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Critical Success Factors for Statistical Process Control in the Enterprises Operating in Hanoi, Vietnam

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Abstract:
Implementing Statistical Process Control (SPC) in enterprises in countries all over the world has been proven, brought quality improvement and cost reduction thereby increased business performance and competitiveness. The research conducted a deep interview expert working in universities and enterprises and a quantitative survey on enterprises implementing SPC in order to identify Critical Success Factor for SPC. 7 CSFs were found. Their impacts on hard and soft quality of products (consequences of SPC) were assessed. Policy implications were proposed for the success of SPC in Vietnamese enterprises.

Keywords: *Statistical process control, critical success factor, hard quality, soft quality*

1. Introduction

In the context of global competition, nation's competitiveness depends on their productivity and product quality. Quality innovation is implementing Statistical Process Control (SPC). Japan is one of countries first implemented SPC. Researches all over the world show that SPC has mainly been implemented in productive enterprises. Benefits of SPC in enterprises are increased quality and reduced costs thereby improved business performance and competitiveness. The Vietnamese government and enterprises are concerned about SPC implementation to improve their product quality. This paper aims at identifying Critical Success Factors (CSFs) and proposing suggestions for SPC deployment in Vietnamese enterprises.

2. Method

This research performed an overview of studies on Statistical Process Control (SPC) implementation.
In order to point out the list of CSFs of SPC in mechanical and manufacturing enterprises operating in Hanoi, a quantitative research was conducted. The deep interview was made to design questionnaire which followed by the survey on enterprises for identifying CSFs of SPC implementation and SPC impacts on (hard and soft) quality.Data collected was processed by SPSS 22 for windows.

3. Results of the Research

3.1. Theoretical Background

SPC is the use of a set of statistical techniques/tools to control the production process, analyze and track the causes of variations in quality characteristics or parameters by which to control and improve it. The concept of SPC was first time introduced by Walter A. Shewhart in 1920. So far, various concepts of SPC have been introduced depending on views, times, countries, and industries.

SPC is a set of statistical techniques used to control the production process (Ben & Antony, 2000; Caulcutt, 1996; Young & Winistorfer, 1999) eliminating errors and deffects (Sower, 1990; Oakland JS, 2003), and used to classify, minimize process variations and manage it systematically (Ben & Antony, 2000; Rosenkrantz, 2002; Juran, 1988).
In order to better understand SPC we need to clarify the terms of process, control, variations and statistics.

Process is a set of activities by which machines and equipments are combined to transform inputs (such as materials, methods, information) to into desired output (product, information, or service) (Oakland, 2003).
*Process variations*are fluctuations of activities and factors in the production process that make results (products, services) of the production process unequal and unstable. Shewhart argues that there are two causes of fluctuations in the production process: (i) Common causes; (ii) Special causes. Common causes, reflecting the nature of the process, include old and worn-out machinery and equipment in the course of operation, environments change over time and differences in the professional capability and the operation of employees in previous versus after production processes. Managers can minimize common causes occurring in the process on a regular basis, but cannot eliminate them completely. Those causes can be detected through control charts and the process is considered statistically controlled. Special causes come from abnormal impacts

such as improper use of rawmaterials and improperly installed or damaged machinery and equipments; Instructions or designs are incomplete or inaccurate; ungrasped customers' needs. Special causes of variations appear out of control and infrequently leading tobig variations because they shift process parameters. The goal of SPC is to discover causesof variations by which to adjust process and eliminating its variations.

SPC is an important measure focusing on efforts to reduce variations resulted from internal and external causes to improve product quality and reduce production costs.

The process needs to be controlled in order tomaintain its stability. Therefore, control is the process of evaluating results, comparing performance with a goal or standard, and taking corrective actions if needed. Critical Success Factor (CSF)is the necessary condition in an organization or a particular project to achieve its mission and goals.

Daniel(1961)emphasized 3 to 6 CSFs which mainly focused in management and can be applied in all fields or any organization. Anthony e.al. (1972)emphasized the need for adjusting CSF for both strategic objectives and management objectives of organizations. According to them planning and control systems are responsible for reporting found $CSF_S$to managers.

