

**SUPPLIER SELECTION AND EVALUATION SYSTEM GENERATION:
AN APPLICATION IN WELDING INDUSTRY**



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**SUPPLIER SELECTION AND EVALUATION SYSTEM GENERATION:
AN APPLICATION IN WELDING INDUSTRY**

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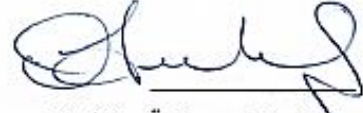
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ÖZET

TEDARİKÇİ SEÇME VE DEĞERLENDİRME SİSTEMİ OLUŞTURMA: KAYNAK SEKTÖRÜNDE BİR UYGULAMA

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Pazarda artan rekabet ortamında işletmeler, tedarik zincirine gereken önemi vermeli ve gelişim göstermelidirler (Christopher, 1998). Tedarik zinciri tanımsal olarak firmalar arasında malzeme, para, işçilik ve sermaye ekipmanları açısından yüksek bilgi akışını ve etkileşimini içerir (Thomas and Griffin, 1996). Böyle bağımlı bir iş ortamında, şirketlerin başarısı sadece kendi performanslarına bağlı değildir. Şirketlerin başarısı kendi performansları kadar, tedarikçilerinin başarısına da bağlıdır. Bu yüzden, tedarikçi seçme ve değerlendirme tedarik zinciri yönetimindeki çok önemli bir süreçtir. Tedarikçinin seçilmesi ve geliştirmesi çok kriterli bir karar verme problemidir, tedarikçi seçim kararlarını etkileyen bir çok faktör vardır (Ho vd., 2010). Bu çalışma, kaynak sektöründe kaynak elektrotu, kaynak teli ve tozu üreten bir firmadaki tedarikçi seçme ve değerlendirme problemini içerir. Çalışmaya konu olan firmanın sahip olduğu mevcut değerlendirme sistemi yetersiz ve uygulanabilirlik açısından zayıf kalmaktadır. Bu sebeple, bu çalışma ile mevcut sistem incelenecek, açıklar tespit edilecek ve ihtiyaçları karşılayan yeni bir tedarikçi seçme ve değerlendirme sistemi geliştirilecektir.

Anahtar Kelimeler---- Tedarikçi Seçimi, Tedarikçi Değerlendirilmesi, Ağırlıklandırılmış Skor Kart Yöntemi, Tedarik, Satın Alma, Kraljic Satın Alma Portföy Modeli

ABSTRACT

SUPPLIER SELECTION AND EVALUATION SYSTEM GENERATION: AN APPLICATION IN WELDING INDUSTRY

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Due to the markets and increasing competitive pressures, firms develop supply chains (Christopher,1998), which involves high interactions between firms in terms of information flow, materials, money, manpower, and capital equipment (Thomas and Griffin, 1996). In such an interdependent business environment, the success of companies depends not only on their performance; it is also affected from the performance of their suppliers. Therefore, selecting and evaluating a supplier regarding firms' goals is a significant process in supply chain management. Assuming that there are several factors affecting supplier selection decisions, the evaluation and selection of supplier is a multi-criteria decision-making problem (Ho et al., 2010).

This study addresses to the supplier selection and evaluation problem in a company producing welding products, such as welding electrodes, rod wires and flux. The company, which has a product-driven supply chain, has an insufficient supplier selection and evaluation system. Moreover, the existing system has a little interest on sustainability and risk assessment. In this respect, a new system is necessary for evaluating and classifying the supplier base. In this study, we investigate the existing system, identify the gaps, and develop a supplier evaluation approach.

Keywords---- Supplier Selection, Supplier Evaluation, Scored Card Weighted, Procurement, Purchasing, Kraljic Purchasing Portfolio Model

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CHAPTER I. INTRODUCTION

1.1. Introduction of the Main Concept and General Aims of the Study

Manufacturers have some problems because of the non-added values works, idle times spent and rework in today's market. To make their customers satisfied, the manufacturers must supply high-quality raw materials and components from suppliers without any problems and delays. The supplier selection is so significant, since reliable ones enable manufacturers to reduce inventory costs and improve product quality. Therefore, it is clear that manufacturers are concerned about supplier selection increasingly (Braglia and Peteroni, 2000).

As the selected company in today's business world, all of the companies have to focus on improving the effectiveness of process and operations. To get ahead in highly competitive place in market, a good supply chain system is essential for the companies. While determining the new system in this study, the vendor-buyer coordination problem, which is examined in many papers, is studied. The criteria determined before helps to form a systematic approach to be able to select and evaluate potential suppliers in supply chain by emphasizing the importance of quality and help to increase the quality and capability of supplier. Companies need an effective procurement process to obtain a competitive advantage for operating in today's challenging market conditions (Aktin and Gergin, 2016).

The case company is a producer of welding products; such as rod wires, flux and welding electrodes since they have an insufficient selection and evaluation system in terms of suppliers that was determined by ISO Audits.

This study provides an efficient supplier selection and evaluation system by considering case company's aims, market requirement, customers' expectations and purchasing habits in with score card weighted model.

1.2. Aim of The Study

The case company is producer of welding products, such as welding electrodes, rod wires and flux. They have an insufficient supplier selection and evaluation system which was determined also by regular ISO audits of supply chain department. The aim of this study is improving existing supplier selection and evaluation approach in order to select better suppliers by using score card. Any type of negativeness deriving from the supplier can seriously affect a lot of areas in production. Particularly huge amount-orders or more critical products affect most of the process and the manufactures are faced with really big problems and additional costs such as; redelivery cost, operate at loss, over labor cost, delay on delivery time, negative effect on supplier and receiver relationship and loss of trust. Conducting a good supplier selection system may reduce the time for searching alternative suppliers. Creating a good supplier evaluation system, may also be good for controlling and practicing sanction power for the buyer company which will raise the good negotiation share. Due to the power, buyers easily direct their suppliers according to their interests such as; payment term, delivery term and catching target price. Creating an effective supplier selection and development system with innovative performance consideration is significant in supplier relationship management (Kanan and Tan, 2002).

In the focal company, the existing system is insufficient and not being used effectively. This study aims to determine main gaps and generate an effective supplier selection and evaluation system. Decision making is a hard task to accomplish in supplier selection process. Thus, supplier selection and evaluation process is a multi-dimensional decision problem because it contains various variables such as quantitative and qualitative criteria (Özdemir and Deste, 2009).

1.3. Research Questions

This study aims to answer the following questions:

1. What is the current situation in supplier selection and evaluation system?
2. What are the gaps of current system?
3. Which criteria should be used for new supplier selection and evaluation systems?
4. How to generate a detailed performance scoring system for the selected criteria?

1.4. Significance of The Study

The aim of the producer is to control all the flow from the beginning of raw material buying to the end of order delivery. The target of supply chain management is to plan all the processes including raw material procurement, production and delivery planning. At that point, having a good supplier selection and evaluation system is so significant for procurement process. Especially in large companies improving and sustaining the system for protecting any type of quality and process problems is crucial. Thus, in this paper, the best and most appropriate supplier selection and evaluation criteria have been investigated in order to generate effective procurement systems meeting the requirements of the company.

1.5. Structure of Thesis

This study is structured as follows: Chapter 2 provides a literature survey, specifically presenting theory of procurement, supplier selection and evaluation with support from prior studies and describing the mixed findings from prior studies. Chapter 3 describes how the new system is generated with its theoretical background. Chapter 4 presents the current system and describing how the criteria were selected and measured. Finally, Chapter 5 is for the discussion of the results and recommendations for further researches.

CHAPTER II. PROCUREMENT IN WELDING INDUSTRY

2.1. Procurement

Procurement includes making buying decisions under conditions of scarcity. Increase in market competition in the late 1990s and *just in time* revaluation in the 1980s led to realize the requirement of quality improvement and cost reduction in procurement and also the proposed potential of procurement as a strategic decision to reduce costs and risks, and to increase value (Lindgreen et al, 2013). Procurement is a function which manages the external resources and gets the best possible inputs (Lindgreen et al, 2013). Procurement is the one of the most crucial activities for companies spending lots of money and time for purchased materials, thereby their success directly correlated with their supplier performance (Lee and Drake, 2010). Procurement spans the whole cycle from identification of the needs, through to the end of services contracts or the end of the useful life of an asset. It involves options of appraisal and the critical 'make or buy' decision, which may result in the provision of services in-house in appropriate circumstances (Murray, 2009).

Procurement involves a lot of processes such as; to identify purchase requirement, plan the process, prepare the documentation, identify possible suppliers, receive back the quotation documentation, evaluate the submissions, negotiation, award and place the contract, delivery, pay the supplier, manage and monitor the contract, and review process.

The procurement process occurred from several steps (Van Weele, 2001);

- Determining the specification of the goods and services in terms of required quantity and requirements
- Selecting the most suitable supplier
- Preparing and conducting negotiations with the supplier in order to establish an agreement
- Placing the order with the selected supplier
- Monitoring and controlling the order

- Following up and evaluating the process by keeping product and supplier information up-to-date, supplier rating and supplier ranking.

There are two types of procurement activities which are often divided into *direct*, production-related procurement and *indirect*, non-production-related procurement (Zenz and Thompson, 1994). Direct procurement occurs in manufacturing settings only, and it encompasses all items as the parts of finished products, such as raw materials, components and parts. The direct procurement is related with production such as; raw materials and production goods, on the other hand, the indirect procurement is non-related with production. This can be about the maintenance, repair and operating supplies. The direct procurement affects directly production process, in contrast the indirect procurement is interested with operating resources. It contains a wide variety of goods and services, from standardized low value items as office supplies and machine lubricants to complex and costly products and services; like heavy equipment and consulting services.

