

Total Quality Management in the Top Rank of the Dairy Industry in Jordan

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Abstract

In this paper an investigation was carried out to assess the extent of the individual as well as the collective application of Total Quality Management (TQM) factors in each of the companies of the top rank of the dairy industry in Jordan. The investigation was conducted on the basis of a five point Likert scale survey. Cronbach's Alpha was computed to establish the consistency and reliability of the survey data. Using the score of the collective application of TQM factors in each company as the independent variable, the quantity in tons, of the milk processed for making all the products sold during the year of the survey for each company, was considered as the dependent variable affected by the impacts. Although the extent of the application of TQM factors showed some variation, from factor to factor and from company to another, the investigation established the significance of the extent of the application. It also showed that the correlation between the extent of the overall application and the values of the chosen performance indicator was direct and positive. A discussion of the results of the investigation, in the light of the environment pertinent to the companies, was made.

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1. Introduction

The variety of dairy products in Jordan typically includes milk, yoghurt (sour milk), labneh (condensed yoghurt), and cheese. Generally speaking, dairy products go through processes that are closely related [1]. Raw milk is primarily stored at a cool temperature. If milk is intended for direct use (drinking, or other purposes), fat content is adjusted, and the milk is homogenized and pasteurised, or sterilized before filling into bottles or other types of containers. In order to make yoghurt, starter cultures are added to ferment the lactose contained in the already homogenized and pasteurised milk. The product is then cooled down, filled into containers and properly stored. After making yoghurt, Labeneh is made through the reduction of the water content down to one third. Cheese making is basically a fermentation and coagulation processes that start after homogenisation and pasteurisation of milk. For fermentation, the right amount of rennet (a natural enzyme) or some industrial substitute is added. The fermentation and coagulation processes lead to the making of curd, which is cut and treated to make the required type of cheese, before washing and storage.

"Total Quality Management (TQM)" was defined as both a philosophy and a set of guiding principles representing the foundation of a continuously improving organization that integrates the fundamental basic management techniques, improvement methods, and technical tools in a wholly

disciplined approach [2]. Even before the advent of the 21st century, TQM had developed in many countries into holistic frameworks aiming at helping organizations achieve world class excellence [3]. Research in TQM, at the beginning, was mainly confined to conceptual case studies [4]. Over the past few years, survey-based TQM research followed, especially in the area of identification and assessment of TQM factors. According to Sila and Ebrahimpur [5], 347 survey-based studies were published between 1989 and 2000. These studies dealt with, amongst other things, the very significant topics of critical factor identification, and measurement as well as the assessment of the impacts of the so called TQM factors [6].

In Jordan, there have been several studies that focused on the assessment of the extent of application and the impacts of TQM in areas other than the dairy industry [7-9]. The assessment of the extent of application and the impacts of TQM in the Jordan dairy industry, to the best of researchers' knowledge, has not been addressed so far. The dairy industry in Jordan comprises private sector companies. These companies widely vary in technology, age, size, location, and scope of the product mix. To make any investigation result in meaningful conclusions, segmentation of the industry was seen imperative. Accordingly, it was decided to select the most developed and best established companies of the sector. On the basis of a survey involving the dairy companies and the major departmental stores and supermarkets, it was concluded that this section comprised six companies. These companies used modern technology, and they were well settled in terms of share in the market and capacity utilization, and practically offered the same types of products. One of the companies was not prepared to be

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involved, leaving five companies that underwent the investigation.

The aim of this investigation is to judge the progress of the overall TQM application and to assess the impacts on the performance in each of these five companies. This will cover two aspects namely:

- The extent of the application of the individual TQM factors and the application of all these factors collectively in each individual company.
- The impacts of the TQM factors, collectively applied, on the performance indicator of each individual company.

Towards this end, it was decided to resort to a survey based on a suitably designed and carefully distributed questionnaire that included statements pertinent to each type of TQM factors. For each company, responses to the statements are assessed on a five point Likert scale. On the basis of the statements scores, the factor scores and the individual company overall TQM application score are assessed. Testing of the hypothesis will assess the significance of the application of each factor and all the factors in each company. To judge the impact of TQM on the companies, the overall TQM application score of each company was envisaged as an independent variable. The quantity in tons, of the milk processed for making all the products sold during the year of the survey for each company, was considered as the dependent variable affected by the impacts.

As the managements of the companies considered their business quality indicators sensitive information, it was agreed that companies will be referred to by their designations (C_c), ranging from C_1 to C_5 .

