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Supplier Selection Based On AHP Method

- Supplier from China for Suomen Koristetuonti

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As international purchasing becomes a common practice and markets increasingly competitive, supplier selection – as an important part of purchasing process and supply chain management – evolves to be more complex and attention-catching. Especially, supplier selection assumes a strategic role in determining the success of a start-up company.

Due to its growing importance, supplier selection has gained much attention in research and studies. Many evaluation and selection methods have evolved over the last two decades and the Analytic Hierarchy Process (AHP) as one of the most prominent methods.

This paper was commissioned by the company, Suomen koristetuonti, to find a best suitable supplier in China. The case company is a newly established home decor company based in Espoo, Finland. It intends to import wall stickers from a Chinese supplier to Finland for their more competitive and versatile offerings.

Through online supplier search engine, alibaba.com, and pre-filtering method, the author located 7 possible Chinese suppliers. Their detailed information was then gathered through online questionnaire survey and was analysed via the AHP approach.

In this paper, the author found the most suitable supplier for the case company via considerately selected evaluation criteria and successfully implemented AHP analysis. A standard four-step supplier search and selection procedure was developed in the case studies.

The thesis serves as an example of utilizing the AHP approach in evaluating suppliers in China. It was directed in Finnish context which might be of good value for companies that are interested in expanding or shifting their supply source(s) to low-cost countries.

Keywords	Purchasing, supplier selection, China, AHP

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1 Introduction

As globalization and internationalization progress, low cost countries become attractive and accessible sources of supply. Finland is an active trading economy supporting its large manufacturing sector with a variety of imported goods including foodstuffs, petroleum, machinery and textiles. In addition, the Finnish retail sector is highly import dependent and relies on connections to central Europe and Asia – China being one of the largest sources of imported goods (EconomyWatch, 2010).

In the modern business scenario, the complex international business environment lifts purchasing department's strategic weight to a company's competitiveness and profitability. As a mark of successful purchasing, selecting reliable suppliers usually means lower risk, higher profit margin, and happier customers. However, a supplier who is perfect for one company is not necessarily a suitable choice for another. The compatibility of the company profile and business needs between the purchasing company and the supplier is a decisive factor in a successful supply relationship.

Supplier selection is usually a complex multi-criteria problem involving both qualitative and quantitative elements. There is no one proven best method in evaluating and selecting suppliers and companies deploy a variety of different approaches. Choosing the best supplier should meet the goal of receiving the right quantity on the right time with the right cost.

The Analytic Hierarchy Process (AHP) is a prominent approach in multi-criteria decision making problems; and in practice it has found widespread application in supplier evaluation and selection problems, alone or in combination with another tool. (Chai, Liu and Ngai, 2013) Therefore, an AHP supplier selection model was drafted by the author and then applied in the supplier selection process for the case company, Suomen koristetuonti.

1.1 Objectives

Suomen koristetuonti, established in the early 2013, is a startup company in Finland dealing in design home decoration items. Sourcing from China is a crucial part to Suomen koristetuonti's competitiveness and differentiation.

In 2012, the popularity of wall stickers in Asia and the lack of similar offerings with competitive prices in Finland have raised the interests of the company to research into importing wall stickers from China to Finland.

This paper was commissioned by the co-founder of the company to explore the supply sources of wall stickers in China and to propose the final supplier selection. Furthermore, this project aimed to establish a standard supplier selection process for the case company.

In establishing a home decor entrepreneurship in Finland through sourcing from China, finding the suitable Chinese supplier and establishing a reliable supply partnership are the cornerstones contributing to the success of the case company in the present study. This study concentrated on exploring the evaluation criteria for selecting Chinese suppliers and implementing analytic hierarchy process (AHP) approach in the supplier selection process for the case company.

This study is an implementation example for the AHP approach in selecting Chinese suppliers. The supplier evaluation criteria and their priorities identified by this paper might be of good reference for business practices or future studies.

The paper also serves as an example of expanding product selections in Finland through importation from low-cost countries. Another contribution of this research is that it focuses on a small company operating in Finland – comparing to vast researches done on multinational companies under the American context. The information content can be of good value to any student or future entrepreneur looking for material concerning importing businesses between Asia and Finland.

1.2 Research problems

The research questions aim to find out and present the possible choices for Suomen koristetuonti to procure wall stickers from supplier in China. The following questions help to formulate clear and comprehensive understanding of importing business:

How to find a suitable supplier in China?

This question tries to find existing search channels which are viable and effective to look for potential Chinese suppliers. Especially for the case company, it is relevant to understand what channel(s) would be the most efficient and low cost to form a list of potential suppliers in China.

What criteria are important in evaluating Chinese suppliers?

As the complexity of evaluating suppliers increases when purchasing across borders, answering this question is an essential step in selecting suitable evaluation criteria that suit the features of importation and the sourcing market, as well as the needs of the case company.

Is AHP approach a viable solution for the case company in selecting a suitable Chinese supplier?

AHP approach is a widely deployed method in multi-criteria decision making. It is also a recognized tool in evaluating suppliers. In implementing AHP approach to selecting suitable Chinese supplier for the case company, the author tries to have a better understanding of the tool and to prove its usefulness for the case company. In the end, the author would propose the final selection if the AHP approach was successfully applied during the process.

1.3 Methodology

This section introduces the research methods deployed in this study. It includes two main parts: data gathering methods and data analysis methods. In the end of this section, the structure of this paper is also presented.

1.3.1 Data gathering methods

The paper firstly used online search engine – alibaba.com – to build a long list of potential suppliers matching basic requirements. Then pre-filters, which were defined by the author, were used to locate most potential supplier candidates – which in this case was 7 suppliers. The filtering process will be explained in the case studies.

This research utilized a questionnaire survey to gather primary data for analysis. The questionnaire was distributed to the 7 individual suppliers in China through emails to supply companies' contact person. Online questionnaire survey is quick and low cost which suited the case background and the author's objectives.

The author prepared the questions on the questionnaire with regard to selected supplier evaluation criteria and sub-criteria which will be discussed in Chapter 4. The original questionnaire was in Chinese and the translated English version is shown in Appendix 2.

The questionnaire consisted of four parts: 1) general information – contact information; 2) business information – company profile and management; 3) production information – production capabilities and machineries and customization capability; and 4) product specifications – price, variety and quality features.

The questionnaire design included fill-in questions, click boxes and open-ended questions receiving both qualitative and quantitative answers. With a 100% response rate, the findings were considered a meaningful material for comparing and selecting the best supplier for the case company.

The secondary data were gathered through data mining which involved the search for published data from reliable sources including published literature and electronic research papers, journals and articles. For the case studies, the author also deployed information from reliable websites, such as supplier companies' website and the Internet supplier search engine – alibaba.com. Detailed explanations will be presented in the case study chapter.

1.3.2 Data analysis methods

The author used the Analytical Hierarchy Process (AHP) tool for a multivariate analysis of collected data. As supplier selection is a multi-criteria decision making problem which naturally needs a method that can analyze multiple measurements including both qualitative and quantitative information. The AHP method's widespread usage in supplier evaluation and its effectiveness meet the data analysis requirements.

The AHP method deploys a pair-wise comparison matrix to interpret and measure qualitative data. In the same process, qualitative data is transferred to quantitative figures through computations. The final results of the AHP tool implementation are presented in quantitative form and could be easily interpreted by the ranking of total scores.

The paper is organized in 5 chapters. The start chapter of the paper presents the reader with the purpose and value of this research as well as the methodologies used to resolve the set research questions. In the second chapter, the paper explores relevant literature on international purchasing with a focus on the Chinese market. The paper proceeds by presenting a literature review on supplier selection criteria and AHP selection approach in Chapter 3. Chapter 4 demonstrates the supplier selection process and actual findings of the case company through applying the theoretical framework. The final conclusions of this research and recommendations are discussed in Chapter 5.

1.4 Limitations

The major limitation of this study is that it is a case study within home decor industry; therefore the results may not be applied to supplier selection process in other industries. As the case company is a small startup company and is considering single sourcing, the results found in the study may not be directly applied to multinational companies with multiple sourcing needs.

The data gathered for the case studies were from potential suppliers with no audits. Although some companies provided certificate copies and facility pictures, other information, such as financials, could not be confirmed. There was almost non-existent officially published information of supplier companies, as they were private limited companies and small or medium in size.

Another limitation was the size of sample suppliers. Due to time limitation, only 7 potential suppliers were selected to distribute the questionnaire and to discuss the possible partnership further. Although the potential suppliers were carefully selected on the biggest Chinese supplier marketplace – alibaba.com, suppliers who are not registered on this website were not taken into consideration. Though the project has successfully implemented AHP approach in the supplier selection process and proposed the final best choice, there still might be better choices outside the candidate pool.

There are also limitations of the AHP method. For example, as cited in professor Min's work (1994), "AHP cannot effectively take into account risk and uncertainty in assessing the supplier's potential performance because AHP presumes that the relative importance of attributes affecting the supplier's performance is known with certainty." Another limitation is the limited expertise of the author in applying AHP approach as it desires expert judgments in its pair-wise comparison process.

Despite the limitations, this study would provide valuable and practical information for Finnish companies who are already doing business with Chinese suppliers or are considering starting sourcing activities in China.

2 International purchasing from China

2.1 The role of international purchasing

Companies are profit focused. Traditionally, managers have given strong emphasis to sales revenue – the incoming money. Nowadays, due to fierce competition, increasing price has become a difficult strategic choice. Consequently, growing emphasis has been given to the cost – the outgoing money. Naturally, purchasing as the largest expenses to a company has been receiving an increasingly amount of attention and effort.

The terms international sourcing and international purchasing are often used interchangeably. According to Nassimbeni and Sartor (2006: 32), the expression 'international sourcing' refers to the purchase of materials, components, and finished products from suppliers across international boundaries.

International sourcing has been gaining increasing popularity. Global market interdependence, advanced communication technology, developed transportation models, and gradually harmonized trading practices have all favored global procurement.

International purchasing could assist companies to explore more business opportunities and to create and sustain market competitiveness. The companies sourcing outside the domestic market often grasp a wider product selection, improved product quality, reduced costs and increased profit margin. On the other hand, risks and uncertainties rise due to the same cause. Table 1 demonstrates the general advantages and disadvantages of international sourcing.

Table 1 International Perspective: Advantages and Disadvantages of Outsourcing (Seyoum, 2009: 414-416)

Advantages and Disadvantages of Outsourcing	
Advantages	**Disadvantages**
1. Lower price	1. Difficulty in evaluating and selecting qualifies suppliers
2. Higher-quality products (qualified suppliers)	2. Potential problems with quality and delivery times
3. Supply of products not available domestically	3. Political and labor problems
4. Advanced technology available from foreign sources	4. paperwork and extra documentation a well as added costs such as freight, insurance import duties, cost of letter of credit, travel, marketing, etc.
5. Safety countertrade obligations	5. Currency fluctuations and payment problems
6. Improve international competitiveness	6. Harder to quickly respond to market changes

To give a good summary, as said by Mr. Branch (2009: 58), a senior professor and consultant, "Global sourcing is not simply a buying function; it is the process of obtaining a product/service in line with consumer needs and technology, thereby enhancing the attraction, the profile, the quality or the value-added benefit".