Industrial procurement is an important, complex and time sensitive process. The information search should be dynamic and has wide variety since the industrial procurement function includes multi-phase, multi-person, multi-departmental and multi-objective processes (Johnston and Lewin, 1996). Supplier evaluation is a crucial component of industrial procurement process which is one of the most significant functions for companies (Raut et al., 2010). The industrial procurement is extremely complicated as a result of uncontrollable and unexpected factors which can directly affect the final decision (Raut et al., 2010). Supplier selection provides a connection for getting a good supply chain and it is a critical success factor for companies (Labib, 2010).

This study focuses today's requirement through proposing a new detailed structure for supplier selection and evaluation for improving the quality and effectiveness of the procurement systems. All qualitative and quantitative criteria were adapted, combined and weighted based on previous studies.

2.2. Supplier Selection and Evaluation

Procurement generally puts emphasis on low cost and revolved around short-term contracts without considering quality (Lindgren et al., 2013). At the beginning of the pre-1990 era; most of the evaluation criteria were quantitative in procurement process. However in the post-1990 era, qualitative criteria became popular in literature with the increasing development of the purchasing processes. The first study in supplier selection area was published by Dickson in 1966. Dickson's 23 different selection criteria should be considered while developing a supplier evaluation method.

Over seventy-five generic criteria have been used in different purchasing framework through industries in different vendor selection and evaluation literature which are listed in Table 1 (Ho, Xu and Dey, 2010; Weber, Current and Benton, 1991). They have been used in different purchasing contexts across industries (Kar, 2014).

In today's market, manufacturer faces with awful situations because of the non-added values works, rework and idle times spent. In order to have satisfied customers, the manufacturers have to supply good raw materials and components from the suppliers without any delays and problems. Thus, the supplier selection is so important. Because reliable suppliers enable manufacturers to reduce inventory costs and improve product quality. Therefore, it is understandable that manufacturers are increasingly concerned about supplier selection (Braglia and Petroni, 2000).

The enterprises must find more efficient suppliers to increase supply chain competitiveness (Chen, 2011). Consumer and market demands are increasing in modern industry due to the reason of short product lifecycles and the need providing immediate customer response. There are many suppliers and the companies need to learn how to choose good suppliers for establishing long-term relationships the selection and evaluation of suppliers is a very important issue which affects total cost in a company. Catching a good supplier service level is significant because only by this way, customer satisfaction can be achieved through the provision of good product quality without any problems.

Table 1. The Different Supplier Evaluation Criteria in Literature**(Adapted from Ho, Xu and Dey, 2010; Weber, Current and Benton, 1991)**

Product Quality	Delivery Reliability	Warranties
Exporting Status	Packing Capability	Intellectual Property Rights
Product Pricing	Production Capability	Order Acknowledgements
Financial Position	Vendor Reputation	Management Capability
Labor Relations	Self-audits	Past Business Records
Cultural Fitment	Reciprocal Arrangements	Communication Barriers
Inventory Position	Technical Capability	Value-added Productivity
Trade Tariffs	Foreign Exchange Rates	Geographical Distance
Supply Variety	Service Design	Electronic Data Interchange
Trade Restrictions	Buyer's Commitment	E-Transaction Capability
Documentation	Design Capability	Acceptable Parts per Million
Response Flexibility	Safety Adherence	Purchase Order Stability
Lead Time	Quality Management	Rejection Rate During Inspection
Innovation	Facility Planning	Dollar Value of Performance
Domain Experience	Exporting Status	Conflict Resolution Systems
Customs Duties	Product Line Diversity	Intimacy of Relationships
Indirect Costs	IT Standards	Cost Reduction Capability
Electrical Capacity	Judgment	Service Quality Experience
Risk Perception	Total Cost of Acquisition	Certification and Standards
Availability of Parts	Organizational Culture	Research and Development
Response Time	Sub-component Pricing	Cost Reduction Performance
Indirect Costs	Receiving Inspection	Education Level of Personnel
Billing Accuracy	Regulatory Compliance	Rejection From Customers
Data Administration	Procedural Compliance	Improvement Commitment
Skill level of Staff	Vendor's Commitment	Service Quality Credence

Having good suppliers provides reduction of costs by eliminating wastes, continuous improvement in quality to reach zero defects, improving flexibility to meet the requirements of the end-customers, reducing lead-time at different stages of the supply chain (Kar, 2014). Purchasing should be a part of corporate strategy. For this reason, it is important that purchasers know how to evaluate risk and maximize profits by having the right approach in procurement.

There are several papers regarding the application of supplier selection and supplier evaluation in the literature. According to the Dickson's study, there 23 factors and quality, delivery and performance history were endorsed as the most important criteria (Dickson, 1966). Another study about this subject in literature was belonging to Weber (Weber, 1991). Price was the highest-ranked factor in these studies and delivery and quality came. Additionally, geographical location was determined. Table 2 summarizes the criteria and their importance ranking according to Dicksons (1966) and Weber (1991).

External and internal factors should be considered in order to meet the need of markets within global changing environment (Chen, 2011). There are lots of methods for supplier selection and supplier evaluation such as Analytical Hierarch Process, Multi-Objective Programming, Simulation, etc (Chen, 2011).

The expectations and requirements are still changing. There are several studies with different methods and techniques for selecting and evaluating suppliers. In the literature, the most observed criteria are "Price", "Delivery", "Quality" and "Production capacity and location". The researchers demonstrated that, quality was perceived to be most important, followed by delivery and cost.

Sen et al. (2008) suggested a hierarchical criteria system for an electronics company which includes cost, quality, service, reliability, management, organization and technology. Labib (2010) focused on four criteria which are quality, delivery, service and cost for vending market and suggested that few criteria are more effective due to the reason of time waste of handling more parameters in evaluation.

Table 2. Important Criteria for Supplier Selection**(Adapted from Dicksons, 1966 and Weber, 1991)**

Evaluation Criteria	Importance Ranking of Dickson	Importance Ranking of Weber
Price	6	61
Deliver on time	2	44
Quality	1	40
Equipment and capability	5	23
Geographic location	20	16
Technical Capability	7	15
Management and organization	13	10
Industrial reputation	11	8
Financial situation	8	7
Historical performance	3	7
Maintenance service	15	7
Service attitude	16	6
Packing ability	18	3
Production control ability	14	3
Training ability	22	2
Procedure legality	9	2
Employment relations	19	2
Communication system	10	2
Mutual negotiation	23	2
Previous image	17	2
Business relations	12	1
Previous sales	21	1
Guarantee and compensation	4	0

Another research is belonged to Raut et al. (2010). That study was conducted in a manufacturing and assembly Company. Quantity, quality, delivery, service, responsiveness, technical capability, production facility and pricing were taken as the

evaluation criteria. These criteria are dependent on market and type of the product. All supplier selection criteria support the same aim, which is optimizing the supply chain through successful supplier relationships (Sen et al. 2008, Spina et al. 2013). The below table shows some studies about supplier selection and evaluation generation.

Table 3. Some Studies about Supplier Selection and Evaluation Generation

Author(s)	Published Year	Criteria According to Importance Weights	Study About
Dicksons	1966	Price, Delivery, Performance History, Policies, Production Facilities	Evaluation
Ellram	1990	Finance, Organizational Culture, Strategy, Technology	Evaluation
Weber	1991	Price, Delivery, Quality	Selection
Barbarosoğlu & Yozgaç	1997	Performance, Technical Capability, Financial Capability, Quality System	Evaluation
Sen et al.	2008	Quality, Delivery, Price	Selection
Sen et al.	2010	Cost, Quality, Service Reliability, Management & Organization, Technology	Evaluation
Raut et al.	2010	Quantity, Quality, OTD, Service, Responsiveness, Technical Ability, Production Facility, Pricing Structure	Evaluation
Labib	2010	Quality, Delivery, Service, Cost	Evaluation

2.3. Supplier-Buyer Relationship Models

Over the past few years, there have been crucial changes in companies' supplier-buyer relationship approach. The importance of supplier-buyer relationship has been increased. Instead of the old-style purchasing relationship, which based on short-term contracts, competing especially on price with several alternative suppliers, single-sourcing relationships with long-term contracts including mutual benefits for two sides have become the preference of most companies. A relationship between the supplier and buyer must be established for close business collaboration as strategic partners

(Aksoy and Ozturk, 2011). There are three types of relationship approach which are partnership sourcing, lean supply and network sourcing.

According to Ellram and Krause's description, partnership is a continuous relationship between firms which includes a long term contract, and a mutual sharing of information and the risk and rewards of the relationship (Ellram and Krause, 1994). Moreover, Ellram defined 5 factors for establishing successful supplier-buyer relationships. These are respectively mutual information sharing, top management support, mutual goals, early announcement to suppliers and supplier's distinctive features contribution (Ellram, 1995).

The lean supply model developed by Lamming in 1993, which based on automotive industry. According to Lamming, key elements of relationships among buyers and suppliers are organizational structure, communications, business aims and culture (Lamming, 1993). People should be more interested with their working environment for achieving lean supply (Lamming, 1993).

The other supplier-buyer relationship view is network sourcing. The key factors of network sourcing are supplier coordination, supplier development, and ranking of supply within each company for each supplier. The network-sourcing model developed by Hines in 1994 presenting today's Japan industry. Also, Hines claims that partnership cannot be always appropriate for all relationships. For achieving success, to identify relationship's characteristics which involve advantages and, understanding limitations of cost and timescales are crucial. That model suggests 10 features which are summarized as follows (Hines, 1996).

The strategy of both sides avoids from individual's interests and from win-lose relationship. In order to improve, both sides accept the win-win relationship approach. Ellram has identified this as an agreement between a buyer and a seller that involves a commitment over an extended time period and includes the information sharing along with a sharing of the risks and rewards of the relationship (Ellram, 1991).