Pinto and Slevin (1987) considered CSFs to be factors, if resolved, that would significantly improve the chances of project implementation. However, according to Esteves (2004), both did not mention the comprehensive concept proposed by Rockart (1979), in order to find an ideal combination of environment conditions and business characteristics of a specific company.

3.2. Statistical tools in SPC

Many quality consultants and SPC users have suggested that there are 07 basic tools (traditional) collected and introduced by Ishikawa in 1985, Mizuno (1988) introduced 07 new ones, a few argue that there are 12 to 15 different tools (Caulcutt, 1996).

The statistical tools used by many enterprises are the following (7QC Tools) including: (i) Check Sheet; (ii) Cause and Effect Diagram; (iii) Control Chart; (iv) Scatter Diagram; (v) Process Flow Chart; (vi) Pareto Chart; (vii) Histogram (Ishikawa, 1985; Oakland J.S., Statistical Process Control, 2003; Diện, 1994).

3.3. Research Directions for SPC Success

Researches on this topic have been performed in three directions: Building a process of implementing SPC; CSFs for SPC inenterprises; Results of successful SPC implementation in enterprises.

Implementing SPC is a process which main activities relate to Management, Statistical, Teamwork, Engineering (MEST): Culture change and knowledge sharing; Statistical knowledge; Management skills; and engineering (Ben & Antony, 2000; Antony & Taner, 2003).

CSFs of SPC

Researches on finding CSFs have been done in two directions; Firstly,(qualitative) research based on personal experience and the success of typical businesses to show the success factors of SPC implementation; Secondly, (quantitative) experimental research through practical research projects implemented in businesses.

<u>3.3.1. Qualitative Researches</u>

Qualitative researches suggested a step-by-step procedure for SPC implementation in production and services enterprises (Does e.al., 1997; Robinson e.al., 2000; Antony & Taner, 2003) and pointed out CSFs for SPC deployment (Xie and Goh, 1999; Antony, 2000; Robinson e.al., 2000)

<u>3.3.2. Quantitative Researches</u>

A lot of quantitative researches had been performed on enterprises in various indistries in different countries (Gordon e.al., 1994, and Harris & Yit, 1994, in the US; Rungtusanatham e.al. (1997, in Sweden; Rungasamy e.al., 2002, and Grigg, 2004, in the UK; Phyanthamilkumaran and Fernando, 2008, in Malaysia; Evans & Mahanti, 2012, in India; Rantamaki et.al., 2013, in Finand; Soriano e.al., 2017, in Brazil).

Results of researches mentioned above revealed that most of the proceduresh ad been built step by step - from perception, deployment, training, formation of SPC teams, measurement to data collection systems and control chartbuilding. However, the specific explanations for theimplementation of SPCin enterprises have not been paid enough attention.

Most of researches pointed out CSFs for SPC implementation in enterprises are: (i) Top management Commitment; (ii) Team work; (iii) SPC training and education; (iv) Control charts; (v) Identification of priority process; (vi) Identification of important characteristics of quality; (vii) Analysis of the measurement system; (viii) Knowledge exchange and sharing; (ix) Experimental research; (x) Use SPC software; (xi) SPC instructor; (xii) Data storage; (xiii) Quality Department; (xiv) SPC deployment.

Successful application of SPC in enterprises is reflected in the following aspects: (i) Product quality and economic factors; (ii) Employees' attitude and behavior; (iii) Organization structure;(iv)Capability of the process; (v) Other factors.

According to Wilkinson (1992) results of successful SPC implementation can be clarified into two categories. Firstly, hard quality including a series of factors related to production engineering management, control process of quality functions deployment, reflecting direction of production management in enterprises. Secondly, soft quality pays more attention on establishing producer's perception, raising customer satisfaction and improving management competence and experience.

3.4. Research model

Inheriting results of previous researches done on manufacturing and mechanic enterprises and our results obtained by the experts interview we select the following CSFs for SPC implementation: (i) Top management commitment; (ii) Team work; (iii) SPC training and education; (iv) Process focus; (v) Role of quality department; (vi) Deployment SPC and (vii) Documentation and update of knowledge. The seventh factor will lead to expenses incurred by enterprises and it is difficult to fulfill. However, data must be considered as one of inputs of the SPC operation. Data needs to be maintained in the repository and team members should have access to them to apply SPC (Figure 1).

