Vendor Selection in Supply Chain Management by Expert Systems and a Case Study

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Abstract— Recent advances in world order and intensified competitive environment, force firms immediately to incorporate techniques into the company culture that will radically and drastically improve the main performance criterions of quality, service, speed, and cost. This challenging surrounding in commerce and industry which emerged in the second half of the twentieth century, push the limits of the production management techniques. In recent years, the importance of a supply chain management that has the ability to respond agile and flexible market increased. Certainly, the success of a supply chain management depends on various decisive factors and can be achieved by managing several components efficiently. In this study, one of such significant factors, management and selection of vendors is examined and an expert system is designed to give rational decisions in vendor selection. For this purpose, an expert system model is developed for selection and handling of suppliers in Shoes Industries and the corresponding case study is presented.

Keywords— : **Supply chain management, Expert systems**

I. INTRODUCTION

In modern organizations, customer satisfaction is one of the major strategic responsibilities that will provide accomplishment in business world. The strategy of any company doing business whether internally or internationally, must devise their primary goal to ”maximization of market share” instead of traditional ”maximization of profits”. The addition of economic and social crisis to advances in management science and technology obliged the companies to new pursuits. The globalized world markets by moving beyond local borders with the increase of productivity provided by technological advances, the acceleration to pass into civilization of information, alternating customer demands carried the competition to astonishing dimensions [1]. In 1960’s, the tendency of competition was defined as domination in manufacturing, while today innovation, flexibility and speed are rising merits.

These transformation in management of firms also has consequences in management of production. The main target of efforts is adjusting to market by supplying the needs and demands of the market. In this context, the managers of manufacturers developed new techniques such as MRP, MRPII, ERP, JIT, FMS, TQM, Lean manufacturing and Agile manufacturing to follow these trends. These techniques improved the traditional relation of buyer and supplier and made the foundation of modern notion of supply chain management [2]. Building close relationship with vendors, which is the main rule of the supply chain management, requires to include suppliers in the manufacturing system and to make them a part of the production process. For this reason, supply chain management should be seen as a decision support system which produces logistic values to improve the efficiency and effectual criterions and customer satisfaction.

Time is the critical factor for companies to fulfill the demands of the market. The response to customer demand without delay has the same importance as developing new products for the market and the extra additions of the production management should be considered to improve this capability. The research indicates that the lead time of purchased goods and services are the most important component of the overall sojourn time [3]. For this reason, purchasing turns into supply of all values that will contribute to the product which will dispatched to the consumer. The increasing proficiency of the companies and becoming complex structures require integration and management of relations of suppliers with their own suppliers and customers with their own customers.

II. TRADITIONAL BUYER-SUPPLIER RELATION

In literature, the relations of buyer-suppliers are investigated in two main categories as traditional(competitive) and associative by ,[10]. In traditional buyer-supplier relation, purchasing function has compromising task between the parties. In this model, the target is minimizing the cost of the

purchased commodity. The main assumption of the model is defined as the vendors are indifferent except the price [4]. In this type of relation, the buyer can purchase a specific goods or service from various suppliers. In this way, buyer can force suppliers to compete in price and nonprice items and provide continuity of production process by supply. Traditional buyer-supplier relations are subject to competitive approaches that depend on the "win-lose" philosophy. In case there exist disagreement between the parties, trade relations ceased after the contract duration or, in some situations, straight away.[8]

Traditional buyer-supplier relation characterized on price base. Companies, have several vendors for each part primarily selected by price. There is no expectation from the relations that can recur between buyer and supplier [9]. Most of the time, buyer is enforced to accept the conditions of the seller. Relations in traditional form are slow operating, short-termed, based on competition and not sharing information. Furthermore, they do not have the trust and other functional cross-relations [5].

