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Determining the Criteria and their Importance Level of Calibration Supplier Selection

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***Abstract*—**Quality control is the crucial step for ISO 9001 Quality System Management Standard for companies. While measuring the quality level of both raw material and semi product/product, the calibration of the measuring device is an essential requirement. Calibration suppliers are in the service sector and therefore the calibration supplier selection is becoming a worthy topic for improving service quality.

This study presents the results of a questionnaire about the selection criteria of a calibration supplier. The questionnaire was applied to 103 companies and the results are discussed in this paper. The analysis was made with MINITAB 14.0 statistical programs. "Competence of documentations" and "technical capability" are defined as the prerequisites because of the ISO/IEC17025:2005 standard. Also "warranties and complaint policy", "communication", "service features", "quality" and "performance history" are defined as very important criteria for calibration supplier selection.

***Keywords*—**Calibration, criteria of calibration supplier selection, calibration supplier selection, questionnaire

I. Introduction

CALBRATION is defined as the checking of a measurement device against an accurate standard to determine any deviation and correct for errors. The requirements for calibration are standardized with ISO/IEC17025:2005 General requirements standard for the competence of testing and calibration laboratories standards. It specifies the general requirements for the competence to carry out tests and/or calibrations, including sampling. It covers testing and calibration performed using standard methods, non-standard methods, and laboratory-developed methods. Therefore, the calibration supplier has to be certified with ISO 17025 standard for calibration.

Supplier selection problems are handled with many papers in literature. Also, calibration supplier selection problems should be considered in the same way as supplier selection problems due to the rising number of calibration suppliers and the cost of calibrations.

Papers about supplier selection are published in two main categories: determining the criteria for supplier selection and selecting the suppliers according to these criteria.

Dickson conducted wide research on the criteria of supplier selection and many papers have used the results of this study [1].

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He determined that quality, delivery, performance history and warranties, and price are very important criteria; capacity, price, technical capability, and financial position are important criteria for selecting the raw material or parts suppliers. Weber et al presented a literature review about supplier selection problems in 1966-1991 and determined that price, delivery, quality, production capacity and location are handled in many papers [2]. Also, Tam and Tummala proposed criteria that had significance as quality, cost, problem solving capability, and proficiency and reputation for the telecommunication sector [3]. Supplier selection criteria has changed according to requirements over the years and produced several papers [4-6].

The supplier selection problems are also examined with respect to used methods in literature: Linear weighted methods [2-6], the analytic hierarchy process [7-8], the analytical network process [9-10], mathematical programming [11-12], goal programming [13], multi-objective programming [14-15] and fuzzy set theory [16-17].

The integrating AHP and goal programming methods are used to evaluate the weights of criteria and to determine the best supplier respectively [18-19]. Wia and Wu presented a paper using the AHP and multi-objective mixed integer programming model for supplier selection [20]. Demirtas and Ustun studied ANP and goal programming by collaborating with three objective functions [21].

With reference to the literature, the criteria for calibration supplier selection have not yet been considered. In this paper, the criteria and their weights for calibration supplier selection were investigated by questionnaire. The methodology and results are given in the second and third sections respectively.

II. Methodology

Calibration supplier selection criteria and their weights were determined by questionnaire [22]. The questionnaire covered both demographic information and questions about criteria and weights. The first five questions were related to the demographic information such as number of employee, sector, having ISO 9001 Quality Management System: requirements standard, number of devices and location of calibration supplier. The other section was arranged into 14 sub-sections and 31 questions. These were quality, competence of documentations, delivery on time, performance history, service features, technical capability, and competence of finance, warranties and complaint policy, capability of packing, reputation and position, price and payment policy, communication, management and organization, and location of calibration supplier. These sections were organized with a 5-scale Likert for determining the importance level of each criterion. One hundred and three companies answered the questionnaire in Turkey and the return rate was 51.5 %. This percentage is higher than general questionnaire turn over since

many questionnaires were applied by appointment with companies. Many interviews for questionnaires were made face to face. The reliability of the questionnaire was measured using Cronbach's Alpha. The reliability results are given in Table 1. As can be seen, the reliabilities of the questionnaire for each title are rather high values. It can be said that the reliability of questionnaire is acceptable.

TABLE I
RELIABILITY OF QUESTIONNAIRE

Criteria	Cronbach Alpha
Quality	0.7998
Competence of documentation	0.8147
Delivery on time	0.8188
Performance history	0.7963
Service features	0.7878
Technical capability	0.8015
Competence of finance	0.8131
Warranties and complaint policy	0.7947
Capability of packing	0.7988
Reputation and position	0.8172
Price and payment policy	0.7924
Communication	0.7987
Management and organization	0.8138
Location	0.8117
General reliability	0.8159

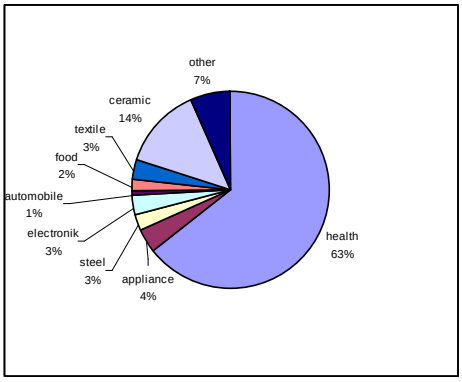

Fig. 1 Sector distribution of questionnaire

III. RESULTS

Figure 1 shows the sector distribution of the questionnaire. As can be seen the health sector covers a high percentage (63%) of research due to the importance of calibration for human health and the production sector makes up 30%.