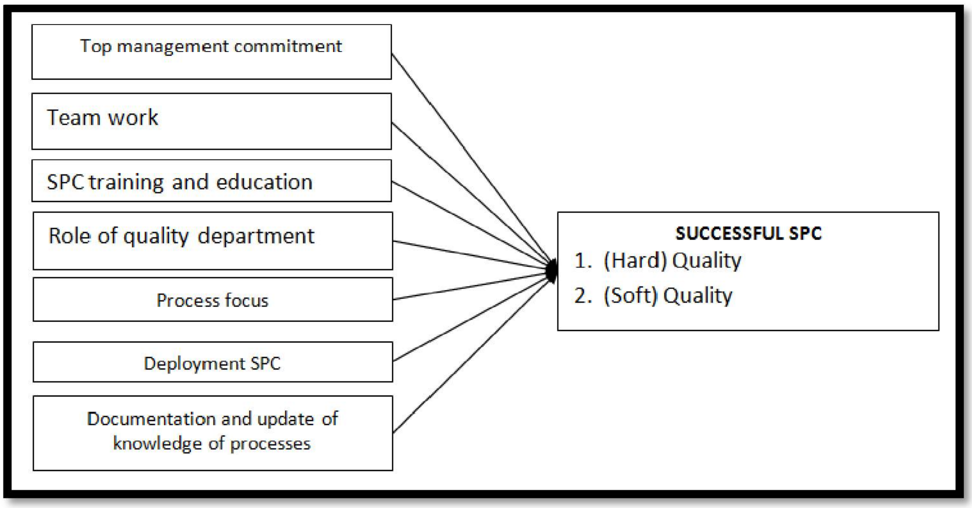

Figure 1: Research Model

*Results and interpretations.*09 experts (of which 05 are top managers in enterprises - managers from operation, technical, and quality department, and executive managers; 04 lecturers working in this field (at Hanoi Industrial University, Hanoi Technology University, the National Economics University) were interviewed in order to design questionnaire for enterprise survey. Questionnaire includes variables using Likert scale of 5 (1= Completely disagree, 5 = Completely agree). 600 copies of questionnaire were sent to mechanical and manufacturing enterprises in industrial zones and clusters in Hanoi. 384 responses (64 percent) were received, 272 (70.9 percent) left after screening. Observations are sufficient for analyzing and testing: n = 195, (Hair e.al., 1998) - minimum amount for EFA and exceeds minimum for multiple regression.

3.5. Hypothesis

CSFs of SPC (hard quality)

- H1.1 Top management commitment positively influences hard quality
- H1.2 Team work positively influences hard quality
- H1.3SPC training and educationpositively influences hard quality
- H1.4Role of quality departmentpositively influences hard quality
- H1.5Process focuspositively influences hard quality
- H1.6Deployment SPC positively influences hard quality
- H1.7Documentation and update ofknowledge of processespositively influences hard quality

CSFs of SPC (soft quality)

- H2.1 Top management commitment positively influences soft quality
- H2.2 Team work positively influences soft quality
- H2.3 SPC training and educationpositively influences soft quality
- H2.4 Role of quality department positively influences soft quality
- H2.5 Process focus positively influences soft quality
- H2.6 Deployment SPC positively influencessoft quality
- H2.7Documentation and update ofknowledge of processespositively influences soft quality

3.6. Independent Variable Scale and Coding

Items of independent variables and their code are shown in Table 1.