2.2 Why Choose China as the Sourcing Market?

From the last decade until now, how to buy in China has become a hot topic for companies of all sizes around the world. It has been a crucial strategic consideration for the profitability as well as survival of a company.

Why China? For the last decades, China has become the world workshop mainly due to its low manufacturing expenses, especially a vast labour force with low compensation costs. As mentioned in the earlier section, tapping the cost reduction potential of low cost countries – China among the top selections – is the single most important goal of purchasing globally.

While material costs are often relatively the same in different countries, it is the labour cost that makes the major difference in manufacturing costs (Branch, 2009). To illustrate this fact, Figure 1 showed total hourly compensation cost differences in various economies.

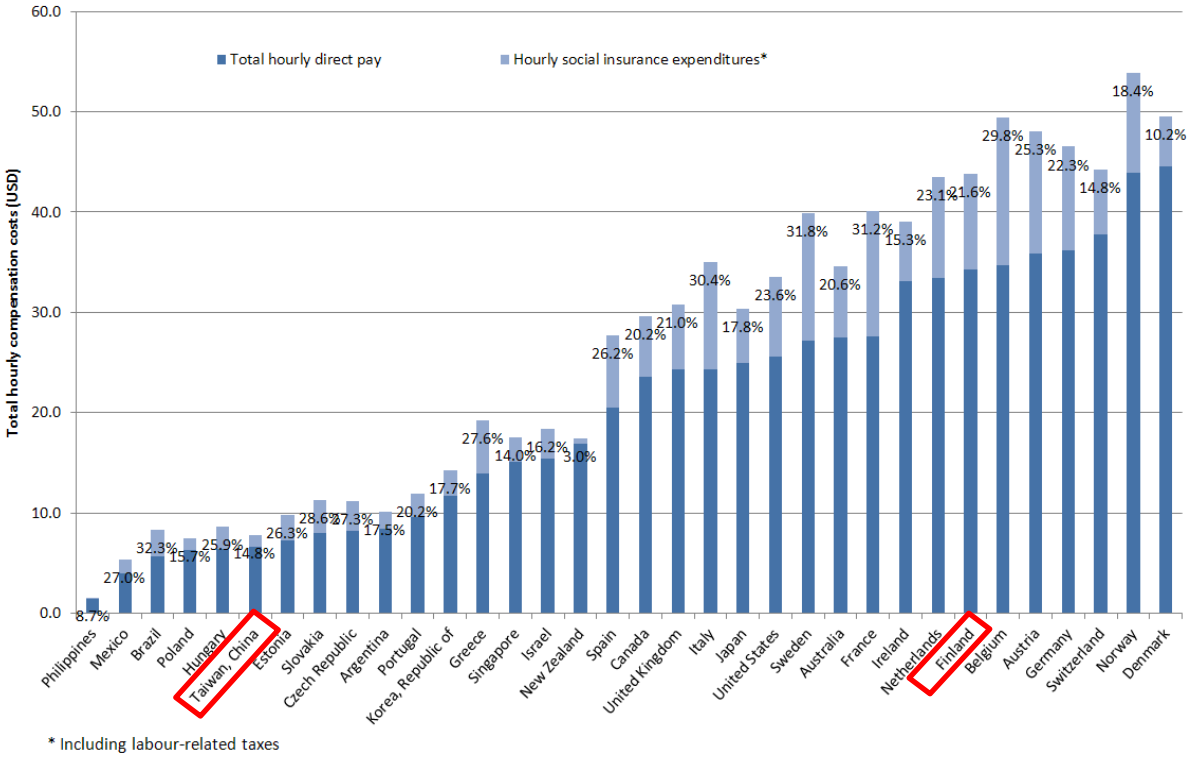

Figure 1 Hourly compensation costs of all employees in manufacturing, by total hourly direct pay and hourly social insurance expenditures (including labour-related taxes), 2009[1] (International Labour Organization, 2011)

According to this figure, in 2009, while the hourly labour cost was less than 10 USD in China, it was over 40 USD in Finland. This big gap in labour compensation costs has contributed to the large movements of manufacturing activities from domestic markets to China.

Although, it can be deduced from the same figure that there are countries offering cheaper labour costs than China, many other factors in those developing countries signal too much uncertainties and obstacles. Foremost, insufficient infrastructure, unsta-

[1] The percentages shown in the bars are the share of social insurance expenditures in total compensation costs.

ble political environment, low technology capability, and underdeveloped supply chain make choosing those countries an expensive and hard work.

PEST analysis, sometimes referring to PESTLE, stands for political, economic, social and technological environment analysis. It is an effective tool for evaluating foreign market macro-environment that has been widely utilized in company practices as well as research projects. (PESTLE Analysis, 2013) For a better understanding of the Chinese market environment, the author drafted the PEST analysis of China:

Political environment

For the recent decade, China has experienced a rather stable political environment. The new successive political leaders claim to political and market reforms for a more open China. The government has a receiving attitude toward foreign companies and investments; however, the continuous high level of corruption and low level of transparency have created many obstacles. Recent legislative changes in environmental protection and employment have planted much uncertainty of their long-term influences on business operations in China.

Economic environment

China's economy has continuously experienced startling GDP growth before the recent global financial crisis. Although the recent crisis has slowed down China's growth, China still embraces the highest economic growth rate around the world. Its growing middle level social group has been developing an ever more strong domestic market which attracts many foreign investors and companies. China is the largest exporting country in the world.

China has been advocating a more open economy by creating free trade zones and special trading regions, joining trade agreements, reducing state-owned enterprises, and offering tax incentives. Good amount of foreign investments, established diverse industry clusters, functioning infrastructure around busy economic areas, and a huge pool of cheap labor force are favoring the growth of this big economy.

However, still immature market regulation and practices, low ethical standards companies offering unqualified or even dangerous products, lack of internationally experienced and capable labour force, and shockingly uneven income distribution are pressing factors threatening its economic future prospect.

Social environment

Language and cultural differences are obstacles to doing busines in China. While Mandarin is the official language of the country, every region has their own local dialect which is even undistinguishable from each other. Business cultures are also different than in the Western countries as relationship counts the most and there is little separation between work and life.

The huge population in China provides a great source of labor force. However, aging population is becoming a pressure to the whole nation. The social welfare system is far from adequate to serve the huge population, especially the elderly groups. Another factor impeding the labor force development is the big discrimination against women in the workplace. The big income gap between the poor and the rich also creates instability in the society.

Technological environment

The Chinese government has been spending vast money on building up infrastructure to speed economic growth. Through countertrade and collaborations with Western companies, advanced technologies and experiences have been flowing to China. China has also shifted much attention on R&D. It is expected to increase 11.6% of its R&D expenses this year, while the global R&D projection is 3.7%. (Naik, 2012)

China also has a strong focus on energy efficiency development due to its vast population and industrial needs. Moreover, many technologically advanced multinational companies have established or are planning to open manufacturing and research facilities in China.

Even though there are many threats and difficulties existing, China presents a good choice for its vast opportunities and possibilities.

2.3 Sourcing practices in China

As summarized by professor Nassimbeni and Sarto (2006: 72-86) with a sample of Italian companies having sourcing activities in China, there are three main types of sourcing existing in China: imposed international sourcing, intermediated international sourcing, and direct international sourcing.

The presence of these three distinguishable types is caused by China's considerably different market conditions comparing to Western countries. In China, based on diverse purchasing code, industry, and company profile, there were different governmental intervention and limitations, types of intermediate third parties, existing agreements between countries, etc.

Imposed sourcing is literally another word for countertrade. Foreign companies operating in those 'strategic' industries, as described in the Chinese legislation, have to source from local alternatives in order to sell their products in the Chinese market. These industries are generally described as of high importance to the nation or local economy. Not only for the protection purpose, it is also a strategic consideration for China to absorb good practices and technologies from Western companies. However, some Western companies also use this form of sourcing to increase their local presence, to reduce bureaucratic obstacles, and to gain tax incentives.

When using a third party to meet the needs between the buyer and the supplier, it is called intermediated sourcing. The third party's services can include analysing products/services, finding suitable suppliers, inspecting supply quality, drafting agreements, contracting carriers, and the actual buying-selling activity. It is the simplest way to purchase in China, but with the least control and little experience and knowledge gained by the buying company.

Another most common sourcing type is direct souring. It is where the buyer and the seller making deals directly with each other without any authority constraints. When

the buyer only has contract manufacturing with the supplier, it can be called ‘pure’ direct sourcing. On the other hand, the buy and the supplier may have collaborative activities in their partnership, such as joint product development and logistics. Deeper commitment to collaboration might result in joint ventures or even wholly foreign-owned enterprises.

3 Supplier selection

Supplier selection is one of the most important components of purchasing and supply chain management for many companies. Supplier selection is of particular importance if companies spend a high portion of capital on supply and supply costs count a significant part of the total cost.

Selecting proper suppliers, especially in an international market, significantly reduces costs and increases competitiveness – if the selection was wrong, it may result in long-lasting litigation, low quality products/services, delivery delays, product shortage, currency fluctuation, etc. While choosing the right supplier(s) could improve companies' global competitiveness through reduced lead time, lower costs, reduced risks, improved products, and satisfied customers.

3.1 Supplier selection process

Based on a research project of a sample of German companies having sourcing experiences in China, a practical supplier search process (Figure 2) was summarized by Professor Hedderich et al. (2006).

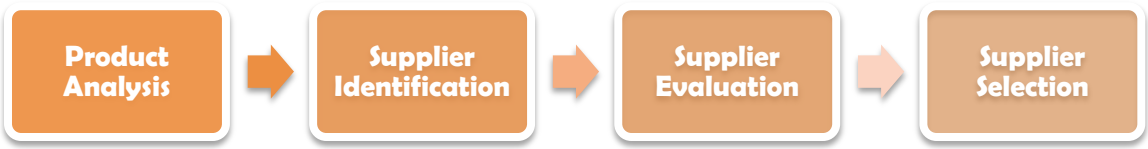

Figure 2 Supplier selection process (Hedderich et al., 2006)

Step 1: Product Analysis

According to Hedderich et al. 2006, "carefully analysing sourcing needs and selecting appropriate items for purchasing in China are indispensable first steps." Analysing the product contents as well as the competitors' offerings within the same industry are included in the process. A product content analysis usually includes: labour content, cost saving potential, purchase volume, demand pattern, and product.

Step 2: Supplier Identification

Researching the most suitable suppliers is part of the company's international purchasing strategy embraced with its global strategic supply chain management. Professor Branch (2009: 89) said, "This process shall utilize all means available, including trade directories, trade associations, trade exhibitions, logistic operators and cyberspace (i.e. the Internet)".

Purchasing in foreign countries is usually a complex process. Gathering reliable information is a good start leading to success. The company shall make a long list of potential suppliers through available searching channels:

1) Mouth-to-mouth experience. Meaning the valuable information you can obtain from your relatives, friends, colleagues, logistics operators or even competitors who have related experiences.
2) Trade exhibitions and fairs. This channel offers a great opportunity to communicate with various suppliers and to compare their offerings. However, it is not a time-efficient channel since they happen so rarely, especially with your product specification.
3) Trade directories.
4) Professional trade associations.
5) Foreign embassies.
6) Local Department of Commerce. It usually maintains up-to-date lists of names and addresses of foreign companies under specific product catalogues.
7) The foreign trade department of major banks. They have great collections of business data in the countries they serve. They will also offer practical information on local customs and procedures.
8) The Internet search engines. Local websites or international websites that provide supplier information.