2. Identification of TQM Factors and The Design of The Questionnaire

The identification of the factors contributing to TQM varied extensively. Sila and Ebrahimpur [5], on the basis of a survey research, extracted 25 most commonly quoted factors. Applying a cause-and-effect analysis, these factors boiled down to what Besterfield [2] identified as the five main bases of TQM, namely: instilling quality culture, the so called quality chain (treating each element as a customer and producer simultaneously), quality assurance, commitment to continuous improvement and finally the support of top management. The establishment of these bases required attention to several areas of resource management. The required actions were described as TQM enablers or factors. Through some cause-and-effect analysis, the basic enablers, meaning TQM factors, were reduced to the following:

- Instilling quality culture
- Focus on employees involving employee participation, training and motivation
- Focus on operations including continuous improvement
- Focus on customers
- Strategic competitive management

The essence of each of the factors above is reflected by the statements of the questionnaire (shown in the Appendix as Figure I) dedicated to measure that factor.

The above five factors were considered variables through which the extent of the application of TQM in

each company is measured. For each company, the assessment of these variables is made on the basis of the statements of the questionnaire designed for the purpose of the investigation.

The questionnaire, as shown in Figure I, consists of five sections. Each section is dedicated to measure one of the TQM factors. Each section comprised a number of statements. The responses to each statement are meant to reflect the status quo of some aspect of the factor. Five predesignated responses (R_1 to R_5) are envisaged. The response designation, the essence of the response and the response value on the five point Likert scale, are as follows:

Response designation	R_1	R_2	R_3	R_4	R_5
Type of response	Never	Rarely	Sometimes	Often	Always
Likert scale value	1	2	3	4	5

For each company the responses to each statement are considered as a sample from the population relevant to the pertinent factor of the pertinent company. The number of the valid copies of the questionnaire, finally used for the survey, will make the size of this sample.

3. Proposed Statistical Treatment and Analysis

To examine the consistency and reliability of the data collected on the basis of the questionnaire, the Cronbach's Alpha of the data is proposed to be computed using the following formula [10]:

$$C\text{Alpha} = \left[\frac{K}{K-1} \right] * \left[1 - \frac{\sum Var_c}{TVar_c} \right]$$

Where: CAlpha = Cronbach's Alpha

K = the number of statements in the test (questionnaire)

$\sum Var_c$ = the sum of the variances of the scores of the statements of the individual companies .

$TVar_c$ = the variance of the totals of the scores of the statements of the individual companies For most applications a Cronbach's Alpha of 0.8 or higher is considered acceptable

For the statistical treatment of the variables relevant to each company (C_c), the responses (X_{ji}) to each statement (S_i) of each factor (F_j) are assessed, and the mean value of the responses (\bar{X}_{ji}) as well as the standard deviation ($\sigma_{x,ji}$) are computed. The central tendency of the extent of application of each factor is measured by the mean of the means of the factor statement scores, $F\bar{X}_j = \bar{\bar{X}}_{ji}$. The dispersion of the extent of application of each factor is measured by the mean of the standard deviations of the factor statements scores, $F\sigma_{x,j} = \bar{\sigma}_{x,ji}$.

As the number of statements relevant to each factor varies, the central tendency for the extent of the overall application of TQM (represented by all the factors in each company) is measured by the weighted mean of the means of the factors

$$C\bar{X}_c = \sum_j (w_j * F\bar{X}_j) / \sum_j w_j, \text{ where } (w_j)$$

is the number of statements involved in each factor.

Similarly the dispersion of the extent of the overall application of TQM (represented by all the factors in each company) is measured by the weighted average of the standard deviations of the factors

$$C\sigma_{x,c} = \sum_j (w_j * F\sigma_{x,j}) / \sum_j w_j$$

The number of responses (n) to each statement is deliberately made large enough to justify using the standard deviation of the sample for the standard deviation of the population. Also, using a large enough sample size justifies the assumption of a normal distribution of the mean of the sample [11]. As such, the standard deviation

of the factor statements' means is $F\sigma_{x,j} = F\sigma_{x,j} / \sqrt{n}$

and that of the company overall TQM application statements' means is $C\sigma_{x,c} = C\sigma_{x,c} / \sqrt{n}$.