Top management commitment- TMC	
Top managers commit making efforts to improve quality	TMC1
Top managers commit providing sufficient human resources for SPCimplementation	TMC2
Top managers commit providing sufficient financial resources for SPCimplementation SPC	TMC3
Teamwork- TW	
Groups often discuss about quality improvements	TW1
Members of the quality group come from different departments	TW2
Someone supervises problem solving problems of quality group	TW3
Quality improvement groups are clearly directed with efficiency and quality goals	TW4
SPC training and education- TR	
Training on SPC for employees before implementation	TR1
Quality-related training for managers and supervisors	TR2
Knowledge of SPC must be practiced after learning	TR3
Data from actual production is applied immediately in the SPC	TR4
Regularly organize training classes, apply SPC	TR5
Process Focus - PF	
Select a process to implement SPC with priority	PF1
The manager supports selecting prioritized processes	PF2
Flow chart, cause and results help determining the prioritized process	PF3
Roles of quality department - QD	
There are experts in the quality department to help implementing SPC	QD1
Quality department provides on-site technical support	QD2
A staff in the quality department supervising SPC implementation	QD3
The quality department organizes discussion on actual data obtained	QD4
The quality department detects problems that need to be solved on the database	QD5
Quality department encourages those who are afraid of changes in SPC implementing	QD6
Quality department organizes discussions between SPC implementers	QD7
Deployment SPC- DP	
SPC is implemented in different parts in the enterprise	DP1
SPC is implemented according to a complete plan	DP2
SPC is being implemented by quality improvement teams	DP3
The majority of SPC implementers have related work	DP4
Documentation and update of knowledge of processes - DUP	
Collecting data on the process has to be performed on a regular basic	DUP1
Data collected must be complete, accurate and reliable	DUP2
Data should be stored for future use	DUP3
Data must be in good storage, and corrected if needed	DUP4

Table 1: Independent Variable Scale and Coding

3.7. Dependent Variable Scale and Coding

Items of dependent variables and their code are shown in Table 2.

Quality Performance hard aspects- QPHA	
Decreased excess raw materials and remade products	QPHA1
Decreased fluctuations in production process	QPHA2
Decreased Production time	QPHA3
Improved product distribution	
Quality Performance soft aspects- QPSA	
Increased customer satisfaction	QPSA1
The company has more experiences of improvement and quality assurance	QPSA2
Improved company image	QPSA3
More strict production process management	QPSA4

Table 2: Dependent Variable Scale and Coding

3.7.1. Desreptive Statistics of the Sample

By type of ownership, 230 respondents are in the private sector, accounted for 84.6 percent, 33 are join stock, accounted for 33.1 percent, 9 are state-owned, accounted for 3.3 percent.

By scale, most of respondents are SMEs - 178 small enterprises or 65.4 percent, 90 medium one or 33 percent, while only 4 large enterprises or 1.5 percent.

By age, 11 enterprises (4 percent) are less than 5 year-, 44 enterprises (16.2 percent) are 6 – 10 year-, 102 enterprises (37.5 percent) are 11 – 15 year- and 115 enterprises (42.3 percent) are more than 15 year- old (Table 3)

		Frequency	**Percentage**	**Cumulative Percentage**
Type of ownership	State	9	3.3	3.3
	Join stock	33	12.1	15.4
	Private	230	84.6	100
	Total	272	100	
Scale	Large	4	1.5	1.5
	Medium	90	33.1	34.6
	Small	178	65.4	100
	Total	272	100	
Age	<=5 years	11	4.0	4.0
	6-10 years	44	16.2	20.2
	11-15 years	102	37.5	57.7
	> 15 năm	115	42.3	100
	Total	272	100	

Table 3: Desreptive Statistics of the Sample

3.7.2. Descriptive Statistics of the Level of Using Quality Instruments

Most of surveyed enterprises use 07 basic quality instruments, the average level is 2,813 – 3,335, in some processes. New quality instruments are used less, only in cases of problematic production processes, the evarage level is 2,077 – 2,235 (Table 4).

	N	Minimum	Maximum	Mean
Flow charts	272	1.0	5.0	3.060
Check sheet	272	1.0	5.0	3.335
Cause effect diagram	272	1.0	5.0	3.092
Pareto charts	272	1.0	5.0	2.982
Histogram	272	1.0	5.0	2.941
Scatter diagram	272	1.0	5.0	2.813
Control Charts	272	1.0	5.0	3.070
Affinity Diagram	272	1.0	5.0	2.140
Matrix Diagram	272	1.0	5.0	2.077
Relation Diagram	272	1.0	5.0	2.235
Matrix Data Analysis	272	1.0	5.0	2.158
PDPC - Process Decision Program Chart	272	1.0	5.0	2.235
Arrow Diagram	272	1.0	5.0	2.228
Check sheet	272	1.0	5.0	2.206
Listwise	272			