As provided by Hedderich et al. (2006), some specific sources for prior research of potential Chinese suppliers are demonstrated in Figure 3:

Figure 3 Information Sources for Supplier Identification (Hedderich et al., 2006)

Step 3: Supplier Evaluation

This is the step to shorten the long list of potential suppliers based on information collected and interactions with those suppliers. During this process, companies can filter suppliers through analysing published information, contacting suppliers through phone interviews or mail/email questionnaires, requesting product samples, and/or visiting suppliers' facilities.

It is an important phase for buyers and suppliers to develop more interests toward each other and to have a more realistic picture a possible long-term business relationship.

Step 4: Supplier Selection

The final step is to make the selection decision based on the data collected and audited during the supplier evaluation process. Both selecting the evaluation criteria and implementing an effective selection method are crucial parts in successfully choosing appropriate suppliers. More detailed literature reviews on evaluation criteria and methods will be discussed in the next sub-sections.

3.2 Supplier selection criteria

Supplier selection usually needs more than one evaluation criteria. Individual suppliers commonly have different performance for different criteria.

Throughout the past decades, supplier evaluation criteria embraces increasingly complex factors: price, quality, delivery, service, capacity, financial performance, communication systems, geographic location, historical supplier performance, and perceived risks including environmental, social, economic and political. Moreover, many criteria are in conflict with one another. For example, overseas supply might bring down costs because of cheap local labor, but perceived risks will rise due to increased uncertainties and loose control. Technologically advanced suppliers offer quality products, but it might mean high purchasing costs.

Supplier selection criteria have been studied and mentioned in many literatures, which is not surprising considering its importance. The mostly suggested criteria are: price, quality, delivery, location, past performance, technical, financial, managerial, and facilities. For cross border purchase, factors as perceived risks, trade restrictions, cultural and communication barriers should also be taken into considerations. (Seyoum, 2009: 407-423)

- *Price*: traditionally, this single factor decides the sourcing activities. It includes purchase price, delivery cost, taxes, and if cross borders, customs and administrative expenses.
- *Quality*: the supplier shall be able to provide certain quality certificates, such as ISO certificate. For different industries and product specifications, there are various certificates necessary for supplying the product. Quality criterion also includes raw material and production machineries. The supplier shall also have the technical capability to control quality levels and overall product performance.
- *Financials*: supplier's financial healthiness will have impact on long-term stability, in-time and continuous supply, quality, and their terms on payment and delivery methods. Different payment terms and delivery terms offered by the supplier will have a big influence on the purchasing activities' financial conditions.

- *Technical*: supplier shall demonstrate a high level of technical capability and investment in R&D and product development.
- *Perceived risks*: includes political, economic, social and legal environmental instabilities, floating exchange rates, and transportation.
- *Trade restrictions*: tariff and non-tariff barriers, countertrade requirements by supplier or sourcing country.
- *Cultural and communication*: the differences in language, business customs, ethical standards, communication styles and channels all create barriers for smooth international purchasing practices.

As selection criteria and their importance level are country specific, there was a valuable research project, done by Nassimbeni and Sarto on a sample of 15 Italian companies having purchasing activities in China, offering great insights of the importance of different criteria in sourcing in China. The sample companies are scattered in various industries. The valuation of criteria used a 5-point Likert scale (1 = not important … 5 = very important). (The research result is shown in Table 2)

Table 2 Average Valuation of The Suppliers' Selection Criteria in China (Nassimbeni and Sarto, 2006: 89)

Factor	**Average valuation**
Quality	4.8
Price	4.2
Vendor's financial solidity	3.8
Delivery punctuality, timeliness, and completeness	3.5
Know-how and product uniqueness	3.3
Research and technological development capability	3.0
Access to advanced technologies	3.0
Product mix	2.8
Terms of payment	2.7
Relations consolidated over time	2.5
Geographic location	2.3
Post-sale services	2.3
Certifications from recognized institutions	1.7
References	1.3

As can be seen the table, quality criterion was considered to be the most important factor with a 4.8 score that is rather high than the second important factor – price. The

following important factors are financial solidity, delivery performance, and product offering with rather close scoring.

3.2 Supplier selection: the Analytic Hierarchy Process (AHP) approach

Selecting suitable suppliers is the cornerstone of successful purchasing. However, identifying suitable suppliers is not an easy task. One can argue that it is extremely difficult for any single supplier to excel in all criteria. An actual choice of supplier unavoidable involves trade-off among the attribute levels of different suppliers (Verma and Pullman 1998). Therefore, establishing objective methods of supplier selection will build up companies' effective procurement process.

As stated in many relevant literature reviews (for example, Min 1994, Karande and Chakraborty 2012), supplier selection methods have been evolved with time and conditional changes: from using price as the single criterion to Multi-Criteria Decision-Making (MCDM), weighted-total method, matrix approach, vendor profile analysis (VPA), analytic hierarchy process (AHP), and multiple objective programming (MOP) such as goal programming. Unfortunately, most literature on supplier selection is within domestic market. Many researches on international supplier selection are a mere enhancement from the domestic methods with added influential criteria.

Professor Asamoah and et. (2012) stated that, from 2000 to 2011, researchers, after studied sixty articles from various journals and conferences, found that the most widely applied method in supplier selection was data envelopment analysis (DEA), but they recommended using AHP to effectively cope supplier selection problems in the future. As said by Vijayvargiya and Dey (2010), "rather than prescribing a "correct" decision, the AHP helps the decision makers find the one that best suits their needs."

"Analytic Hierarchy Process is one of the most widely used multiple criteria decision-making tools". (Tahriri & et. 2008) The AHP method made it possible to weight both qualitative and quantitative data in the supplier evaluation process. It, as well, makes informed conclusions based on incorporated subjective judgments of experienced purchasing managers and/or experts and objective data collected.

The main features of AHP method can be summarized as follow:

1) Creating a hierarchy reflecting the selection problem, including the goal, the evaluation criteria and sub-criteria, and the alternatives.
2) Giving preference values to the elements of the hierarchy based on expert judgments through pair-wise comparisons. Then the overall priorities for each alternative can be calculated.
3) Checking the consistency ratio of every pair-wise comparison to check the consistency of the subjective judgments.

AHP starts with choosing a few main evaluation criteria groups. Then it extends the main criteria into sub criteria. The evaluation begins with ranking criteria based on their importance level through pair-wise comparison of the alternatives. AHP met the need to accommodate preference differences between criteria.

Based on Tahriri's et al. research paper (2008), there are six major steps in implementing AHP in supplier selection process:

Step 1: Define criteria for supplier selection

It is very important to decide evaluation criteria in the first stage. It is the starting point to structure interviews, questionnaires, and audits. It is also important in sorting and grouping information under each criterion for later evaluation.

Step 2: Define sub criteria and sub sub-criteria for supplier selection

Sub criteria and sub sub-criteria shall be defined under each main criterion. They are selected for more detailed weighing of main criteria to generate a more comprehensive supplier evaluation.

Step 3: Structure the hierarchical model

This is the phase to construct the analytic hierarchical tree and to make preference judgments through pair-wise comparisons. The hierarchical model usually has five lev-

els from top to down: the goal, the criteria, sub-criteria, sub sub-criteria, and supplier alternatives.

In AHP, it uses pair-wise comparisons to determine preferences between alternatives. It is to compare two elements at a time. This method tries to construct the relative importance matrix of the various criteria using the nine-point scale developed by Saaty. (As demonstrated in Table 3)

Table 3 The AHP Pair-Wise Comparison Measurement Scales Between Two Elements (Tahriri & et., 2008; developed by Saaty)

Intensity of importance	**Definition**	**Explanation**
9	Extreme importance	The evidence favouring one element over another is of the highest possible order of affirmation
7	Very strong importance	One element is favoured very strongly over another
5	Strong importance	Experience and judgement strongly favour one element over another
3	Moderate importance	Experience and judgement slightly favour one element over another
1	Equal importance	Two elements contribute equally to the objective
2, 4, 6, and 8	Intermediate values between two adjacent judgments (when compromise is needed)	

After constructing the pair-wise comparison matrix and making the normalization computation to form the matrix elements onto a common scale, you can obtain the priority ranking of the criteria through calculating row averages.

Meanwhile, doing a consistency check is an essential step of implementing the AHP method. It verifies the consistency, thus the acceptance, of priority judgments. It measures how consistent the judgments have been comparing to large samples of purely random judgments.

The consistency ratio (CR) computation formula is: CR = Consistency Index (CI) / Random Consistency Index (RI). As $A_x = \lambda_{max}X$, where A is denoted as the pair-wise comparison matrix and X as row averages, CI can be calculated by:

$$\mathrm{CI} = (\lambda_{max} - \mathrm{n}) \,/\, (n-1) \qquad (n \text{ represents the number of criteria})$$

Then the corresponding value of RI is found in the Saaty's table below: (Table 4)

Table 4 Average Random Consistency: The Reference Values of RI for Different Matrix Sizes (Alsuwehri, 2011; developed by Saaty)

Size of Matrix	1	2	3	4	5	6	7	8	9	10
Random Consistency	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49

Using the responding RI found in the above table, we can receive the consistency ratio CR = CI/RI. If the CR value is less than 0,1, then we say the judgments are consistent and acceptable. (Asamoah et al, 2012)

Step 4: Prioritize the order of criteria or sub criteria

Having completed the calculative comparisons, this step will rank the criteria according their preference values to give a better grasp of evaluation emphasis.

Step 5: Measure supplier performance

This phase is to implement the evaluation model to assess every supplier's performance under each criterion. A total score of each supplier will be generated through adding up the weighted scores – multiplied preference values with scores – with respect to criteria.

Step 6: Identify supplier priority and selection

Last step is to rank the overall supplier performance based on the mathematical results – the overall weighted score for each supplier. Through ranking, the supplier with the

best score will be chosen as the suitable supplier as it should have a compelling performance level comparing to all alternatives and satisfy all the goals and objectives of the company.

The Tahriri model gives a clear instruction on how to deploy the AHP approach for a company supplier selection project. This relatively complex approach, which combines much mathematical calculations and experienced judgments, should be a good assistance in finding the right supplier(s).

4 Case studies: Chinese supplier selection for Suomen koristetuonti

Wall stickers are an affordable, self-manageable and artistic way to radically enhance home appearance. The case company was impressed by the popularity of wall stickers in the Asian countries, especially in China. When researching on this product category, the prices in Finland could be as much as 30 times more expensive than similar offerings in China. Aroused by this interesting business idea and the lack of competitive offerings in Finland, the case company intends to import wall stickers from China to sell in home markets.

