Prioritization of Customer Order Selection Factors by Utilizing Conjoint Analysis: A Case Study for a Structural Steel Firm

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***Abstract*—**In today's business environment, companies should make strategic decisions to gain sustainable competitive advantage. Order selection is a crucial issue among these decisions especially for steel production industry. When the companies allocate a high proportion of their design and production capacities to their ongoing projects, determining which customer order should be chosen among the potential orders without exceeding the remaining capacity is the major critical problem. In this study, it is aimed to identify and prioritize the evaluation factors for the customer order selection problem. Conjoint Analysis is used to examine the importance level of each factor which is determined as the potential profit rate per unit of time, the compatibility of potential order with available capacity, the level of potential future order with higher profit, customer credit of future business opportunity, and the negotiability level of production schedule for the order.

***Keywords*—**Conjoint analysis, order prioritization, profit management, structural steel firm.

I. Introduction

Reinforcement concrete, steel, wood, and concrete precast structures are the types of the structural system alternatives in the construction sector. Since being a well-known and cost effective construction material, the reinforced concrete structure is the most widespread structure type in the Turkish construction industry. Because the construction site is the production area, the companies in this structure type do not require a factory or machinery; besides they are able to undergo reductions/expansions in size of labors, equipment, etc. Contrarily, for the other structure types these situations are reversed, so important problems caused by indirect and investment costs occur. To overcome these problems, maximizing the fulfillment of the design and production capacities by placing orders in sufficient amount can be considered as an efficient action. While taking this action, maximizing the profit through selecting appropriate customer order should be taken into consideration.

Profit-making companies of which scopes are design and production always put profit increase into perspective. Therefore, when they brush up against orders that exceed their capacities, demand management becomes an important issue for them. In this case, these companies should prefer to accept the orders that maximize their profit within the bounds of production and man-power capacities. Many researchers [1]-[4] pointed out the significances of effective methods, that can be used for the decision of whether accepting or rejecting the order, in order to maximize the profit, when the available capacities are under the capacity needs of all current potential orders.

Under the condition of having potential orders with different profitability values when the capacities of the companies are inadequate for these orders, an order selection decision should be made while taking the maximization of the profit into account.

In this study, Turkish Steel Structure Industry is focused on. The companies in this sector have commonly three main divisions: design, production, and erection. Since, the structural steel elements are designed in the technical office and produced in factory instead of construction site, the design and factory phases cover the vast majority portion of the work. On the contrary, the erection is done in the construction site and requires a very little workmanship. For instance, the firm that is under consideration of this study describes these portions as 90% and 10% of the total work respectively. Thus, the capacity constraints of these companies are defined as the design and production capacities, while erection capacity is not stated as one.

These companies would have to make accept/reject decisions for the potential customer orders by evaluating them with respect to many conflicting and incommensurable factors which may have different priorities. These evaluation factors can be prioritized by utilizing conjoint analysis [5]. Conjoint analysis requires decision makers to make trade-offs among generated alternatives that are characterized by different performance levels of specified factors. Instead of directly asking decision makers which factors they find more important, judgments are assessed indirectly in this approach. In this study, conjoint analysis which provides a prioritization model is developed in order to let the firm be aware of which combination of factors is most influential on their decision of selecting the most profitable projects among the potential orders under the inadequate capacities of the firm.

This study consists of four main sections. In the second section, the related evaluation factors that will be prioritized are expressed. In the third section, the details of the iterative steps of the proposed framework and the case study are explained. In the final section conclusions and further suggestions are given.

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II. Related Evaluation Factors for the Order Selection Decision

Profit maximization is a vital requirement and primary objective for all profit-making organizations to survive. On the other hand, accepting the order that has the highest profit is not always the best alternative due to different capacity utilization of current potential orders. Also, an order with higher profit margin but a longer operation time may not be profitable compared to an order with lower profit margin but a shorter operation time [6]. Thus, potential profit rate, which represents profit per unit of time, is used instead of potential overall profit [7]. In this study, "potential profit rate per unit of time" is selected as a factor for the customer order selection problem.

There are two types of production alternatives: make-to-stock (MTS) and make-to-order (MTO). MTS producers hold finished products in stock as a buffer against variety of demands [8] whereas MTO producers are process-focused and generally use similar operations to produce unique products which differ in design, usage, and other various specifications [9]. As stated in [10]-[13], product inventories are constraint resources for MTS firms so inventory rationing should be taken into consideration. Contrarily, MTO firms are not able to produce before the acceptance of the order. The constraints of these firms are man-hour and production capacities. Rationing problems for MTO firms are examined in [14]-[16]. To accept or to reject a new customer order for a MTO firm is highly dependent on the available capacity as well as the potential profit rate per unit of time for the relevant firm [8]. The firm of concern is a MTO firm, thus, it has to manage the available capacities to gain a long-term sustainable profit per unit of time [9]. At this point, managing the capacities means accepting orders through a deliberative evaluation by considering the remaining capacity, so "compatibility of potential order with available capacity" is considered in the model.

