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Effect of ISO 9000 Certification on the Small & Medium Business in Busan

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부산 지역 중소기업의 ISO 9000 인증효과분석

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ISO 9000 is an efficient quality system for the customer's confidence and satisfaction. Of late years, the revised edition of ISO 9000 quality management system may give lots of positive business values to companies running ISO 9000 system. Despite its tremendous popularity, there is some criticism against the effect and performance of ISO 9000 certification.

This research explores the performances and effects of ISO 9000 quality system in small & medium size industrial companies. For this research, 202 companies certified by ISO 9000 standard and 67 companies not certified as contrast group were selected. The related data were collected by web-poll survey. The major analyses are focused on the effect and performance of the ISO 9000 certification, and we established various hypotheses to verify the effect and performance of quality system. Results of statistical analyses show that total performance of quality system is significantly different between certified companies and not certified.

Keywords: ISO 9000, quality system, performance of ISO 9000, effect of ISO 9000 certification

1. Introduction

1.1 Overview of the Study

Korean companies registered ISO 9000 certificate have had positive effects such as international market competition, consistent management of quality documents, and continuous improvement of quality management by periodical internal audits. Korean researchers using survey and statistical analysis methods have studied to investigate impact on the management of organizations and efficiency of quality management from ISO 9000 registration (Lim *et al*. 1996; Choe *et al*. 1998). Researches have been done to investigate quality management practices, necessity of ISO 9000 registration, and

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impact on organizations, and to compare advantages and disadvantages for ISO 9000 registration by using statistical methods based on survey results (Acharya and Ray, 2000; Chaudhuri and Acharya, 2000; Huarng *et al*., 1999; Terziovski *et al*., 1999 and 1997; Forker, 1997; Park *et al*. 2001; Terziovski *et al*., 2003).

In this paper we consider statistical analysis of the effect of ISO 9000 certification and performance of quality system based on the data obtained by web-poll survey. The major analyses are focused on the effect and performance of the ISO 9000 certification and quality system, and we establish various hypotheses related the performance and effects. As statistical analysis tools, ANOVA/ANCOVA/ MANOVA/ correlation analysis are considered. Moreover, for statistical rigorousness of analysis, we use various checking functions for the assumptions of analysis.

1.2 Data Acquisition via Web-poll Survey

In this study we collected the data by web-poll survey during a month, 7/2/2002∼8/1/2002. The companies in this survey were limited in area of Busan, Korea, and all companies were classified to certified group and not certified group of ISO 9000. The certified companies are subdivided into group supported by and not supported financially by Busan metropolitan city in certifying ISO 9000 quality system.

The number of companies responded to the survey are as follows.

- Total number: 269(companies)
- Certified companies with financial support: 184
- Certified companies without financial support: 18
- Not certified companies: 67

2. Testing Statistical Hypotheses

2.1 Hypothesis

Through this study we are to verify following three questions:

Question 1: Is there a significant difference in performance of ISO 9000 system according to the number of employee or company size? (Q1)

Usually, the number of employees or annual amount of sales accounts for company size. That is, the number of employees or amount of sales is an alternative characteristic of company size. In this study we classified all companies into three groups of size, that is, company group of size 1 has little employee (1∼20), and size 2 group, size 3 group has, respectively, 21∼50 employees and more than 50 employees.

In this question, there are two approaches to answer the question Q1. The first method is to use simple regression analysis or correlation analysis. The other approach uses ANOVA by conversion of the number of employee variable to grouping variable. In these two approaches we construct the statistical hypotheses as follows.

For the correlation analysis, we consider correlation coefficient ρ, and following hypothesis (HP1).

$$H_0 : \rho = 0 \ \ v.s. \ \ H_1 : \rho \neq 0$$

That is, the null hypothesis means that the number of employees and the performance of quality system are independent(not correlated). The hypothesis HP1 is also verified by using simple linear regression model with slope parameter β, and in this case the parameter related to the hypothesis is β. The null hypothesis of HP1 is equivalent to hypothesis β is 0. However we just use the correlation analysis for HP1 only.

