Impact of Quality Strategies and Training on Process Innovations

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Abstract

Objectives: To determine the relationships between quality improvement and train upon process innovation and also to find its effect on operational performance. **Methods/Statistical Analysis:** By a literature review of innovation, constructs are established for the determination and evaluation of the mentioned relationships and the improvement of operational performance. The main underlying proposal is the four constructs developed to establish the relationships. A questionnaire for the evaluation of the constructs is validated and applied to gather data to test four hypotheses with confirmatory factorial analysis. Several non-parametric tests are applied and explained their use. **Findings**: The questionnaire developed was validated and adequate for the measurements of the constructs. Personnel from product and process engineering of 27multinational plans replied with a response size of 236. Data is suitable, indicates the Kaiser-Meyer-Olkin test and the sphericity test exhibits the rationality of the constructs under the predictor type relationships of the factors influencing the variables. The four hypotheses cannot be rejected. Training has a positive impact on process innovation and on quality improvement projects. Process innovation is an important predictor of operational performance. Quality improvement and training are key factors in the development of process innovation and these innovations positively affect performance, as evidenced by the structural model [χ2=177.38; df=98; [χ2/df=1.87; p<.01; CFI=0.97; RMSA=0.59], it is advisable that the manufacturing industry takes this as reference for the improvement of operational performance. **Application/Improvements:** This model enhances the explanation power of this theory, also advices the companies about some of the organizational factors to consider for the increase of operational performance by process innovations.

Keywords: Factor Analysis, Predictor Model, Process Innovations, Production Performance, Quality Strategies

1. Introduction

In the highly complex global markets, companies develop innovations to cope with the increasingly intensity of rivalry, volatility and market uncertainties, which exert pressures to improve product and process technologies[1]. Because, the development of technological innovations is a key factor for the accomplishment of profitability through improvements in production processes, then, innovation is a key factor for the competitiveness of the companies. In the industrial practice, companies develop innovations in accordance with their own culture and this constitutes a questionable practice, as it is explained in the literature review of the development of process innovation, quality and training.

Innovation is the transformation of an idea into an improved product, an improvement in a process, or the

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development of a new product. It is a successful development process of new and creative ideas, which require two features, novelty and use[2]. Therefore, innovation has become a key factor in companies for the achievement high performance products and processes. The development of innovations positively and significantly affects the performance of production operations[3], besides, it provides a differentiation against competitors and generates growth opportunities[4,5].

The innovation of a process refers to the implementation of new or improved equipment and technologies production[6]. When this implementation consists in improvements of the process with some degree of innovation, without breaking the actual technological scheme, it is called incremental innovation. This type of innovation is a common practice used in manufacturing companies and is closely associated to quality strategies, such as Lean Manufacturing or Six Sigma[6,7]. Radical innovation refers to the implementation of big changes in technological assets that break the actual products or processes[8].

Quality is one of the main factors influencing innovation[9], among the most common strategies deployed by companies to confront the challenges of globalization and market changes[10], because the quality efforts are focused on the elimination of defects, errors and their causes[11] quality improvement activities increase performance and constitute a source of competitive advantage[3].

Some studies[12] report that companies implementing quality improvement activities develop more incremental innovations than companies with large expenditure in research and development. Incremental change is more likely to happen in companies committed to high efficiency and controls, to stabilized operations, this focus can inhibit the development of radical process innovation. Keeping the status quo implies the inhibition of innovation, because the latter means change and less adherence to the present state of things.

The relationship between innovation and quality behaves in two dimensions. In companies committed to deliver a continuous flow of new products by a differentiation strategy based in research and development, quality improvement in the production floor still has application opportunities when the new product is released to be produced. While, in companies with a focus in a cost leadership strategy, high volumes of standardized products are delivered, with price, quality and service enhancements based in improvement strategies. The main differences are the tasks of exploration and experimentation, the levels of quality and risk-taking involved in the two dimensions[5].

The innovation of products and processes is closely related to training, because it is a key factor for learning and the development of knowledge[13]. The relationship is based in the fact that well trained people have the skills needed for the innovation of products and processes,[14] and companies investing in technical training tend to be more innovative[15]. The workforce training is another factor that influences the development of innovations because of the knowledge, skills and techniques acquired by the employees[2] for the development of technological capabilities[3]. Also, are important factors of the attitudes and behaviors because innovations and improvements depend on motivations and abilities for the development of new ideas, changes and the achievement of the company's objectives[16].