Hypothesis testing is envisaged to judge if the extent of the application of each TQM factor as well as the overall TQM application (represented by all the factors together) in each company is significantly above the Likert scale nominal average of $\mu=3$ or not. This is planned to be achieved as follows:

3.1. Formulation of Hypothesis

- On the factor level
Null hypothesis H_0 : the company does not apply the factor: $\mu \leq 3$, Alternative hypothesis H_1 : the company applies the factor: $\mu > 3$
- On the TQM Level
Null hypothesis H_0 : the company does not apply TQM: $\mu \leq 3$, Alternative hypothesis H_1 : the company applies TQM: $\mu > 3$

3.2. Level of Significance (a)

A one sided level of significance, where $\alpha = 0.05$, is envisaged; this level of significance, for a normal distribution, is associated with Z- values as follows:

- On The Factor Level, The Z-Value:
 $FZ_j \leq 1.645$
- On The Company TQM Application Level, The Z-Value:
 $CZ_c \leq 1.645$

3.3. Judgement Criteria

- On the factor level:
Reject H_0 when $FZ_j = (F\bar{X}_j - 3) / F\sigma_{x,j} > 1.645$
- On The Company TQM Application Level:
Reject H_0 when $Z_c = C(C\bar{X}_j - 3) / C\sigma_{x,c} > 1.645$

Considering the settled statuses of the companies, the quantity in tons of the milk processed for making all the products sold by each company during the year of the survey was considered as the dependent variable affected by the impacts. To determine the impacts of TQM application on each company, the dependant variable relevant to that company is plotted against the independent variable (the value of TQM application score in that company, $C\bar{X}_c$). Regression analysis is used to determine the correlation coefficient between the variables.

4. Field work and Assessments

The questionnaire subject matter of Figure I was organized in two sections: A & B. Section A was meant to be answered solely by random samples of the employees of each company. Section B was meant to be randomly answered, in equal proportions, by the employees as well as by the customers of each company. The total distribution of the questionnaire, the number returned, and the number considered valid for analysis are as shown below.

Copies distributed	Number returned	Valid number used for the analysis
250	188	150

Aiming for what could be considered as a large sample size [11], it was decided to settle for randomly selecting 30 properly completed copies for each company.

Relevant to each company, the responses to the statements of the questionnaire were analysed, and the means \bar{X}_{ji} and the standard deviations $\sigma_{x,ji}$ for each statement were computed. Also, for each company (C_c), for each factor (F_j), the values of $F\bar{X}_j$, $F\sigma_{x,j}$, $C\bar{X}_c$ and

$C\sigma_{x,c}$ were also computed. The organization of the data and the results of the computations relevant to the individual companies are shown in the Appendix as

Figure II. Accordingly, the mean score of the application amongst the five companies is 3.4104, and the standard deviation of the scores is 0.3241 - thus providing a coefficient of variation of 9.5%.

On the basis of the data organised in Figure II, the consistency and reliability of the responses to the statements of the questionnaire were examined as a whole, using the Cronbach's alpha formula. The body of the data comprised five columns, each representing the means of the scores of the responses to the statements of the questionnaire relevant to one company. The computed value of the Cronbach's alpha coefficient of the data was 1.005, which is significantly higher than the minimum acceptable value of 0.8.

For each company (C_c) for each factor (F_j), the values of $F\bar{X}_j$, $F\sigma_{x,j}$, $C\bar{X}_c$ and $C\sigma_{x,c}$ were extracted from Figure II and used to assess the values of $F\sigma_{x,j}$, FZ_j ,

$C\sigma_{x,c}$ and CZ_c . These computations, the decisions regarding hypothesis testing, and conclusions based on the decisions are shown in the appendix as Figure III.

For the impact of the extent of the overall applications of TQM in each of the companies, the value of the dependant variable (tons of milk processed) relevant to that company was obtained from the company management. These values, as well as the values of the independent variable (the scores of the overall TQM application in each company) as obtained from figure II, are shown in Figure 1.

A curve representing the value of the dependant variable (tons of milk processed) in each company against the independent variable (the score corresponding to the extent of the overall application of TQM in that company) is shown in Figure 2.

As indicated by the shape of the curve, linear regression could be assumed. To assess the proportion of the variation in the dependant variable that could be attributed to the linear relationship with the independent variable, the coefficient of correlation (r) was assessed as follows (Miller, Freund and Johnson 2004):

$$r = \frac{n \sum XY - \sum X \sum Y}{\sqrt{[n \sum X^2 - (\sum X)^2][n \sum Y^2 - (\sum Y)^2]}}$$

where X = the independent variable
 Y = the dependant variable
 n = the number of observations

The value of the coefficient of correlation of the dependant variable was 0.94

Company	C ₁	C ₂	C ₃	C ₄	C ₅
Independent Variable					
- Mean TQM score	3.387	3.505	3.945	2.955	3.260
Dependant Variables					
Tons of milk processed per year	17500	15500	21500	7800	10900

Figure 1: Values of the independent and dependant variables for the Companies.