When there is a continuous long-term demand potential that exceeds the regular capacities of the firm, it is possible to increase the production capacity by investing in new equipment(s) or plant(s) [7] and also to increase the man-hour capacity by overtime production or sub-contraction [9]. However, the available capacities are fixed for the short-term demand and the firm is not able to increase its capacity due to the lack of time. In this context, MTO firms may deal not only with the capacity utilization problems for current potential orders but also with the management problem of remaining available capacity for future potential customers with higher potential profit rate [7]. The short-term problems are under consideration for this study and therefore "the level of potential future order with higher profit" is added to the model.

Another factor chosen for the model is "Customer credit for future business opportunity"; because, it has an important effect on the decision of accepting or rejecting the order. This decision highly depends on the customer's financial status, past history of payment and backlog [6]. Rejecting an order may oblige the customer to contract with other suppliers and may result in getting no future orders from the customer [9]. Hence, firms may sometimes accept an order with lower potential profit rate per unit of time comparing to the other possible orders to assure the future business opportunities. Thus, "customer credit of future business opportunity" is considered in the model.

The tardiness and deadline of the project can be regarded as major functions of total profit [17], so they are important indicators of a successful cooperation between the firm and the customer as the primary objective is profit maximization under limited capacity. Thus, production schedule should be considered during the acceptation/rejection decision making process. This decision based on the tightness level of schedule is made through the negotiations between the customer and the related managers. Accordingly, "the negotiability level of production schedule for the order" is chosen as the last factor of the model.

III. Proposed Framework and the Case Study

Potential customer orders should be evaluated with respect to many conflicting and incommensurable factors which may have different priorities. Therefore, to support the customer order selection decision, first of all, the aforementioned evaluation factors should be prioritized. In this research, as a case study, conjoint analysis [5] is utilized for prioritization of the factors for a construction firm operating in Turkey.

The firm operates in designing, fabricating, and erecting structural steel and steel parts with an annual production capacity of 12.000 tons per one shift. This firm is able to make three shifts, when it is needed. Its business area covers various industries including oil & gas structures, shipyards, airport structures, educational & health facilities, bridges, maritime structures, heavy and light industry buildings, energy structures both in Turkey and many foreign countries.

In the following sub-sections, the details of the iterative steps of the proposed framework for the case study are explained.

A. Recognizing and Defining the Decision Problem

The firm has started its activities in 1996but it has not confronted with the problem of inadequate capacities until the last two years. Moreover, in the current year, potential demands seem to exceed the available capacities again. The main problem is how to make the decision of accepting or rejecting the orders under current and future potential capacity circumstances.

Order selection becomes a complicated decision especially when the incoming demands exceed the current capacities of the firm. This complicated acceptation/rejection decision is usually made by the top management of the firm including general manager, business development manager, and technical office manager.

B. Specifying Values

The firm under consideration is a fully integrated design, production, and erection firm. Being integrated can be considered as a core competence and it also provides the opportunity of developing dynamic capabilities to serve effectively and efficiently in a highly competitive and dynamic environment.

The firm offers optimum solutions for primary activities including marketing and sales, design and engineering, fabrication, transportation, and erection as well as the support activities. The main target is to become the most preferred engineering, production and erection supplier for both local and international projects by "Building the Optimum".

In the highly competitive environment of construction industry, there are many strong competitors in Turkey and abroad that the firm has to deal with. However, capability of coping with challenging structures is not a common resource for many of them. Also, with the "three Ps", the firm assures Prediction in engineering design, Precision in production and Productivity in erection. Prediction in design provides maximization of potential profit rate by decreasing the number of problems that may occur during the production and erection phases. Another way of potential profit maximization is accepting the orders which the firm is highly experienced. Because, this can also lead the firm to reach its targets: the prediction, precision and productivity easier.

C. Specifying Objectives

The objectives of the firm are based on the values described in previous section and can be expressed as:

i. To increase international project rate comparing to the local projects. Because the international firms pay great attention to the values represented by "three Ps" of the firm.
ii. To increase the awarded project rate of the complex projects in various areas such as energy, offshore, oil and gas, shipyards, airports and shopping malls. Because the firm aims and also its values enable to develop valuable and unique projects.
iii. To make the customer order selection decision in the most profitable way when the available capacities are under the requirements of the potential orders.