Table 4. Network Sourcing Overview (Adapted from Hines, 1996)

1.	A stage supply framework with a heavy reliance on small firms.
2.	A small number of direct suppliers with individual part numbers sourced from one supplier but within a competitive dual sourcing environment.
3.	To divide risk equally between customer and supplier and high degrees of asset particularity among suppliers.
4.	A maximum buy strategy by each company within the semi-permanent supplier network, but a maximum make strategy within these trusted networks.
5.	A high degree of two-sided composition, using equally the knowledge and skills of customer and supplier.
6.	A high degree of supplier innovation in both new products and processes.
7.	A high level of accessibility, trust and profit sharing can be supplied by close, long-term relations between network members.
8.	The use of reliable supplier evaluating systems increasingly allow supplier self-certification
9.	A high level of supplier coordination by the customer company at each level of the tiered supply structure.
10.	To improve their suppliers, a substantial effort reveal by customers at each level of these levels.

2.4. Importance of Procurement in Welding Industry

The welding is the most economical and efficient way to joint materials. Most of things used in our daily life is welded. The welding is nearly used in every industry such as; construction, automobile, vehicles, electrical household appliance. The usage area of welding is unlimited.

Its quality is crucially important which means that supplier selection is the major issue in welding industry because any kind of variation directly affects the final good.

In history, there are two significant examples for understanding the importance of welding. One of them is Titanic which was the largest ship ever built at the time of her construction. She was nearly 900 feet long, stood 25 stories high, and weighed an incredible 46,000 tons (Smithsonian Institution, 1997). When the Titanic clashed with the iceberg, the hull steel and the wrought iron rivets failed because of brittle fracture. A type of catastrophic failure in structural materials, brittle fracture occurs without prior plastic deformation and at extremely high speeds. The causes of brittle fracture include low temperature, high impact loading, and high sulphur content. On the night of the Titanic disaster, each of these three factors was present: The water temperature was below freezing, the Titanic was traveling at a high speed on impact with the iceberg, and the hull steel contained high levels of sulphur (Vicki Bassett, 2000). Charpy tests show whether a metal can be classified as being either brittle or ductile. This is particularly useful for ferritic steels that show a ductile to brittle transition with decreasing temperature. A brittle metal will absorb a small amount of energy when impact tested, a tough ductile metal absorbs a large amount of energy. The ductile-brittle transition temperature determined at an impact energy of 20 joules is -27°C for ASTM A36, 32°C for the longitudinal specimens made from the Titanic hull plate, and 56°C for the transverse specimens. It is apparent that the steel used for the hull was not suited for service at low temperatures. The seawater temperature at the time of the collision was -2°C . As we understand from this example any kind of incorrectness of welding quality can cause serious results. Surely when considering technology at that time, it was also occurred from the lack of know-how. The other example is Swimming Pool Roof Collapse which was occurred in 1980 and 12 people was killed. This disaster was happened due to stress corrosion cracking. According to The Federal Materials Testing Institute, Switzerland, and the Federal Materials Research and Testing Institute of Berlin, the collapse happened because of the chloride-induced stress corrosion cracking. Chloride is a major factor in corrosion of reinforced concrete, the chloride was either already present in the concrete or came from the pool via water vapor. Chloride can overcome the passivity of the natural oxide film on the surface of the steel. The steel, lacking its passive film, readily releases iron atoms into solution (Lonza Engineering Ltd-Newsletter, 2011). If the Pitting resistance equivalent number had been greater than 32, that disaster would not have happened. Any kind of minor changing in welding such as; different value on nitrogen may cause this type of

disaster. Thus, the supplier selection and evaluation is really important in welding industry for also preventing any kind of quality failures that may result in disasters.



CHAPTER III. METHODOLOGY

In the present study, mixed method case study design was utilized.

3.1. Case Study

Case study is an empirical method focused on investigating contemporary phenomena in their context. It is called as a research strategy and stressed the use of multiple sources of evidence by Robson (2002). Benbasat et al. (1997) presents definitions that are more specific, mentioning information collecting from few entities (organizations, groups and people) and the lack of experimental control while Yin (2003) states it a questionnaire and remarks that the boundary between the phenomenon and its context may be unclear.

Case studies also relate to three other major research techniques which are survey, experiment and action research.

- Survey; is standardized information collecting from a specific population or some sample from one generally, but not necessarily whereby a questionnaire or interview (Robson, 2002).

- Experiment (controlled or not) defined by measuring the effects of manipulating one variable on another variable. (Robson, 2002) and that subjects are assigned to treatments by random. (Wohlin et al., 2000). Quasi-experiments, that are similar to controlled experiments but different from them in terms of assigning subjects to treatments not randomly. Ouasi-experiments applied in an industry setting may have many characteristics in common with case studies.

- Action research, aims to influence or change some aspect of whatever is the focus of the research (Robson, 2002), is closely related to case study. A case study is purely observational when action research involved in and focused on the change process. In technology transfer studies (Gorschek et al., 2006) and software process improvement (Dittrich et al. 2008; Iversen et al., 2004) the research method should be defined as action research. We classify the methodology as case study when studying the effects

of change, for instance, in pre-event and post-event studies. There is a discussion on balancing action and research, in Is, where action research is widely used, see e.g (Avison et al. 2001; Baskerville and Wood-Harper 1996). These guidelines are applied as well to the research part of action research.

Case study was used for exploratory purposes primarily, still some researchers limit it for this purpose as discussed by Flyvbjerg (2007). If the generality of the situation or phenomenon is of secondary importance, case study is also used for descriptive aims. Although the isolation of factors may be a problem, case studies may be used for explanatory aims, for example; in interrupted time series design (pre-event and post-event studies) This includes testing of existing theories in confirmatory studies. As mentioned above, case studies in software engineering discipline generally take an improvement approach, similar to action research; see e.g the QA study. (Anderson and Runeson, 2007).

According to Perry et al. (2005) definition, it is expected that a case study;

- to include research questions asked through the study.
- to have data collected in a planned and consistent manner?
- to involve inferences made from the data to get answers to the research questions.
- to explore a phenomenon, producing an explanation, description, or casual analysis of it.
- to address a threat to validity in a systematic way (Perry et al., 2005).

The collected data may be quantitative or qualitative in an empirical study. Qualitative data includes descriptions, words, pictures and diagrams, observations, etc (Saunders et al., 2000). Quantitative data includes numbers, classes, statistical data (Dahmström, 2011). Quantitative data is formed from the analysis involving descriptive statistics, development of predictive models, correlation analysis, and hypothesis testing that are relevant in case study research. The methods for quantitative analysis obviously assume a fixed research design. Qualitative data is examined using categorization and sorting while quantitative data examined using statistics. In case studies, qualitative data is used mostly since these provide a richer and deeper description. However, combining qualitative and quantitative data provides better understanding of the studied phenomenon. (Seaman, 1999); i.e.; this is called "mixed methods" sometimes

(Robson, 2002). In qualitative data, sufficient information from each step of the study and every decision taken by the researcher have to be presented in order to create a clear chain of evidence providing a reader to follow the derivation of results and conclusions from the collected data, since the main objective of the analysis is to derive conclusions from the data.

3.2. Data Collection

Triangulation, means looking at the studied object from different angles to provide a broader picture, is obviously needed relying primarily on qualitative data, is richer and broader, but less precise than quantitative data. However, it is valid for also quantitative data, for instance, to compensate for measurement or modeling errors. There are four different types of triangulation may be applied (Stake, 1995):

- Data (source) triangulation: A collection of the same data at different occasions or using more than one data source.
- Observer triangulation: Benefiting from more than one observer for the study.
- Methodological triangulation: Combining variable types of data collection methods. (e.g. quantitative and qualitative methods)
- Theory triangulation: Benefiting from alternative theories or viewpoints.

In the present study, data source triangulation method was used. All data was comparing with different participants that were attend to structured meetings. Through different perspectives, all decisions were taking impartially. That point was especially important for qualitative researches.

There are two types of data: primary and secondary data. Primary data can be gathered through interviews and questionnaires for a specific study with specific questions but secondary data involves the existing data such as the documents created by a company (Alfredsson and Christenson, 2014). The secondary data helps the existing system deeply more than primary data.

In this study, secondary data was used and in addition primary data collected through structured meetings study for providing a deeper understanding for current system

requirements and discussing the determined criteria. Besides, due to working in the company as a procurement personnel and dealing with the procurement process, participant observation also contributed to the data collection process.

This study was conducted in supply chain department that includes raw material, packing material, operating and consumables material, sub-industry, investment, commercial and service purchasing just without administrative and software and hardware purchasing.

Through the structured meetings, the existing supplier selection and evaluation process was analyzed deeply and determined important and lacking points. The structured meetings were carried out with four people. Two of them are purchasing responsible working in different areas of purchasing, one of them is responsible for supplying raw material and packing material, other one is responsible for supplying operating and consumables materials. Other participant is purchasing unit leader who responsible from all purchasing process. Another one is the supply chain manager of the company who responsible from all purchasing, planning, warehousing, foreign trade process. This group determined the criteria for creating an efficient supplier selection and evaluation system in supply chain through six, 2 hours, bi-weekly meetings. All meetings were organized and moderated by purchasing unit leader (author). Table 5 was summarized details of those meetings.

