000.

Please try to distribute your rating scores across as much of the rating scale as you feel is appropriate

	Criteria	Avg. Rating of all	Avg. Rating Company Specific	Standard Deviation of all	Your Last Rating	Your New Rating
1	Business strategy	130.71		51. 11		
2	Customer satisfaction	125.52		45. 44		
3	Competitors	82.01		25. 77		
5	Software features	103.02		32. 48		
6	Development cost	82.13		30. 37		
7	Calendar time	81.02		29. 37		
8	Extra cost	37.22		26. 48		
9	Resource	61.13		33. 06		
10	After-sale support	46.2		31. 64		
11	Complexity	50.05		25. 43		
12	Evolution	85.52		32. 05		
13	Requirements dependencies	62.32		28. 43		
14	Requirement volatility	53.15		27. 67		
	SUM	**1000**	**1000**		**1000**	**1000**

Outline of fourth-phase interview questions

Sections	Questions
Section A: General information about the company and the software development project	● How many employees the company has? And how many of these are in IT? ● What departments the company has? Please explain the organizational structure. ● How many releases have been launched in the project? ● Is requirements engineering explicitly planned? ● Is there a role defined as a requirements engineer? What is his/her title? For example, he/she might be called a system analyst. ● Who is responsible for prioritizing requirements and who is responsible for selecting which requirements go into a project?
Section B: Reaction to the results of the Delphi survey	● Why did you rate the practical and ideal importance of each criterion like this? ● Do you think the practical importance of the criteria is rational? Could it be improved some way in the future? ● Do you think the practical decision-making of requirements selection have the right balance among the criteria from external market, project management and development and maintenance of the software product? ● Do you agreed with others' rating about the ideal importance of the criteria? Why do you agree or disagree?
Section B: Overview picture of communications among stakeholders	● Can you describe the overview picture of the decision-making process of requirements selection in the project? ● Are any processes used to help select requirements for a project? For example, negotiation or workshops. ● Which methodologies are formally or informally used to select the requirements? For example, cost-benefit analysis. ● Are there any software tools used to help select requirements? ● Will staffs from business, product, and project perspectives interact with each other in the decision-making process of requirement selection? If so, please explain the communication and interaction process among them. If not, do you think it is important or useful, and why? ● Do you think that the current communication process is efficient and effective? What is your opinion of the improvement? ● What are the biggest constraints you face in requirements selection? For example, time, resources or budget.

Appendix B: Results

Selection of Criteria

1. Expert's opinions of requirements selection criteria's relevancy
2. Expert's opinions of criteria's relevancy in the 11 companies
3. The opinions of experts from different-sized companies as to criteria's relevancy
4. The opinions of experts from different perspectives as to criteria's relevancy

Table A. 1: Expert's opinions of requirements selection criteria's relevancy

	The number of the experts that felt it relevant	The percentage of the experts that felt it relevant
1. Business strategy	119 out of 132	90.2%
2. Customer satisfaction	117 out of 132	88.6%
3. Competitors	98 out of 132	74.2%
4. Requirement's issuer	60 out of 132	45.5%
5. Software features	115 out of 132	87.1%
6. Development cost	109 out of 132	82.6%
7. Calendar time	111 out of 132	84.1%
8. Extra cost	95 out of 132	72.0%
9. Resources	96 out of 132	72.7%
10. After-sale support	97 out of 132	73.5%
11. Complexity	97 out of 132	73.5%
12. Evolution	100 out of 132	75.8%
13. Requirements dependencies	98 out of 132	74.2%
14. Requirement volatility	101 out of 132	76.5%