Under the production and technical man-hour capacity limits, maximizing the profit is the primary objective for profit making organizations. Thus, the most significant objective is the third one.

This study aims to prioritize the evaluation factors affecting the customer order selection decisions under the profit maximization perspective while leaving the capacity expansion options, outsourcing and subcontracting out of the scope.

D. Identifying the Evaluation Factors

As aforementioned in Section II, the evaluation factors affecting the customer order selection can be stated as:

- The potential profit rate per unit of time
- The compatibility of potential order with available capacity
- The level of potential future order with higher profit
- Customer credit of future business opportunity
- The negotiability level of production schedule for the order

E. Prioritizing the Evaluation Factors

The next step after coming up with a list of evaluation factors will be assessing importance of each factor. There are several methods that can translate the relative importance of factors into numbers which are often called as "priorities". Unfortunately, there is not any unique method that can be expressed as the best one which can be utilized for all priority assignment problems. An appropriate method can be selected according to the nature of problem, the data type, the structure of the factors, and/or the philosophy of the decision makers.

Methods utilized for assignment of priorities can be classified into two groups, namely direct determination and indirect determination [18].

Direct determination is based on the responses of the decision makers to whom specific questions are posed. It refers to elicit priorities through expert interviews or questionnaire surveys.

On the other hand, priorities can also be indirectly computed from the data of the alternatives, from the answers given to some interactive questions and questionnaire surveys, or from the outputs of some additional techniques (i.e. centrality of cognitive mapping).

F. Utilizing Conjoint Analysis

Conjoint analysis is a statistical method that can be used as an indirect priority determination procedure. It requires decision makers to rank or rate alternatives and derives priorities that provide the best fit of the evaluations for alternatives [19]. Actually, conjoint analysis is a survey research tool that predicts consumer preferences in multi attribute decision making where alternatives are evaluated with respect to several attributes (factors) in a wide variety of product and service context [5]. It became popular in marketing research as it can predict what consumers will buy when they faced with the availability of many brands and a great number of product characteristics [19].

By systematically varying the characteristics of a product or a service and observing how survey participants react to these product/service profiles, the researcher can statistically deduce the scores for each characteristic (factor) participants may have been subconsciously using to evaluate products [19].

For this purpose, first of all, levels within each factor must be developed. In this case, there would be many possible combinations of these factor levels. By using experimental design principles of independence and balance, some of the combinations are carefully chosen; therefore participants do not have to evaluate all possible combinations.

In the 70's, survey participants were requested to evaluate each of many combinations that are printed on separate cards one by one by ranking or rating on a scale. In the 80's, a computerized version called as Adaptive Conjoint Analysis was utilized, which could effectively gather more attributes and levels by focusing on them that were most relevant to each participant. In the 90's, Choice Based Conjoint (CBC) became popular. With CBC, participants were requested to choose

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among a certain number of possible combinations instead of ranking them or rating each of them individually [20].

Nowadays CBC is widely used as consumers in real life do not score each alternative, instead they simply choose among them; which make CBC questions seem more realistic. Generally, a certain number of possible combinations with an additional "none" choice (that can be chosen if none of the combinations is preferred) are presented to the participants.

As a further step, by utilizing regression analysis, as aforementioned, the scores of the factors can be inferred [21]. These scores are useful for determining which preferred levels and the relative priorities of each factor. For this purpose, the scores are scaled to an arbitrary additive constant within each factor [19]. The arbitrary origin of the scaling within each factor is based on dummy coding. When using "effects coding", that is a specific kind of dummy coding, scores are scaled to sum to zero within each factor. In this case, the scores can be regarded as conjoint utilities. After finding the range in the utility values of a factor (i.e. the difference between the maximum utility and the minimum utility), the percentages from relative ranges are calculated. These normalized ranges are the priorities of the factors.

In the case study, in accordance with CBC, the levels within each of the five evaluation factors affecting the customer order selection are developed.

A three-level scale (High-Medium-Low) is used for the following factors:

- Potential profit rate per unit of time
- Compatibility of potential order with available capacity
- Customer credit of future business opportunity
- Negotiability level of production schedule for order

On the other hand, a two-level scale (Exists-Does not exist) is used for

- Level of potential future order with higher profit

By using experimental design, 90 hypothetical customer orders are chosen among 162 of them by the authors acting as researchers. Thirty conjoint cards having three possible orders and an additional "none" alternative are formed (see Fig. 1 for an example).