Based on the theoretical framework discussed in Chapter 3, the author has drafted a modified supplier search process for the case company according to its situation and features: (Figure 4)

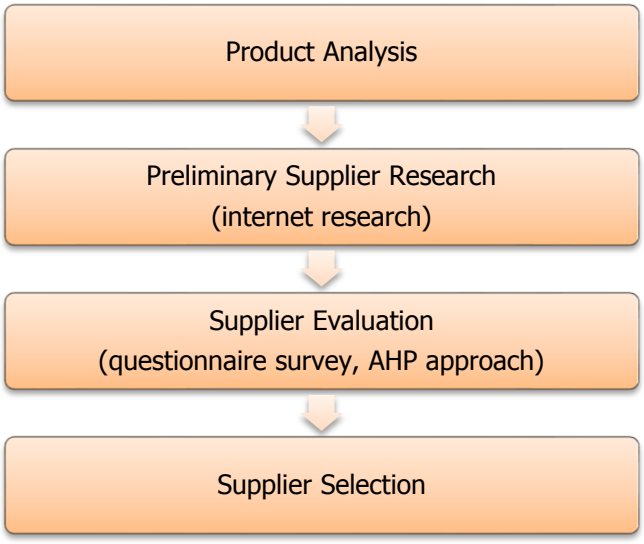

Figure 4 Adjusted Supplier Selection Process Framework for Suomen koristetuonti

The process still started with a product analysis and proceeded with supplier identification. However, due to time and budget limitations, the case company could not afford to have supplier visits or to examine product samples (it might take more than 20 days to receive samples).

Instead, during the supplier evaluation phase, the author used a questionnaire survey to collect data from potential suppliers and implemented AHP approach to make analy-

sis of the data based on carefully selected evaluation criteria. The last phase was to make an application of the evaluation results and to select the appropriate supplier for the case company.

4.1 Product Analysis

Wall stickers are becoming more attractive choices substituting traditional wall papers and hand-painted wall murals. Wall stickers embrace several distinctive features: inexpensive, easy-to-use, removable without damaging walls, environmentally friendly, wide selection, and fashionable.

However, based on differences in raw material, painting and cutting equipment, existing wall sticker products have big quality gaps. Securing imported product quality is a big focus in the purchasing practice. According to the case company requirements, imported products should feature trendy design, eco-friendly and removable. Several certificates and machineries are important in judging wall sticker quality, such as EN71[2] and SGS[3].

For wall sticker products are developing rapidly, it is important that wall sticker is the main product line of the supply company as they would have more interests and capabilities in improving and advancing their production and product offerings.

Another important factor was the level of customization. The supply products should meet the needs and wants of the Finnish customers, which include custom-made design patterns, and product information and installation instruction provided in Finnish language.

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[2] EN71 stands for European standard which specifies safety requirements for toys. It is legally required for all toys sold in the EU. Source: http://ec.europa.eu/enterprise/policies/european-standards/harmonised-standards/toys/

[3] SGS is the world's leading inspection, verification, testing and certification company. They recommend if the product/process/system/service is compliant with either national or international standards and regulations. Source: http://www.sgs.com/en.aspx

4.2 Preliminary Supplier Research

Considering all the available searching channels stated in Chapter 2, the author found that using Internet search engines was the most efficient and cost-saving way to search potential Chinese suppliers for the case company. The author used both local websites and international websites to find possible suppliers and their contact information.

For companies that have more time and bigger budget, using official consulting channels and attending fairs and exhibitions will reduce much uncertainty. Some reliable sources of information provided by third parties in Finland are: the Chinese Chamber of Commerce, Finpro, Golden Bridge, and PWC.

The author used www.alibaba.com[4] as the main supplier search engine. The author has also used www.google.com and www.baidu.com as auxiliary websites for more company information and activity news.

Alibaba.com is a worldwide wholesale marketplace for global importers and exporters with a strong focus in Asia. Since alibaba.com was originated from China, Chinese suppliers are very familiar with its services. It also has a corresponding website in Chinese, china.alibaba.com, which is meant for inland wholesale in China. These features provide alibaba.com the most popular trading website for Chinese exporters.

This online platform's reliability lies on three services provided:

1) Secure payment service Escrow - which is controlled by alibaba.com to release the money only when the transaction has been confirmed by both buyer and supplier;
2) Paid professional third party inspection – which includes initial production inspection, during production inspection, final random inspection, container loading check, and factory audit;

[4] For tips of using alibaba.com, readers could read the article "*7 tips to using alibaba correctly so you don't get scammed*", available from http://under30ceo.com/7-ways-to-get-scammed-on-alibaba/

3) Supplier assessment conducted by globally recognized authorities: Bureau Veritas and TÜV Rheinland – including assessment reports, verified videos and verified main product.

In creating a long list of potential suppliers through alibaba.com, the author did the following steps: 1) tapping 'wall sticker' in the searching bar on alibaba.com, 2) selecting filters: country as China (mainland), product category as Other Home Decor from Home & Garden main category and Stickers from Gifts & Crafts main category, main export market as Northern Europe, 3) choosing supporting ESCROW payment service. After these steps the author obtained a list of 296 suppliers. (A screenshot can be seen as Appendix 1)

After building up a long list of potential suppliers, the author pre-filtered the supply candidates based on several basic features. Table 5 presents the filters and their explanation.

Table 5 Pre-filters and their explanation

Filter	**Explanation**
1. Main product as indoor wall stickers, excluding wall papers, car stickers and mirror stickers	According to the company's product specifications: the products are meant for home decoration and self-manageable
2. Minimum order quantity less than 500 pieces	As the case company is a start-up company and small in size, a big supplier might not pay attention to its special needs
3. Location – coastal areas or close to coastal areas with developed transportation: Guangdong, Jiangsu, Zhejiang, Shanghai and Fujian	As analysed in Chapter 2, only the coastal provinces are economically developed and have great infrastructure. Inland suppliers might imply increased transportation cost and slower product/production development.
4. Having more than 100 product variety	Prove wall sticker is a main product within the company and there will be enough designs for the case company to select.

The author obtained a list of 7 suppliers after the pre-filtering process. These 7 appropriate candidates were then contacted via email and the communication channel pro-

vided by alibaba.com. The author sent them a questionnaire survey, which included a number of questions concerning their company, product offerings, financials, manufacturing facilities, and services.

The questionnaire was originally in Chinese and the translated version can be seen as Appendix 2. The basic information collected about the suppliers is presented in Appendix 3.

4.3 Supplier evaluation

After the needed product was identified and potential suppliers were contacted, this was the phase to implement AHP method mentioned in Chapter 3 to make supplier evaluation based on data collected.

In order to best fit the case company purchasing goals and product features, the author selected 4 main criteria and 10 sub-criteria. The main evaluation criteria are: quality, price, reliability and service. The main criteria and their sub-criteria are explained below:

1. Price – quoted price per piece of wall sticker
2. Quality
    (1) Product variety: range of product selection
    (2) Product quality features: material, removable, waterproof, relevant certificates, cutting/printing techniques, durability, transfer film attached
    (3) Production quality: production lines, machinery, R&D, 3rd party verification
3. Reliability
    (1) Management and organization: ISO certificates, international appearance/experience (export percentage), quality control process
    (2) References: fairs/exhibitions, buyer feedback
    (3) Capital (RMB)
    (4) Annual turnover (USD)
4. Service
    (1) Delivery lead time (days)

(2) Customization capability: size, shape, colour, design, packaging, OEM, design service, label service

(3) Communication: respond time, information accuracy/transparency/details, knowledge of the product/market, professional language, trust

Figure 5 shows the 4 layer hierarchy of the AHP approach for the case company. The first level is the goal, the second and third levels are criteria and sub-criteria, and the fourth level is the alternatives.

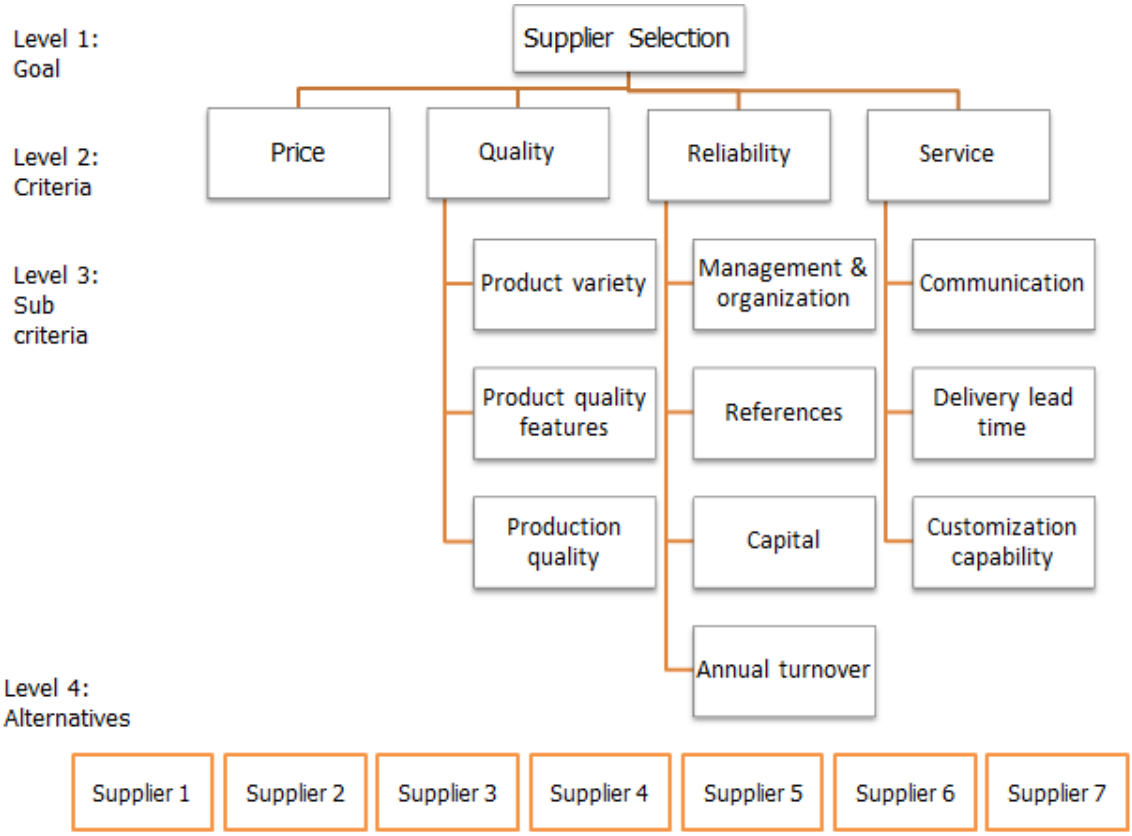

Figure 5 An Illustrative Decision Hierarchy for Supplier Selection

After identifying all criteria, the next step is to determine preferences between alternatives by using pair-wise comparisons. The author started comparing the 4 main criteria in the second row of the hierarchy (see Figure 5) two at a time. These four criteria will be compared by the author as to how important they are to the case company, with respect to the goal.

Table 6 presents the comparison using Saaty scale (Chapter 3, Table 3) mentioned in theoretical framework.

Table 6 Pair-Wise Comparison Matrix Regarding the Selected Criteria

Criteria	Price	Quality	Reliability	Service
Price	1	1/2	1/2	2
Quality	2	1	2	3
Reliability	2	1/2	1	2
Service	1/2	1/3	1/2	1
Total	5,5	2,333	4	8

As can be seen from the table, according to the case company features and the goal, the author has given preference values to each element. The preference value (1/2) of the price criterion to the quality criterion means the author gave moderate importance to quality criterion than price. Correspondingly, the author also moderately preferred reliability to price and moderately preferred price to service.