Table 5. Details of the Structured Meetings

1 st Meeting	Author gave information about literature review and then, the group began to discuss through this informing. Firstly, they talked about how they manage the process Then, they agreed on create general score cards and examined all procurement types which are belonged to supply chain department.
2 nd Meeting	The group was discussed problems faced in the supplier selection process and lacking criteria for supplier selection process. Due to understand the requirement of system, that group was executed additional meetings with maintenance and production departments. The selection criteria were determined through the investigation results.
3 th Meeting	All selection criteria detailed and concluded weighting percentage of criteria through the purchasing type. Additionally, lacking points of evaluation process and inefficiency of existing criteria were discussed. According to these discussion, they decided firstly analyzed the materials according to Klarjic Method. In this analysis, 45.523 different supplied materials were analyzed through determined criteria and weighting percentage. The result of this analysis used in generated evaluation system.
4 th Meeting	They discussed the criteria of evaluation system according to the purchasing type as the selection process and had begun to detail all criteria.
5 th Meeting	All evaluation criteria were detailed and determined the weighting percentage of criteria. Later, creating recommended supplier performance classes and purchasing strategies through supplier class.
6 th Meeting	Instead of recording, notes were taken by author and the last meeting executed with top management for explaining the studies and beginning the requirement works.

3.3. Data Analysis

In this study, quantitative and qualitative data was used. All data was collecting from existing ERP system and Quality system. Through those systems, existing system was analyzed and requirement was determined.

In the mixed method case study, six steps approach was followed:

1. Current system analysis
2. Determining the criteria and indicators for establishing supplier selection and evaluation scorecard
3. ABC analysis
4. Kraljic portfolio analysis
5. Determining the importance weights for each criterion
6. Generating detailed performance evaluation for selection and evaluation criteria

3.3.1. Pareto Analysis

Pareto Analysis is a statistical technique used for decision making that separates a limited number of input factors as having the greatest impact on an outcome, either desirable or undesirable. It known as the 80/20 rule which is also known as the 80-20 rule developed by the Italian Economist Vilfredo Pareto (Karuppusami and Gandhinathan, 2006). Pareto analysis is based on the idea that 80% of a project's benefit can be achieved by doing 20% of the work or conversely 80% of problems are traced to 20% of the causes. It is one of the most commonly used, and easy to implement method. Pareto analysis is a simple and useful methodology for determining the most crucial factors or assignments in an organization (Cervone, 2009). For example, Cervone used Pareto analysis for digital library catalog for determining the most problematic tasks causing customer complaints.

In this study, approximately, 40.000 sale invoices belonging to sold products of 2015 were involved. Pareto analysis was applied on the products sold in 2015 in order to sort and arrange the products based on total revenue effect, which was illustrated in Table 6. The outputs of the Pareto Analysis were used in material analysis in chapter 4.

Table 6. Example of Pareto Analysis of Sold Products of Case Company in 2015

Product Name	The Effect of Total Revenue (%)
A	81
B	81
C	81
D	81
E	81
F	81
G	81

3.3.2. Kraljic Portfolio Purchasing Model

The Kraljic Portfolio Purchasing Model was created by Peter Kraljic and first appeared in the Harvard Business Review in 1983. According to Kraljic (1983) a firm's supply strategy depends on two factors: profit impact and supply risk. The aim of the model is to help purchasers for maximizing supply security and reducing costs. According to the model, there are 4 types of products which are strategic products (high impact – high supply risk), bottleneck products (low impact – high supply risk), leverage products (high impact – low supply risk) and non-critical products (low impact – low supply risk).

Strategic products' example is wire rod for iron steel industry, engines for machine manufacturers and gearboxes for automobile manufacturers. The purchasing strategy for these products is creating partnership (Kraljic, 1983).

Bottleneck products have generally one supplier and due to single sourcing situation, it has high supply risk. Therefore, suppliers have a high power position (Kempeners and Van Weele, 1997). The purchasing strategy for these products is assuring dependency and reduction of the negative effects between buyer and seller (Kraljic, 1983). An alternative strategy suggested by purchasing practitioners is to find other suppliers.

Leverage products have low supplied risk. These products have many different suppliers. Thus, negotiation process is generally favorable for the buyers and these

features are supported with aggressive approach to the supply market (Van Weele, 2000). The purchasing strategy for these products is utilizing power (Kraljic, 1983). Non-critical products have various suppliers. In addition, their unit price is small. These products just cause few technical or commercial problems in the purchasing process but the procurement process can take time. Therefore, the purchasing strategy for these products is ensuring the most efficient method (Kraljic, 1983). General idea of portfolio approach is minimizing supply weakness and creating buying power (Kraljic, 1983).

Overall purchasing strategy recommendation for each portfolio quadrant of Kraljic show in Figure 1. This matrix is commonly referred as Kraljic's Portfolio Matrix (Olsen and Ellram, 1997; Lilliecreutz and Ydreskog, 1999; Van Weele, 2000; Gelderman, 2003). Purchasers separate different supplier relations and choose appropriate strategies for each and thus, suppliers are managed effectively (Nellore and Soderquist, 2000).

Figure 1. The Kraljic Purchasing Portfolio Model (Modified From Kraljic, 1983)

PROFIT IMPACT	LEVERAGE PRODUCTS *UTILIZE POWER	STRATEGIC PRODUCTS * CREATE PARTNERSHIP
	NON-CRITICAL PRODUCTS *ENSURE EFFICIENT METHOD	BOTTLENECK PRODUCTS *GUARANTEE SUPPLY
	SUPPLY RISK	

The Kraljic Portfolio Purchasing Approach is a popular and useful model used in companies worldwide. In this study, this approach was applied on material analysis in Chapter 4. All materials were analyzed according to product criticality, financial criticality and material availability and then, all of them categorized based on Kraljic portfolio model.

3.3.3. Scored Card Weighted Method

Scored Card Weighted method provides a detailed rating system. This study utilizes the method for determining the important criteria for the focal company and generating scorecards. It is used in different industries for supplier selection and evaluation of suppliers. Score cards present the supplier's performance evaluation for defined period such as; a month, 6 months or a year. The criteria should be periodically reviewed, modified and updated according the requirements and criteria importance (Seyedhosseini et al, 2011). There are two indicators in scorecards which are importance weight and performance score. Those two indicators are multiplied and evaluated together. According to score card weighted method, key performance indicators are defined. This approach has been a useful tool for developing a strategic plan that mix more criteria and determining requirements for achieving goals (Chia et al, 2009). Generally, 5 point scales are used for performance score (0-very bad, 1-bad, 2-medium, 3-good and 4-very good). However, it can be changed according to company policy.

The group was used weighted scored card method with ternary ranking system as existing system while creating new supplier selection and evaluation system. In the present study, 1-5-9 scoring system was used and 1 shows bad, 5 shows medium and 9 shows very good. They chose that scoring system since they want all suppliers to take a point for determining the each supplier group's position in their category.

3.3.4. Secondary Data Analysis

Secondary data analysis is the data gathered by someone else for other purpose. Secondary data analysis is a practical way for utilizing existing data and it provides advantage of time and resource usage for researchers whereby it is becoming popular for research (Smith, 2008; Schutt, 2011; Smith et al., 2011; Dahmström, 2011; Andrews et al., 2012). Secondary data analysis that includes a review of previously collected data in the area of interest takes this one-step further. Thanks to flexibility of secondary data analysis, it can be utilized in several ways. Just like collecting and evaluating primary data, secondary data analysis is an empirical exercise with procedural and evaluative steps. (Doolan and Froelicher, 2009).

In this study, secondary data analysis was used for understanding the existing system and the gaps in the purchasing process. Data collection was done between October 2015 and May 2016 from different departments of the company.

As secondary data the following documents were examined:

- Purchasing price list,
- Existing supplier evaluation lists,
- Approved and alternative supplier lists,
- Work flow of purchasing process
- Feasibility forms

CHAPTER IV. ANALYSIS AND NEW SYSTEM GENERATION

4.1. Current System Analysis

In the existing system, there are more than 3500 suppliers and there are some lacking points in the evaluation procedures of current suppliers.

The existing system is an insufficient supplier selection and evaluation system due to the below problems which were determined by ISO Audits.

- ✓ Human-driven system
- ✓ Fail to satisfy for quality expectations of the company/customer
- ✓ Insufficient follow ability
- ✓ Insufficient measurability

There are not any predetermined criteria for new supplier selection, requested criteria depend on people and show variation. When the purchasing responsible searches a new supplier, he/she generally views the supplier's quality and its prices after that he/she considers the delivery time. In addition these, when we look at the evaluation supplier system, the suppliers are just evaluated in terms of three criteria: delivery time, quality and ratio of conformity and non-conformity products. In the existing system, delivery time has 30% of the importance share, quality has 60% and the ratio of conformity and non- conformity products has 10%. According to this division, suppliers' scores are determined.

At the end of the evaluation process, the suppliers are categorized in three different groups which are called as A, B and C. A class suppliers are called as reliable suppliers and A group suppliers has an overall rating point which is between 80 and 100. B class suppliers are called as reliable suppliers but purchasing is risky and this groups' point is between 50 and 79. C class suppliers are called as unreliable suppliers and the preference is not doing any purchase due to its risk. Total rates of C class suppliers are between 0 and 49.