III. MODERN BUYER-SUPPLIER RELATION

Today's buyer-supplier relation have gained more complex structure. The feedback between the parties has altered the density and the type of service and product, significantly [9]. This structure has been called associative model in which the relations are long-termed, and based on philosophy of "win-win". In this new structure, sharing information towards functions, communication and alliance will increase the effect of earnings. In associative model, not only the relations are developed with the seller's department of marketing, but also the quality of suppliers and engineering features are considered. Various agreements are made to construct the effective satisfaction of demand between the buyer and supplier's marketing, order-traction, and production control. For a design of a product or common-value engineering, communications are established between the production and design engineering. This communications continue as the companies have shared business. Moreover, purchasing is not the only contact point for the suppliers and other cross functional relations are developed. The relationships have to be arranged in a complete view in a manner that adds value to service or product.[12]

The companies must produce "common values" to satisfy the needs of the market. These common values will increase the market power of the purchasing and selling companies by strategic alliance. Associative buyer-supplier relations, not only depicts the price but also the principles of quality assurance and flexible distribution. In this kind of relation, unlike traditional model, buyer purchases a certain service or31 product from a few suppliers. In associative model, the role of the supplier is different just a producer of a particular part, but most of the times a contributor to the design process of the product. In developing common values, to the purpose of focusing main expert areas, the buyer may leave much more independence to the supplier and provides logistic support that may be needed in this issue [11]. In associative model, the trust and the share of the risk between the counterparts are higher. In this kind of relations, the syndicated functional relations are well-defined and fast paced, long termed and flexible.[8]

IV. CRITERIA FOR VENDOR SELECTION

In competitive rivalry, the selection of the suppliers is not only one of the most important decisions but also one of the critical success factors that defines the performance of the company. In selection of vendors, first rule is the the suppliers' assessment of the association. The second rule is to work with a few vendors that submit high quality product and service [7], instead of doing business with several supplier that offer low prices. In selection of suppliers, there exist many other secondary important criteria while these two approach are the fundamental. In this study, before defining supplier criterions the classification of suppliers are preferred and they are grouped into three categories:

Potential Suppliers: The vendor companies that we haven't done any business with yet, as either they are new in the market or we do not have any connection.

Suppliers in the pool: The vendor companies which we are doing or have done business with.

Suppliers ousted from the pool: The vendor companies which we have done business with in the past but they had serious declines in their performance or jeopardized us by not meeting their promises.

The criteria for the selection of vendor are defined for a mid-size company that produces shoes. The criteria may be defined differently for companies in differ- ent industries or different companies in the same industry. In identification of criteria in Table 1 and Table 2 criteria set by [6], [9], [3] are taken as base and the requirements of the criterions and their rates are subject to discussion. However, the real problem at hand is to develop an expert system which will select the right decision by the criterions are set to company circumstances the company.

The potential supplier criteria are presented in Table 1 and the supplier company's code, date and product's code in the company is defined. In execution of the model, the most recent form in the records will be used. The descriptions of information to be collected in this form are as follows:

- *The duration of work experience;* 5 points for 1 to 5 years ,10 points for 6 to 10 years,15 points for 10 years or more.
- *Legal Structure of the company;* 5 points for plain company, 10 points for limited company, 15 points for incorporated company.

TABLO I
POTENTIAL SUPPLIER CRITERIA

Supplier code:
Date:
Part Code:

Factors	Rate	Weight
The duration of work experience	10	3.7
Legal Structure of the company	15	5.6
Paid Capital	10	3.7
Technical Workforce	5	1.9
Work Reference	10	3.7
Flexibility	10	3.7
Price Policy	10	3.7
Technical adequacy and R&D	5	1.9
Geographical distance and ease of connection	10	3.7
Reputation of the company	10	3.7
Associative tendency and Share of information	20	7.4
Quality system	20	7.4
Product variety	30	11.1
Legal Obligations	0	0.0
Financial Power	30	11.1
Total(Company Performance)		72.2

