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Adding Value to Software Requirements：
An Empirical Study in the Chinese Software Industry

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Abstract

The rapid growth of the Chinese software industry has attracted attention from all over the world. Meanwhile, software requirements selection has a crucial impact on the final value of a software product and the satisfaction of stakeholders. This paper presents an empirical study, which focuses on the decision-making criteria for requirements selection in market-driven software development projects in international companies in China. The outcome shows that some criteria, such as business strategy, customer satisfaction, and software features, are more important than others when making decisions for requirements selection.

Keywords

Requirements selection, Decision-making criteria, International companies in China

1. INTRODUCTION

Information Technology (IT) has become a critical industry in China since the mid 1990s and has created a threat to other emerging markets in South East Asia, Central Asia and Eastern Europe. The Chinese software industry has grown so fast that it invokes frequent comparisons between Shanghai, one of China's leading software producing regions, and Silicon Valley.

The compound annual growth rate of the Chinese software market for the period 2000-2004 was 18.9% and is predicted to remain at the same rate in the following five years (Snapshots 2005). Due to the large market in China, foreign companies have launched their products into China one after another, and research indicates that foreign companies captured about 70 percent of the Chinese software market in 2003 (Hale and Hale 2003). In many cases, Chinese domestic companies themselves collaborate with foreign companies and export their software products outside China. Although in 2003 China's software exports only achieved $2 billion compared to India's $12 billion, it is estimated that China will be able to catch up with India in software exports by 2006, and will reach $27 billion in 2007 (Kshetri 2005, Meyer and Kolb 2005).

There is incredible pressure on Chinese software companies to achieve and sustain a competitive advantage. Unfortunately, the value of the software is widely underestimated by Chinese people. Software companies in China have to depress the price of software products to attract more customers, so they have to drive down their cost of software development. Fang Liang, President Asia, Freeborders, states that "*There is a common misperception that China IT teams can only succeed in small, low-value development tasks*" (Homes and Euretig 2006). Nevertheless, China aims to develop a high international standard of software by participating in large-scale lead projects.

Now that offshore development is a major new trend, it is affecting everyone in IT. To remain competitive in an era of increasing uncertainty and market globalization it is important to focus on the value of different customers and markets when developing products. Wohlin and Aurum (2005A) argue that the inclusion of software requirements in development should be based on value propositions of stakeholders. Several researchers stress the necessity to include business value to requirements engineering and the importance of a value-based

approach in software development (Favaro 2002; Biffle *et al*., 2005, Boehm 2003). Requirements selection is an important and complex process in software development. On one hand, requirements that are selected to be implemented will have a crucial impact on the final value of a software product and the satisfaction of stakeholders. The value of a software product is created and added through the requirements selection process. On the other hand, requirements selection is in itself a complicated decision-making process due to the interdependency between requirements as well as the different and even incompatible value propositions of stakeholders. Furthermore, in some cases, such as market-driven software development projects, it is difficult for the software developer to get direct access to the customers. They have to make the decisions for requirements selection according to market needs, feedback from previous releases, and market competitors. This characteristic makes the decision-making in market-driven projects more complicated.

This paper intends to examine the decision-making criteria for requirements selection in the software development process in international software companies in China. This research study is significant given that, to the best of our knowledge, there is no existing study that specifically focuses on decision-making criteria for requirements selection in software development in China. This article presents a two-phase Delphi survey, by which data is collected from 74 participants from 6 international software companies in China. The outcome shows that some criteria are and should be more important than others when making decisions about requirements selection. Moreover, it is believed that attaching more importance to some criteria in the future will contribute to the decision-making.

This paper is structured as follows. Section 2 covers related literature. The methodology applied in this study is presented in Section 3. Section 4 describes the major findings, followed by discussion in Section 5. Finally, the paper is concluded in Section 6.

2. LITERATURE REVIEW

2.1 Value-Based Requirements Engineering (VBRE)

Software development companies face incredible pressure under the present knowledge-based economic conditions. 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 tendency has led to the evolution of value-based requirements engineering (VBRE).