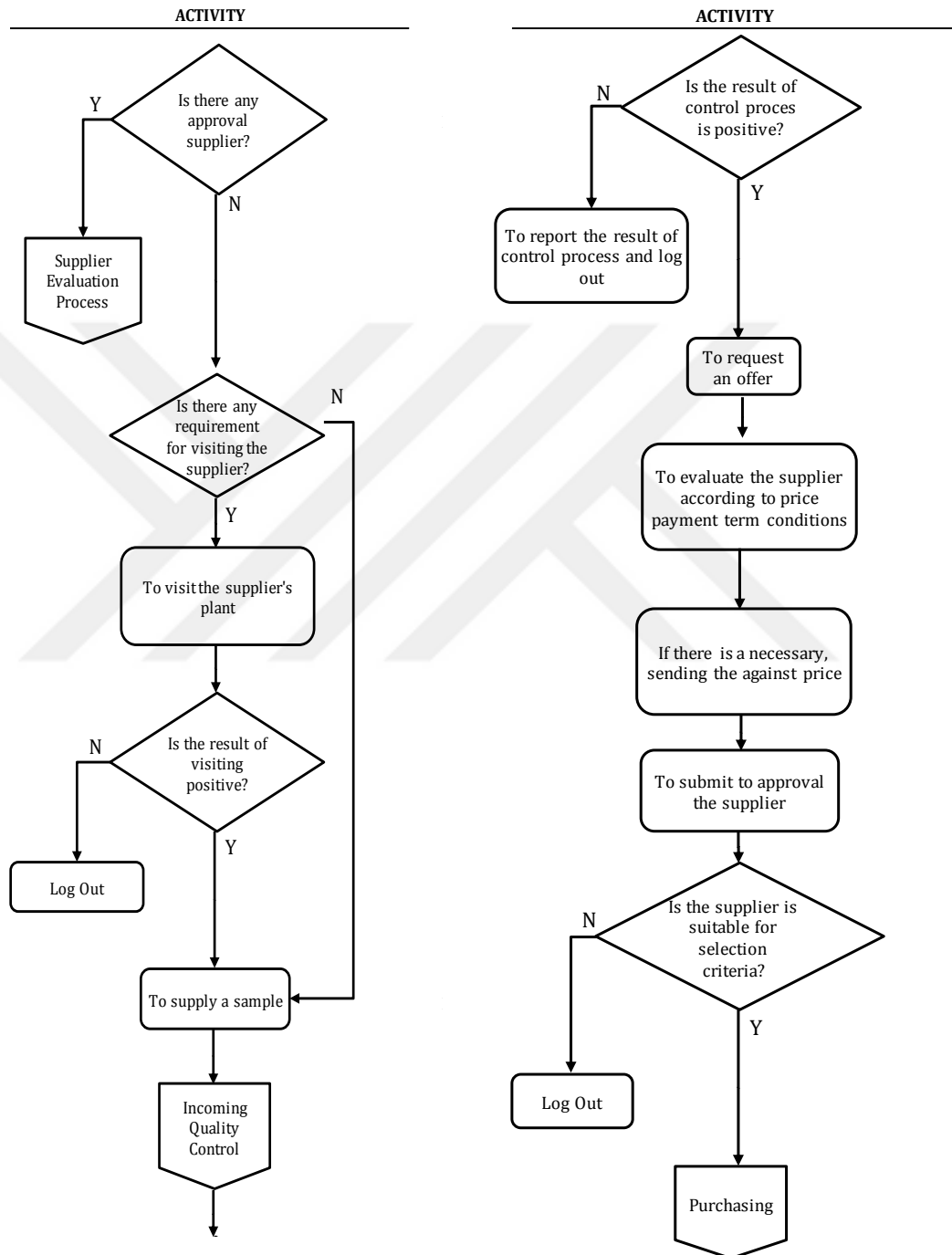
However, this existing system has its problems. For example, there is not any controlling parameter for financial risks, lean applications, geographical advantages

and feedback efficiency. This ends up in poor supplier quality management system. There is not any scored card application. There are nine different purchasing branches. These are raw material, packing material, investment, operating and consumables, sub-industry, commercial, administrative, software and hardware purchasing. The raw material and packing material purchasing are supplied a material which are directly used for producing final product such as; wire rod, minerals, chemical components, dies, boxes, plastics and pallets, etc. Investment purchasing deals with production machines, production machines software, warehouse systems, etc. Operating and consumables materials purchasing is interested operating resources which are used in production process such as; mat, screw, paint, crane, conveyor, machine lubricants, etc. Sub-industry purchasing is interested with machining works such as; maintenance, repair materials. Commercial material is produced in another manufacturer company and directly sell with buyer company brand to customer or just sustain re-packing process and then sell to customer, commercial purchasing is managed and controlled that process. Administrative purchasing is supplied materials such as; stationery equipment, tables, paper towel, detergent, food services, etc. It is up to Human Resources Department. Software and hardware purchasing is up to Information Technology Department. It is supplied the materials such as; printers, computers and computer software, programs etc.

All these purchases depend on the supply chain department except administrative, software and hardware purchasing. Unfortunately, these gaps are also identified in ISO' Audits.

In the current system, supplier selection process is applied according to the below work flow.

Figure 2. Supplier Selection Process of Existing System



If the supplier passes all these steps in supplier selection process, the aim is to make at least three purchases. Then, the supplier is subjected to supplier evaluation process.

According to the following criteria and the weight ratio, the supplier performance is calculated at the beginning of each month with the last six months data.

Table 7. Calculation Table of Supplier Performance in The Existing System

Evaluation Criteria	Weight Ratio	Calculation Method
Quality	40	$\text{Score of Quality} = \left(1 - \frac{\text{Number of Rejected Products}}{\text{Total Quantity}}\right) * \text{Weight Ratio} * 100$
Delivery Time	30	$\text{Score of Delivery} = \left(1 - \frac{\text{Number of Late Order}}{\text{Total Number of Order}}\right) * \text{Weight Ratio} * 100$
Quantity Efficiency	25	$\text{Score of Quantity} = \frac{\sum_{\text{The Last Six Months}} \text{Order Quantity} - \text{Coming Quantity} \geq 0,20}{\text{Number of Order in Six Months}} * \text{Weight Ratio} * 100$
ISO Quality System Certificate	5	<p>If the supplier has ISO Quality System, supplier score is equal to 15, If not, 0.</p> <p>This criterion is just valid for Production Companies.</p>
TOTAL	100	

According to these calculation results, every supplier is gaining a score and according to these scores, actions are taken as follows.

Table 8. Description of the Supplier Classes in The Existing System

Performance Code	Description
A	Between 80 and 100 Approved supplier
B	Between 50 and 79 Approved supplier but improvement is needed.
C	Between 0 and 49, The supplier is suspended and corrective actions are needed. If the supplier takes the same performance code in a specified time, the supplier is out of the supplier list.

In the existing system, to calculate the performance scores of criteria, 1-3-6 point scoring system is being used as showed below.

Table 9. Criteria Calculation of Existing System

Delivery Time=D					
Lower Limit				Upper Limit	Score
		D	≥	74	6
29	≤	D	<	74	3
		D	<	30	1

Regarding above mentioned observations, the company lacks some necessary and essential criteria to evaluate the performances of suppliers. Firstly, there is no scored card application in evaluating suppliers. Moreover, the company needs to add controlling parameters for financial risks, and environmental management system and recycling, lean applications, geographical advantages and feedback efficiency. In this respect company needs essential changes in existing system.

4.2. Supplier Selection and Evaluation System Application

Choosing the right supplier is a significant decision making problem for the producers (Özyürük and Özcan, 2008). A wide range of factors such as value for money, quality, reliability and service affect the selection process. Dickson (1966) suggested 23 different criteria for supplier selection. Business priorities and corporate strategy also affect the importance of these factors. Implementing specific supplier's selection criteria will help to decide on the supply needs of a company, identification of potential suppliers and choosing them.

The procurement process includes two steps. The first step of procurement process is the selection of the supplier and the second one is supplier evaluation system. Companies require an effective procurement process to acquire competitive advantage for operating in today's challenging market conditions (Aktin and Gergin, 2016).

The case company has 9 different types of purchasing branch which raw material, packing material, operating and consumables material, sub-industry, investment, commercial and service purchasing just without administrative and software and hardware purchasing.

Except administrative, software and hardware purchasing, all of them depend on the company's supply chain department.

4.2.1. Supplier Selection Criteria

To begin with, the group discussed and determined the criteria of new supplier selection system according to requirement and aim of the company.

Based on the group meetings, main criterion categories were generated. In the proposed supplier selection process, five main criteria, namely, quality, cost, delivery, suitability of packing and supplier attributes were employed. There are eleven sub-criteria. Product quality and types of possessed certifications, standards, and approval criticality were generated for assessing quality. Unit price utility, payment term and logistic cost factor were determined as cost category. Delivery term and lead time were used for evaluating delivery. Suitability of packing was considered as another

important category in welding industry for the suppliers. Finally, age of the company, type of the company and cooperation performance were evaluated as supplier attributes criterion.

All criteria and weighted ratio were determined within the groups. The most important criteria was cost with the weighting percentage of 0,33. Second important criteria was quality with the weighting percentage of 0,25. Supplier attributes follows the quality with weighting percentage of 0,22. Then the lower criteria are respectively delivery with weighting percentage of 0,14 and suitability of packing with weighting percentage of 0,06. These weighted ratios are valid for raw material, packing material, operating and consumables, sub-industry, and commercial purchasing.

4.2.1.1. Supplier Selection Criteria and Sub Criteria Calculation

4.2.1.1.1 Quality

- **Product Quality**

In selection step, the purchasing responsible has to demand samples from the suppliers. According to quality department's feedback, the sample can have three different results such as; approved, conditional acceptance and reject. A product quality criterion is being graded according to these results. If the result is *approved*, it takes 9 points. If the result is *conditional acceptance*, it takes 5 points. If the result is *rejected*, it takes 1 point.

- **Types of Possessed Certifications, Standards, Approvals Criticality**

Certificates and approvals are really important for trading process. If the supplier has certificate/ approval of 3.1 Chemical, 3.1 Mechanical, 3.2 Chemical, 3.2 Mechanical, TUV, RINA, DB, BV, ABS, CWB, DNV, LR, it takes 9 points. If the supplier has certificate/ approval of 2.2 Chemical, 2.2 Mechanical, ISO 9001, CE, ISO 27001, ISO 14001, OHSAS 18001, ABS, CWB, HAKC, GOST, RMRS, SEPRO, it takes 5 points. If the supplier has not any certificate / approval, it takes 1 point.