Also, the distribution of the number of devices required calibration is given in Figure 2. As seen that, 60 companies have more than 100 devices required calibration. It is indicate that the calibration supplier selection importance.

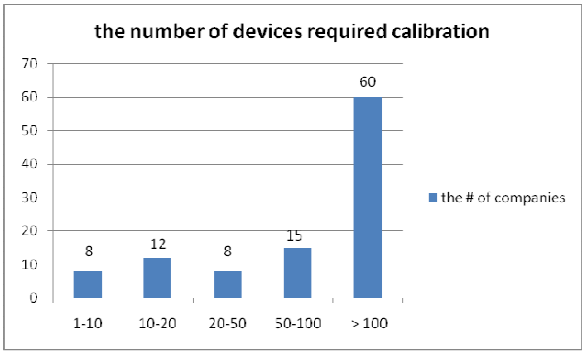

Fig. 2 The disrtibution of the number of devices required calibration

Results were examined with several hypothesis because the number of questionnaires was higher than 30. The first hypotheses were set up to research any differences between the health sector and other sectors given the importance level of calibration supplier criteria.

(1) Hypotheses

H_0: $\mu_{\text{health sector}} = \mu_{\text{not health sector}}$

H_a: $\mu_{\text{health sector}} \neq \mu_{\text{not health sector}}$

At test was applied to the averages of 14 criteria for the health sector and others with a 5% significance level. The results are given in Table II. It is shows that there is no difference between the health sector and other sectors given the importance level of calibration supplier criteria. The criteria of calibration supplier do not depend on the sector. Therefore, the answers can be analyzed as a whole.

TABLE II
T TEST FOR HEALTH AND NON-HEALTH SECTORS

	μ health sector n=66	μ non-health sector n=37	T value	p value
General average	4.134	4.108	0.57	0.565

The second set of hypotheses is on the differences between the 14 criteria. Answers are analyzed in terms of whether there are any significant differences between the 14 criteria of calibration supplier selection with a 5% significance level. One-way ANOVA was carried out for this purpose. The results are presented in Fig.3.

(2) *Hypotheses*

H_0: $\mu_{\text{quality}} = \mu_{\text{comp. of documentation}} = \mu_{\text{delivery on time}} = \mu_{\text{performance history}} = \mu_{\text{service features}} = \mu_{\text{tech. capab.}} = \mu_{\text{copm.of finance}} = \mu_{\text{rwarr. compl.policy}} = \mu_{\text{capab, of packing}} = \mu_{\text{reput. position}} = \mu_{\text{price payment policy}} = \mu_{\text{communication}} = \mu_{\text{manag. org.}} = \mu_{\text{location}}$

H_a: At least two of the means are not equal.

H_0 is rejected, so it indicates that there is at least one mean difference from the others.

Table III shows the averages of each criterion that represent the weights of calibration supplier selection criteria. Also, criteria are categorized as “prerequisite”, very important” and “important” by

considering the importance level. Two criteria, “competence of documentations” and “technical capability”, which had the highest values (4.71 and 4.5 respectively), are defined as the prerequisite because of the ISO/IEC17025:2005 standard. If one supplier does not have ISO/IEC17025:2005 certification, it cannot be a calibration supplier. Also, if one supplier does not have the technical capability for each measurement device, it cannot calibrate that device. These interpretations are supported by the answers from the questionnaire.

“Warranties and complaint policy”, "communication”, “service features”, “quality” and “performance history” are defined as very importance criteria.

The third set of hypotheses was conducted to analyze whether the criteria average that represents the medium value of the 5-scale Likert was greater than three. One-sample t-test was carried out with a 5% significance level. The results are given in Table IV.

(3) *Hypotheses*

H_0: $\mu_{criteria} = 3.0$

H_0: $\mu_{criteria} > 3.0$

All average values of the criteria were greater than the medium value. This indicates that the criteria examined in this study are important for calibration supplier selection.

IV. Discussion

After evaluating the answer of questionnaire, “competence of documentations” and “technical capability” criteria are defined as the *prerequisite* because of the ISO/IEC17025:2005 standard. Also, “warranties and complaint policy”, "communication”, “service features”, “quality” and “performance history” are defined as *very important*.