Although the creation, development and use of innovation capabilities might be multifactorial problems, with too many causes influencing the processes and outcomes, this paper explores the effects on innovation of just two factors, training and quality improvement, also is explored the contribution of process innovations on operational performance. More precisely, the purpose is to determine if quality improvement and training significantly influence the development of process innovations and if process innovations significantly improve the performance of the manufacturing companies investigated in the sample taken from Ciudad Juarez multinational companies.

2. Methodology

The theory of structural equations is applied to analyze the relationship between two factors, the quality

improvement projects and training and their effect on the innovation of industrial processes. The people subject of this research were managers, supervisors, engineers and technicians involved with quality strategies and innovation processes, working in the manufacturing industry in Ciudad Juarez, Chihuahua, Mexico. The methodology is divided into four parts that are described below.

2.1 Hypothesis and Structural Model Assumed

In this research is proposed a predictor type relationship model, [17] which establishes a predictor relationship between a strategy and financial performance. In this work, the basic assumption is the positive effects of training and quality improvement on process innovations and, in turn, that process innovations also improve operational performance. These relationships are represented with the arrows labeled with "H" in Figure 1.

The boxes in Figure 1, represent the observed variables or indicators, which are measured by the questionnaire. The letters "H" represent the hypotheses:

H_1: Quality improvement efforts are significant predictors of process innovations.

H_2: Training is a significant predictor of process innovations.

H_3: Training is a significant predictor of quality improvement.

H_4: Process innovations are a significant predictor of the operational performance of the company.

2.2 Questionnaire Design

The factors, variables and constructs were determined through literature review and they are presented in Appendix 1. The instrument of measurement is composed
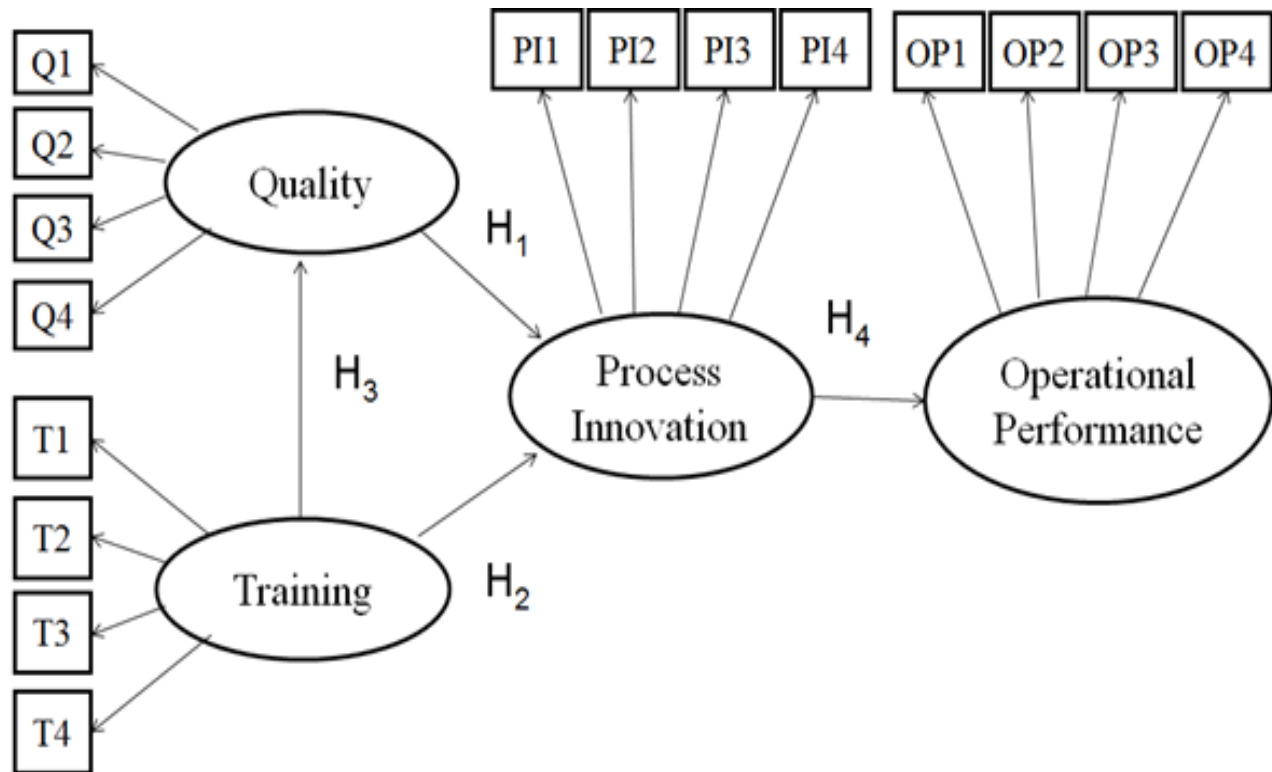