Table A. 2: Expert's opinions of criteria's relevancy in the 11 companies

	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10	C-11
1. Business strategy	72.7%	100%	91.7%	77.8%	100%	100%	90%	85.7%	100%	100%	81.8%
2. Customer satisfaction	90.9%	90%	66.7%	83.3%	92.3%	91.7%	90%	85.7%	100%	100%	90.9%
3. Competitors	72.7%	80%	58.3%	72.2%	76.9%	83.3%	100%	64.3%	81.8%	90%	45.5%
4. Requirement's issuer	45.5%	40%	50%	61.1%	53.8%	33.3%	40%	64.3%	36.4%	30%	27.3%
5. Software features	90.9%	80%	58.3%	100%	92.3%	66.7%	100%	85.7%	90.9%	90%	100%
6. Development cost	90.9%	90%	50%	94.4%	76.9%	83.3%	90%	85.7%	81.8%	80%	81.8%
7. Calendar time	90.9%	100%	58.3%	77.8%	76.9%	83.3%	90%	85.7%	90.9%	90%	90.9%
8. Extra cost	45.5%	90%	58.3%	77.8%	76.9%	66.7%	60%	64.3%	100%	100%	54.5%
9. Resources	90.9%	80%	58.3%	72.2%	69.2%	83.3%	70%	57.1%	90.9%	100%	36.4%
10. After-sale support	36.4%	80%	83.3%	77.8%	53.8%	75%	90%	64.3%	72.7%	90%	90.9%
11. Complexity	54.5%	70%	75%	61.1%	92.3%	75%	90%	85.7%	63.6%	100%	45.5%
12. Evolution	63.6%	90%	66.7%	88.9%	69.2%	91.7%	80%	57.1%	45.5%	100%	81.8%
13. Requirements dependencies	54.5%	60%	66.7%	88.9%	61.5%	75%	90%	71.4%	72.7%	90%	81.8%
14. Requirement volatility	72.7%	80%	75%	50%	69.2%	91.7%	90%	78.6%	100%	90%	63.6%

Table A. 3: The opinions of experts from different-sized companies as to criteria's relevancy

	Ex-large (XL)	Large (L)	Medium (M)
1. Business strategy	82.9%	93.9%	93.1%
2. Customer satisfaction	87.8%	84.8%	91.4%
3. Competitors	75.6%	78.8%	70.7%
4. Requirement's issuer	48.8%	42.4%	44.8%
5. Software features	87.8%	81.8%	89.7%
6. Development cost	90.2%	72.7%	82.8%
7. Calendar time	82.9%	78.8%	87.9%
8. Extra cost	65.9%	72.7%	75.9%
9. Resources	80.5%	72.7%	67.2%
10. After-sale support	65.9%	81.8%	74.1%
11. Complexity	63.4%	75.8%	79.3%
12. Evolution	82.9%	63.6%	77.6%
13. Requirements dependencies	75.6%	75.8%	72.4%
14. Requirement volatility	68.3%	87.9%	75.9%

Table A. 4: The opinions of experts from different perspectives as to criteria's relevancy

	Business	Project	Product
1. Business strategy	86.1%	100.0%	87.3%
2. Customer satisfaction	88.9%	87.9%	88.9%
3. Competitors	58.3%	78.8%	81.0%
4. Requirement's issuer	52.8%	33.3%	47.6%
5. Software features	88.9%	87.9%	85.7%
6. Development cost	80.6%	81.8%	84.1%
7. Calendar time	80.6%	87.9%	84.1%
8. Extra cost	63.9%	75.8%	74.6%
9. Resources	69.4%	75.8%	73.0%
10. After-sale support	80.6%	69.7%	71.4%
11. Complexity	63.9%	78.8%	76.2%
12. Evolution	83.3%	69.7%	74.6%
13. Requirements dependencies	69.4%	81.8%	73.0%
14. Requirement volatility	63.9%	84.8%	79.4%

Practical importance of Criteria

1. Dispersions of the practical importance between the 11 companies
2. Practical importance of different criteria for different-sized companies
3. Practical importance of different criteria for different-perspective stakeholders

Table A. 5: Dispersions of the practical importance between the 11 companies

	Dispersions of practical importance between the 11 companies
1. Business strategy	6.7%
2. Customer satisfaction	5.3%
3. Competitors	4.3%
5. Software features	5.3%
6. Development cost	4.6%
7. Calendar time	6.8%
8. Extra cost	2.9%
9. Resources	4.0%
10. After-sale support	5.9%
11. Complexity	3.3%
12. Evolution	4.6%
13. Requirements dependencies	2.8%
14. Requirement volatility	5.7%

Table A. 6: Practical importance of different criteria for different-sized companies