- *Paid Capital;* 5 points for 10-30%, 10 points for 31-60% points, 15 points for 61% or more.
- *TechnicalWorkforce,WorkReference,Flexibility,Price Policy,Technical adequacy and R&D ,Geographical distance and ease of connection* 0 points for poor, 5 points for not sufficient, 10 points for fairly sufficient, 15 points for sufficient
- *Reputation of the company;* (-15) points for poor, 5 points for not sufficient, 10 points for fairly sufficient and 15 points for sufficient.
- *Associative tendency and Share of information, Quality system, Product variety;* 0 points for poor, 20 points for fairly sufficient and 30 points for sufficient
- *Legal Obligations*; Since the existence of this criterion has a destroying effect on other criteria, therefore should have negative value. Hence, (-300) points for an obligation, 0 points otherwise.
- *Financial Power;* Likewise, the poor existence of this criterion has a destroying effect on other criteria. (-300) points for poor, 20 points for medium and 30 points for good.

In potential supplier criteria if all factors get full points the total points would be 70. To find the relative weights each point is divided by 270. In Table 1.

The criteria for the suppliers in the pool are presented in Table 2. They are investigated in two parts as long-term and most recent trade transaction values. For long term values 15 factor has been diagnosed based on the industry and company and the following factors may also be added:

- Dependency(-)/Independency(+) on another company
- Producer(+)/ Caterer(-)
- Order lead time
- Fitness of Order Process
- Source of Information Technologies
- Effective coordination

In Table 2, 0 points for poor, 5 points for not sufficient, 10 points for fairly sufficient and 15 points for sufficient in non-marked items. The double-marked items have twice importance level, hence 0 points for poor, 20 points for fairly sufficient and 30 points for sufficient. The triple-marked item of Financial Power has three importance level as weakness of this criteria will negatively effect other factors. Thus, (-300) points for poor, 20 points medium, 30 points for good are assigned.

There are records about the last transaction in the second part of the criterion of the suppliers in the pool. Price criteria, 15 points for the lowest,10 points for the second, 5 points for the third and 0 points for the forth and the above. Delivery criteria is valued as follows: 15 points for no-tardiness, 10 points for 1-2 days, 5 points for 3-5 days, 5-7 days 0 points and one week or more tardiness -15 points.In quality criterion, the defect rate of the last party is evaluated. 15 points for 98% of the items are admissible, 10 points for 95-97%, 5 points for 90-94%, 0 points for 85-89% and -15 points for 85% and less. Paying option criteria 15 points for 3 month financing, 10 points for 2 months financing, 5 points for 1 months financing and 0 point for cashing in. Discount rate criteria 15 points for high, 10 points for medium, 5 points for low and 0 points for no discount. Meeting the promises criteria in which the supplier has caused serious damage to the

company by not delivering the product agreed in price, quality and time, hence, -600 points for failing and 0 points for satisfactory delivery.

In the first part of the criteria for the suppliers in the pool are the longterm factors and weighted as 70% and the second part is the last transaction evaluation and weighted as 30 %. If it is given the maximum points to the criterions for the supplier selection, then total points would be 243 points. To calculate the weighted values the relative points are divided by 243. The performance of the supplier in the table has been found as 63.8.

TABLO II
CRITERIA TO SELECT FROM THE SUPPLIER IN THE POOL

Supplier Company Code:
Date:
Part Code:

	Factor	Points		
			Percentage	Weight
Long Term Values 70%	Company past performance	15	10.5	4.3
	Price Policy	10	7	2.9
	Supply chains	15	10.5	4.3
	Technical adequacy and R&D	10	7	2.9
	The duration of trade relations	5	3.5	1.4
	Capacity Flexibility	0	0	0.0
	Packaging facility	10	7	2.9
	Geographical distance and ease of connection	15	10.5	4.3
	Quality Control Techniques	10	7	2.9
	Associative tendency and Share of information(**)	20	14	5.8
	Quality System(**)	30	21	8.6
	Product Variety(**)	0	0	0.0
	Risk Share Degree(**)	20	14	5.8
	Reliability(**)	20	14	5.8
	Financial Power(***)	20	14	5.8
Last Party 30%	Price	15	4.5	1.9
	Delivery	10	3	1.2
	Paying Option	10	3	1.2
	Discount Rate	5	1.5	0.6
	Meeting the promises	0	0	0.0
			Total	63.8

The form for the expelled suppliers is the third form suppliers in the pool in table 2 is revoked and a new form under the name as the suppliers expelled from the pool in which the information in previous form has been kept. The form of the expelled suppliers is as in Table 3 and a new table is added for future changes. If the performance width is in between 60-40% than functional advances are expected. If it is between 0-40% then structural advances are expected. If there exist negative performance then radical changes such as new owner are required. If one of the expectations are satisfied then the supplier can be re-admitted to system.