Figure 1. The structural model, considers Quality, training, process innovation and operational performance.

Appendix 1: Questionnaire

Construct Quality
Observable Variables
For your company, the importance of quality is:
The use of parts and components through strong supply chains is:
The influence of quality strategies on process innovations is:
The accomplishment of quality policies is:
The influence of quality strategies on product innovations is:
Construct Training
Observable Variables
Training for the development of the technical competences and abilities needed for innovation is:
Training is based on diagnostics and planning:
The assistance to training is:
There is a company Wide training program.
Construct Process Innovation
Observable Variables
The elimination of waste activities in operations is:
The deployment of process improvements is:
The improvement of production methods, workstations, is:
The improvements on production equipment and machinery is:
Construct Production Performance
Observable Variables
The reduction in costs, whether parts or production unit cost is:
The reduction of scrap is
The increases in production volume is:
The accomplishment of production plans, master programs, is:

of four sections, in each one of the sections consists of a construct and its observable variables which were measured with a Likert scale of five categories. The construct Quality relating the quality strategies and improvements in production processes to the development of innovations, which in turn, improve the operational performance of the company[5,14,18]. The questions are based in the first part of the Appendix 1.

Regarding the workforce training some authors[14,19] suggest that with training, people acquire knowledge

and develop skills to do their best work and at the same time, increase their creativity and the development of innovations. About process innovation, the questions are based in work of various authors [14,19,20], which take into account the improvements or changes made in production processes in the last five years. The construct of operational performance is based from the prediction relation, suggesting that process innovation reduces costs and increases operational performance[18,19,21]. Finally, also includes a few questions to gather information concerning the size of the company, rotation and position of the person surveyed.

In relation to the validity of the questionnaire[21], five experts were consulted to see the clarity and precision of the questions and their relationship to the construct, then, a survey was applied to sample of 40 subjects for the validation with Alpha Cronbach index. The Alpha value test[22] was 0.96 which is bigger than the 0.70 suggested, so that the questionnaire internal consistency is acceptable.

2.3 Application of the Questionnaire

The questionnaire was applied in the 27 manufacturing plants owned and operated by multinational corporations with integrated research and development functions, this population was sensed; the staffs surveyed were managers, engineers, supervisors and technicians involved in the processes related to the implementation and development of innovations. The sample size[22] were of four

surveys for each item of the questionnaire, therefore, 250 surveys were collected.

2.4 Data Analysis

The information gathered was analyzed with the computational package SPSS. By removing surveys with absences of data. For the analysis were considered 236 surveys. In order to verify if the sample was suitable to a factorial analysis, the Kaiser-Meyer-Olkin and Bartlett's tests were performed[23]. To improve the understanding of the matrix of correlations, the Varimax rotation method[22] was applied. Finally, the structural model was tested applied a covariance approach using AMOS v. 16.

3. Results

The results obtained are shown below, beginning with a description of the sample, the questionnaire validation and finally, the structural model.

3.1 Sample Description

Because not all participants answered completely, 14 surveys were cancelled, remaining a total of 236 surveys. The Table 1 displays information of the people who answered the questionnaires.