- 2.2 chemical and 2.2 mechanical are test reports which include statement of compliance with the order chemically and mechanically, with indication of results of non-specific inspection order.
- 3.1 chemical and 3.1 mechanical are inspection reports which cover the statement of compliance with the order chemically and mechanically, with indication of results of specific inspection. They are prepared by manufacturer.
- 3.2 chemical and 3.2 mechanical are test reports which consist of statement of compliance with the order in chemically and in mechanically, with indication of results of specific inspection. They are prepared by both manufacturer and independent third-party.
- ISO 27001 is an international standard system for the management of information security.
- ISO 14001 is a standard, which specifies the requirements for an environmental management system according to legal requirements and other requirements to which the organization subscribes, and information about significant environmental perspective.
- ISO 9001 is another standard for defining requirements for a quality management system where an organization needs to prove its ability for satisfying customer and statutory and regulatory requirements.
- OHSAS 18001 is an occupational health and safety management standard which defines the requirements of occupational health and safety management.
- ABS Type Approval is available for a wide range of products for marine and offshore applications, industrial plant and processes and the information technology sector.
- Det Norske Veritas and Germanischer Lloyd (DNV-GL) is an approval about safety and sustainability of business and its services to maritime, oil & gas and energy industries.
- Lloyd's Register (LR) is an independent quality assurance, which is the world's leading provider of independent assessment services including certification, validation, verification and training across a broad spectrum of standards and schemes, with recognition from over 50 accreditation bodies.

- RINA approval includes classification, certification, verification of conformity, inspection and testing in marine, environment and energy, steel construction.
- Bureau Veritas (BV) is a technical publication related to marine units and/or specific equipment's of marine units and provides applicable requirements for certification and classification.
- Türk Loydu (TL), HAKC, Russian Maritime Register of Shipping (RMRS) and SEPRO are same as Lloyd's Register but these are not international approvals, each of them just valid in specific regions. TL is valid in Turkey, HAKC, and RMRS are valid in Russia for marine class production.
- GOST and SEPRO are marking approvals as CE, which show that respectively the products are applicable to Russian and Ukraine standards, technical norms or recipes.
- Technical Inspection Association (TUV) is an international approval for construction industry.
- Conformity Marking (CE) is requested certificate for selling products to European Union Countries.
- DB approval is request for steel construction and railway industries.
- Authorized Economic Operator (AEO) and Authorized Carrier (AC) are about customs regulations of international movement goods, if buyer and seller have these certificates; they can do customs procedures at determined place independently of customs.

Table 10. Detailed Assessment Rating for Quality in Supplier Selection

Quality		
Sub criteria	Detailed score	Calculation Method
Product quality	9	The result of sample test is approved
	5	The result of sample test is conditional acceptance
	1	The result of sample test is rejected
Types of possessed certifications, standards, approvals criticality	9	3.1 Chemical/ 3.1 Mechanical/ 3.2 Chemical/ 3.2 Mechanical/ TUV/ DB/ TL/ BV/ DNV-GL/ RINA/ LR/ AEO/ AC
	5	2.2 Chemical/ 2.2 Mechanical/ ISO 9001/ CE/ ISO 27001/ ISO 14001/ OHSAS 18001/ ABS/ CWB/ HAKC/ GOST/ RMRS/ SEPRO
	1	Nothing

4.2.1.1.2 Cost

- **Unit Price Suitability**

In order to calculate the unit price suitability, the current purchasing price and offered price are compared according to the below formulation.

$$\text{Unit Price Suitability} = \frac{(\text{Offered Price} - \text{Current Purchasing Price})}{\text{Current Purchasing Price}} * 100$$

If the result of this equation is less than or equal to -10%, it takes 9 points. If the result of this equation is greater than or equal to 0% and less than -10%, it takes 5 points. If the result of this equation is greater than 0%, it takes 1 point.

- **Payment Term**

Suppliers get a point according to payment terms. If the payment term of supplier is greater than cash against goods payment with 60 days term, it takes 9 points. If the payment term of supplier is greater than cash against goods payment with 30 days term and less than or equal to cash against goods payment with 60 days term, it takes 5 points. If the payment term of supplier is payment in advance, cash with order, cash before delivery, cash at customs/warehouse or cash against goods payment with 29 days term, it takes 1 point.

- **Logistics Cost Factor**

Logistic cost is one of the biggest expenditure in total cost. It can directly affect the final decision while selecting a supplier. In this study, logistic cost was being controlled according to approximate geographical location's cost factor via existing ERP system.

If the approximate geographical location cost factor is equal to 1 and less than or equal to 1,04, it takes 9 points. If the approximate geographical location cost factor is greater than 1,04 and less than or equal to 1,08, it takes 5 points. If the approximate geographical location cost factor is greater than 1,08, it takes 1 point.

Table 11. Detailed Assessment Rating for Cost in Supplier Selection

Cost		
Sub Criteria	Detailed Score	Calculation Method
Unit Price Utility (%)	9	Unit price suitability = $\frac{(\text{offered price} - \text{current purchasing price})}{\text{current purchasing price}} * 100 \leq -10$
	5	$0 \leq$ Unit price suitability = $\frac{(\text{offered price} - \text{current purchasing price})}{\text{current purchasing price}} * 100 < -10$
	1	Unit price suitability = $\frac{(\text{offered price} - \text{current purchasing price})}{\text{current purchasing price}} * 100 > 0$
Payment Term	9	Cash against goods with 60 days term
	5	Cash against goods with 30 days term - Cash against goods with 60 days term
	1	Payment in advance, Cash with order, Cash before delivery, Cash at customs/warehouse, Cash against goods with 29 days term
Logistics Cost Factor	9	1.00 - 1.04
	5	1.05 - 1.08
	1	> 1.08

4.2.1.1.3 Delivery

- **Delivery Term**

Suppliers take a point according to delivery term based on Incoterms. If the delivery term of supplier is counter party payment / CIF / CIP / DDP / DAP / CPT / DAT, it takes 9 points. If the delivery term of supplier is FOB / FCA / FAS, it takes 5 points. If the delivery term of supplier is Cash on delivery / EXW, it takes 1 point.

- **Lead Time**

Suppliers get a point according to lead time which involves the production time of supplier and transit time. If the lead time of supplier is less than or equal to 21 days, it takes 9 points. If the lead time of supplier is less than or equal to 60 days and greater than 21 days, it takes 5 points. If the lead time of supplier is greater than 60 days, it takes 1 point.

Table 12. Detailed Assessment Rating for Delivery in Supplier Selection

Delivery		
Sub Criteria	Detailed Score	Calculation Method
Delivery Term	9	Counter party payment / CIF / CIP / DDP / DAP / CPT / DAT
	5	FOB / FCA / FAS
	1	Cash on delivery / EXW
Lead Time (Transit Time + Production Time)	9	≤ 21 Days
	5	22 - 60 Days
	1	> 60 Days

4.2.1.1.4 Suitability of Packing

All purchased materials have technical specifications or technical drawing; thereby suppliers are also graded according to the suitability of their packing.

If the supplier's packing is in compliance with the specifications / technical drawing, it takes 9 points. If the supplier's packing is in compliance with the specifications / technical drawing conditionally, it takes 5 points. If the supplier's packing is not in compliance with the specifications / technical drawing or damaged, it takes 1 point.

Table 13. Detailed Assessment Rating for Suitability of Packing in Supplier Selection

Criteria	Detailed Score	Calculation Method
Suitability of Packing	9	Compliance with specifications
	5	Conditional acceptance
	1	Non-compliance with specifications + Break Down + Damaged

4.2.1.1.5 Supplier Attributes

- **Age of The Company**

The other criterion of supplier selection is the age of the company. If the supplier's company has been established for more than 15 years, it takes 9 points. If the supplier's company has been established for more than 5 years and less than or equal to 15 years, it takes 5 points. If the supplier's company has been operating for less than 5 years, it takes 1 point.

- **Type of Company**

Furthermore, supplier is being checked based on the company type. If the supplier is a manufacturer, it takes 9 points. If the supplier is an agent or trader who has a warehouse in Turkey, it takes 5 points. If the supplier is a trader, it takes 1 point.

- **Cooperation Performance**

The other selection criterion is cooperation performance. This criterion is a subjective criterion depending on the purchasing responsible opinion.

The responsible grades the supplier's performance according to company's objectives. When the responsible grades the supplier's performance, 5 points are considered which are namely, feedback efficiency, providing alternative solutions, price negotiation performance, technical assistance and support for technical subject or if the supplier has an agent, technical capability of agent and providing a samples as a free of charge.

Each supplier gets a point according to the determined intervals. For instance; feedback efficiency score interval is between 0 and 20, providing alternative solution score interval is between 0 and 15, price negotiation performance score interval is between 0 and 40, technical assistance and support of supplier or if the supplier has an agent, technical capability of agent's score interval is between 0 and 15, providing a samples as a free of charge's score interval is between 0 and 10.

Table 14. Detailed Assessment Rating for Supplier Cooperation Performance

Cooperation Performance	
Sub Criteria	Rating Interval
Feedback Efficiency	0 - 20
Providing Alternative Solutions	0 - 15
Price Negotiation Performance	0 - 40
Technical Assistance of Supplier or Supporting For Technical Subject, If The Supplier Has An Agent, Technical Capability of Agent	0 - 15
Providing a Samples as a Free of Charge	0 - 10

To sum up, if the supplier's total score is determined between 81 and 100, it takes 9 points. If the supplier's total score is determined between 51 and 80, it takes 5 points. If the supplier's total score is determined between 0 and 50, it takes 1 point.