TABLO III
SUPPLEMENTAL FORM

Supplier Company Code:
Date:

The reason for expelling from the pool	
The pool exiting performance	
Expected Variation	
60-40 %	
40-0%	
Negative Performance	

V. SOLUTION OF THE MODEL WITH EXPERT SYSTEMS

The expert system for the selection of the supplier in the shoes industries has been developed and programmed in Prolog. The goal of the designed model (Figure 1) is the selection of the best suitable supplier with managing the files of the suppliers in the pool, potential supplier and the suppliers expelled from the pool. There are 42 rules for the execution of the model. In the starting rules if the performance of the supplier is below 60 points the are sent to expelled suppliers pool. If there are changes in a supplier which formerly expelled then they are taken back to the potential suppliers. In the files of the potential suppliers, the ones with 75 or better performance are selected as the suppliers in the pool.

The second type of rules which are the assignment of the performance, selects the code of the needed part and 3 suppliers from the pool with highest performance. The reason for selecting 3 suppliers is to support vendors for alternative operation. If there aren't enough supplier then sufficient suppliers has been selected from the potential suppliers file. The performance of the selected suppliers from the ones in the pool has been checked against their last performance. If it is 5 point less then an alternative is sought. In this stage, the performance of potential supplier must be higher then the one in the pool.

TABLO IV
ORDER PERFORMANCE OF FIRMS

Factor	Firm A	Firm B	Firm C
Price	Good (2*10)	Poor(2*0)	Good(2*10)
Discount	Good(2*10)	Good(2*10)	Good(2*10)
Pay Option	Medium(1*5)	Good(1*10)	Medium(1*5)
Delivery	Poor(1*0)	Medium (1*5)	Good(1*10)
Total	45	35	55

The third type of the rules in the model are the closing rules and collecting offers about prices, discounts, delivery and payment. The offer factors are evaluated as good (10), medium (5), poor (0) and price and discount have twice the impotance and will be multiplied by 2 when the offer performance has to be calculated. The offer performances will be added to supplier performance to calculate the total performance, and the decision will be given on this total performance. In case the total performance are close to each other, the order will be given in segments from higher to lower. If the performances are distinctive then the total order will be given to supplier with the highest performance.

In the experimental study to test the model, two firms (A and B) are selected from the suppliers in the pool. The firm C is chosen from potential supplier file and proposals are collected from the companies A, B and C. These performances are evaluated in table 4. The summed total performance is displayed in Table 5. Since, the total performance of A and C are close within 3 point range, the order has been distributed with segments.

TABLO V
TOTAL PERFORMANCE OF FIRMS

	Firm A	Firm B	Firm C
Company Performance	87	74	74
Order Performance	45	35	55
Total Performance	132	109	129

As a result, the decision rules of the system are constructed as follows:

Fact 1: #of_suppliers_in_the pool=2
RULE : **If** #of_suppliers_in_the pool=2 Then "Potential_supplier =1 "

Fact 2: Potential_supplier=2
RULE : **If** #of_suppliers_in_the_pool=2 AND Potential_supplier=1 Then "#_of_suppliers=3"
Fact 3: #_of_suppliers=3, Performance=2 of them within
RULE : **If** #_of_suppliers=3 AND Performance=2 of them within
Give order; Supplier 1 80%,

supplier 2 20%, supplier 3 0% Fact 3:"80% of

orders to firm A, 20% to firm C"

VI. RESULT

In this structure developed to chose the best alternative in the decision model of supplier selection, the Prolog Expert system language has been used. The objective is to make the decision of selecting the supplier successfully, which is vital in the management of supply chains. The required knowledge has been used adequately in order to make this decision and evaluated for a rationaledecision for the system. Eliminating subjective assessments of the decision maker will add value to the system. Moreover, the time allocated by the expert person will significantly reduce. In the execution of the model "the split of orders between A and C by 80% and 20% respectively". There will be different results if different values assigned to coefficients related ro factors.