Next we consider the ANOVA method. For this approach we use company size as categorical predictor instead of the number of employees to test whether the performance of quality system is significantly different according to the company size or not. We consider following hypothesis (HP2):

$$H_0 : \mu_1 = \mu_2 = \mu_3 \ \ v.s. \ \ H_1 : \text{Not } H_0$$

where $\mu_i \ (i = 1, 2, 3)$ is the average performance of the i^{th} group (company size).

Question 2: Is there a significant difference in performance of quality management system between certified companies and not certified companies? Moreover difference between companies supported financially by Busan city and companies not supported is statistically significant? (Q2)

We have already divided all companies into certified and not certified companies. For five areas, that is, MgR(Management Responsibility with 5 questions), RsM(Resource Management with 11

questions), PSR(Product/Service Realization with 32 questions), MAI(Measurement, Analysis and Improvement with 17 questions) and QMS(Quality Management System with 10 questions), the performances of quality system (with total 75 questions) for each area were evaluated respectively. We use these abbreviates as five areas of quality system through this paper.

In the question Q2, we construct following statistical hypothesis (HP3):

$$H_0 : \mu_{CS} = \mu_{CI} = \mu_{NC} \quad v.s. \quad H_1 : \text{Not } H_0$$

where μ_{CS} and μ_{CI} mean respectively average performance of quality system for certified companies with and without financial support from Busan city, and μ_{NC} stands for the average of not certified companies.

Moreover we consider the performance of quality system as 5 areas simultaneously whether the performances are significantly different or not according to groups. For the purpose of multiple analyses, five variables MgR, RsM, PSR, MAI and QMS are measured by average value of their response scores. The multiple test is performed by MANOVA(Multivariate ANOVA), and the hypotheses are similar to HP3 except that five variables are used as response variables instead of performance of total quality system with 75 questions. Let $\mu^A{}_B$ be the mean performance of area A for group B. With this notation, the hypothesis is defined as follows (HP4):

$$H_0 : \begin{pmatrix} \mu^{MgR}{}_{CS} \\ \mu^{RsM}{}_{CS} \\ \mu^{PSR}{}_{CS} \\ \mu^{MAI}{}_{CS} \\ \mu^{QMS}{}_{CS} \end{pmatrix} = \begin{pmatrix} \mu^{MgR}{}_{CI} \\ \mu^{RsM}{}_{CI} \\ \mu^{PSR}{}_{CI} \\ \mu^{MAI}{}_{CI} \\ \mu^{QMS}{}_{CI} \end{pmatrix} = \begin{pmatrix} \mu^{MgR}{}_{NC} \\ \mu^{RsM}{}_{NC} \\ \mu^{PSR}{}_{NC} \\ \mu^{MAI}{}_{NC} \\ \mu^{QMS}{}_{NC} \end{pmatrix}$$

$v.s. \quad H_1 : \text{Not } H_0$

Question 3: Is there a significant association (correlation) among the effects of ISO 9000 certification and performance of quality system? (Q3).

The evaluations of effects of ISO 9000 certification are performed by 2 parts, which are tangible effect (TE) and intangible effect (IE). The TE is measured by cost down, sales growth, export growth and cost of quality. The other effect of ISO 9000 certification, the intangible effect, is evaluated by degree of understanding and satisfaction for the ISO 9000 system. These measures of effect are observed only for the certified companies. Therefore, we just analyze the association among these effects instead of those differences between certified and non-certified companies. For reference, all questions related to effects are composed by five-point Likert scale.

For the question Q3, we construct following statistical hypothesis (HP5):

H_0 : Two measures of effect and performance are not associated. v.s. H_1 : Not H_0

2.2 Variables for Analysis

First consider variables for question Q1. To answer the question Q1, we test two hypotheses HP1 and HP2. In each hypothesis, independent (exploratory or predictor) and dependent (response) variables are defined as follows.

Variables for testing the hypothesis HP1.