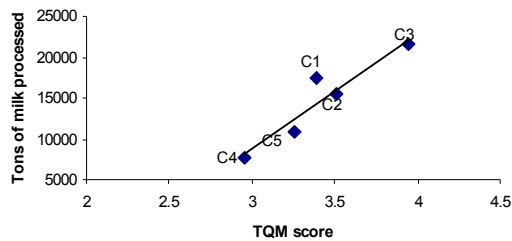


Figure 2: Impacts of TQM on performance.

5. Discussion of Results

The Cronbach's alpha value for the companies' scores of 1.005 is well above the minimum acceptable value of 0.8, thus indicating that the design and the distribution of the questionnaire, taken as a whole, managed to provide the necessary consistency and reliability of the data.

TQM factor application, as obtained from Figure II, showed that the companies varied over the attention they paid to the various factors. The "focus on operations" averaging 3.958 and "focus on instilling TQM culture" averaging 3.709 received the highest attention. The "focus on employees" averaging 2.876 received the lowest. As far as the "attention to employees" is concerned all the companies except C3 scored below the nominal average of 3.0. Generally speaking, factor attention goes in line with the prevailing attitude of seeking excellence through spending on equipment and preaching for good performance without paying sufficient attention to the necessary development of human resources. In fact, a previous investigation involving the health sector gave

similar results [9]. Although the companies did significantly focus on the "attention to customers", this factor ranked second from the bottom. Marketwise, this situation resulted in the fact that imports of dairy products of comparable quality and prices still capture a share of the market.

6. Conclusions and Recommendations

The mean overall TQM application scores on the 5 point Likert scale for the relevant companies as obtained from Figure II and the percentages these scores represent out of the maximum possible score are shown below.

Company	C ₁	C ₂	C ₃	C ₄	C ₅
Mean TQM application score	3.387	3.505	3.945	2.955	3.260
% representation of the max. possible score	0.677	0.701	0.789	0.591	0.652

Considering hypothesis testing, Figure III indicated that companies C1, C2 and C3 significantly applied TQM while C4 and C5 did not. Company C3, the youngest of the companies and the most modern achieved the highest score of 3.945, and company C4, the oldest and least modern, scored the minimum of 2.9545.

The relationships between the values of the performance indicator (Tons of milk processed per year) and the overall TQM scores of the companies are shown by the curve of Figure 2. The correlation coefficient was 0.94, indicating a direct and consistent linear relationship.

This survey-based investigation managed to contribute to the application of TQM in dairy industry in Jordan through the assessment of the extent of the factor as well as the overall TQM application in each of the companies subject matter of the investigation. It also managed to assess the impact of the application on the performance indicator. As this investigation sheds the light on the status quo, it points to the direction and the extent of some relevant actions required in the relevant areas.

Similar investigations are recommended for other industries in Jordan, where the scopes for improvements are widely needed.

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Appendix

Statement no: S _i	Quality statement
1- Instilling quality culture	
S ₁	Plans for TQM are prepared and discussed on a large scale.
S ₂	Employees are educated to observe public hygiene requirements.
S ₃	Employees are educated to observe infection prevention procedures
S ₄	Employees are regularly scanned for safety from infectious diseases
S ₅	TQM plans, procedures ,instructions, reports and documents are documented for easy access and reference
S ₆	Top management helps in instilling beliefs, integrity and devotion through out the organization.
S ₇	Sterility of equipment and material is asserted
S ₈	Performance measures are explained to all employees by top management.
S ₉	Top management explains the concept of quality chain (customer/supplier interface) to all employees.
S ₁₀	The bases of TQM and its benefits are properly explained for all employees in the organization
S ₁₁	Management clarifies the importance of the human role in achieving quality and customer satisfaction.
S ₁₂	Management explains to employees what they are trying to achieve and how they can meet the objectives.
S ₁₃	Management tries to change attitudes from simply working to finish a job to working to achieve an outcome.
2- Focus on employees	
S ₁₄	Employees are involved in decision making concerning their specialty.
S ₁₅	Management allows employees to participate and make suggestions in solving problems in their own departments.
S ₁₆	Management effectively encourages team work
S ₁₇	Human resource department has effective role in helping employees overcome problems at work.
S ₁₈	Adequate authority is given to employees according to their specialization
S ₁₉	Collective incentives recognizing individual contributions are granted
S ₂₀	Team incentives are granted according to the level of contribution in favor of the company
S ₂₁	Management encourages constructive competition between employees and departments.
S ₂₂	Employees are held accountable for not doing their job properly.
S ₂₃	Employees are rewarded morally for excelling in their jobs.
S ₂₄	The organization has a training department or training section.
S ₂₅	Annual Budgets for training are adequate.
S ₂₆	Trainers and advisors are available to help new recruits
S ₂₇	Sometimes trainees are employed to conduct further training downstream
S ₂₈	Training-equipment and facilities are available and efficient.
S ₂₉	Training plans, procedures, instructions, reports and documents are documented for easy access and reference
S ₃₀	Employees are trained for multiple jobs and tasks.
S ₃₁	Employees are evaluated to ensure proper training
S ₃₂	Employees are trained in quality improvement skills.
S ₃₃	Employees are supported when seeking higher qualifications
S ₃₄	Employees are trained in problem identification and problem solving techniques.