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*. 1998). With the value-based view, it is important for a software supplier to develop software that satisfies stakeholders' needs and expectations so as to gain a competitive advantage (Erdogmus *et al*. 2004). Theory W, which was proposed by Boehm and Ross (1989), suggests that satisfying all the stakeholders is the only way for a software project to be successful. Eliciting stakeholders' value propositions and then reconciling them into a mutually-agreed set is an integral element of VBRE (Boehm 2005). In essence, requirements engineering is the process of transforming stakeholders' needs into software requirements to be implemented in the software products. A requirements engineering process will directly or at least indirectly affect the value creation of organizations in which software is developed (Boehm and Sullivan 2000).

2.2 Requirements Selection

Requirements selection, as an important activity in requirements engineering process, is even highlighted by VBRE. Requirements prioritization and selection has become a powerful way of creating and controlling software value (Wohlin and Aurum 2005 B). It is important to discover which requirements should be implemented and which requirements could be postponed for later implementation or even rejected. However, the decision-making of requirements selection should be aligned with a company's business objectives (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) suggest that requirements selection decisions must be made according to value propositions of business-perspective stakeholders to ensure that the requirements are in line with the goals and strategies of the company.

Some studies have been conducted on requirements prioritization and selection, concerning approaches or mathematical methods for it. (Karlsson and Ryan 1997, Karlsson *et al*. 1998, Boehm *et al*. 2001, Halling *et al*. 2003，Ruhe *et al*. 2003). Wohlin and Aurum (2005A), Barney (2005), and Barney *et al*. (2006) have studied the decision-making criteria for requirements selection and value created in this process. They conclude that the business-perspective criteria, especially the external market of the software, were the most influential factors in selecting the requirements. This study has followed their steps to explore the decision-making criteria for requirements selection in international companies in China.

3. METHODOLOGY

3.1 Research Questions

The main objective of this study is to explore the decision-making criteria when adding value in requirements selection for market-driven software development projects in international companies in China. This paper examines the following research questions:

RQ1: Which criterion is more important for the decision-making of requirements selection in international companies in China?
RQ2: How does the practical importance of the criteria differ from the industry perception of the optimal application?

3.2 Development of requirements selection criteria

As an initial step, a list of decision-making criteria for software requirements selection has been 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, and Regnell *et al.*'s (2001) in requirements engineering. A summary of requirements selection criteria is listed in Table 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 was kept updated through empirical study according to these two principles.

Table 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 a customer's needs - 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 party responsible for issuing the requirement is taken into account – which stakeholder (internal or external) 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 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 to customers should be provided 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

3.3 Method and questionnaire design

A two-phase Delphi survey was conducted in the study: identifying the key decision-making criteria for requirements selection and ranking the criteria based on their relative importance. Two connected questionnaires were developed for the first-phase and second-phase Delphi survey respectively.

In the first questionnaire, the 14 criteria were listed with their explanations and motivations. The participants were asked to place a tick or cross before each criterion to show whether the criterion was relevant to their decision-making of requirements selection or not. In addition, the participants were encouraged to submit as many extra missing criteria as possible. The second questionnaire was developed for the second-phase Delphi survey, according to Wohlin and Aurum's (2005A) study. The criteria validated and updated by the first phase were listed in the table. The participants were asked to fill out two columns, 'today' and 'future'. In the two columns, the participants 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, 'today', asked about the way different criteria were valued practically, while the other, 'future', was what the participants thought it should be optimally.

3.4 Data collection process

The first questionnaire was delivered to the contact persons or the participants in 6 international companies in China. 74 responses were received from the 6 companies out of 92 questionnaires sent out. The participants covered the stakeholders from business, project, and product perspectives, including product manager, project manager, marketing analyst, senior consultant, and software developer. After getting the results of the first-phase survey, the second questionnaire was sent to the 74 first-phase participants by Email. In total, 72 responses were finally obtained. 2 participants decided to quit the study. The 6 recruited companies are international companies which develop software for worldwide customers. 2 of them are western-based software companies, while the other 4 are Chinese-based companies but in collaboration with foreign companies. All of them employ more than 2000 staff.