After establishing the pair-wise judgments, the next essential step is to adjust values measured on different scales to a denoted common scale, in this case the author use 1, and to obtain their average. This normalization calculation was done by dividing the figures of one column by the total of that column. Table 7 presents the results of normalization as well as calculated row averages and sum.

Table 7 Normalized Matrix of Paired Comparisons and Rank

Criteria	Price	Quality	Reliability	Service	Row averages (Priority)	Sum
Price	0,182	0,214	0,125	0,250	0,193	0,771
Quality	0,364	0,429	0,500	0,375	0,417	1,667
Reliability	0,364	0,214	0,250	0,250	0,269	1,078
Service	0,091	0,143	0,125	0,125	0,121	0,484
	1	1	1	1	1	

As an example of the normalization calculations, the price = 1/5,5 = 0,182. Can be derived from the above table, quality (0,417) was the most preferred criterion, the

second was reliability (0,269), and price (0,193) and service (0,121) were the third and fourth ranked criterion. At this stage, the author has obtained the global weights of the criteria.

Moreover, as stated in AHP theory, checking the consistency ratio (CR) is an essential step to determine the acceptance of the priority weighting. Below is the computation of CR:

$$0{,}193\begin{bmatrix}1\\2\\2\\1/2\end{bmatrix}+0{,}417\begin{bmatrix}1/2\\1\\1/2\\1/3\end{bmatrix}+0{,}269\begin{bmatrix}1/2\\2\\1\\1/2\end{bmatrix}+0{,}121\begin{bmatrix}2\\3\\2\\1\end{bmatrix}=\begin{bmatrix}0{,}771\\1{,}667\\1{,}078\\0{,}484\end{bmatrix}$$

Dividing all the elements of the weighted sum matrices by their respective priority and calculating the average:

$$\lambda_{max}=\frac{\frac{0{,}771}{0{,}193}+\frac{1{,}667}{0{,}417}+\frac{1{,}078}{0{,}269}+\frac{0{,}484}{0{,}121}}{4}=\frac{3{,}995+3{,}998+4{,}007+4}{4}=4$$

$$\mathrm{CI}=\frac{\lambda_{max}-\mathrm{n}}{\mathrm{n}-1}=\frac{4-4}{4-1}=0$$

Taking the random consistency ratio (RI) from Saaty (Chapter 3, Table 4) for a matrix size of four, RI = 0,9. Calculating the consistency ratio:

$$\mathrm{CR}=\frac{\mathrm{CI}}{\mathrm{RI}}=\frac{0}{0{,}9}=0$$

As CR value is much less than 0,1, the pair-wise comparison evaluations are consistent, and thus acceptable. Similar pair-wise comparison and normalization calculations were completed for sub-criteria under each criterion to obtain their local weights.

Table 8 demonstrates the calculation results including their local weights and global weights. Global weights were derived from multiplying sub-criteria's local weights with criteria's global weights. (For detailed calculations, see Appendix 4)

Table 8 Composite priority weights for criteria and sub-criteria

Criteria	Global Weights	Sub-Criteria	Local Weights	Global Weights
Price	0,193			0,193
Quality	0,417	Product variety	0,104	0,043
		Product quality features	0,665	0,277
		Production quality	0,231	0,096
Reliability	0,269	Management & organization	0,556	0,150
		References	0,229	0,062
		Capital	0,122	0,033
		Turnover	0,093	0,025
Service	0,121	Communication	0,648	0,078
		Delivery lead time	0,122	0,015
		Customization capability	0,230	0,028

As presented in the table, product quality features (0,277) is the single most important criteria which also meets the case company's concerns and needs. The second most important criterion is price (0,193) and tightly followed by management & organization criterion (0,150).

Based on the judgements given by the author, the AHP has derived the priority weights for all criteria and sub-criteria. After obtaining priority weights for every criterion, the next important step was to transfer the qualitative and quantitative figures collected from the suppliers to measureable forms for feasible pair-wise comparisons.

Table 9 on the next page demonstrates the meaning of value 1-9 for every sub-criterion based on data collected through supplier questionnaire survey (data can be seen as Appendix 3). The author used a 1-9 value scale for easier collaboration with Saaty's preference value scale for later pair-wise comparisons of suppliers under each sub-criterion.

Table 9 Assignment of the rating scale to the sub-criteria connected data

Value	Price	Product variety	Product quality	Production quality	M&O	References	Capital	Turnover	Communication	Delivery	Customization
1	Extremely high > US $ 10 piece	<200	Basic	3 production lines	Basic certificates, export < 50%	No references	< RMB 100,000	<US$ 1 Million	Basic	30 days	No customization
2		300	+ Vinyl/PVC material			Buyer feedback		<US$ 2 Million	Acceptable		Size
3	High	400	waterproof, removable	5 PL	Certificates & EP <70%	Fairs in China	RMB 100,000	<US$ 3 Million	Fast	15 days	Size, shape
4		500	+ UV printing			+ Buyer feedback		<US$ 5 Million	+ good language		Size, shape, colour
5	Middle < US $ 5 piece	600	+ 1 Certificate	+ Machinery pictures/ videos	Good quality control, EP<80%	Fairs in HK	RMB 500,000	<US$ 7 Million	+ detailed information	10 days	Size, shape, colour, design
6		700	+ 2 Certificates					<US$ 10 Million	+ knowledge		OEM, design service, label
7	Competitive	800	+ High durability	+ 3rd party verification	EP<90%			<US$ 20 Million	+ accuracy	7 days	Packaging
8		900	+ Film					<US$ 30 Million	+ professional		
9	Low < US $ 1 piece	>1000	With every certificate & feature	R&D, 10 PL, 3rd party verification	International certificates EP > 90%		RMB 1,000,000	>US$ 30 Million	+ trust in contact person	5 days	

According to the evaluation values in Table 9, the author assigned values to criteria under each supplier based on suppliers' qualitative and quantitative information. The assignment of values can be seen in Table 10.

Table 10 Assignment of values to every supplier

	S_1	S_2	S_3	S_4	S_5	S_6	S_7
Price	6	8	2	9	4	8	7
Product variety	8	8	5	1	9	4	9
Product quality features	3	5	2	8	4	5	9
Production quality	2	1	8	7	4	4	7
M&O	1	2	4	6	8	3	9
References	1	1	5	1	5	2	4
Capital	3	9	5	5	1	3	3
Turnover	2	9	7	8	4	1	4
Communication	2	3	6	9	2	4	8
Delivery lead time	6	9	5	4	1	5	3
Customization capability	5	4	6	7	5	6	3

Having assigned values to all elements under alternative suppliers, the author then continued to make pair-wise comparisons in regard of each sub-criterion. On the next page, Table 11 shows the final scores of each supplier and detailed calculation of pair-wise comparisons can be seen as Appendix 5.

Under each supplier, local weights were based on normalized pair-wise comparison results; and global weights were calculated through multiplying local weights with corresponding sub-criterion's global weights (from Table 7). The total score on the bottom of the table is the sum of every supplier's global weights under the 10 sub-criteria.

As can be seen from the table, supplier 7 (0,267) has the highest total score among all alternatives. Supplier 4 tightly follows supplier 7 with a total score 0,219. Supplier 1, 2, 3, 5, 6 score 0,066, 0,121, 0,107, 0,114 and 0,106 respectively.

Table 11 Total weighted scores of suppliers

		S_1		S_2		S_3		S_4		S_5		S_6		S_7	
	Global Weight	Local Weight	Global Weight	Local Weight	Global Weight	Local Weight	Global Weight	Local Weight	Global Weight	Local Weight	Global Weight	Local Weight	Global Weight	Local Weight	Global Weight
Price	0,193	0,096	0,019	0,185	0,036	0,029	0,006	0,265	0,051	0,049	0,009	0,185	0,036	0,191	0,037
Product variety	0,043	0,163	0,007	0,163	0,007	0,072	0,003	0,024	0,001	0,265	0,011	0,049	0,002	0,265	0,011
Product quality features	0,277	0,054	0,015	0,105	0,029	0,037	0,010	0,257	0,071	0,070	0,019	0,105	0,029	0,370	0,102
Production quality	0,096	0,048	0,005	0,033	0,003	0,329	0,032	0,213	0,020	0,082	0,008	0,082	0,008	0,213	0,020
M&O	0,150	0,032	0,005	0,045	0,007	0,084	0,013	0,152	0,023	0,258	0,039	0,059	0,009	0,370	0,056
References	0,062	0,061	0,004	0,061	0,004	0,272	0,017	0,061	0,004	0,272	0,017	0,105	0,007	0,169	0,010
Capital	0,033	0,074	0,002	0,455	0,015	0,142	0,005	0,142	0,005	0,040	0,001	0,074	0,002	0,074	0,002
Turnover	0,025	0,043	0,001	0,344	0,009	0,184	0,005	0,254	0,006	0,073	0,002	0,030	0,001	0,073	0,002
Communication	0,078	0,040	0,003	0,061	0,005	0,150	0,012	0,370	0,029	0,040	0,003	0,081	0,006	0,258	0,020
Delivery lead time	0,015	0,139	0,002	0,299	0,004	0,094	0,001	0,065	0,001	0,024	0,000	0,094	0,001	0,286	0,004
Customization capability	0,028	0,116	0,003	0,082	0,002	0,180	0,005	0,269	0,008	0,116	0,003	0,180	0,005	0,056	0,002
Total Score		0,066		0,121		0,107		0,219		0,114		0,106		0,267	

4.4 Supplier selection

According to the results (Table 11) found in the supplier evaluation, Supplier 7 appears to be the best choice of all 7 suppliers based on its highest total score. Even though Supplier 4 is strongest in price criterion, it lacks product variety and has less desirable performance in product quality, management and organization features, and references comparing to the Supplier 7.

S_7 features great product variety, the best product quality, competitive pricing, best management and organization, short delivery lead time, speed and professional communication, and good production quality and references.

Based on the analysis of AHP results, Supplier 7 would be the appropriate choice for the case company. Choosing S_7 meets the goal the case company and its product specification. In addition to low price, S_7 provides a high level of trustworthy and a lower level of expected risks.

Moreover, the results found through AHP implementation were valid and reliable as the evaluation criteria matched the case company's objectives, pair-wise comparisons were made via informed judgments and were consistent, and mathematical calculations were carefully completed and re-examined through Excel.

4.5 Concluding remarks of key findings

During the supplier selection process for the case company, the author found that utilizing the Internet for the preliminary supplier research was rather sufficient, especially for small and middle size suppliers who do not have own webpage and are not registered in big trade directories or the database of consulting agencies.

Through contacting with potential suppliers, the author got to know that many sound suppliers have mainly participated in international fairs and exhibitions in Hong Kong and Germany. Finding information on these events and making comparisons of suppliers on the real spot seems to be another efficient way to find potential suppliers and develop relationship further.

The implementation of AHP approach in the supplier selection process for case company was rather successful. The AHP results also offered a solid reference framework for choosing right supplier(s) under various conditions. The approach was easy to implement but took much effort in its vast calculations. It was also flexible enough to embrace situational changes. For example, once had the original calculation framework on Excel, you can always re-input new judgements to the priorities of the criteria according to current situations and needs. Then the rest of the calculations will be completed automatically by Excel.