Table 4: Descriptive Statistics of the Level of Using Quality Instruments

3.8. Evaluation of Scales

3.8.1. Descriptive Statistics of Independent Variables, Testing Distribution

Independent variables' scale is relatively divergent. Minimum and maximum is in the interval of 1 to 5.
The average value of observations belongs to the interval of (3.53 – 3.81) showing similar assessment of importance of independent variable. Test of Skewness and Kurtosis showed their absolute value is in allowed limits (for Skewness, it is less than 3 and for Kurtosis it is less than 5). This means scale of independent variables is normal distribution.

		N	Minimum	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
1	TCM1	272	2	5	3.74	.750	-.112	.148	-.339	.294
2	TCM2	272	1	5	3.72	.737	-.277	.148	.223	.294
3	TCM3	272	1	5	3.80	.752	-.337	.148	.229	.294
4	TW1	272	1	5	3.72	.705	-.118	.148	.183	.294
5	TW2	272	1	5	3.77	.704	-.151	.148	.214	.294
6	TW3	272	1	5	3.81	.772	-.634	.148	.600	.294
7	TW4	272	1	5	3.80	.782	-.094	.148	-.314	.294
8	TR1	272	1	5	3.64	.683	-.180	.148	.333	.294
9	TR2	272	1	5	3.72	.769	-.022	.148	-.238	.294
10	TR3	272	1	5	3.63	.743	-.150	.148	.061	.294
11	TR4	272	1	5	3.67	.735	-.122	.148	.070	.294
12	TR5	272	1	5	3.68	.732	-.102	.148	.059	.294
13	QD1	272	1	5	3.55	.818	-.501	.148	.416	.294
14	QD2	272	1	5	3.61	.829	-.504	.148	.462	.294
15	QD3	272	1	5	3.54	.823	-.422	.148	.160	.294
16	QD4	272	1	5	3.57	.856	-.444	.148	.359	.294
17	QD5	272	1	5	3.65	.796	-.184	.148	-.145	.294
18	QD6	272	1	5	3.61	.788	-.154	.148	-.134	.294
19	PF1	272	1	5	3.66	.781	-.302	.148	.261	.294
20	PF2	272	1	5	3.74	.764	-.379	.148	.222	.294
21	PF3	272	1	5	3.68	.782	-.344	.148	.060	.294
22	DP1	272	1	5	3.67	.665	-.048	.148	.281	.294
23	DP2	272	1	5	3.68	.705	-.037	.148	.106	.294
24	DP3	272	1	5	3.75	.716	-.319	.148	.398	.294
25	DP4	272	1	5	3.61	.720	-.286	.148	.239	.294
26	DUP1	272	1	5	3.53	.748	-.220	.148	.594	.294
27	DUP2	272	1	5	3.58	.725	-.330	.148	.197	.294
28	DUP3	272	1	5	3.67	.709	-.239	.148	.295	.294
29	DUP4	272	1	5	3.76	.797	-.330	.148	-.011	.294
30	QPHA1	272	1	5	3.72	.700	-.269	.148	.400	.294
31	QPHA2	272	1	5	3.78	.704	-.372	.148	.570	.294
32	QPHA3	272	1	5	3.76	.684	-.219	.148	.427	.294
33	QPHA4	272	1	5	3.78	.696	-.326	.148	.536	.294
34	QPSA1	272	1	5	3.81	.728	-.333	.148	.367	.294
35	QPSA2	272	1	5	3.77	.655	-.353	.148	.810	.294
36	QPSA3	272	1	5	3.78	.700	-.252	.148	.395	.294
37	QPSA4	272	1	5	3.77	.744	-.364	.148	.319	.294
	Valid N (listwise)	272								

Table 5: Descriptive Statistics of Scale Of Variables

All Cronbach Alfa coefficients are larger than .7 (Table 5) meaning that items in a scale of all 07 independent and 02 dependent variables are closely correlated.