CARD 1				
	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Customer credit of future business opportunity	HIGH	MEDIUM	LOW	
The potential profit rate per unit of time	MEDIUM	HIGH	LOW	
The negotiability level of production schedule for the order	MEDIUM	LOW	HIGH	NONE
The level of potential future order with higher profit	DOES NOT EXIST	EXISTS	EXISTS	
The compatibility of potential order with available capacity	MEDIUM	LOW	HIGH	

Fig. 1 A representative conjoint card

General Manager (GM), Business Development Manager (BDM), and Technical Office Manager (TOM) of the firm under consideration are requested to examine 10 different conjoint cards and to select the most preferred alternative in each card. Sawtooth software [22] is used for the necessary calculations required for statistical analysis based on logistic regression.

As a result, the researchers come up with the conjoint utilities of the levels and then the priorities of the evaluation factors.

G. Findings

The conjoint utilities of levels based on the responses of the participants can be seen at Table I. The computed relative priorities of the evaluation factors are given at Table II.

As can be seen from the findings, the most important evaluation factor is "the compatibility of potential order with available capacity" (31.02%) followed by "the potential profit rate per unit of time" (25.62%) and "customer credit of future business opportunity" (23.85%). The average results are in accordance with those of BDM. There is a slight difference with average results and those of TOM. On the other hand, according to GM, the most important factor is "customer credit of future business opportunity".

IV. Conclusions and Further Suggestions

In this study, a decision framework is proposed to determine evaluation factors that can be used in potential customer order selection problem and to assess the priorities of them. A case study is conducted for a firm operating in Turkish steel structure industry. Based on the judgments of the top managers of this firm who participate in a CBC analysis, the researchers come up with the priorities.

TABLE I
Conjoint Utilities

	GM	BDM	TOM
Compatibility of potential order with available capacity			
HIGH	22.60	75.54	72.60
MEDIUM	29.31	43.44	44.42
LOW	-51.92	-118.98	-117.01
Potential profit rate per unit of time			
HIGH	19.41	78.54	40.92
MEDIUM	35.07	17.84	38.01
LOW	-54.48	-96.38	-78.93
Customer credit of future business opportunity			
HIGH	22.13	43.28	53.66
MEDIUM	62.45	-14.78	31.62
LOW	-84.59	-28.50	-85.29
Negotiability level of production schedule for the order			
HIGH	-47.14	-21.59	-3.58
MEDIUM	-1.11	25.89	16.47
LOW	48.25	-4.30	-12.89
Level of potential future order with higher profit			
EXISTS	43.40	-5.65	-11.12
DOES NOT EXIST	-43.40	5.65	11.12

TABLE II
PRIORITIES OF THE EVALUATION FACTORS

	GM	BDM	TOM	Ave.
Compatibility of potential order w. avail. capacity	16.25%	38.90%	37.92%	31.02%
Potential profit rate per unit of time	17.91%	34.98%	23.97%	25.62%
Customer credit of future business opportunity	29.41%	14.36%	27.79%	23.85%
The negotiability level of prod. schedule fororder	19.08%	9.50%	5.87%	11.48%
Level of potential future order with higher profit	17.36%	2.26%	4.45%	8.02%

Although CBC findings cannot be generalized for the steel structure industry, it would be an insight for the prioritization of customer order selection factors. Managers do not have to be very experienced in statistics to understand and use the concept of orthogonal designs, main effects' assumptions, or utility estimation required by conjoint analysis. The proposed framework utilizing the conjoint analysis software can support managers in a reliable way in their decisions.

The goal of the decision problem on hand can be stated as "choosing the most profitable order under the limited capacities of the firm". In accordance with this goal, the findings reveal that the most important evaluation factors for the firm under consideration are "the compatibility of potential order with available capacity" and "the potential profit rate per unit of time".

The proposed framework can also be utilized in other firms in the construction sector to find the priorities of the managers of those firms. An alternative research avenue could be using Delphi technique or a similar approach to aggregate the judgments of the majority of the executives working in the sector. A similar approach can be utilized in other sectors, as well.

The stages of identifying and prioritizing the evaluation factors should be followed with the stages of assessing performance values of alternatives (i.e. potential orders) with respect to criteria (i.e. factors) and then utilizing an appropriate solution technique to find preferences of decision makers (i.e. managers) for the alternatives. In this case, the whole process would be a typical multi criteria decision making (MCDM) process. Accept/reject decisions for potential customer orders can be made through MCDM process. This study can be expanded in such a way to support the decision makers.

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