1) Dependent variable: performance of quality system evaluated by average of responses of 75 questions.
2) Independent variable: the number of employees

Variables for testing the hypothesis HP2.

1) Dependent variable: performance of quality system evaluated by average of responses of 75 questions.
2) Independent variable: categorical variable grouped by the number of employees.

Next, variables for question Q2 are similarly defined as follows.

Variables for testing the hypothesis HP3.

1) Dependent variable: performance of quality system evaluated by average of responses of 75 questions.
2) Independent variable: categorical variable grouping whether certified or not, and certified with financial support from Busan city or without. There are three groups(C_identifier).

Variables for testing the hypothesis HP4.

1) Dependent variables: performances of quality system separated by 5 areas. Each variable is evaluated by average of responses of correspondent questions.
2) Independent variable: categorical variable grouping whether certified or not, and certified with financial support from Busan city or without. There are three groups

(C_identifier).

Finally, variables for question Q3 are defined by only response variable as follows.

Variables for testing the hypothesis HP5.

1) Response variables: effects of certification of ISO 9000 separated by 2 parts and the performance of quality system. Each variable is evaluated by average of responses of correspondent questions.

2.3 Results of Analysis

2.3.1 Models and checking assumptions of analysis

In general linear model, the data model of ANOVA is described as follows:

$$y_{ij} = \mu_i + \epsilon_{ij},\ i = 1, \cdots k; j = 1, \cdots n,$$

where y_{ij} is j^{th} observation of i^{th} group, and μ_i is mean of i^{th} group. The error term ϵ_{ij} is usually distributed as normal with mean 0 and variance σ^2. On the other hand, MANOVA is multivariate version of ANOVA. It has multiple response variables, and its model is similarly described to ANOVA.

While, ANCOVA means analysis of covariance, and it is usually used when there is covariate, which effects to the response. The covariate needs to be independent of the grouping variable. Generally in one-way ANCOVA, there are three variables: continuous response variable, categorical grouping variable and continuous covariate. ANCOVA model is described as follows:

$$y_{ij} = \mu_i + \beta x_{ij} + \epsilon_{ij},\ i = 1, \cdots, k; j = 1, \cdots, n,$$

where β is regression coefficient(slope parameter) and x_{ij} is covariate observation.

To use ANOVA or ANCOVA in general linear model, we have to check the assumptions of the analyses. The critical assumptions (A1, A2, A3) for ANOVA and ANCOVA are as follows. For reference, through this paper, all of analyses are performed by data analysis software STATISTICA (version 6.0).

Assumption A1. Normality of response variable (ANOVA, ANCOVA)

In Figure 1 and Figure 2, there is not big problem for the normality assumption, except for two outliers in group NC(not certified companies). However we did not delete these outliers in analysis, since these data have something that is not negligible, although the data were resulted in outliers statistically.

Assumption A2. Equal variances (ANOVA, ANCOVA)

Table 1. Results for tests of homogeneity of variances

	Tests of Homogeneity of Variances Effect: "C_Identifier"				
	Hartley F-max	Cochran C	Bartlett Chi-Sqr.	df	P
Performance	1.344911	0.371320	0.552308	2	0.758696

In Table 1, results of test for homogeneity of variances, we can accept the homogeneity of variances for the groups NC, CI (certified companies without financial support from Busan city) and CS (certified companies with financial support from Busan city) by Hartley, Cochran, Bartlett and Levene's test with high p-value in common. That is, the null hypothesis that variances are all equal is accepted.

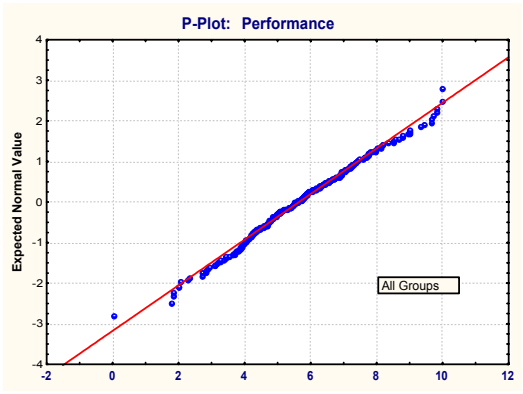


Figure 1. Normal probability plot.

