IARJSET

ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Factura '20 - National Conference On Emerging Trends In Manufacturing

NSS College of Engineering, Palakkad, Kerala, India

Vol. 7, Special Issue 1, August 2020

Role of Manufacturing and Quality Practices in the Economic Performance of Manufacturing Firms

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Abstract: Among other parameter the manufacturing practices and quality practices of a firm adopt tends to influence the economic performance of industry. This study tries to probe the role of the manufacturing and quality practices in the economic performance of the industry. The study has been conducted on 31 manufacturing industries. The data used for this study has been separated in to manufacturing practices and quality practices. The exploratory factor analysis (EFA) method was used to classify the factors affecting on manufacturing practices and quality practices. The factors affecting the manufacturing practices are extracted in to 6 components and the factors affecting the quality practices are extracted in to 2 components by using Principal Component Analysis (PCA). The multiple regression analysis with value added as the dependent variable and the manufacturing and quality practices as the independent variables reveals that major parameters which affecting the economic performance as tools and technology, practices aspect of employee, human resources and employee work performance.

Keywords: Manufacturing Practices, Quality Practices, Economic Performance, Factor Analysis, Regression Analysis.

I. INTRODUCTION

Major objective of a manufacturing industry is to have the operation efficiently for achieving high level of performance. There are so many factors which affect the performance and the manufacturing and quality practices are the some of the key factors which affect the economic performance. The economic performance can be measured using deferent parameter. Value added is the one of the parameter. The manufacturing practices are categorized in to several factors which are tools and technology, manufacturing paradigms, relationship with customer, impact on business and peoples of organization. Quality practices are also affecting the value added of a firm, and some of the parameters which are accuracy of the job, tolerance of the part, surface roughness and coating thickness. Quality practices are also related with the delivery of the products and the transportation.

II. OBJECTIVE

Based the literature review and discussion with the concerned persons major objective of the study is formulated as

1. Identify the manufacturing and quality practices adopted in a firm.
2. Measuring the level of manufacturing and quality practices followed in a firm.
3. Probing the role of manufacturing and quality practices in the economic performance in a firm

Ⅲ. METHODOLOGY

A) Economic Performance

Economic performance is measured by using the value added of the firms. Value added is calculated by the difference between industries gross output and the cost of intermediate inputs. The energy cost, labour cost and material cost are considered as the intermediate inputs.

B) *Manufacturing Practices*.

Based on the literature review, the following factors related to the manufacturing practices were identified.

1. Tools and Technology.

The variables identified to explain modern tools and technology are as follows

a) Computer Aided Design And Manufacturing(CAD CAM) System

In order to probe whether they are using tools and technology we have collected data on the extent of using Computer Aided Design and Manufacturing.

b) Total Productive Management(TPM)System

We have probed whether the firm uses the total productive management system and if so to what extent for achieving better tools and technology. TPM is the approach to eliminate waste associate with production equipment and machinery.

c) Total Quality Management(TQM) System

Total quality management is the continual process of detecting and reducing the errors in manufacturing. We have to find out what extent the TQM practices are using in the manufacturing process.

d) Automatic Storage & Retrieval System(ASRS)

This system consists of computer controlled system for automatically placing and retrieving items. In order to find the impact of tools and technology we have to obtain whether the firms are using the ASRS or not.

e) Material Requirement Planning (MRP)

It is a system for identifying the materials and components needed for manufacturing product. We have to probe whether the firms are using this modern technology for better performance.

f) Concurrent Engineering (CE)

It is a method of designing and developing a product by the different stages simultaneously. We have to measure the extent to which a firm is using this modern technology for efficient product development.

g) Productivity Improvement Program (PIP) &Waste Elimination

It is a structured process to obtain the implemented solution which the firm needs. We have to probe what extend this methods are adopted in the firms for better performance.

2. Manufacturing paradigms.

The variables identified to explain modern manufacturing paradigms are as follows.

a) Mass Production System

It is required to probe extent of standardized products being manufactured in the firms.

b) Batch Production System

It measures the level of production of specified groups of products being manufactured within a time frame

c) Flexible Manufacturing System

Flexible manufacturing system covers the ability to produce new products types, and ability to change order of the operation executed on a part. This study probes the extent to which this modern technology is adopted in the firm.

d) Lean Manufacturing System

The wastage of the material is the one of the challenge facing in the recent manufacturing system. It was decided to probe whether the firms are using the method of lean manufacturing for elimination of waste from the manufacturing process.

e) Agile manufacturing system.