S35	Social security and health insurance schemes are available
S36	Top management encourages participation in social events.
S37	Management organizes social and recreational activities
S38	Management applies a profit sharing scheme
3- Focus on operations including continuous improvements	
S39	Management attracts the best of the resources
S40	The company strives to improve the quality of dairy products and enhance their storage life.
S41	The company has a research and development department or team.
S42	The company uses new technologies to reduce waste and improve quality and productivity.
S43	The company has strict cleaning procedures for workers and machines to ensure food safety.
S44	Management follows a policy of benchmarking targets.
S45	Various tests are conducted in different stages of the production process to ensure good quality
S46	Suppliers are evaluated concerning the quality, delivery time, reliability and cost of their supplies (raw milk).
S47	Material handling techniques are improved to minimize waste of time.
S48	Management treats each section as a client and producer simultaneously.
S49	Environmental conditions such as temperature and humidity are accurately controlled to avoid variations in product quality and to ensure product safety.
S50	Management keeps written records of testing, to detect variations in the production process that affect product quality and safety.
S51	Operational and supporting staff are kept updated for relevant developments
S52	New products are introduced to increase sales and market shares.
S53	Management uses all means available to minimize cost and improve quality.
S54	All means are employed to minimize errors and mistakes.
S55	Testing equipments are regularly serviced, maintained and calibrated.
S56	.Equipments and appliances are regularly serviced, maintained and/or calibrated
S57	Management regularly updates testing equipments.
4- Focus on customers	
S58	Market research is carried out on regular basis to assess customers' needs, expectations and satisfaction.
S59	Customers' complaints are taken seriously, and actually considered.
S60	Products are packaged in different forms and sizes
S61	Management uses the media to keep the public well informed about the improved/New products.
S62	Supply and delivery of products are reliable
S63	Direct and indirect contacts between customers and employees are systematically encouraged and organized
S64	Customer support systems such as website and/or a 24 hours phone service are used to ensure contacts with customers.
5- Assessment of quality performance	
S65	Plans for future improvements are prepared
S66	Developments in the dairy industry, else where, are monitored and introduced.
S67	Strategic plans are customer driven.
S68	Quality audits are conducted in the various sections of the company.
S69	Top management sets specific and clear vision, mission, and strategies and makes them understood by all employees of the company.
S70	Management keeps open channels where employees can send and receive information.
S71	Management keeps easy and effective communication with and among all the company employees, suppliers and customers.

S72	Quality is measured in each and every department all over the organization.
S73	Statistical quality control is used in the company.
S74	The company uses statistical ways to aid in measuring and controlling the quality of the products and processes.
S75	Quality assessment results are used to improve factory's performance.
S76	Quality measures set by the company contribute to improve overall performance.
S77	The company management system is regularly revised and updated.
S78	The company checks the validity and reliability of the quality assurance measures.
S79	An effective production planning system is used

Figure I: The questionnaire.