	Cronbach's Alfacoefficient	Number of Items	Significant of Cronbach Alfa Coefficient
Top management commitment	.845	4	Significant
Team work	.751	4	Significant
SPC training and education	.849	4	Significant
Role of quality department	.834	6	Significant
Deployment SPC	.783	3	Significant
Documentation and update of knowledge of processes	.867	6	Significant
Process focus	.736	4	Significant
Hard quality	.857	6	Significant
Soft quality	.867	6	Significant

Table 6. Value of Cronbach Alfa coefficient

3.8.2. Testing Correlations

All correlation coefficients between total score of each respondent and score of each item are significant at 99 percent(Table 7)therefore regression of dependent (hard quality or soft quality) on independent (Top management commitment, Team work, SPC training and education, Role of quality department, Deployment SPC, Documentation and update of knowledge of processes, and Process focus)can be run by each of the two models.

		F_Commitment	F_Teams	F_Training	F_Qualitydepart	F_Process	F_Deployment	F_Documentation	HardQuality	SoftQuality
F_Commitment	Pearson Correlation	1								
	Sig. (2-tailed)									
	N	272								
F_Teams	Pearson Correlation	.226**	1							
	Sig. (2-tailed)	.000								
	N	272	272							
F_Training	Pearson Correlation	.357**	.215**	1						
	Sig. (2-tailed)	.000	.000							
	N	272	272	272						
F_Qualitydepart	Pearson Correlation	.291**	.178**	.184**	1					
	Sig. (2-tailed)	.000	.003	.002						
	N	272	272	272	272					
F_Process	Pearson Correlation	.447**	.232**	.303**	.365**	1				
	Sig. (2-tailed)	.000	.000	.000	.000					
	N	272	272	272	272	272				
F_Deployment	Pearson Correlation	.403**	.327**	.310**	.268**	.369**	1			
	Sig. (2-tailed)	.000	.000	.000	.000	.000				
	N	272	272	272	272	272	272			
F_Documentation	Pearson Correlation	.349**	.210**	.230**	.161**	.295**	.221**	1		
	Sig. (2-tailed)	.000	.000	.000	.008	.000	.000			
	N	272	272	272	272	272	272	272		
HardQuality	Pearson Correlation	.421**	.303**	.340**	.296**	.260**	.379**	.353**	1	
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000		
	N	272	272	272	272	272	272	272	272	
SoftQuality	Pearson Correlation	.434**	.341**	.351**	.308**	.383**	.414**	.344**	.720**	1
	Sig. (2-tailed)	.000	.000	.000	.000	.000	.000	.000	.000	
	N	272	272	272	272	272	272	272	272	272

Table 7: Correlations

3.8.3. Testing Hypothesis

*Results of regression of first mode. l*Run *regression* Hard Quality on CSFs of SPC.
Adjusted R Square = 0,304.F = 17.887, sig = .000b(Table 8)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.567a	.322	.304	.48610

Table 8: Model Summary
a. Predictors: (Constant), F_Documentation, F_Qualitydepart, F_Teams, F_Training, F_Deployment, F_Process, F_Commitment

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	29.586	7	4.227	17.887	.000b
	Residual	62.381	264	0.236		
	Total	91.967	271			

Table 9: ANOVAa
a. Dependent Variable: Hard Quality
b. Predictors: (Constant), F_Documentation, F_Quality depart, F_Teams, F_Training, F_Deployment, F_Process, F_Commitment

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.434	.314		1.382	.168		
	F_Commitment	.185	.057	.202	3.254	.001	.665	1.505
	F_Teams	.131	.057	.126	2.307	.022	.855	1.169
	F_Training	.138	.054	.144	2.556	.011	.813	1.230
	F_Qualitydepart	.136	.054	.141	2.537	.012	.832	1.202
	F_Process	-.064	.058	-.068	-1.106	.270	.688	1.454
	F_Deployment	.177	.066	.158	2.658	.008	.727	1.376
	F_Documentation	.201	.060	.185	3.332	.001	.835	1.197

Table 10: Coefficientsa
a. Dependent Variable: HardQuality

All Beta coefficients have expected sign. F = 17,887, sig = 0,000 or there is a relation between CSFs of SPC and Hard Quality at 95 percent confidence. All VIF are less than 2 or there is no multicollinearity. The relation between dependent and independent variables is following

QPHA = 0,434+ 0,185TMC+ 0,131TW+ 0,138TR+ 0,136QD+ 0,177DP+ 0,210DUP+ ε

Results of testing by the first model show that $H_{1.1}$, $H_{1.3}$, $H_{1.4}$, $H_{1.6}$, $H_{1.7}$ are accepted at 95 percent confidence.