	Ex-large (XL)	Large (L)	Medium (M)
1. Business strategy	14.7%	10.5%	11.5%
2. Customer satisfaction	12.4%	12.1%	11.0%
3. Competitors	7.1%	6.2%	7.4%
5. Software features	10.4%	11.7%	11.5%
6. Development cost	8.9%	10.4%	8.5%
7. Calendar time	8.6%	7.2%	9.1%
8. Extra cost	3.9%	4.4%	4.6%
9. Resources	6.1%	6.8%	8.0%
10. After-sale support	3.1%	6.7%	4.1%
11. Complexity	6.1%	5.8%	6.2%
12. Evolution	6.5%	6.8%	6.4%
13. Requirements dependencies	6.3%	6.1%	5.9%
14. Requirement volatility	5.9%	5.4%	5.8%

Table A. 7: Practical importance of different criteria for different-perspective stakeholders

	Business	Project	Product
1. Business strategy	13.7%	11.8%	11.3%
2. Customer satisfaction	12.1%	11.4%	11.9%
3. Competitors	6.6%	7.3%	7%
5. Software features	10.8%	11.4%	11.6%
6. Development cost	8.9%	9.2%	9%
7. Calendar time	8.3%	8.3%	9.1%
8. Extra cost	4.3%	4.3%	4.4%
9. Resources	7%	6.8%	7.8%
10. After-sale support	4.4%	4.6%	4.2%
11. Complexity	5.8%	6.1%	6.2%
12. Evolution	7.2%	6.2%	6.4%
13. Requirements dependencies	5.6%	6.7%	5.5%
14. Requirement volatility	5.3%	6%	5.6%

Ideal importance of criteria

1. Descriptive statistics of criteria's ideal importance from the second-phase survey
2. Ideal importance of different criteria for all participants
3. Dispersions of the ideal importance between the 11 companies
4. Ideal importance of different criteria for different-sized companies
5. Ideal importance of different criteria for different-perspective stakeholders

Table A. 8: Descriptive statistics of criteria's ideal importance from the second-phase survey

	Mean All	Std. Dev.	Mean C-1	Mean C-2	Mean C-3	Mean C-4	Mean C-5	Mean C-6	Mean C-7	Mean C-8	Mean C-9	Mean C-10	Mean C-11
1. Business strategy	130.71	51.11	157.27	140.5	124.55	135.25	116.92	155.42	116.00	131.88	112.73	137.78	104.55
2. Customer satisfaction	125.52	45.44	145.45	126.50	138.18	130.05	113.08	141.67	120.00	128.44	108.81	118.89	106.36
3. Competitors	82.01	25.77	65.45	81.50	73.64	92.13	80.00	79.58	83.00	84.78	83.68	95.00	80.91
5. Software features	103.02	32.48	98.18	124.00	107.27	101.19	93.85	101.25	125.00	92.63	98.18	107.78	92.73
6. Development cost	82.13	30.37	81.82	98.00	104.55	90.18	79.23	69.17	89.50	73.93	73.69	58.89	85.45
7. Calendar time	81.02	29.37	74.55	102.00	100.91	86.31	82.31	71.25	89.00	61.29	58.18	75.56	89.09
8. Extra cost	37.22	26.48	38.64	40.50	30.91	38.06	47.69	31.25	32.00	40.58	32.73	34.44	41.36
9. Resources	61.13	33.06	45.45	42.00	78.18	52.75	61.54	65.00	55.00	71.83	47.73	67.22	91.36
10. After-sale support	46.20	31.64	47.27	58.00	37.27	43.38	41.15	30.00	48.50	49.06	70.91	48.89	38.18
11. Complexity	50.05	25.43	60.91	43.00	40.00	43.38	56.54	39.58	54.00	47.63	57.27	48.89	60.91
12. Evolution	85.52	32.05	57.73	55.00	51.82	76.19	91.54	107.5	108.00	97.50	113.68	100.00	81.82
13. Requirements dependencies	62.32	28.43	70.00	45.00	49.09	69.63	69.23	48.75	54.00	69.87	84.68	61.11	58.18
14. Requirement volatility	53.15	27.67	57.28	44.00	63.64	41.50	66.92	59.58	26.00	50.58	57.73	45.56	69.09