4. RESULTS

4.1 Relevant Criteria

According to the results of the first questionnaire, more than 80% of the participants regarded the following 5 criteria as relevant: 'business strategy' (criterion 1), 'customer satisfaction' (criterion 2), 'software features' (criterion 5), 'development cost' (criterion 6), and 'calendar time' (criterion 7). However, 'requirement's issuer' (criterion 4) was regarded as relevant by less than half participants. Thus, 'requirement's issuer' was removed from the list of criteria in the second questionnaire. The other 8 criteria were regarded as relevant by less than 80% but more than 68% participants. In addition, it was worth mentioning that several additional criteria were proposed by the participants, including 'total ownership cost', 'business model', and 'industry character'. However, the set of criteria identified by the researcher in advance was believed to cover these 3 additional criteria. None of them were added in the second questionnaire.

4.2 Practical Importance of Criteria

As mentioned in the questionnaire development, the assignment of points for the criteria was divided into 'today' and 'future' in the second questionnaire. This subsection presents the findings regarding the situation 'today'. (Before the analysis, where three participants failed to assign points to 1000, the values were scaled to 1000 by the researcher). According to 'today', the practical importance of each criterion was analyzed by taking the sum of the points provided by the participants and then normalizing the sum to a percentage figure (Figure 1). The list of criteria can be found in Table 1. Although 'requirement's issuer' (criterion 4) was removed from the list, the same number is applied to each criterion in the second questionnaire and its analysis to avoid confusion. The degree of importance in percentage terms reveals the proportion that the criteria contributed to the requirements selection decisions (Wohlin and Aurum 2005A).

The results indicated that some criteria were more important than others when practically making the decisions of requirements selection. The 3 most important criteria were (in order): 'business strategy' (criterion 1), 'customer satisfaction' (criterion 2), and 'software features' (criterion 5). The 3 criteria contributed more than 10% each to the practical decision-making. This indicated that the issues related to companies' strategy, customers, and features of the software were more important than others. On the other hand, 'extra cost' (criterion 8) and 'after-sale support' (criterion 10) were the least and second least important criteria with an importance degree below 5%. This showed that these 2 criteria did not contribute much to the decision-making.
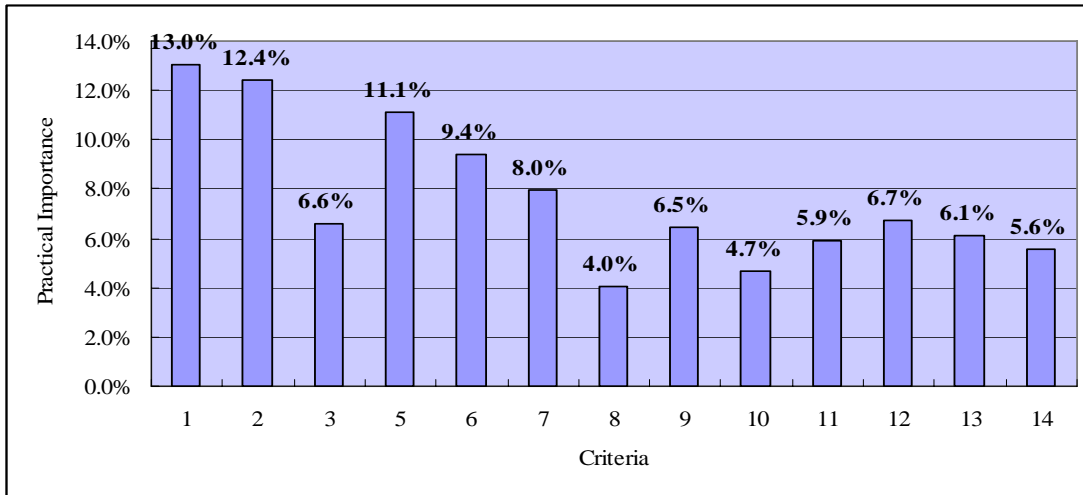
Figure 1: Practical importance of the criteria for requirements selection
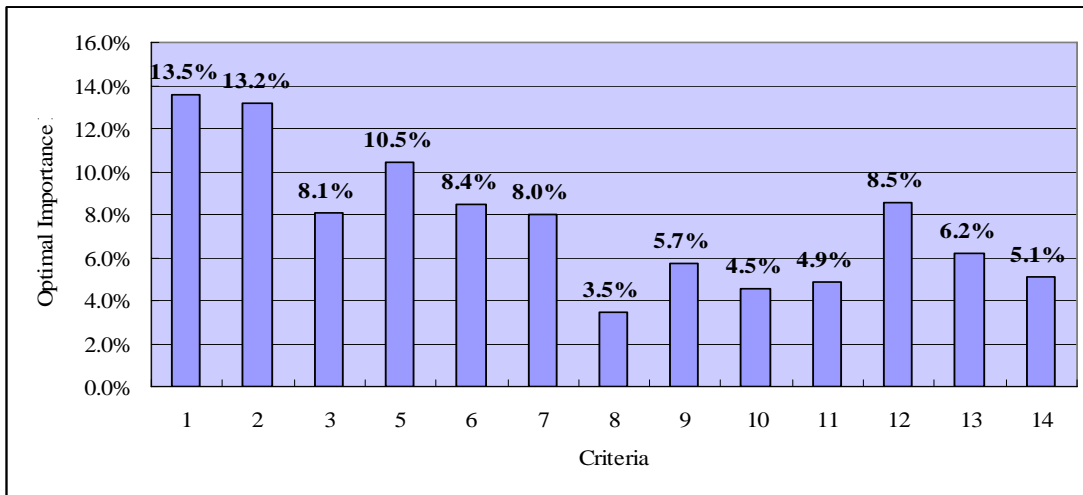