VII. SUMMARY ANDA CONCLUSIONS

The model developed for selection of a supplier can be used in purchasing one type of product, and does not have the capability of selecting the supplier offering various products while acquiring several products. If this structure is added to the model and several operations are conducted, it will provide more advantages in the reduction of supplier amount. The model also lacks the function of producing alternative suppliers in the new product design, and should be enhanced with this feature. The assessment and objective selection of criteria can be a subject of further study. The model has been developed for medium size shoe manufacturing companies and different designs and factors can be done for other industries.

In further research, to get a most realistic model, it is possible to add quantitative parameters to model such as production per unit time, machine hours, labor hours and alternative raw material. Besides, to adapting this model to real life, general rules should be extended. For example, to define political circumstances of the target society, new rule sets can be added to the model.

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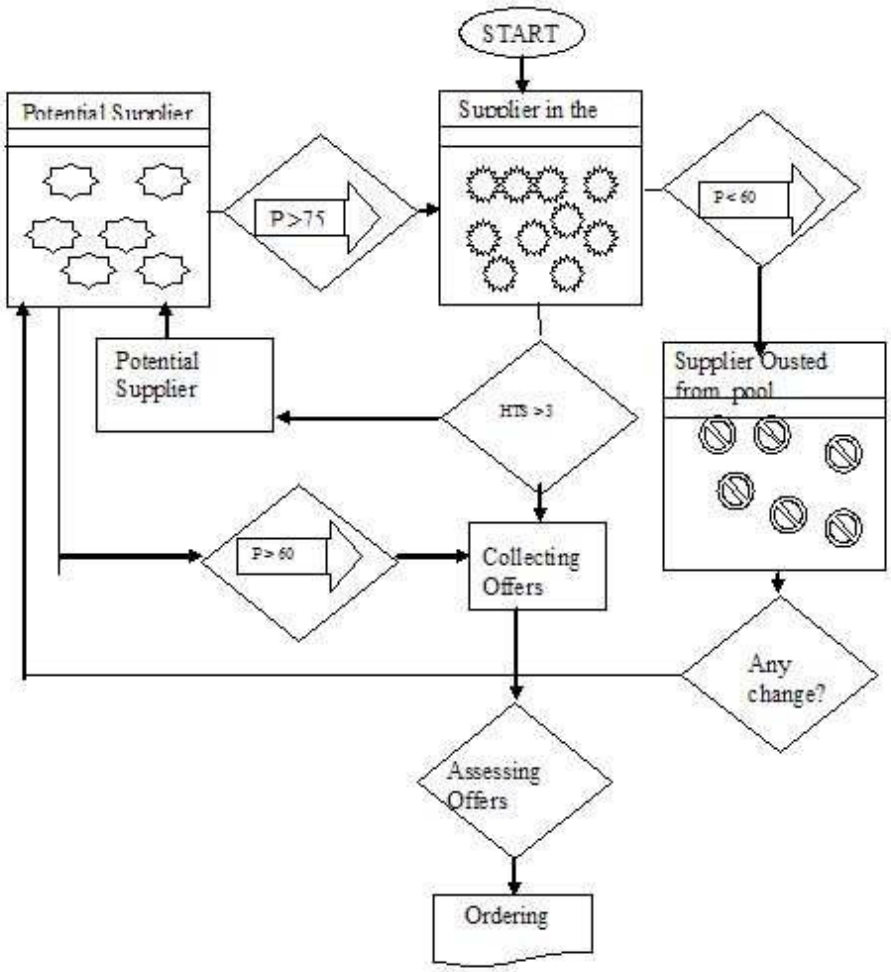

Figure 1. Expert System Model