Regression Analysis by the second model. Run regression Soft Quality on CSFs of SPC.

All Beta coefficients have expected sign. All VIF are less than 2 or there is no multicollinearity. Adjusted R Square = 0,337. F = 20.703, sig .000b (figure12) or there is a relation between Soft Quality and factors influencing successful SPC at 95 percent of confidence

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.595a	.354	.337	.48692

Table 11: Model Summary
a. Predictors: (Constant), F_Documentation, F_Quality depart, F_Teams, F_Training, F_Deployment, F_Process, F_Commitment

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	34.360	7	4.909	20.703	.000b
	Residual	62.592	264	.237		
	Total	96.952	271			

Table 12: ANOVAa
a. Dependent Variable: Soft Quality
b. Predictors: (Constant), F_Documentation, F_Qualitydepart, F_Teams, F_Training, F_Deployment, F_Process, F_Commitment

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.134	.315		.426	.671		
	F_Commitment	.155	.057	.165	2.727	.007	.665	1.505
	F_Teams	.162	.057	.152	2.834	.005	.855	1.169
	F_Training	.126	.054	.128	2.335	.020	.813	1.230
	F_Qualitydepart	.107	.054	.109	2.005	.046	.832	1.202
	F_Process	.091	.058	.093	1.555	.121	.688	1.454
	F_Deployment	.187	.067	.163	2.811	.005	.727	1.376
	F_Documentation	.160	.060	.144	2.654	.008	.835	1.197

Table 13: Coefficients[a]
a. Dependent Variable: SoftQuality

Results of testing by the second model show that $H_{2.1}$, $H_{2.2}$, $H_{2.3}$, $H_{2.4}$, $H_{2.6}$,$H_{2.7}$, are accepted at 95 percent confidence.
The relation between dependent and independent variables is following
QPSA = 0,134+ 0,155TMC+ 0,162TW+ 0,126TR+ 0,107QD+ 0,187DP+ 0,160DUP+ ε

3.8.4. Comparasion Impact of Group in Each Control Variable

3.8.4.1. By First Model

The results of testing Homogeneity of Variances by the first model are shownin the Table 16. Basing on that we can conclude that variances are different in groups given controlled variables *scale* and *type of ownership*, therefore they cannot be used for analysis of variance, and variances are not different in groups given controlled variable *enterprise's age* therefore they can be used for analysis of variance (Table 16).

	Levene Statistic	df1	df2	Sig.	Decision
Scale	6.152	2	269	.002	Accepted
Enterprise's age	.696	3	268	.555	Rejected
Type of ownership	3.209	2	269	.042	Accepted

Table 14: Test of Homogeneity of Variances

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.224	3	.408	1.205	.308
Within Groups	90.743	268	.339		
Total	91.967	271			

Table 15: ANOVA

The result of ANOVA shows that there is no relation between *enterprise's age* and Hard Quality.

3.8.4.2. By Second Model

The results of testing Homogeneity of Variances by the first model are shownin the Table 18. Basing on that we can conclude that variances are different in groups given controlled variables *enterprise's age* and *type of ownership*, therefore they can be used for analysis of variance, and variances are different in groups given controlled variable *enterprise's scale* therefore they can be used for analysis of variance (Table 16).