As shown in Table 1, it can be seen that 66% of respondents occupy a position of managers and engineers; the other 34% is operating personnel related to the manufacturing processes and related to innovation processes. On

Table 1. Positions of respondents

Position	Number of persons	Percentage (%)
Manager	37	15.67%
Engineer	97	41.10%
Supervisor	59	25.00%
Technician	43	18.22%

Table 2.   Industrial sector segmentation

Industrial Sector	Respondents	Percentage (%)
Automotive	103	43.64%
Electric	25	10.59%
Electronic	32	13.55%
Packaging	7	2.96%
Medical	30	12.71%
Plastic	8	3.38%
Others	31	13.13%

the other hand, in Ciudad Juarez there are located around 400 "maquiladoras"[24] distributed in the different industrial sectors as shown in the Table 2.

3.2 Reliability and Validation of the Instrument

The Table 3 presents the Alpha Cronbach indexes obtained for each construct of the questionnaire. As shown in the Table 3, all the constructs have a high reliability because their value is higher than 0.70 which is the minimum value recommended[20, 21].

3.3 Suitability of the Sample

The Kaiser-Meyer-Olkin and Bartlett's tests are used to verify if the data obtained is adequate. Table 4 shows that the Kaiser-Meyer-Olkin index is 0.926, which indicates that the partial correlations are small, therefore, measure the same factor. In the Bartlett's Test of Sphericity, the significance tends to 0 so the identity matrix hypothesis is rejected indicating that there are variables that explain the same and therefore can be grouped.

Table 3.   Validation of the different constructs

Construct	Cronbach Alpha
Quality	0.849
Workforce Training	0.901
Process innovation	0.904
Operational Performance	0.813

Table 4. KMO test and Test Barlett's Test

Kaiser-Meyer-Olkin Measure of sample adequacy			0.926
Barlett's Test			4171.1
		Degrees of Freedom	666
		Significance	0.000

3.4 Structural Model

The results of the convergent validity of the structural model are shown in Table 5. First, given that the Average Variance Extracted (AVE) values of each construct is greater than 0.5, all the models' latent variables explain a substantial part of the indicator's variance.

Table 5. Convergent validity

Construct	Item	AVE	λ	λ (average)
Quality	C1	0.611	0.706	0.78
	C2		0.808	
	C3		0.756	
	C4		0.851	
Training	ET1	0.699	0.896	0.833
	ET2		0.880	
	ET3		0.709	
	ET4		0.847	
Process Innovation	IP1	0.688	0.776	0.828
	IP2		0.851	
	IP3		0.872	
	IP4		0.816	
Operational Performance	DP1	0.546	0.816	0.734
	DP2		0.806	
	DP3		0.699	
	DP4		0.617	

Source: Self- prepared, by utilizing the survey results

Table 6. Structural model evaluation

x^2	DF	x^2/DF	NFI	IFI	TLI	CFI	RMSEA 90% Confidence interval	
177.38	98	1.807	0.931	0.968	0.96	0.97	0.059	
P = 0.000							(0.045 - 0.072)	
Values Recommended		4	1	1	1	1		

NFI: Bentler and Bonett's Non-normed Fit Index; IFI: Bollen's Incremental Fit Index; TLI: Tucker-Lewis Index; CFI: Bentler's Comparative Fit Index; RMSEA: Steiger y Lind's Root Mean Square Error of Approximations.