“Management and organization”, “delivery on time”, “capability of packing”, “price and payment policy”, “reputation and position” and “location” were found to be importance because their average values were significantly greater than 3.00.

One-way ANOVA: QUALITY; COMP. OF DOCUM; DELIVERY TIME; ...

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Source    DF       SS      MS      F      P
Factor    13  130.576  10.044  18.07  0.000
Error   1428  793.854   0.556
Total   1441  924.431

S = 0.7456   R-Sq = 14.13%   R-Sq(adj) = 13.34%

Individual 95% CIs For Mean Based on
Pooled StDev
Level            N    Mean   StDev  --------+---------+---------+---------+-
QUALITY        103  4.2175  0.5359               (---*----)
COMP.OF DOCUM  103  4.7087  0.5711                          (----*---)
DELIVERY TIME  103  3.9355  0.7205        (---*----)
PERFOR. HIST.  103  4.1505  0.5893              (----*---)
SERVICE FEATU. 103  4.3641  0.5866                    (---*---)
TECH. CAPAB.   103  4.4393  0.4323                      (---*---)
COMPET.FINANCE 103  3.7184  1.0234  (---*---)
WARR. COMPL.   103  4.5049  0.5355                        (---*---)
CAPAB. PACK.   103  3.8738  0.9870       (---*---)
REPUT. POSITION 103 3.8058  0.6787     (---*---)
PRICE PAYM.    103  3.8641  1.0177      (---*----)
COMMUNICATION  103  4.3689  0.6714                    (---*---)
MANAG. ORGAN.  103  4.0000  0.8044          (---*---)
LOCATION       103  3.7961  0.9326    (---*----)
--------+---------+---------+---------+-
3.85      4.20      4.55      4.90

Pooled StDev = 0.7456

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons

Individual confidence level = 99.92%
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Fig. 3 One way ANOVA for 14 criteria

TABLE III
AVERAGE AND CATEGORY OF CRITERIA

Criteria / Suppliers	Average	Category
Competence of documentation	4.71	Prerequisite
Technical capability	4.50	
Warranties and complaint policy	4.48	Very important
Communication	4.44	
Service features	4.36	
Quality	4.24	
Performance history	4.15	
Management and organization	4.00	Important
Delivery on time	3.93	
Capability of packing	3.87	
Price and payment policy	3.86	
Reputation and position	3.805	
Location	3.796	
Competence of finance	3.72	

V. CONCLUSION

Calibration is the one of the important service areas and is necessary for the accuracy of measurement systems. Also, companies have many measurement devices, nowadays, so, the selection of calibration supplier is becoming more important and the number of calibration suppliers is rising.

This study researched which criteria are important and the importance levels of criteria for calibration supplier selection using a questionnaire. The questionnaire reliability was calculated and found to be appropriate. This study is the first in literature to research calibration supplier criteria. Papers on determining the criteria and criteria's importance level of calibration supplier selection, and methods of calibration supplier selection should increase in literature.

TABLE IV
ONE SAMPLE T TEST FOR THIRD SET OF HYPOTHESES

One-Sample T: QUALITY; COMP. OF DOCUM; DELIVERY TIME; ...
Test of mu = 3 vs. not = 3

Variable	N	Mean	StDev	SE Mean	95% CI	T	P
QUALITY	103	4.2175	0.5359	0.05280	(4.11275; 4.32220)	23.06	0.000
COMP.OF DOCUM	103	4.7087	0.5711	0.05627	(4.59713; 4.82034)	30.37	0.000
DELIVERY TIME	103	3.9355	0.7205	0.07099	(3.79473; 4.07634)	13.18	0.000
PERFOR. HIST.	103	4.1505	0.5893	0.05806	(4.03532; 4.26565)	19.81	0.000
SERVICE FEATU.	103	4.3641	0.5866	0.05780	(4.24943; 4.47872)	23.60	0.000
TECH. CAPAB.	103	4.4393	0.4323	0.04259	(4.35484; 4.52380)	33.79	0.000
COMPET.FINANCE	103	3.7184	1.0234	0.04259	(4.35484; 4.52380)	33.79	0.000
WARR. COMPL.	103	4.5049	0.5355	0.05276	(4.40020; 4.60951)	28.52	0.000
CAPAB. PACK.	103	3.8738	0.9870	0.09725	(3.68089; 4.06668)	8.99	0.000
REPUT. POSITION	103	3.8058	0.6787	0.06688	(3.67317; 3.93848)	12.05	0.000
PRICE PAYM.	103	3.8641	1.0177	0.10028	(3.66517; 4.06299)	8.62	0.000
COMMUNICATION	103	4.3689	0.6714	0.06616	(4.23771; 4.50015)	20.69	0.000
MANAG. ORGAN.	103	4.0000	0.8044	0.07926	(3.84279; 4.15721)	12.62	0.000
LOCATION	103	3.7961	0.9326	0.09189	(3.61384; 3.97839)	8.66	0.000

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