Through pair-wise comparison of selected 4 evaluation criteria and 10 sub-criteria, the author developed a better understanding of the purchasing objectives and strategies of the case company. While price scored third in importance; the quality criterion ranked the most important and was followed by reliability. It implicates that while companies are attracted by low cost offerings in China – which are much more competitive than the local ones, securing quality standards and managing relationship and risks are critical to successfully take advantages of the reduced cost.

AHP approach offered a viable and effective solution for the case company to find the suitable supplier without visiting overseas factories. The author believes that after several rounds' interaction with the selected supplier, AHP approach would become a more dependable and effective method for supplier selection and after-supply evaluation due to more reliable data collected and better and experienced judgments.

One difficulty of AHP approach is that it needs more experienced personnel to carefully select and structure the analytic hierarchy tree and to make pair-wise comparisons with consideration of offsetting effects among criteria and sub-criteria. Another drawback of AHP approach is that it can only take consideration a limited number of factors, either regarding selection criteria or the number of potential suppliers. Too many factors will make pair-wise comparison difficult and time-taking.

Last, one big limitation of this paper is the information collected directly from potential suppliers. Due to lack of experience in international purchasing and the absence of audits and confirmation from authorities, the truthfulness of supplier information is rather doubtful.

5 Conclusion

International sourcing could be a big enhancement for a company. For the case company, low price products help the company achieve competitiveness in its home market and has lower capital requirement for a start-up company. Low cost sourcing also enables the company to have better choices in product quality and features as well as the level of customization. The difficulties of international purchasing lie with searching for and selecting the right supplier(s) as well as maintaining the supplier relationship.

This paper is a good test of international supplier selection for a small business as it demonstrates both the benefits and the difficulties.

Responding to the difficulties, the paper has successfully met its three goals. First, the author used Internet channels to locate potential suppliers. The Internet offers a great amount of supplier information according to product category or geographic locations. Some Internet suppler search engines also have 3rd party audit reports on suppliers with a price. Some of those search engines provide direct communication channels with suppliers. It significantly saves time and cost comparing to many other channels, such as trade directories or third party consultation.

The second contribution of this paper was the identification of the important evaluation criteria for the supplier selection process. Through reviewing relevant literature and research projects on supplier selection criteria, the author identified price, quality, reliability and service as the most important criteria for case company in selecting Chinese supplier. The author has also defined 10 sub-criteria for more accurate and comprehensive evaluation.

Another important contribution was the successful implication of the multi-criteria decision tool – AHP. The paper has successfully applied the AHP approach in finding the most suitable supplier, and therefore the AHP approach is proved to be an effective tool of supplier evaluation for the case company.

In short, the AHP approach offers an effective and efficient way to select suppliers. It requires accurate and extensive information collected from the suppliers. It also incorporates a consistency check to reduce human discrepancy, thus ensures more objec-

tive results than many other supplier evaluation approaches. By ranking and giving preference values to selected criteria, AHP reduces the offsetting effects between different criteria.

Moreover, as proved by pair-wise comparisons, price criterion was not the most decisive factor in selecting Chinese suppliers; quality and reliability were factors taken more seriously than price for the case company.

At last, during the implementation process, the paper has developed a standard supplier selection procedure for the case company. It is a four-step process: product analysis, preliminary supplier research, supplier evaluation, and supplier selection. It was proven to be a viable solution for the company as it met company objectives by effectively embracing product requirements and company needs in the supplier selection process.

5.1 Recommendations

For sole proprietors and small businesses, the Internet offers great possibilities and opportunities in developing and assisting business activities. However, finding the reliable Internet sources needs a few rounds of error-and-trial.

For business operations in China, the Internet is a comparably immature source of information as it lacks in regulation and standards. The business culture in China also requires a lot of direct interaction. Confirming and contacting directly with the Chinese suppliers is of crucial importance.

The popularity of the AHP approach in supplier selection is fairly reasonable as it truly provides a method combining objective factors and subjective expert judgments in international purchasing source evaluation. It also takes account of both qualitative and quantitative information. In this paper criteria like product quality features, production quality and service can be taken into consideration.

By comparing suppliers using appropriated criteria, the AHP approach also enables purchasing managers to analyse the strengths and weaknesses of supplier companies.

Moreover, as time goes by, gained experiences and more accurate information will make the AHP a more effective tool in both new supplier selection and existing supplier performance tracking.

As evidenced in the implementation, price criterion is not necessarily the most decisive factor in sourcing from low cost countries, even with an ultimate purchasing goal of tapping cost reduction potential. As prices in those countries are already significantly cheaper than domestic sources, some other criteria – such as quality and reliability – should be more important than or as important as price criterion in making comparisons of low cost suppliers.

5.2 Critiques

One of the underlying assumptions of the AHP implementation was that the data gathered from the suppliers were true and certain. In the present study, the data used in the AHP analysis were received directly from suppliers without actual confirmation or 3rd party verification. The collected data served its uses in implementing the AHP tool, but it might raise risks in real business practices for the case company.

Another underlying assumption of the case studies was that the author could give expert judgments when giving priorities to criteria in the pair-wise comparison process. The author has made informed judgments based on theories, relevant field studies, case company's objectives, and the data collected. However, one of AHP method's outstanding features is that the method could enable a big contribution of expert(s)' or experienced manager(s)'s opinions to the implementation process which makes the final result is not the best one choice for all but the best choice for the end user – the company or a company department who is evaluating or selecting supplier(s). Therefore, the author's informed judgments do not match up to expert(s)' or manager(s)'s experienced and knowledgeable judgments.

Moreover, in the case studies, the AHP approach was proven to be an effective way to evaluate and select suppliers. However, in order to use this tool it would take much time for the first-time users to understand it first, especially for those who do not have a mathematical or computational background. After understanding the functions of the

approach, it still takes quite much effort and time in its vast calculations, especially when there are many evaluation criteria and alternatives.

The supplier search engine, alibaba.com, was a long-standing online platform providing the biggest online supply market of China. For the case company, this online platform should be sufficient to serve its purpose of finding a suitable supplier. However, there might be other noticeable Chinese suppliers meet the case company's objectives that are not registered on alibaba.com because of their established businesses and partnerships. Those suppliers are usually on the global supplier list of sourcing consulting agencies, professional organizations, and governmental departments, such as the Chamber of Commerce.

To increase the trustworthiness of the collected data, the methods used in gathering information shall be improved. For more serious business practices, online data and questionnaire survey might not suffice the purpose of selecting a right supplier, especially for a start-up company who lacks experience and sources in judging the credibility of supplier information. With time and budget allowed, in order to find a suitable supplier and to establish a reliable business relationship, arranging interviews and on-site visits with potential suppliers and evaluating samples would be more appropriate methods to gather the evidence.

5.3 Further research

Further research could be directed to how to improve the structuring of analytic hierarchy in implementing AHP approach in supplier evaluation. One possibility is using different methods to group criteria and sub-criteria, and then comparing their results to identify a better structure.

There could be more research done on how to improve the business interaction and information exchange between small businesses around the world, especially those who have strong interests in expanding their business activities abroad. It has to be low or even free cost, time efficient, easy-to-use, direct interaction, and with reliability. The Internet is a great place for developing this platform, but how to introduce a global standard for information exchange and interaction between small companies would

be a difficult task, especially for those companies located in developing economies with immature electronic business practices.

Some practical tests could also be directed in implementing the AHP approach with other relevant or even competing tools, such as goal programming (GP) and quality function deployment (QFD), and fuzzy set theory under uncertain decision environments.

References

Books

Branch, A.E. (2009) *Global supply chain management and international logistics*, New York: Routledge.

Nassimbeni, G. and Sartor, M. (2006) *Sourcing in China: Strategies, methods and experiences*, Hampshire: Palgrave Mcmillan.

Seyoum, B. (2009) *Export-import theory, practices, and procedures*, New York: Routedge.

Articles

Asamoah, D., Annan, J. & Nyarko, S. (2012) AHP approach for supplier evaluation and selection in a pharmaceutical manufacturing firm in Ghana, *International Journal of Business and Management*, 7 (10), pp. 49-62. Available via http://www.ccsenet.org/journal/index.php/ijbm/article/view/14402/11396 [accessed at 11.04.2013]

Chai, J., Liu, N.K. and Ngai W.T. (2013), Application of decision-making techniques in supplier selection: A systematic review of literature, *Expert Systems with Applications*, 40, pp. 3872-3885

EconomyWatch (2010) *Finland Trade, Finland Exports, Finland Imports*, Available via http://www.economywatch.com/world_economy/finland/export-import.html [accessed at: 14.01.2013]

Hedderich, F., Giesecke, R. and Ohmsen, D. (2006) Identifying and evaluating Chinese suppliers: China sourcing practices of German manufacturing companies, *PACTIX*, 6, pp. 1-8. Available from http://www.econbiz.de/archiv/myk/whumyk/controlling/suppliers_china_practices.pdf [accessed at: 26.03.2013]

Kahraman, C., Cebeci, U. & Ulukan, Z. (2003) Multi-criteria supplier selection using fuzzy AHP, *Logistics Information Management*, 16 (6), pp. 382-394.

Karande, P. and Chakraborty, S. (2012) Decision making for supplier selection using MOORA method, *The IUP Journal of Operations Management*, XI(2), pp.6-18.

Min, H. (1994) International supplier selection: a multi-attribute approach, *International Journal of Physical Distribution & Logistics Management*, 24(5), pp.24-33.

Naik, G. (2012) Research outlays to decline next year, *Wall Street Journal,* (online) available from http://online.wsj.com/article/SB10001424127887324677204578185552846123468.html [accessed at 13.04.2013]

Tahriri, F. & et. (2008) AHP approach for supplier evaluation and selection in a steel manufacturing company, *Journal of Industrial Engineering and Management,* 1 (2), pp. 54-76.

Verma, R. and Pullman M. (1998) An analysis of the supplier selection process, *Omega: The International Journal of Management Science*, 26(6), pp. 739-750.

Vijayvargiya, A. and Dey, A.K. (2010) An analytical approach for selection of a logistics provider, *Management Decision*, 48(3), pp. 403-418

Websites

International Labour Organization (2011) *KILM 16. Hourly compensation costs*, Available via: http://kilm.ilo.org/manuscript/kilm16.asp [accessed at 05.03.2013]

PESTLE Analysis (2013) *What is PESTLE analysis?* Available via www.pestleanalysis.com [accessed at 13.04.2013]

University of Michigan (2008) *Topic 8: how to critique a research paper assignment*, Available via https://open.umich.edu/sites/default/files/Topic8Assignment-CritiqueArticle.pdf [accessed at 10.05.2013]

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Suppliers wall sticker Search or
Advanced Search

Related Searches: vinyl **wall sticker**, **wall stickers** home decor, wall decoration More

Suppliers >**"wall sticker"** : 41,964 Product(s) from 527 Supplier(s)

Category
Gifts & Crafts
- Stickers (244)
- Painting & Calligraphy (9)
- Paper Home Decor (1)
- Paper Crafts (3)

Home & Garden
- Other Home Decor (52)
- Wall Clocks (21)
- Mirrors (14)

Other Category
- Wallpapers/Wall Coating (14)
- Poster Materials (11)

Active Filters Clear
Main Market
Northern Europe ×

Mgnt Certification
- ISO 9001:2000 (277)
- ISO 9001:2008 (185)
- ISO 14001:2004 (111)
- Others (105)
- QS-9000 (58)
- HACCP (54)
- ISO/TS 16949 (38)

Products | **Suppliers** Beta

Country: China (Mainland) Clear

Province: Guangdong Jiangsu Zhejiang Shanghai Clear
Fujian

Gold Supplie Onsite Checked Assessed Supplier Online ESCROW 1 of 11 : Page

Shanghai Eyemove Imaging & Printing Co., Ltd.