Quality statement no.: S _i	Companies (C _c)									
	C ₁		C ₂		C ₃		C ₄		C ₅	
	\bar{X}_{ji}	$\sigma_{x,ji}$	\bar{X}_{ji}	$\sigma_{x,ji}$	\bar{X}_{ji}	$\sigma_{x,ji}$	\bar{X}_{ji}	$\sigma_{x,ji}$	\bar{X}_{ji}	$\sigma_{x,ji}$
1- Instilling quality culture										
S ₁	3.07	1.230	4.03	0.809	4.00	0.263	3.23	1.382	3.43	1.006
S ₂	4.27	0.944	4.63	0.556	3.83	0.834	4.27	0.980	4.47	0.776
S ₃	3.63	1.299	3.90	1.125	4.20	0.484	3.33	1.373	3.87	1.383
S ₄	4.67	0.884	4.83	0.531	3.83	0.986	4.43	1.008	4.83	0.531
S ₅	4.70	0.596	4.67	0.802	3.77	0.679	3.37	1.497	4.07	1.048
S ₆	3.17	1.341	4.17	1.053	4.40	0.563	3.63	1.217	3.53	1.224
S ₇	4.73	0.521	4.87	0.434	4.73	0.450	4.47	0.860	4.53	0.730
S ₈	3.30	1.291	4.03	0.964	3.83	0.461	3.07	1.172	3.07	1.202
S ₉	2.60	1.192	3.67	1.155	4.17	0.461	2.53	1.502	3.00	1.259
S ₁₀	3.10	1.348	3.70	0.952	3.63	0.490	2.13	1.279	2.20	1.215
S ₁₁	3.33	1.269	3.73	1.112	4.23	0.430	2.83	1.392	3.07	1.507
S ₁₂	3.10	1.348	3.67	1.155	4.10	0.305	2.70	1.208	3.00	1.462
S ₁₃	2.90	1.373	3.27	1.337	4.23	0.430	2.53	1.252	2.83	1.392
TQM factor statistics in each company										
$F\bar{X}_j = F\bar{X}_1$	3.582		4.090		4.073		3.271		3.531	
$F\sigma_{x,j} = F\sigma_{x,1}$		1.126		0.922		0.526		1.240		1.133
2- Focus on employees										
S ₁₄	2.57	1.104	3.00	1.259	4.23	0.568	3.00	1.554	3.03	1.245
S ₁₅	2.53	0.973	3.03	1.299	3.33	0.479	3.03	1.629	3.13	1.408
S ₁₆	2.70	1.149	3.40	1.248	4.07	0.365	2.83	1.367	3.57	1.223
S ₁₇	2.47	1.224	2.77	1.547	3.90	0.712	1.97	1.299	3.20	1.540
S ₁₈	2.77	1.073	3.10	1.494	4.20	0.847	2.97	1.608	3.23	1.251
S ₁₉	2.37	1.326	2.57	1.524	3.83	0.986	2.90	1.447	3.00	1.145
S ₂₀	1.83	1.147	2.90	1.626	3.83	0.747	2.33	1.213	3.00	1.390
S ₂₁	1.80	1.064	2.47	1.332	4.13	0.730	2.53	1.224	2.63	1.351
S ₂₂	4.03	0.999	4.63	0.669	4.17	1.206	4.33	0.959	4.17	1.234
S ₂₃	2.27	0.785	2.50	1.383	3.67	0.884	2.4	1.221	2.87	1.332
S ₂₄	2.90	1.269	1.57	1.223	2.97	0.556	1.27	0.785	1.67	1.124
S ₂₅	2.40	1.133	1.63	1.245	3.17	0.791	1.33	0.758	1.63	1.066
S ₂₆	3.03	1.217	1.57	1.223	3.60	0.563	3.03	1.691	2.80	1.472
S ₂₇	2.93	1.143	1.73	1.337	3.77	1.223	1.7	0.837	2.37	1.402
S ₂₈	2.80	1.126	1.60	0.968	3.77	0.504	2.20	1.270	2.63	1.402