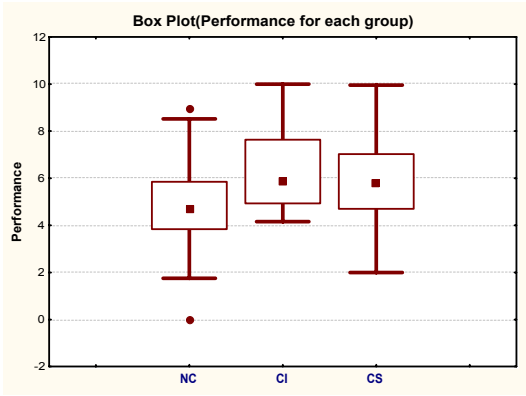


Figure 2. Box plot for each group.

Assumption A3. Equal slope parameter β for each group in linear regression with covariate and response (ANCOVA)

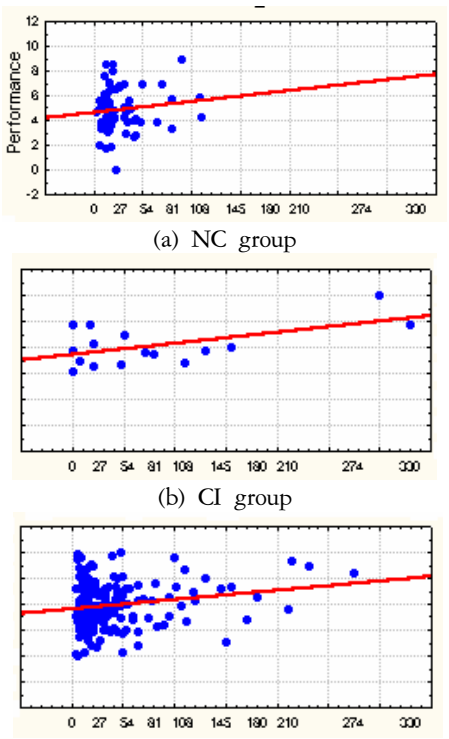
We perform linear regression analysis for check the ANCOVA assumption: the slope parameters in each group are all equal. The following 3 lines are fitted functions by LSE(least squares estimation), and the estimated slope parameters(0.0088, 0.0085 and 0.0072 for NC, CI and CS respectively in Figure 3) are very similar. So we accept the assumption of equal slope parameter β too.

$$y_{NC} = 4.613 + 0.0088 \times x$$
$$y_{CI} = 5.413 + 0.0085 \times x$$
$$y_{CS} = 5.599 + 0.0072 \times x$$

where y_A means performance of group A , and x is the number of employees. For reference the fitted line for all data without separating group(see Figure 5) is as follows:

$$y = 5.298 + 0.0088 \times x\,.$$

Strictly speaking, to check the assumption A3 we may have to test the parallelism of regression lines. But we pass over this assumption lightly just by considering estimators of slope parameters.



(a) NC group

(b) CI group

(c) CS group

Figure 3. Scatter plots and regression lines for performance versus number of employee.

2.3.2 Results of statistical test

First, we consider the hypothesis HP1. The hypothesis HP1 is tested by correlation analysis, and the results are as follows:

Test statistic: T=3.9397(n=267)
Sample correlation coefficient: r = 0.2352
p-value=0.0001.

Therefore, the performance of quality system and the number of employees are strongly correlated. That is, the performance is positively affected by number of employee.

Now in another aspect, we would like to answer the question Q1 through the hypothesis HP2. The hypothesis is tested by ANOVA. For ANOVA we classified the companies to three groups. The companies having below 20 employees belong to group 1. Companies having 20 to 50 employees compose group 2 and companies having above 50 employees compose group 3. The classification was decided by the distribution of the number of employee. The p-value of ANOVA is 0.04, and there is somewhat significant difference of performance according to company size.