Table 15. Detailed Assessment Rating for Supplier Attributes in Supplier Selection

Supplier Attributes		
Sub Criteria	Detailed Score	Calculation Method
Age of The Company	9	> 15
	5	6 - 15
	1	≤ 5
Type of The Company	9	Manufacturer
	5	Agent or Trader who has warehouse in Turkey
	1	Trader
Cooperation Performance	9	Total Score 81-100
	5	Total Score 51-80
	1	Total Score 0-50

4.2.2. Supplier Evaluation Criteria

This process starts with analyzing the material and determining the supplier material criticality which is significant for understanding the requirement of the system is essential. Materials are being analyzed according to 3 main criteria: Material Criticality, Financial Criticality (\$) and Material Availability Risk. The most important criterion was agreed to be product criticality with the weight of 0,50, financial criticality followed product criticality with the weighting percentage of 0,35. Material availability risk has the lowest criteria with the weighting percentage of 0,15.

- **Material Criticality**

Material is used in production process or operations directly. Due to measure supplied material criticality, all 2015 sold products (2025 different products) were listed and applied this list pareto approach. According to pareto analysis results, all products bill of material was exploded. After this process, if the material which is appear in greater than or equal to 80 percent and less than or equal to 100 percent contribution product to revenue, it takes 9 points. If the material which is appear in greater than equal to 1 percent and less than 80 percent contribution product to revenue, it takes 5 points. If the material is not appear in this list or it is appear in 0 percent contribution product to revenue, it takes 1 point.

- **Financial Criticality**

Financial Criticality is determined based on the purchasing unit price of material. If the material's purchasing unit price is greater than or equal to \$ 10.000, it takes 9 points. If the material's purchasing unit price is greater than or equal to \$ 1.000 and less than \$10.000, it takes 5 points. If the material's purchasing unit price is less than \$ 1.000 it takes 1 point.

- **Material Availability Risk**

Material availability is about the number of approved suppliers. If the material has 1 supplier, it takes 9 points. If the material has greater than or equal to 2 and less than 4 suppliers, it takes 5 points. If the material has greater than or equal to 4 suppliers, it takes 1 point.

Table 16. Detailed Assessment Rating for Material Analysis

Criteria	Detailed Score	Calculation Method
Material Criticality	9	The effect rate on total revenue 80 % - 100 %
	5	The effect rate on total revenue 20 % - 79 %
	1	The effect rate on total revenue < 20 %
Financial Criticality (\$)	9	Unit price \geq \$ 10.000
	5	Unit price \$ 1.000 - \$ 9.999
	1	Unit price < \$ 1.000
Material Availability Risk	9	Number of approved supplier = 1
	5	Number of approved supplier 2 - 4
	1	Number of approved supplier > 4

After the result of that analysis, all the products are divided into 4 different classes based on Kraljic Portfolio Purchasing Model as Bottleneck, Strategic, Non-critical, and Leverage. The total score of strategic material is between 76 and 100, the total score of bottleneck materials is between 51 and 75, the total score of the leverage materials is between 26 and 50 and the total score of the non-critical materials is between 0 and 25. This analysis output is used in supplier performance evaluation process.

The supplier evaluation performance evaluation process is composed from five main criteria, which are quality, cost, logistics capability, research & development, and supplier attributes. There are fifteen sub-criteria.

Rejected parts per million, approval availability, certificate availability, failure response time and packing & labeling precision were generated as quality sub-categories.

Payment term and approximate cost of inspection determine cost. Delivery precision, production time precision and order fill rate were employed for evaluating logistics capability. Sample availability and innovation are for assessing research and development category.

Finally, cooperation performance, supplied material category and warranty are used for supplier attribute evaluation. All criteria and weighting percentage ratio were determined through group meetings. The most important criterion is quality with the weighting percentage of 0,40. Second important criterion is found to be logistics capability with weighting percentage of 0,25. Cost and supplier attributes criteria have the same weighting percentage, 0,13. Then the criterion with the lowest weight is research and development with weighting percentage of 0,09.

Additionally, evaluation process is applied the supplier who has at least 3 purchasing activity as existing system. The aim of this condition is providing fair and getting a progressive improvement system.

4.2.2.1 Supplier Evaluation Criteria and Sub Criteria Calculation

4.2.2.1.1 Quality

- **Rejected Parts Per Million (RPPM)**

Suppliers are evaluated according to product quality which was measured via calculation of rejected parts per million (RPPM) in every shipment. The PPM value is calculated as the number of rejected parts divided by the total quantity delivered and

multiplied by 1 000 000. The case company while incoming quality control, they used sampling method thus, PPM value range is length. If the PPM value of supplier is less than or equal to 0, it takes 9 points. If the PPM value of supplier is greater than or equal to 1 and less than equal to 200.000, it takes 5 points. If the PPM value of supplier is greater than 200.000, it takes 1 point.

- **Approval Availability**

Approval availability is crucial in welding industry. Suppliers are marked according to the importance of available approval. If the supplier has approval of ABS/CWB, it takes 5 points. If the supplier has approval of HAKC/GOST/RMRS/SEPRO, it takes 1 point.

- **Certificate Availability**

Certificate is another important issue in welding industry. In order to take a place in important industrial projects, available certificates are getting more and more important. Certificates provide big competitive advantages and they are also important for establishing long-business relationships. Suppliers are also evaluated according to the importance of available approval. If the supplier has certificate of 3.1 Chemical/3.1 Mechanical/AEO/ AC, it takes 9 points. If the supplier has certificate of 3.2 Chemical/3.2 Mechanical/CE/ISO 27001/ISO 14001/OHSAS 18001, it takes 5 points. If the supplier has only certificates of 2.2 Chemical/2.2 Mechanical/ ISO 9001, it takes 1 point.

- **Failure Response Time**

The feedback time for non-conformance and detailed 8D report are crucial in quality management. A systematic approach to nonconformity management and continuous improvements are the key elements of every management system. 8D methodology uses a structured eight-step approach to problem solving. 8D report shows the corrective actions process for solving problems. It includes root analysis, definition of the problem and corrective actions. At this point, if the supplier provides immediate response with 8D report, it takes 9 points. If the supplier provides response in 72 hours

with 8D report, it takes 5 points. Finally, if the supplier provides a response greater than 72 hours with 8D report or without 8D report, it takes 1 point.

- **Packing and Labeling Precision**

The last sub-criteria of quality is packing and labeling precision. All materials have specifications in the existing system. The precision of packing and labeling criteria is crucial criteria since it is providing an infrastructure for avoiding non-value added work such as loss of time and rework. If the supplier's all shipments are in compliance with specifications, it takes 9 points. If the supplier's shipments in 6 months are conditionally accepted 2 times, it takes 5 points. If the supplier's shipments in 6 months are conditionally accepted more than 2 times or all shipments are in non-compliance with shipment or damaged, it takes 1 point.

Table 17. Detailed Assessment Rating for Quality in Supplier Evaluation

Quality		
Sub Criteria	Detailed Score	Calculation Method
RPPM	9	Rejected parts per million 0 ppm
	5	Rejected parts per million 1 – 200.000 ppm
	1	rejected parts per million > 200.000 ppm
Approval Availability	9	TUV, DB, TL, BV, DNV-GL, RINA, LR,
	5	ABS, CWB
	1	HAKC, GOST, RMRS, SEPRO
Certificate Availability	9	3.1 Chemical, 3.1 Mechanical, AEO, AC
	5	3.2 Chemical, 3.2 Mechanical, CE, ISO 27001, ISO 14001, OHSAS 18001
	1	2.2 Chemical, 2.2 Mechanical, ISO 9001
Failure Response Time	9	Immediate response with 8D report
	5	Response in 72 hours with 8D report
	1	> 3 days with 8d report/ without 8D report
Packing & Labeling Precision	9	All shipments compliance with specifications
	5	2 times conditional acceptance in 6 months
	1	> 2 times conditional acceptance in 6 months, All shipments non-compliance with specifications, Damaged

4.2.2.1.2 Cost

- **Payment Term**

That criterion is calculated as in payment term criteria of supplier selection process. If the payment term of supplier is cash against goods payment with 60 days term, it takes 9 points. If the payment term of supplier is greater than cash against goods payment with 30 days term and less than or equal to cash against goods payment with 60 days term, it takes 5 points. If the payment term of supplier is payment in advance, cash with order, cash before delivery, cash at customs/warehouse or cash against goods payment with 29 days term, it takes 1 point.

- **Approximate Cost of Inspection**

Especially for critical and high amount products, inspection has a significant role and it is a costly process in purchasing. Therefore, suppliers are evaluated according to cost of inspection. If the supplier's approximate cost of inspection is equal or less than 1000 €/Batch or there is no need for inspection, it takes 9 points. If the supplier's approximate cost of inspection is between 1001 €/Batch and 1500 €/Batch, it takes 5 points. If the supplier's approximate cost of inspection is greater than 1500 €/Batch, it takes 1 point.

Table 18. Detailed Assessment Rating for Cost in Supplier Evaluation

Cost		
Sub Criteria	Detailed Score	Calculation Method
Payment Term	9	Cash against goods with 60 days term
	5	Cash against goods with 30 days term - Cash against goods with 60 days term
	1	Payment in advance, Cash with order, Cash before delivery, Cash at customs/warehouse, Cash against goods with 29 days term
Approximate Cost of Inspection	9	There is no need for inspection , 1 - 1000 €/batch
	5	1001 - 1500 €/batch
	1	> 1500 €/batch

4.2.2.1.3 Logistics Capability

• Delivery Precision

Delivery precision is measured by the tolerance limits (e.g. -2, +1) decided by the group. According to these criteria, if the supplier's all shipments in 6 months are on time, it takes 9 points. If the supplier has 2 times delay or less in 6 months, it takes 5 points. If the supplier has more than 2 times delay in 6 months, it takes 1 point.