S ₂₉	3.00	1.232	1.83	1.020	4.40	0.563	1.8	1.126	2.43	1.431
S ₃₀	3.70	1.179	3.53	1.137	3.93	0.450	3.90	1.322	3.60	1.102
S ₃₁	2.77	1.165	2.13	1.548	4.50	0.682	2.13	1.252	2.57	1.305
S ₃₂	3.70	1.088	3.40	1.303	4.73	0.450	2.8	1.472	3.17	1.177
S ₃₃	2.20	1.031	1.60	1.276	3.57	0.504	2.03	1.189	2.00	1.203
S ₃₄	2.97	1.129	2.40	1.476	3.67	0.802	2.50	1.225	2.37	1.299
S ₃₅	4.87	0.434	5.00	0.000	4.27	0.828	4.37	1.217	4.73	0.521
S ₃₆	1.80	0.961	1.73	1.258	2.60	1.329	2.83	1.599	1.73	1.048
S ₃₇	1.63	0.999	1.83	1.289	3.03	0.964	2.97	1.542	2.00	1.114
S ₃₈	1.33	0.884	1.67	1.398	3.33	0.884	1.20	0.761	1.97	1.326
TQM factor statistics in each company										
$F\bar{X}_j = F\bar{X}_2$	2.695		2.544		3.787		2.574		2.780	
$F\sigma_{x,j} = F\sigma_{x,2}$		1.073		1.243		0.745		1.263		1.244
3- Focus on operations including continuous improvements										
S ₃₉	4.20	0.961	4.57	0.568	4.67	0.547	3.23	1.331	4.00	0.947
S ₄₀	4.43	1.073	4.67	0.711	4.33	0.479	3.70	1.119	4.00	0.947
S ₄₁	2.20	1.540	3.17	1.683	3.10	1.155	2.27	1.507	2.30	1.535
S ₄₂	3.93	0.980	4.43	0.858	4.40	0.498	3.27	1.311	3.57	1.135
S ₄₃	4.43	1.073	4.67	0.479	4.67	0.711	3.93	1.143	4.07	0.785
S ₄₄	3.83	1.085	4.33	0.606	3.73	0.583	3.10	1.348	3.63	1.159
S ₄₅	4.77	0.430	5.00	0.000	4.70	0.466	3.93	1.258	4.30	0.915
S ₄₆	4.60	0.675	4.87	0.346	4.30	0.794	4.20	1.157	4.47	0.860
S ₄₇	3.87	0.937	4.07	1.015	4.47	0.571	3.77	1.331	3.90	1.062
S ₄₈	2.97	1.245	2.83	1.555	3.43	0.858	2.30	1.393	2.97	1.189
S ₄₉	4.13	1.008	4.43	0.898	4.90	0.305	3.67	1.322	4.47	0.629
S ₅₀	4.47	0.776	4.90	0.305	4.53	0.571	4.63	1.033	4.60	0.932
S ₅₁	3.07	1.230	3.30	1.055	3.90	0.759	3.5	1.306	3.33	1.322
S ₅₂	4.13	1.106	4.23	0.774	3.50	0.938	3.23	1.305	3.77	1.194
S ₅₃	4.03	0.999	4.30	0.702	4.60	0.563	4.00	1.174	4.17	1.085
S ₅₄	3.63	1.273	4.37	0.850	3.93	0.785	3.67	1.398	3.87	0.900
S ₅₅	4.27	1.285	4.50	0.682	4.50	0.572	3.40	1.276	4.17	0.834
S ₅₆	4.43	0.898	4.53	0.507	4.20	0.484	3.5	1.358	4.00	1.017
S ₅₇	4.10	0.923	4.47	0.730	3.33	0.802	3.03	1.351	3.73	1.230
TQM factor statistics in each company										
$F\bar{X}_j = F\bar{X}_3$	3.973		4.297		4.168		3.491		3.859	
$F\sigma_{x,j} = F\sigma_{x,3}$		1.026		0.754		0.655		1.285		1.036
4- Focus on customers										
S ₅₈	3.77	1.165	3.50	1.225	3.77	0.858	2.60	1.102	2.43	1.073
S ₅₉	4.47	0.860	4.13	1.074	4.70	0.466	3.77	1.135	4.13	0.900
S ₆₀	3.33	1.269	2.87	1.358	2.67	1.028	3.53	1.279	2.73	1.363
S ₆₁	3.80	1.095	3.50	1.075	3.53	1.042	2.67	1.184	2.00	0.910
S ₆₂	2.77	1.305	3.30	1.149	2.97	1.245	2.50	1.280	2.10	1.029
S ₆₃	3.17	1.440	2.20	1.375	3.33	1.241	2.70	1.179	2.07	1.230
S ₆₄	3.63	1.377	3.63	0.999	3.13	1.479	2.60	1.522	2.43	1.305
TQM factor statistics in each company										
$F\bar{X}_j = F\bar{X}_4$	3.563		3.304		3.443		2.910		2.556	
$F\sigma_{x,j} = F\sigma_{x,4}$		1.216		1.179		1.051		1.240		1.116

5- Strategic competitive management										
S65	4.10	0.803	4.23	0.728	4.67	0.479	2.50	1.306	3.77	1.104
S66	3.43	1.194	3.03	1.189	4.37	0.850	2.47	1.279	2.83	1.206
S67	3.70	0.988	3.57	0.898	3.93	0.254	2.53	1.306	3.30	0.837
S68	3.80	1.064	4.27	1.015	4.27	0.785	3.43	1.431	3.77	0.935
S69	3.10	1.296	3.63	1.299	3.43	0.568	2.37	1.326	2.83	0.950
S70	3.00	1.145	3.10	1.296	3.90	0.885	3.57	1.591	3.63	1.217
S71	2.97	1.273	3.23	1.223	4.23	0.568	2.77	1.591	3.27	1.112
S72	3.77	0.858	4.10	0.759	4.30	0.535	3.27	1.363	3.33	1.241
S73	3.50	0.900	3.90	1.125	3.50	0.682	2.7	1.368	3.40	0.932
S74	3.77	0.898	3.80	1.243	3.53	0.681	2.33	1.422	3.30	1.291
S75	3.40	0.724	3.97	0.999	3.93	0.583	2.27	1.258	3.60	1.163
S76	3.73	0.785	3.87	1.042	4.30	0.466	2.83	1.341	3.70	1.291
S77	3.83	1.177	3.13	1.525	4.23	1.194	2.27	1.311	3.03	1.189
S78	3.67	0.844	3.50	1.225	4.00	0.695	2.20	1.215	3.40	1.329
S79	3.43	1.194	4.03	0.964	4.17	0.834	2.37	1.426	3.80	1.186
TQM factor statistics in each company										
$F\bar{X}_j = F\bar{X}_5$	3.547		3.691		4.051		2.659		3.397	
$F\sigma_{x,j} = F\sigma_{x,5}$		1.009		1.102		0.671		1.369		1.132
Overall TQM application statistics in each company										
$C\bar{X}_c$	3.387		3.505		3.945		2.955		3.260	
$C\sigma_{x,c}$		1.071		1.040		0.700		1.283		1.143