Table A. 9: Ideal importance of different criteria for all participants

	Second-phase	Third-phase
1. Business strategy	13%	12.8%
2. Customer satisfaction	12.5%	12.2%
3. Competitors	8.2%	8.8%
5. Software features	10.3%	9.8%
6. Development cost	8.2%	8.2%
7. Calendar time	8.1%	8.2%
8. Extra cost	3.7%	4.4%
9. Resources	6.2%	6%
10. After-sale support	4.6%	4.6%
11. Complexity	5%	5.2%
12. Evolution	8.5%	8.5%
13. Requirements dependencies	6.2%	6.3%
14. Requirement volatility	5.3%	5.1%

Table A. 10: Dispersions of the ideal importance between the 11 companies

	Dispersions of ideal importance between the 11 companies
1. Business strategy	3.7%
2. Customer satisfaction	3.2%
3. Competitors	2.5%
5. Software features	5.2%
6. Development cost	3.9%
7. Calendar time	4.1%
8. Extra cost	5.8%
9. Resources	4.1%
10. After-sale support	3.8%
11. Complexity	2.6%
12. Evolution	6.4%
13. Requirements dependencies	3.1%
14. Requirement volatility	3.1%

Table A. 11: Ideal importance of different criteria for different-sized companies

	Ex-large (XL)	Large (L)	Medium (M)
1. Business strategy	14.3%	11.7%	12.5%
2. Customer satisfaction	13.4%	11.8%	11.8%
3. Competitors	8.5%	8.5%	9.1%
5. Software features	10%	9.5%	9.9%
6. Development cost	8.2%	8.5%	7.9%
7. Calendar time	8.3%	8.2%	8.1%
8. Extra cost	3.7%	5.3%	4.3%
9. Resources	5.1%	6.4%	6.4%
10. After-sale support	4.1%	5%	4.6%
11. Complexity	5%	5.8%	5.1%
12. Evolution	7.9%	8.6%	8.7%
13. Requirements dependencies	6.6%	6.2%	6.1%
14. Requirement volatility	5%	4.3%	5.6%

Table A. 12: Ideal importance of different criteria for different-perspective stakeholders

	Business	Project	Product
1. Business strategy	13.3%	12.7%	12.6%
2. Customer satisfaction	12.5%	12.2%	12.2%
3. Competitors	9.1%	8.6%	8.7%
5. Software features	10%	9.9%	9.6%
6. Development cost	8.4%	8.1%	8%
7. Calendar time	8.3%	8.2%	8.2%
8. Extra cost	3.9%	4%	4.8%
9. Resources	5.4%	6.7%	6%
10. After-sale support	4.8%	4.5%	4.5%
11. Complexity	4.9%	4.9%	5.6%
12. Evolution	8.5%	9%	8.2%
13. Requirements dependencies	6.1%	6%	6.5%
14. Requirement volatility	4.9%	5.4%	5.1%

Influence of three perspectives

1. Practical and ideal importance of three perspectives for the 11 companies
2. Practical and ideal importance of three perspectives for different-sized companies
3. Practical and ideal importance of three perspectives for different-perspective stakeholders

Table A. 13: Practical and ideal importance of three perspectives for the 11 companies

	Business perspective		Project perspective		Product perspective	
	Practical	Ideal	Practical	Ideal	Practical	Ideal
Company-1	46.7%	45.3%	25.6%	25.4%	27.7%	29.2%
Company-2	42.6%	45.0%	32.3%	29.0%	25.0%	26.0%
Company-3	42.9%	38.0%	32.3%	36.6%	24.7%	25.2%
Company-4	41.6%	46.5%	30.1%	25.2%	28.4%	28.2%
Company-5	39.7%	41.0%	30.1%	26.6%	30.3%	32.3%
Company-6	46.8%	46.9%	26.0%	25.5%	27.4%	27.6%
Company-7	42.0%	44.7%	28.6%	26.5%	29.4%	28.9%
Company-8	42.1%	44.1%	28.7%	25.0%	29.3%	30.8%
Company-9	36.7%	41.6%	25.1%	22.4%	38.2%	36.0%
Company-10	44.9%	46.3%	28.7%	23.1%	26.4%	30.6%
Company-11	39.2%	40.3%	31.1%	29.9%	29.8%	29.7%