ESCROW

Country/Region : China (Mainland)
Main Products : Advertising Print Product, Silk Screen Print Product, Digital Photographic Print Product, UV Print Product, Advertising Props Product
Mgnt Certification : ISO 9001:2008

Contact Supplier Offline Contact Details

Matching Products 10+ similar products


wall sticker /car ...


Fridge sticker,w...


Kid Wall Sticker

Taizhou Yeeto Decorative Material Co., Ltd.

ESCROW

Country/Region : China (Mainland)
Main Products : Home Sticker,PVC Self Adhesive Foil,Static

Matching Products 200+ similar products

A screenshot of supplier search on alibaba.com

Supplier evaluation survey

Dear supplier,

In order to better understand your business, and as an important step in establishing a good business relationship with you, we request that you please provide us with the following information. This questionnairse will be the main assessment material for our supplier selection.

Please return this form to Ms. Chengjing Jounio, chengjingy@gmail.com. (No later than 20.4.2013)

If you have any questions concerning the questionnaire, please contact Ms. Chengjing Jounio, the co-founder of Suomen koristetuonti, Phone +358442090488.

Thank you!
Suomen koristetuonti .

Supplier Questionnaire

General information:

Company name:	
Primary address:	
Contact person & title:	Email address:
Telephone:	Fax:
Company website:	

Business information:

Business type ☐ sole proprietorship ☐ partnership ☐ public limited company ☐ limited company ☐other (please specify)	
Register year:	Register capital (RMB):
Annual turnover (USD):	Export volume (%):
Average delivery lead time:	Accepted payment currency:
Accepted payment terms:	
Quality assurance (If possible, please provide scanned copies as attachments):	
What fairs or exhibitions has your company attended? If it does not apply, please write 'NO'.	
Could you describe your R&D (personnel, investment, etc.)? If it does not apply, please write 'NO'.	

Production information:

Product lines (no.):	
Manufacturing machineries: (If you have pictures or videos, please provide them as attachments)	
Customization capability:	☐ Size ☐ Shape ☐ Colour ☐ Design ☐ OEM ☐ Label ☐ Packaging
Could you describe your company's quality control system? If it does not apply, please write 'NO'.	

Product specifications: *(indoor vinyl/PVC wall stickers)*

Quoted price for 500 pieces purcashing volume: US $ per piece
Product variety (no.):
Certificates: (details – year, certified product/process/service; if you have scanned pictures, please provide them as attachments.) ☐ EN71 _____ ☐ SGS _____ ☐ CE _____ ☐ Other _____
Product features: (details) ☐ Waterproof ☐ Removable (without damaging walls) ☐ Durability (years): ☐ With transfer film (material): ☐ UV Printing ☐ Fire-retardant Others:

Comments:

Basic information of selected potential suppliers collected

Source: supplier questionnaire survey; alibaba.com

	S1	S2	S3	S4	S5	S6	S7
Price	$ 0.3 - 2/piece	US $ 0.68 - 0.98 / Piece	US $ 0.01 - 20 / Piece	US $ 0.1 – 1 / Piece	US $ 0.1 – 10 / Piece	US $ 0.2 – 1.5 / Piece	US $ 0.5 – 1.5 / Piece
Product variety	922	990	600	180	>1000	500	>1000
Product Quality features	PVC, removable, waterproof, eco friendly	CE Product Safety Compliance Certificate PVC, removable, waterproof	Vinyl, PVC, non-toxic, eco-friendly	Vinyl, PVC, non-toxic, UV printing, EN71, RoHS, Phthalate, fire-retardant, removable	PVC, partial removable, waterproof, eco-friendly	Waterproof, Eco-friendly, Removable, PVC	Milky white film, PVC, Vinyl, UV printing, removable, high durability, EN71, CE certificate
Production quality	3 production lines, Pictures provided	3 production lines	Pictures, video provided, verified by 3rd party Strong machinery 10 production lines	Pictures provided, More than 10 production lines	5 production lines, pictures provided	5 production lines, Pictures provided	5 production lines, Great R&D investment, high level machinery, pictures and details provided
Management &		ISO 9001:2000	ISO 9001:2008 High quality con-	ISO 9001:2000 ISO 14001:2004	ISO 9001:2008 SGS, TUV	ISO 9001:2000 ISO 9001:2008	ISO 9001:2000 great machinery

organization			trol, procedure provided, flat structure	Good quality control, SGS certifications: ink, wall sticker, marker pen		Transparent and flat structure	and standards, TUV, SGS certificates provided, adopting international standard product marking certificate, Great quality control
3rd party inspection	CCSI(PRC)	CCSI(PRC)	TÜV Rheinland CCSI(PRC)	CCSI(PRC)	CBI	ZD Info	CCSI(PRC)
References			China sourcing fair, HK		China sourcing fairs, HK	5 star feedback	Canton fair, CN 4,5 star feedback
Capital	RMB 100,000	RMB 1,000,000	RMB 500, 000	RMB 500,000	RMB 30,000	RMB 100,000	RMB 100,000
Turnover	US$ 1,5 Million	US$ 45 Million	US$ 20 Million	US$ 30 Million	US$ 3,5 Million	<US$ 1 Million	US$ 4 Million
Export percentage	41% - 50%	61% - 70%	61% - 70%	81% - 90%	81% - 90%	51% - 60%	91% - 100%
Delivery lead time	7 days for stock, 15 days for customize	5 days	10 days	10 – 15 days	30 days	10 days	15 days
Customization capability	Size, shape, design, colour	OEM Service Offered Design	OEM Service Offered Design	OEM Service Offered Design	OEM Service Offered Design	OEM Service Offered Design	OEM, design

		Service Offered Buyer Label Offered	Service Offered Buyer Label Offered Size, design, material	Service Offered Buyer Label Offered Custom packing, size, designs	Service Offered Buyer Label Offered Shape size	Service Offered Buyer Label Offered Shape, size, color	
Payment currency	USD, CNY	USD	USD, CNY, HKD		USD, EUR, JPY, CAD, AUD, HKD, GBP, CNY	USD, EUR	USD, EUR, AUD, HKD, GBP, CNY

Detailed normalization calculations of pair-wise comparisons of sub-criteria

Quality												
	PV	PQF	PQ						Ave.	Sum	λ_{max}	
PV	1,000	0,200	0,333			0,111	0,138	0,062	0,104	0,311	2,990	
PQF	5,000	1,000	4,000			0,556	0,690	0,750	0,665	1,995	3,000	
PQ	3,000	0,250	1,000			0,333	0,172	0,188	0,231	0,693	2,996	
	9,000	1,450	5,333			1,000	1,000	1,000	1,000		2,995	
Reliability												
	MO	R	C	AT						Ave	Sum	λ_{max}
MO	1	3	5	5		0,577	0,621	0,526	0,500	0,556	2,224	4,000
R	0,333	1	3	2		0,192	0,207	0,316	0,200	0,229	0,915	3,996
C	0,2	0,333	1	2		0,115	0,069	0,105	0,200	0,122	0,490	4,016
AT	0,2	0,5	0,5	1		0,115	0,103	0,053	0,100	0,093	0,371	3,989
	1,733	4,833	9,5	10		1,000	1,000	1,000	1,000	1,000		4,000
Service												
	C	DLT	CC						Ave	Sum	λ_{max}	
C	1	5	3			0,652	0,625	0,667	0,648	1,944	3,000	
DLT	0,2	1	0,5			0,130	0,125	0,111	0,122	0,367	3,008	
CC	0,333	2	1			0,217	0,250	0,222	0,230	0,689	2,996	
	1,533	8	4,5			1	1	1	1		3,001	

Detailed normalization calculations of pair-wise comparisons of suppliers under every sub-criterion

Price																		
	S1	S2	S3	S4	S5	S6	S7									Ave	Sum	λ_{max}
S1	1,000	0,500	4,000	0,333	2,000	0,500	0,750		0,098	0,072	0,129	0,105	0,103	0,078	0,091	0,096	0,675	7,031
S2	2,000	1,000	6,000	0,500	4,000	1,000	2,000		0,195	0,145	0,194	0,157	0,205	0,156	0,241	0,185	1,293	6,989
S3	0,250	0,167	1,000	0,143	0,500	0,167	0,200		0,024	0,024	0,032	0,045	0,026	0,026	0,024	0,029	0,202	6,966
S4	3,000	2,000	7,000	1,000	5,000	1,500	2,000		0,293	0,289	0,226	0,315	0,256	0,234	0,241	0,265	1,854	6,996
S5	0,500	0,250	2,000	0,200	1,000	0,250	0,333		0,049	0,036	0,065	0,063	0,051	0,039	0,040	0,049	0,343	7,000
S6	2,000	1,000	6,000	0,500	4,000	1,000	2,000		0,195	0,145	0,194	0,157	0,205	0,156	0,241	0,185	1,293	6,989
S7	1,500	2,000	5,000	0,500	3,000	2,000	1,000		0,146	0,289	0,161	0,157	0,154	0,312	0,121	0,191	1,340	7,016
	10,250	6,917	31,000	3,176	19,500	6,417	8,283		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		6,998
Product Variety																		
	S1	S2	S3	S4	S5	S6	S7									Ave	Sum	λ_{max}
S1	1	1	3	7	0,5	4	0,5		0,149	0,149	0,190	0,184	0,140	0,188	0,140	0,163	1,139	6,988
S2	1	1	3	7	0,5	4	0,5		0,149	0,149	0,190	0,184	0,140	0,188	0,140	0,163	1,139	6,988
S3	0,333	0,333	1	4	0,25	2	0,25		0,050	0,050	0,063	0,105	0,070	0,094	0,070	0,072	0,501	6,958
S4	0,143	0,143	0,25	1	0,125	0,333	0,125		0,021	0,021	0,016	0,026	0,035	0,016	0,035	0,024	0,170	7,083
S5	2	2	4	8	1	5	1		0,297	0,297	0,254	0,211	0,280	0,234	0,280	0,265	1,853	6,992
S6	0,25	0,25	0,5	3	0,2	1	0,2		0,037	0,037	0,032	0,079	0,056	0,047	0,056	0,049	0,344	7,020
S7	2	2	4	8	1	5	1		0,297	0,297	0,254	0,211	0,280	0,234	0,280	0,265	1,853	6,992
	6,726	6,726	15,75	38	3,575	21,33	3,575		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		7,003