Figure II: Responses to the questionnaire and computation of the factor and overall application scores.

Company C_c	Factor F_j	$F\bar{X}_j$	$F\sigma_{x,j}$	$F\sigma_{x,j}^-$	FZ_j	Decision	Conclusion
C ₁	j=1	3.582	1.126	0.205579	2.831035	Reject H ₀	Factor applied
	j=2	2.695	1.073	0.195902	-1.5569	Accept H ₀	Factor not applied
	j=3	3.973	1.026	0.187321	5.194289	Reject H ₀	Factor applied
	j=4	3.563	1.216	0.22201	2.535919	Reject H ₀	Factor applied
	j=5	3.547	1.009	0.184217	2.969319	Reject H ₀	Factor applied
	TQM application in company C ₁						
		$C\bar{X}_1$	$C\sigma_{x,1}$	$C\sigma_{x,1}^-$	CZ_1	Decision	Conclusion
		3.387	1.071	0.196	1.974	Reject H ₀	Company applies TQM
C ₂	j=1	4.090	0.922	0.168	6.475	Reject H ₀	Factor applied
	j=2	2.544	1.243	0.227	-2.009	Accept H ₀	Factor not applied
	j=3	4.297	0.745	0.136	9.536	Reject H ₀	Factor applied
	j=4	3.304	1.179	0.215	1.412	Accept H ₀	Factor not applied
	j=5	3.691	1.102	0.201	3.434	Reject H ₀	Factor applied
	TQM application in company C ₂						
		$C\bar{X}_2$	$C\sigma_{x,2}$	$C\sigma_{x,2}^-$	CZ_2	Decision	Conclusion
		3.505	1.040	0.190	2.658	Reject H ₀	Company applies TQM
C ₃	j=1	4.073	0.526	0.096	11.173	Reject H ₀	Factor applied
	j=2	3.787	0.745	0.136	5.786	Reject H ₀	Factor applied
	j=3	4.168	0.655	0.120	9.767	Reject H ₀	Factor applied
	j=4	3.443	1.051	0.192	2.309	Reject H ₀	Factor applied
	j=5	4.051	0.671	0.123	8.579	Reject H ₀	Factor applied

TQM application in company C ₃							
		\overline{CX}_3	$C\sigma_{x,3}$	$C\sigma_{x,3}^-$	CZ_3	Decision	Conclusion
		3.945	0.700	0.128	7.383	Reject H ₀	Company applies TQM
C ₄	j=1	3.271	1.240	0.226	1.197	Reject H ₀	Factor applied
	j=2	2.574	1.263	0.231	-1.847	Accept H ₀	Factor not applied
	j=3	3.491	1.285	0.235	2.093	Reject H ₀	Factor applied
	j=4	2.910	1.240	0.226	-0.398	Accept H ₀	Factor not applied
	j=5	2.659	1.369	0.250	-1.364	Accept H ₀	Factor not applied
TQM application in company C ₄							
		\overline{CX}_4	$C\sigma_{x,4}$	$C\sigma_{x,4}^-$	CZ_4	Decision	Conclusion
		2.955	1.283	0.234	-0.192	Accept H ₀	Company does not apply TQM
C ₅	j=1	3.531	1.133	0.207	2.567	Reject H ₀	Factor applied
	j=2	2.780	1.244	0.227	-0.969	Accept H ₀	Factor not applied
	j=3	3.859	1.036	0.189	4.541	Reject H ₀	Factor applied
	j=4	2.556	1.116	0.204	-2.179	Accept H ₀	Factor not applied
	j=5	3.397	1.132	0.207	1.921	Reject H ₀	Factor applied
TQM application in company C ₅							
		\overline{CX}_5	$C\sigma_{x,5}$	$C\sigma_{x,5}^-$	CZ_5	Decision	Conclusion
		3.260	1.143	0.209	1.281	Accept H ₀	Company does not apply TQM

Figure III: Hypothesis testing .