Table A. 14: Practical and ideal importance of three perspectives for different-sized companies

	Business perspective		Project perspective		Product perspective	
	Practical	Ideal	Practical	Ideal	Practical	Ideal
Ex-large	44.6%	46.2%	27.5%	25.3%	27.9%	28.6%
Large	40.5%	41.5%	28.8%	28.4%	30.8%	29.9%
Medium	41.4%	43.3%	30.2%	26.7%	28.4%	30.1%

Table A. 15: Practical and ideal importance of three perspectives for different-perspective stakeholders

	Business perspective		Project perspective		Product perspective	
	Practical	Ideal	Practical	Ideal	Practical	Ideal
Business-perspective stakeholder	43.2%	44.9%	28.5%	26%	28.3%	29.2%
Project-perspective stakeholder	41.9%	43.4%	28.6%	27%	29.6%	29.8%
Product-perspective stakeholder	41.8%	43.1%	30.3%	27%	27.9%	29.9%

Appendix C: Additional criteria

7 additional criteria were proposed by the experts in the first-phase survey.

1. Relationship with customer

Explanation: *the impact of the requirement implementation on the customer-oriented business concept and effective marketing service flow*

Motivation: *when deciding to include a requirement, we may consider customer benefit so as to enhance the loyalty of the customer.*

The first additional criterion was identified by the general manager in Company-2. The researcher thought that ‘relationship with customer’ was related to ‘customer satisfaction’ (criterion 2). Customer satisfaction is the foundation to have a tight and steady relationship with the customers.

2. Total ownership cost (TOC)

Explanation: *including development cost (criterion 6), calendar time (criterion 7), and resources (criterion 9)*

Motivation: *TOC is the most important criterion to evaluate the software development, including the cost of license, implementation, and maintenance*

The criterion was identified by a software developer in Company-4. The researcher decided to keep three criteria, ‘development cost’ (criterion 6), ‘calendar time’ (criterion 7), and ‘resources’ (criterion 9) separately, instead of combining them into ‘total ownership cost’, which made it possible to compare the importance of these 3 criteria.

3. Business model

Explanation: *the impact of the requirement implementation on the model for a corporation to run its business*

Motivation: *business model is the foundation of competitive advantage of the company, so we may not include a requirement which will impair the advantage.*

The criterion was identified by the same software developer in Company-4 as the second additional criteria. 'Business model' is found to be relative to 'business strategy' (criterion 1). Business model of a company is involved in its business strategy.

4. Industry character

Explanation: *industry's common character, i.e. common business model*

Motivation: *some industries have common characters by which companies in the industry competes with each other, so we may not include a requirement which will not satisfy the common business model.*

The criterion was identified by the same software developer in Company-4 as the second additional criteria. 'Industry character' is found to be relative to 'business strategy' (criterion 1). Industry's common business model is included in its business strategy.

5. Document management

Explanation: *the management of requirements' documents*

Motivation: *if there is no good document management in the requirements selection process, it will bring troubles for latter software development and maintenance.*

The fifth additional criterion was identified by an application engineer in Company-5. The researcher found that document management was an important activity and task in requirements engineering, rather than a decision-making criterion for requirements selection.

6. Business objective

Explanation: *the impact of the requirement implementation on the company's business objective*

Motivation: *we may not want to implement a requirement if it is believed that the requirement may cause negative effect on the business objective.*

The sixth additional criterion was identified by a project manager in Company-5. The researcher considered that 'business objective' was most likely related to 'business strategy' (criterion 1) and 'customer satisfaction' (criterion 2). In order to focus on the importance of each individual criterion, the criteria should be reasonably independent, so 'business objective' were not added into the list.

7. Customer value

Explanation: *the impact of the requirement implementation on the customer value.*

Motivation: *we may want to include a requirement if it will bring high value to customer.*

The last additional criterion was identified by a project manager in Company-11. The researcher found that 'customer value' was related to 'customer satisfaction' (criterion 2). Customers will be satisfied if the implementation of a requirement can provide high value to them.