• Production Time Precision

Production time precision is important for managing the procurement process since all related departments are organized their process according this information such as; planning department prepare production plan through checking existing and expected

stock level or maintenance department organize shutdown period according to these information. Any type of change in lead time can be caused lots of non-value added works. Therefore, suppliers are graded according to the lead time precision. If the supplier has not any shipment week revision in 6 months, it takes 9 points. If the supplier has less than or equal to 7 times shipment week revision in 6 months, it takes 5 points. If the supplier has greater than 7 times shipment week revision in 6 months, it takes 1 point.

- **Purchase Order Fill Rate**

The other sub-criteria is purchase order fill rate. Purchase order fill rate is defined as the difference between requested quantity and coming quantity divided by total quantity of order. If the supplier's purchase order fill rate is less than or equal to 10 percent, it takes 9 points. If the supplier's purchase orders fill rate is greater than 10 and less than or equal to 20 percent, it takes 5 points. If the supplier's purchase order fill rate is greater than 20 percent, it takes 1 point.

Table 19. Detailed Assessment Rating for Logistics Capability in Supplier Evaluation

Logistics Capability		
Sub Criteria	Detailed Score	Calculation Method
Delivery Precision	9	All shipments on time in 6 months
	5	2 times delay in 6 months (outside tolerance limits)
	1	> 2 times delay in 6 months (outside tolerance limits)
Production Time Precision	9	No shipment week revision in 6 months
	5	Shipment week revision in 6 months < 7
	1	Shipment week revision in 6 months > 7
Purchase Order Fill Rate	9	$\frac{ Requested\ Quantity - Coming\ Quantity }{Total\ Quantity\ of\ Order} \leq 0.10\ %$
	5	$\frac{ Requested\ Quantity - Coming\ Quantity }{Total\ Quantity\ of\ Order} 0.11\ \% - 0.20\ \%$
	1	$\frac{ Requested\ Quantity - Coming\ Quantity }{Total\ Quantity\ of\ Order} > 0.20\ \%$

4.2.2.1.4 Research and Development

- **Sample Availability**

The buyer company has a growth target and it has Technical Marketing, R&D and Maintenance Departments. They are conducting different projects. That is why the company gives importance to the supplier's contribution to these projects. If the company gives importance to the supplier's contribution to these projects. If the supplier provides free of charge samples with DAP terms of shipping, it takes 9 points. If the supplier provides free of charge samples with EXW terms of shipping, it takes 5 points. If the supplier does not provide free of charge samples or requires fee for sample, it takes 1 point.

- **Innovation**

The company aims to reach its growth target by improvement of the suppliers. Therefore, they evaluate their suppliers according research and development department existence. If the supplier has a R&D department, it takes 9 points. If the supplier does not have a R&D department or it has some initial work for establishing a R&D department, it takes 1 point.

Table 20. Detailed Assessment Rating for Research and Development in Supplier Evaluation

Research And Development		
Sub Criteria	Detailed Score	Calculation Method
Sample Availability	9	Free of charge sample - DAP
	5	Free of charge sample - EXW
	1	For a fee sample + Fail to satisfy
Innovation	9	R & D department exist
	1	R & D department not exist / There is an infrastructure work

4.2.2.1.5 Supplier Attributes

- **Cooperation Performance**

That criterion is calculated as in cooperation performance criteria of supplier selection process and all the data will be updated in every 6 months for keeping up to date. This criterion is a subjective criterion provided in terms of the purchasing responsible opinion. The responsible grades the supplier's performance according to company objectives. When the responsible grade the supplier's performance, he/she examines 5 points which are feedback efficiency, providing alternative solutions, price negotiation performance, technical assistance of supplier or supporting for technical subject, if the supplier has an agent, capability of agent and providing a samples as a free of charge. Each point have same details as generated supplier selection system.

- **Supplied Material Category**

These criteria is used the outputs of the material analysis. If the supplier's provided products fall into the bottleneck material or strategic material category, it takes 9 points. If the supplier's provided products fall into non-critical material category, it takes 5 points. If the supplier's provided products fall into leverage material category, it takes 1 point.

- **Warranty**

The last sub-criteria of organization criterion is warranty. It is especially important for long-term business and high amount purchasing. The company wants the suppliers to stand behind their products so the duration of warranties should reflect this logic. If the supplier provides a warranty for 2 years or more, it takes 9 points. If the supplier provides less than 2 years warranty or it does not provide any type of warranty, it takes 1 point.

Table 21. Detailed Assessment Rating for Supplier Attributes in Supplier Evaluation

Supplier Attributes		
Sub Criteria	Detailed Score	Calculation Method
Cooperation Performance	9	Total Score 81-10
	5	Total Score 51-80
	1	Total Score 0-50
Supplied Material Category	9	Bottleneck Material + Strategic Material
	5	Routine Material
	1	Leverage Material
Warranty	9	≥ 2 Years
	1	< 2 Years + Nothing

After all selection and evaluation criteria detailed and determining weighting percentage, the next step is defining supplier classes and determining the purchasing strategy according to supplier classification.

4.3. Supplier Classification and Strategy Development

Purchasing strategies of a firm emphasize either efficiency or effectiveness of operation. Companies develop their procurement strategies from various perspectives. Depending on the total ratings which have been collected by scorecards and by taking the minimum and maximum potential ratings into consideration, the recommended supplier classes can be described as following.

Table 22. Proposed Supplier Performance Classes

TOTAL RATING	SUPPLIER PERFORMANCE CLASS
7,40 – 9	A
5 – 7,39	B
1 – 4,99	C

The group determined the proposed supplier classification, which had same performance class with the existing system. Additionally, they developed strategies owing to proposed supplier classification.

For A class suppliers, the best performing ones, the aim is to create long-term relationships with contracts. That group suppliers have priority for projects or contracts, considered first to invest and collaborate within the projects. Organizing regular visiting for these suppliers to increase control level of relationship.

For B class suppliers, providing feedbacks for the poor rates, in their scorecards, giving specific goals for meeting the expectations and specify corrective actions for improvement can be the strategies that can be undertaken. If necessary, showing and explaining the process is necessary for deeper understanding. B class suppliers need improvement in certain areas.

C class suppliers have the lowest performing scores. Instead of making any investment or meetings, determining specific goals for corrective actions in a specific time period can be a good strategy for this class. If the corrective actions would not work, the suppliers can be eliminated from the supplier lists.

CHAPTER V. CONCLUSION

5.1. Discussion and Implication

This study was conducted in a company which producer of welding products. The aim of this study is to establish a systematic approach for selecting and evaluating potential and new suppliers by using specific industrial and commonly used criteria. This study will help for developing better supplier selection and evaluation systems for supply chain process in welding industry.

To manage the study, the structured meetings were conducted from 4 different people who work in the case company. In these meetings, the study was processed by 4 research questions. All these questions were discussed in structured meetings and through the meetings results the process was managed impartially. These questions were respectively as follows; What is the current situation in supplier selection and evaluation system?, What are the gaps of current system?, Which criteria should be used for new supplier selection and evaluation systems?, How to generate a detailed performance scoring system for the selected criteria?.

The first and second research questions were help to understand the existing system and for determining the gaps in the system. The last two researched questions were analyzed the way of getting a good supplier selection and evaluation system. Supplier classification helps to group suppliers and strategy generation. Developing strategy for suppliers according to their class is more significantly important steps in supply chain process. In existing system, there was not these type of strategically approach for suppliers. However, the generating system was solved that problem. All existing suppliers will be informed about the new evaluation system for explaining the expectations. Through the improving system, their performance is followed regularly. That tracking system also improves the case company's quality for their customers.

The generated system provides several advantages to the case company. Firstly, establishing steady and systematic supplier selection and evaluation system for procurement process is an important output for the company. All procurement processes were identified and defined. Secondly, the suggested structure can help to develop procurement strategy to achieve cost effectiveness for the purchased items and

reliable sources for protecting scarcity and risks. Thirdly, due to this study all materials were analyzed and categorized according to Kraljic Approach. This classification was contributed to inventory management since all materials' safety stock level has begun to be reviewed. This analysis also contributes to strategy development and relationship management by focusing the purchasing criticality. Lastly, criteria of provided framework like available certificate, available approval and research & development can provide a competitive advantage for the buyer company.

All companies have to focus on improving the effectiveness of process and operations in today's business world as the selected company. In order to get ahead in highly competitive place in market, companies should have a good supply chain system. The vendor-buyer coordination problem is studied in many papers which contribute to this study while determining the new system. The determined criteria helps to establish a systematic approach for selecting and evaluating potential suppliers in supply chain by emphasizing the importance of quality and help to increase the quality and capability of supplier.

To sum up, this study will be beneficial for developing better selection and evaluation systems in terms of suppliers by establishing a new systematic approach. To achieve this aim, 4 research questions were prepared to see existing system's gaps and to form new strategies by analyzing the way of getting a good supplier selection and evaluation system. Newly generated system provides some advantages in terms of procurement process; cost effectiveness, reliable sources for protecting scarcity and risks, stock level, purchasing and competitiveness. Today's business world requires effectiveness and in order to provide this, companies should have a good supply chain system. In this study, a new system was formed by utilizing the vendor-buyer coordination problem and a new solution was offered by emphasizing the quality and capability of supplier.

5.2 Further Research and Limitation

The evaluated system will be expanded and developing a selection and evaluation score cards for each purchasing branches which raw material, packing material, operating and consumables material, sub-industry, investment, commercial, service, administrative and software and hardware purchasing. Additionally, the

generated system were prepared in Excel, the other further study will prepared a software system to apply in existing ERP system. Through the improving system, suppliers' performance will be controlled more than existing system. Due to this system, supplier's quality will be improved according to the case company's aims and annual purchasing aims will be planning more clearly.



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