	Levene Statistic	df1	df2	Sig.	Decision
Enterprise's scale	8.948	2	269	.000	Accepted
Enterprise's age	.105	3	268	.957	Rejected
Type of ownership	2.867	2	269	.059	Rejected

Table 16: Test of Homogeneity of Variances

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.775	3	.258	.720	.541
Within Groups	96.177	268	.359		
Total	96.952	271			

Table 17: ANOVA Enterprise's Age and Soft Quality

F test (sig. = .541) shows that there is no relation between *enterprise's age* and Soft Quality

	Sum of Squares	Df	Mean Square	F	Sig.
Between Groups	18.602	2	9.301	31.933	.000
Within Groups	78.350	269	.291		
Total	96.952	271			

Table 18: ANOVA Type of Ownership and Soft Quality

F test (sig. = .000) shows that there is a relation between *type of ownership* and Soft Quality.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
1	9	3.0833	.88388	.29463	2.4039	3.7627	1.75	4.75
2	33	3.1970	.65776	.11450	2.9637	3.4302	2.00	4.75
3	230	3.8946	.50437	.03326	3.8290	3.9601	2.25	5.00
Total	272	3.7831	.59813	.03627	3.7117	3.8545	1.75	5.00

Tale 19: Descriptive Statistics of Average of Soft Quality by Ownership Groups

Description of average value of Soft Quality in Table 19shows differences between groups by type of ownership. The average value of group1 is 3.0833; group 2 is 3.1970, group 3 is 3.8946.

4. Discussion and Conclusion

SPC is widely adopted by quality practitioners to assist, monitor, manage, analyze and improve performance of the process by eliminating causes of its variations. Use of data obtained from SPC isthe way of scientific management in which decisions are made based on actual data, not based on conjecture or experience. SPCis proven the effective method of management by enterprises all over the world.

All seven CSFs ((i) Top management commitment; (ii) Team work; (iii) SPC training and education; (iv) Process focus; (v) Role of quality department; (vi) Deployment SPC and (vii) Documentation and update of knowledge) are tested and proved important in SPC implementation in Vietnamese enterprises in mechanic and manufacturing industries.

For successful implementation of SPC in Vietnamese enterprises it must be taken step by step starting from smaller, easier and advantageous fields to ensure smooth and effective implementation before deployment it on a large scale. *Top management commitment the first CSF.* Top managers determine quality goals and directions for achieving them by strong commitments to provide human and financial resources. *Training and education on SPC* should be carried out continuously, employees training each other using knowledge and data on the production process of the enterprise and benefits of SPC implementation must be pointed out. *Quality Department* need to play its role in guiding and supporting SPC practicing, and organize discussion to find bad and good points and select divisions as a pilot for SPC.

Managers also need to seriously consider following factors; Control charts; identification of importance of quality; Analysis of the measurement system; Exchange knowledge; Use SPC software. A lot of previous studies have also shown that these factors still have a positive effect on the implementation of SPC. Special attention have to paid on the application of information technology, or apply SPC software to data management such as Microsoft Excel, or specific software of each company to create and analyze control charts making data easily understandable and comparable. However, the application of computer software packages should only be allowed after the basic principles of SPC has been understood and the participants have gained skills to interpret control charts.

4.1. Policy implications

In order to encourage the successful application of SPC in businesses in addition to the efforts of each business, appropriate macro policies should be in effect. *Firstly*, specific guidances, policies and action programs needed to be introduced in order to universalizing SPC knowledge and training formally. Incentives must be provided for vocational schools and universities to include SPC into their training curriculum on administration in general and enterprise administration in particular, with increased theoretical and practical volume, and training time. Conferences and researches on this topic should be encouraged at Vietnamese enterprises. *Secondly*, the SPC implementation and other methods such as 5S Kaizen, Lean in business management should be encouraged, in the initial phase the stateshould create favorable conditions for businesses to visit and learn from good practices, especially enterprises in FDI sector like Toyota, Honda, or Panasonic; technical, financial and advisory supports are needed for SPC deployment.

Thirdly, the government's recommendation about product quality differences between groups by ownership is needed. Indeed, most state-owned enterprises have paid not enough attention on SPC. Therefore, for state-owned enterprises, a specific roadmap for SPC must be developed by the government. To promote SPC implementation local governments should provide state-owned enterprises with supports relating to SPS consultancy and training.

4.2. Limitations

The research was made on mechanical and manufacturing fields in Hanoi. Further researches should be done on other regions (HoChiMinh city, Haiphong, DongNai, BinhDuong) and fields (electronics, garment, foodstuff, healthcare, hospitality), and include other factors influencing success of SC implementation, such as control charts; Identification of important characteristics of quality; Analysis of the measurement system; Exchange and share knowledge.

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