Figure 2: Optimal importance of the criteria for requirements selection

4.3 Optimal Importance of Criteria

A similar analysis was conducted for the 'future' situation. Figure 2 presents how the participants wanted to see the optimal application of the 13 criteria for requirements selection. The results implied that there was no major shift in priorities of the criteria between practical and optimal situation. The most and least important criteria that participants wanted to see in the future remained the same as the practical situation. However, the participants believed that 'competitors' (criterion 3) and 'evolution' (criterion 12) should be much more important to requirements selection in the future than the practical situation. This illustrated that participants thought more emphases should be put on 'competitors' and 'evolution' of the software. Meanwhile, the participants considered that 'development cost' (criterion 6), 'resources' (criterion 9), and 'complexity' (criterion 11) had been attached too much importance in practice. The participants believed that these shifts would contribute to better decision-making of requirements selection.

Wilcoxon tests were conducted for each criterion to further analyze what changes should be made in the future to be perceived as beneficial. A significance level of 0.05 was applied in the tests. The results suggested that there was a statistically significant difference between practical and optimal importance of 'competitors' (criterion 3), 'development cost' (criterion 6), 'resources' (criterion 9), 'complexity' (criterion 11), and 'evolution' (criterion 12). In other words, the participants considered that the 5 criteria should be optimally applied differently from the practical situation to be perceived as beneficial in requirements selection. The statistical analysis supported and validated the observed findings.

5. DISCUSSION

5.1 Relevant Criteria

It may seem surprising that more than half of the participants from the 6 companies considered 'requirement's issuer' (criterion 4) as irrelevant to their decision-making of requirements selection. This result was different with Wohlin and Aurum's (2005A) study and Barney's (2005) study, which conducted similar studies in Sweden, Germany and Australia. In their studies, more than 85% of the participants regarded this criterion as relevant.

A potential reason might be the typical character of the Chinese software industry, which is different from western countries. The software industry in China was still in its initial stage and the customers were not mature (Hale and Hale 2003). The customers were unaware of what they wanted before the development. In most cases, the issuer of the software requirement was the software developers themselves based on their past development experiences and the software features. In other words, the requirement was issued by the software development company instead of the important customers or market representative. Additionally, no matter which internal stakeholders generated the requirements, they all represented the company. Therefore, the 'requirement's issuer' was not taken into account when making the decisions.