Next, consider the question Q2. The hypothesis HP3 is verified by ANOVA. However we have perceived that the number of employees affects the performance of quality system. So we use ANCOVA instead of ANOVA to verify and eliminate the effect of covariate, the number of employee.

Table 2 is ANCOVA result table. In the table the performance of quality system is significantly different (p-value is0.000197) according to the companies certified or not of ISO 9000. The p-value is outcome after elimination of the effect of covariate (the number of employees).

Table 2. ANCOVA table for test of HP3

GENERAL Effect	Degr. Freedom	Performance SS	Performance MS	Performance F	Performance P
Intercept	1	2735.287	27.5.287	953.2963	0.00000
No. of Employee	1	12.390	12.390	4.3180	0.03867
C_Identifier (NC, CI)	2	50.574	25.287	8.8129	0.00019
Error	265	760.363	2.869		
Total	268	831.682			

While, to test whether significant difference between CI and CS is or not, we perform Tukey

HSD test and test using contrast. The result is that there is no significant difference between CI and CS. Figure 4 displays main effect plot. The plot supports the result of statistical test by ANCOVA.

Considering covariate, from Figure 5, we know that in small sized companies (having small number of employee), big variation of performance occurs. But there is a pattern that performance of quality system is growing with increasing number of employees.

Next, from the test results of HP4 we conclude that RsM, PSR, MAI and QMS are significantly different whether certified or not (largest p-value is smaller than 0.001). However MgR(p-value=0.117) is not significant. The result of MANOVA is described in Table 3.

In Figure 6 we can infer that the group CI (certified companies without financial support) shows high performance in each area and the group NC (not certified companies) has low performance overall. But there is no significant difference between group CI and CS in each area. That is, the difference in Figure 6 between CI and CS is not statistically significant.

Note that the performance of MgR(management responsibility) area shows a peculiar result. We consider that CEOs or managers of all company have some rules about management and responsibility to manage company. The result of no difference in management responsibility may be caused by this reason.

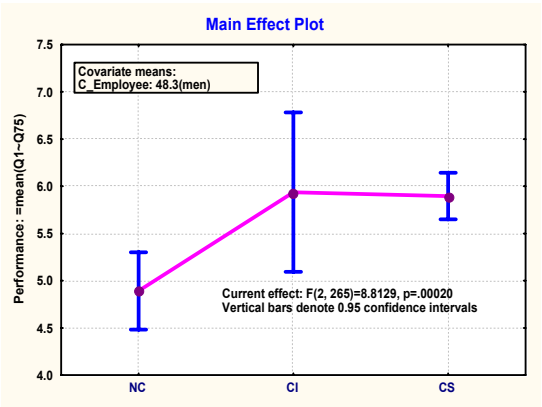


Figure 4. Main effect plot of performance.

Finally, we consider the hypothesis HP5. We tested HP5 by correlation analysis, and Table 4 shows the correlation matrix and p-values for testing HP5, including the performance of quality system. From Table 4 we conclude that 2 measures of effect

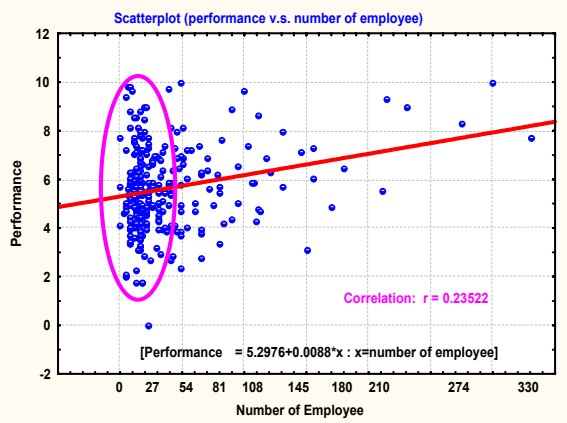


Figure 5. Scatter plot for all group.