Product Quality Features																	
	S1	S2	S3	S4	S5	S6	S7									Ave	Sum	λ_{max}
S1	1	0,5	2	0,2	0,5	0,5	0,167		0,054	0,048	0,083	0,047	0,033	0,048	0,067	0,054	0,381	7,056
S2	2	1	3	0,333	2	1	0,25		0,108	0,097	0,125	0,078	0,133	0,097	0,100	0,105	0,737	7,019
S3	0,5	0,333	1	0,167	0,5	0,333	0,143		0,027	0,032	0,042	0,039	0,033	0,032	0,057	0,037	0,262	7,081
S4	5	3	6	1	4	3	0,5		0,270	0,290	0,250	0,233	0,267	0,290	0,199	0,257	1,800	7,004
S5	2	0,5	2	0,25	1	0,5	0,2		0,108	0,048	0,083	0,058	0,067	0,048	0,080	0,070	0,493	7,043
S6	2	1	3	0,333	2	1	0,25		0,108	0,097	0,125	0,078	0,133	0,097	0,100	0,105	0,737	7,019
S7	6	4	7	2	5	4	1		0,324	0,387	0,292	0,467	0,333	0,387	0,398	0,370	2,589	6,997
	18,5	10,33	24	4,283	15	10,33	2,51		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		7,031
Production Quality																		
	S1	S2	S3	S4	S5	S6	S7									Ave	Sum	λ_{max}
S1	1	2	0,167	0,2	0,5	0,5	0,2		0,047	0,071	0,059	0,040	0,039	0,039	0,040	0,048	0,335	6,979
S2	0,5	1	0,143	0,167	0,333	0,333	0,167		0,023	0,036	0,051	0,033	0,026	0,026	0,033	0,033	0,228	6,909
S3	6	7	1	2	4	4	2		0,279	0,250	0,356	0,397	0,312	0,312	0,397	0,329	2,303	7,000
S4	5	6	0,5	1	3	3	1		0,233	0,214	0,178	0,199	0,234	0,234	0,199	0,213	1,490	6,995
S5	2	3	0,25	0,333	1	1	0,333		0,093	0,107	0,089	0,066	0,078	0,078	0,066	0,082	0,577	7,037
S6	2	3	0,25	0,333	1	1	0,333		0,093	0,107	0,089	0,066	0,078	0,078	0,066	0,082	0,577	7,037
S7	5	6	0,5	1	3	3	1		0,233	0,214	0,178	0,199	0,234	0,234	0,199	0,213	1,490	6,995
	21,5	28	2,81	5,033	12,83	12,83	5,033		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		6,993

Management & Organization																	
	S1	S2	S3	S4	S5	S6	S7								Ave	Sum	λ_{max}
S1	1	0,5	0,333	0,2	0,143	0,5	0,125	0,036	0,022	0,025	0,027	0,034	0,028	0,051	0,032	0,222	6,938
S2	2	1	0,5	0,25	0,167	0,5	0,143	0,071	0,044	0,038	0,034	0,039	0,028	0,058	0,045	0,313	6,956
S3	3	2	1	0,5	0,25	2	0,2	0,107	0,089	0,075	0,069	0,059	0,111	0,081	0,084	0,591	7,036
S4	5	4	2	1	0,5	3	0,333	0,179	0,178	0,150	0,137	0,117	0,167	0,135	0,152	1,063	6,993
S5	7	6	4	2	1	5	0,5	0,250	0,267	0,300	0,275	0,235	0,278	0,203	0,258	1,806	7,000
S6	2	2	0,5	0,333	0,2	1	0,167	0,071	0,089	0,038	0,046	0,047	0,056	0,068	0,059	0,414	7,017
S7	8	7	5	3	2	6	1	0,286	0,311	0,375	0,412	0,469	0,333	0,405	0,370	2,592	7,005
	28	22,5	13,33	7,283	4,26	18	2,468	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		6,992
References																	
	S1	S2	S3	S4	S5	S6	S7								Ave	Sum	λ_{max}
S1	1	1	0,25	1	0,25	0,5	0,333	0,063	0,063	0,070	0,063	0,070	0,048	0,051	0,061	0,426	6,984
S2	1	1	0,25	1	0,25	0,5	0,333	0,063	0,063	0,070	0,063	0,070	0,048	0,051	0,061	0,426	6,984
S3	4	4	1	4	1	3	2	0,250	0,250	0,279	0,250	0,279	0,286	0,308	0,272	1,902	6,993
S4	1	1	0,25	1	0,25	0,5	0,333	0,063	0,063	0,070	0,063	0,070	0,048	0,051	0,061	0,426	6,984
S5	4	4	1	4	1	3	2	0,250	0,250	0,279	0,250	0,279	0,286	0,308	0,272	1,902	6,993
S6	2	2	0,333	2	0,333	1	0,5	0,125	0,125	0,093	0,125	0,093	0,095	0,077	0,105	0,733	6,981
S7	3	3	0,5	3	0,5	2	1	0,188	0,188	0,140	0,188	0,140	0,190	0,154	0,169	1,186	7,018
	16	16	3,583	16	3,583	10,5	6,499	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		6,991

Capital																		
	S1	S2	S3	S4	S5	S6	S7									Ave	Sum	λ_{max}
S1	1	0,167	0,5	0,5	2	1	1		0,074	0,079	0,065	0,065	0,087	0,074	0,074	0,074	0,517	6,986
S2	6	1	4	4	8	6	6		0,444	0,470	0,516	0,516	0,348	0,444	0,444	0,455	3,184	6,998
S3	2	0,25	1	1	4	2	2		0,148	0,118	0,129	0,129	0,174	0,148	0,148	0,142	0,994	7,000
S4	2	0,25	1	1	4	2	2		0,148	0,118	0,129	0,129	0,174	0,148	0,148	0,142	0,994	7,000
S5	0,5	0,125	0,25	0,25	1	0,5	0,5		0,037	0,059	0,032	0,032	0,043	0,037	0,037	0,040	0,278	6,950
S6	1	0,167	0,5	0,5	2	1	1		0,074	0,079	0,065	0,065	0,087	0,074	0,074	0,074	0,517	6,986
S7	1	0,167	0,5	0,5	2	1	1		0,074	0,079	0,065	0,065	0,087	0,074	0,074	0,074	0,517	6,986
	13,5	2,126	7,75	7,75	23	13,5	13,5		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		6,987
Turnover																		
	S1	S2	S3	S4	S5	S6	S7									Ave	Sum	λ_{max}
S1	1	0,143	0,2	0,167	0,5	2	0,5		0,043	0,054	0,033	0,039	0,034	0,067	0,034	0,043	0,302	7,023
S2	7	1	2	2	5	8	5		0,298	0,375	0,332	0,464	0,337	0,267	0,337	0,344	2,409	7,003
S3	5	0,5	1	0,5	3	6	3		0,213	0,187	0,166	0,116	0,202	0,200	0,202	0,184	1,286	6,989
S4	6	0,5	2	1	4	7	4		0,255	0,187	0,332	0,232	0,270	0,233	0,270	0,254	1,779	7,004
S5	2	0,2	0,333	0,25	1	3	1		0,085	0,075	0,055	0,058	0,067	0,100	0,067	0,073	0,508	6,959
S6	0,5	0,125	0,167	0,143	0,333	1	0,333		0,021	0,047	0,028	0,033	0,022	0,033	0,022	0,030	0,207	6,900
S7	2	0,2	0,333	0,25	1	3	1		0,085	0,075	0,055	0,058	0,067	0,100	0,067	0,073	0,508	6,959
	23,5	2,668	6,033	4,31	14,83	30	14,83		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		6,977

Communication																	
	S1	S2	S3	S4	S5	S6	S7								Ave	Sum	λ_{max}
S1	1	0,5	0,25	0,142	1	0,5	0,167	0,043	0,028	0,034	0,057	0,043	0,037	0,039	0,040	0,282	7,050
S2	2	1	0,333	0,167	2	0,5	0,2	0,087	0,056	0,045	0,067	0,087	0,037	0,047	0,061	0,426	6,984
S3	4	3	1	0,333	4	2	0,5	0,174	0,167	0,136	0,134	0,174	0,148	0,117	0,150	1,050	7,000
S4	7	6	3	1	7	5	2	0,304	0,333	0,409	0,402	0,304	0,370	0,467	0,370	2,591	7,003
S5	1	0,5	0,25	0,143	1	0,5	0,167	0,043	0,028	0,034	0,058	0,043	0,037	0,039	0,040	0,282	7,050
S6	2	2	0,5	0,2	2	1	0,25	0,087	0,111	0,068	0,080	0,087	0,074	0,058	0,081	0,566	6,988
S7	6	5	2	0,5	6	4	1	0,261	0,278	0,273	0,201	0,261	0,296	0,233	0,258	1,803	6,988
	23	18	7,333	2,485	23	13,5	4,284	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		7,009
Delivery Lead Time																	
	S1	S2	S3	S4	S5	S6	S7								Ave	Sum	λ_{max}
S1	1	0,333	2	2	5	2	3	0,085	0,047	0,186	0,156	0,161	0,157	0,182	0,139	0,974	7,007
S2	3	1	4	5	8	4	6	0,256	0,140	0,372	0,390	0,258	0,314	0,364	0,299	2,093	7,000
S3	0,5	0,25	1	2	4	1	2	0,043	0,035	0,093	0,156	0,129	0,078	0,121	0,094	0,655	6,968
S4	0,5	0,2	0,5	1	3	0,5	2	0,043	0,028	0,047	0,078	0,097	0,039	0,121	0,065	0,452	6,954
S5	0,2	0,125	0,25	0,333	1	0,25	0,5	0,017	0,017	0,023	0,026	0,032	0,020	0,030	0,024	0,166	6,917
S6	0,5	0,25	1	2	4	1	2	0,043	0,035	0,093	0,156	0,129	0,078	0,121	0,094	0,655	6,968
S7	6	5	2	0,5	6	4	1	0,513	0,699	0,186	0,039	0,194	0,314	0,061	0,286	2,004	7,007
	11,7	7,158	10,75	12,83	31	12,75	16,5	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		6,974

Customization Capability																		
	S1	S2	S3	S4	S5	S6	S7									Ave	Sum	λ_{max}
S1	1	2	0,5	0,5	1	0,5	2		0,111	0,160	0,086	0,140	0,111	0,086	0,118	0,116	0,811	6,991
S2	0,5	1	0,5	0,333	0,5	0,5	2		0,056	0,080	0,086	0,093	0,056	0,086	0,118	0,082	0,573	6,988
S3	2	2	1	0,5	2	1	3		0,222	0,160	0,171	0,140	0,222	0,171	0,176	0,180	1,263	7,017
S4	2	3	2	1	2	2	4		0,222	0,240	0,343	0,279	0,222	0,343	0,235	0,269	1,885	7,007
S5	1	2	0,5	0,5	1	0,5	2		0,111	0,160	0,086	0,140	0,111	0,086	0,118	0,116	0,811	6,991
S6	2	2	1	0,5	2	1	3		0,222	0,160	0,171	0,140	0,222	0,171	0,176	0,180	1,263	7,017
S7	0,5	0,5	0,333	0,25	0,5	0,333	1		0,056	0,040	0,057	0,070	0,056	0,057	0,059	0,056	0,394	7,036
	9	12,5	5,833	3,583	9	5,833	17		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000		7,007