5.2 Practical Importance of Criteria

It was expected that 'Business strategy' (criterion 1), 'customer satisfaction' (criterion 2), and 'software features' (criterion 5) would have the most significant influence on the requirements selection practically. A company would get competitive advantage only if it had value-based business strategy and was able to satisfy their customers (Ahmed and Yannou 2003). Besides, the feature of a software product was the foundation to satisfy the customers and follow the business strategy. However, it was surprising that 'competitor' was not regarded as very important. The result is different from Barney's (2005) study in Australia, which concluded that 'competitor' is the third most important criterion among the 14 criteria. The difference may result from the monopolistic competition market of the Chinese software industry. There were many software providers in the market, but their target customers and their products had large differentiation (Kshetri 2005). Thus, in practical situation, competitors had not been considered much. Additionally, 'extra cost' (criterion 8) and 'after-sale support' (criterion 10), which were the least and second least important criteria, are both related to issues after the purchase of the software product. The results indicated that the installing, training, or supporting of the software would rather be considered and provided later.

5.3 Optimal Importance of Criteria

The results implied that some changes of criteria's importance in the future would be perceived as beneficial. First of all, 'evolution' (criterion 12) should be much more important when making the decision of requirements selection in the optimal situation. However, the practical and optimal importance of 'evolution' almost remained the same in Wohlin and Aurum's (2005A) study and Barney's (2005) study. 'Evolution' determined the future of the software, and in turn the future of the company. The stakeholders in China had realized that these issues should be considered at the requirements selection stage so as to lighten the pressure on the latter process. Therefore, long-term evolution should occupy a crucial position in the decision-making process of requirements selection. Moreover, participants believed that 'development cost' (criterion 6), 'resources' (criterion 9), and 'complexity' (criterion 11) should be less important to requirements selection optimally. This could be expected, because more standard and common development tools would be applied in software development, which made cost, resources, and complexity less important.

5.4 Validity threats

The following presents the validity threats to the findings, considering 4 kinds of validity, including conclusion validity, internal validity, construct validity, and external validity.

- **Conclusion validity:** the data size was relatively large in this study, which would contribute to the conclusion validity of the study. Nonetheless, the participants of this study came from different working positions. It would lead to better conclusion validity if participants of the same role were recruited.

- **Internal validity:** potential threats to internal validity were related to the questionnaires. It was always difficult to know whether the participants had understood the questions as intended and whether the participants had a similar conception of '1000' to each other.

- **Construct validity:** there are some potential threats to the construct validity. It was easier for the participants to agree with the set of criteria identified by the researcher in advance than disagree, because they knew that the criteria on the list indicated that the researcher considered them as relevant. In addition, it

was easier to stick to the stated criteria than proposing new criteria. No new criteria were added to the second questionnaire. This meant that important criteria might be missing.

- **External validity:** the 6 companies were all international companies in China; the 6 companies all had more than 2000 employees; and this study focused on market-driven software development projects only. It is not a representative sample of the Chinese software industry. Caution should be taken when generalizing the results obtained from this study away from the characteristics of the companies and projects.

6. CONCLUSIONS

The study indicated that 'business strategy', 'customer satisfaction', and 'software features' were and should be more important than other criteria when making the decisions of requirements selection in international companies in China. Moreover, the study has shown that stakeholders believed that some changes in the future regarding the importance of the criteria would obtain more benefits. However, the typical character of the Chinese software industry made the results different from similar studies in other countries e.g. Sweden, Germany and Australia (Barney 2005, Barney *et al.* 2006, Wohlin and Aurum 2005A). 'Requirement's issuer' was regarded as irrelevant to the decision-making of requirements selection because of customers' immaturity. Meanwhile, the monopolistic competition environment meant that not much importance was attached to the 'competitors'.

The study provided an overall picture of how the decisions were made of requirements selection in international companies in China. It can be seen as a foundation for understanding and improving the decision-making process. Additionally, the list of criteria could provide a comprehensive checklist to support the decision-making process of requirements selection in the best possible way. The following presents several suggestions to software developers in China when making the decisions for requirements selection as a conclusion of the paper:

- Decisions of requirements selection should be made according to value propositions of stakeholders from different perspectives.
- Business strategy and customers' satisfaction should be the major concerns when making the decisions.
- Competitors of the company and the evolution of the software should be considered when making the decisions.
- Installing, training, and supporting of the software could be considered and provided in the later stage of the development process.

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