Source: Self-prepared, utilizing survey results

This also implies that the variance shared between every one of the constructs and the indicator is bigger than the measurement error variance. Additionally, given that the factorial load of the indicators for each construct
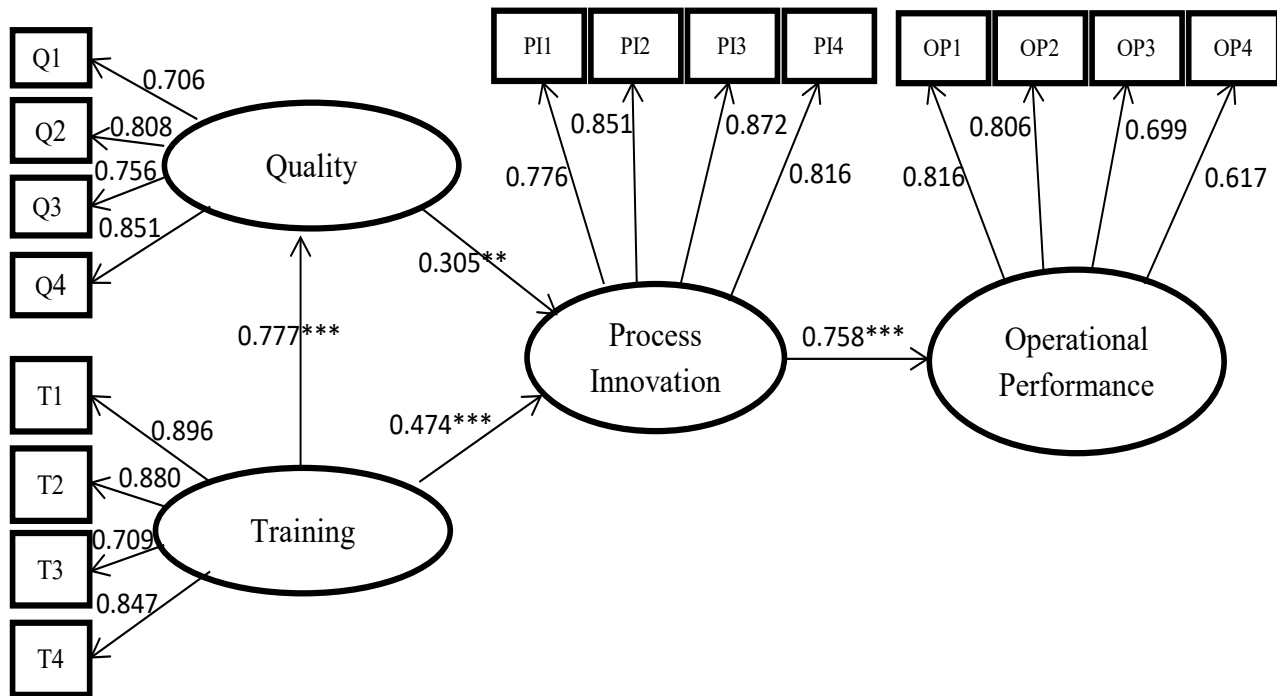
*Significance at 0.05%

** Significance at 0.01%

*** Significance at 0.001%

Figure 2. The structural model.

Source: Own preparation, from the survey data.

is greater than 0.070, they share a high proportion of variance with its construct. On the other hand, Table 6 shows the several indexes of goodness of fit used to assess the structural model. As can be seen, all the indexes reflect an appropriate model's fit according to the values recommended[25].

Figure 2 shows the estimation of the prediction relationships between the constructs. As can be seen, training exhibits two effects on process innovation. It has a positive and direct relation (path=0.474), and in the same fashion, also influences quality, (path= 0.777). Although presents an indirect but positive effect on innovation through quality efforts, (path=0.0305). Process innovation has a positive and direct effect on operational performance, (path=0.758).

The values of the standardized coefficients indicate a moderating relationship between training, quality improvement and their contribution to process innovations, nonetheless, the latter has a strong influence on operational performance and constitutes an important predictor of operational performance. To verify the hypotheses, the significance of the coefficients leads to the acceptance of the four hypotheses.

H_1: Quality improvement efforts are significant predictors of process innovations.

H_2: Training is a significant predictor of process innovations.

H_3: Training is a significant predictor of quality improvement.

H_4: Process innovations are a significant predictor of the operational performance of the company.

Quality improvement and training are key factors in the development of process innovation and these innovations positively affect the operational performance of the production as evidenced by the structural model, which is evidence that the manufacturing industry can take as reference for its development projects in process innovation.

4. Conclusions

As mentioned in the literature review, there are several factors involved in the development of technological innovation, being quality and training two of the main ones. Although the increase of competitiveness in the industrial practice of maquiladora twin plants are multifactorial greatly depends on the improvement and innovation of process technologies. The predictor model relating quality and training to increases of operational performance, possibly, indicates another perspective of this issue, meaning that the essential purpose of quality strategies is the creation and development of the technological capabilities needed for innovation and improvement of products and processes, although, most of the times, they are deployed, in the short term, as projects for the redesign or improvement of productivity and quality. Also, it is verified that training significantly affects quality strategies and, therefore, the development of process innovation.

Hence, implications and conclusions of this study are bounded by the context of the research, but future research could involve the replication of this study in a number of different contexts to generalize its results. Additionally, investigating other constructs not included in this study will provide a better understanding about the impact of process innovations on operational performance in manufacturing companies. This study provides important theoretical implications for process innovations' theory and contributes to the literature of Critical Success Factors, specifically, those related to the development of the process innovations.

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