Table 4. Correlation matrix and p-value for HP5

Variable	Correlations (Data_file) Marked correlations are significant at p<0.002 N=81 (Casewise deletion of missing data)		
	Performance	TE	IE
Performance	1.0000	.2745	.3121
	p=---	p=.013	p=.005
TE(Tansible Effect)	.2745	1.0000	.3106
	p=.013	p=---	p=.005
IE(Intangible Effect)	.3121	.3106	1.0000
	p=.005	p=.005	p=---

of ISO 9000 and the performance of quality system are highly correlated. That is, two variables of effects of ISO 9000 certification, tangible effect (TE) and intangible effect (IE) are all affected by the performance of quality system. And two measures of effect are also correlated each other.

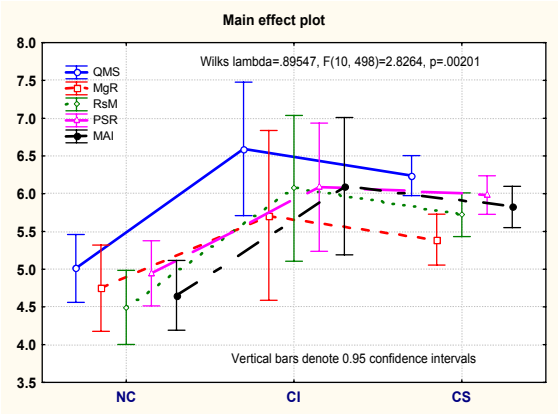


Figure 6. Performance of quality system for five areas according to group NC, CI and CS.

Table 3. MANOVA table for test of HP4

GENERAL Effect	Degr.of Freedom	QMS SS	QMS MS	QMS F	QMS p	MgR SS	MgR MS	MgR F	MgR p	RsM SS	RsM MS	RsM F	RsM p
Intercept	1	3779.38	3779.38	1171.94	0.0000	298.11	2983.11	571.546	0.0000	3148.95	3148.95	816.873	0.0000
C_Identifier	2	76.06	38.03	11.79	0.0000	22.61	11.30	2.166	0.1168	75.87	37.94	9.841	0.0001
Error	253	815.89	3.22			1320.50	5.22			975.28	3.85		
Total	255	891.95				1343.11				1051.16			
		PSR	PSR	PSR	PSR	MAI	MAI	MAI	MAI				
Intercept	1	3436.33	3436.33	1152.91	0.0000	3261.86	3261.86	953.923	0.0000				
C_Identifier	2	51.49	25.75	8.64	0.0002	68.00	34.00	9.943	0.0001				
Error	253	754.09	2.98			865.11	3.42						
Total	255	805.58				933.11							

3. Concluding Remarks

Through this study we verified that the company size (number of employee) affects positively to the performance of quality system. Also we know that the total performance of quality system has significant difference between certified or not certified company of ISO 9000 via ANCOVA. In ANCOVA, we eliminated the effect of the covariate (number of employee which is equivalent to company size conceptually) when we verify the hypothesis of significant difference between the certified and the not certified companies.

Moreover the performances of 5 areas of quality management system were also tested by MANOVA whether those performances are different according to the groups. The result became clear that the performances of the certified companies are significantly higher than those of not certified companies of ISO 9000. However, for the performance of management responsibility (MgR), there is no significant difference between certified and not certified companies.

We also verified that how the performance of quality system affects to the effects of ISO 9000 certification. As the results of test, the performance of quality system positively affects to the effect of ISO 9000 certification. This result means that the performance and the effect have positively significant correlation.

Finally, the companies having high performance of ISO 9000 quality system show not only positive tangible effect such as cost down, sales growth, export growth and cost but also positive intangible effect, degree of understanding and satisfaction for the ISO 9000 system. However there are some companies which did not show high effect of ISO especially in small companies. It stems from lack of organizational performance or just pursuit of advertisement and formality. And it also means that the small sized companies can achieve high improvement in business by overcoming these problems.

This research is limited to regional firms in Busan, Korea. About wider region and more large number of company, detailed survey and analyses are required. It remains to be further study.

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