Agile manufacturing is a term applied to an organization that has created the processes, tools, and training to enable it to respond quickly to customer needs and market change while still controlling cost and quality.

f) Product Quality & Reliability

Every manufacturing industry always ensures good quality of the products. But it is necessary to continue the quality for the products for long period of time. So we have to probe whether or not the product quality ensure the reliability

3. Relationship with customer

The variables identified to explain the relationship with the customer are listed.

a) Customer Satisfaction

Customer satisfaction is the one of the main parameter to measure whether the requirement of the customer has been attained by the use of the product.

b) Information Accessible To Customers

The customer should be able to access the information which is provided by the manufacturing industry.

c) Trust Based Relationship With Customer

The products ordered by the customer may have the inefficiency of the usage and proper conditions which leads to loss of trust for the other firms. So it is essential to keep good trust based relationship with customer.

d) Involvement Of Customer In Product Development Process

It is important to develop sustainable product quality for long-time relationship. The lack of a sustainable product may be due to absence of customer involvement in the product development processes.

e) Customer Feedback & Complaint System

The relationship with the customer will not confine only to the delivery of the products. It is essential to have a system for collecting the feedback from customer side and attending the complaints of the customer with the product.

f) On Time Delivery To Customer

On time delivery is measure the finished process and supply efficiency. It can be calculated as the amount of units delivered on time versus total orders shipped.

4. Impact on business environment

The variables identified to explain the impact on business environment are listed.

a) Competition in Indian market

The effect of product market competition on the economic performance in Indian manufacturing sector is to be examined in this research.

b) Competition in global market.

The effect of global competition on the economic performance needs to be probed and the extent of global the competition is to be assessed.

c) Change in technology.

Change in technology is one of the major factors affecting economic efficiency of the products. Adoptability of a firm to changes can be identified by observing the extent of creation of new product or process. Also we have to probe how fast a firm reacts to technological changes by having innovations on the manufacturing system.

d) Requirement of working capital &high cost of capital.

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The financial ability of a firm has a major effect on the improvement of the business environment. The working capital is required to ensure that a firm is able to continue the manufacturing operation.

5. People of organization.

The variables identified to explain the people of organization are listed.

a) Employee satisfaction.

We have to measure of worker's contentedness with their job, whether or not they like the job or individual aspects or facets of job, such as nature of work or supervision.

b) Employee trust on management.

We have to assess the sense of trust in an employee-management relationship. It is important to ascertain that the employees are able to perform their job with satisfaction and by taking extra efforts.

c) Centralized decision making.

It is necessary for a manufacturing industry to have development process which included quality information and situational determinants of communication behaviour.

d) Motivation of man power.

People are the most important factor on performance improvement. Since all organization combines two subsystems, technical and human, these sub system must be balanced and co-ordinated in order to function effectively.

e) Appropriate mix of youth and experienced employee.

Manufacturing industry today tends to use advanced and sophisticated technology which may be appealing to a younger demographic. Workers need to have good knowledge and skill base in order to be an expert in the operation of the most sophisticated equipment. This context calls for an appropriate mix of youth and experienced employees.

C) Quality Practices.

Factors related to quality practices identified based on the literature review are listed.

1. Practice of constantly maintaining the accuracy
2. Keeping up the tolerance up to +/-0.025
3. Practice of maintaining high process capability tolerance
4. Practice of maintaining the surface roughness standard value 3.2µm
5. Practice of maintaining the coating thickness 25µm
6. Performing employees are properly trained and qualified
7. Practice of implementing the lean technique to improve the delivery and transportation
8. Practice of maintaining reduced lead time
9. Practice of maintaining reduced cycle time
10. Practice of avoiding delivery of defective part

D) factor analysis

The analysis in this section was performed using the Statistical Package for Social Sciences (SPSS 25.0). By gathering the responses obtained through the survey and grouping them based on their respective factors (tools and technology, manufacturing paradigms, relationship with customer, impact on business environment and peoples of organization), each group of responses were analysed using exploratory factor analysis to identify the set of underlying variables within each factor. First, to evaluate the data's suitability for exploratory factor analysis, the Kaiser-Meyer- Olkim (KMO) Measure of Sampling Adequacy and Bartlett's Test of Sphericity was performed. By checking that the KMO value lies above 0.5 and the significance level from Bartlett's test falls below 0.05 this ensures that the data is suitable for factor analysis1.

1. *Factor analysis on manufacturing practices*

Table. I Factor analysis, KMO, and Bartlett's tests for each research variable as regards manufacturing practices

Factor titles	Statements	KMO	BT	DF	p-Value
Tools and technology	computer aided design and manufacturing	0.879	184.232	21	0.000
	total productive manufacturing				
	total quality management				
	material requirement planning				
	concurrent engineering				
	automatic storage & retrieval system				
	productivity improvement program & waste elimination				
Manufacturing Paradigms	agile manufacturing system	0.748	79.487	15	0.000
	lean manufacturing system				
	product quality & reliability				
	flexible manufacturing system				
	batch production system				
	mass production system				

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Relationship with customer	Trust based relationship with customer	0.708	52.095	15	0.000
	information accessible to customer				
	Involvement Of Customer In Product Development Process				
	customer satisfaction				
	On Time Delivery To Customer				
	Customer Feedback & Complaint System				
People of organization	Employee Satisfaction	0.591	49.643	15	0.000
	Employee Trust On Management				
	Centralized Decision Making				
	Motivation Of Manpower				
	Training and skill development of people				
	Appropriate Mix Of Youth And Experienced Employees				

Results of the Kaiser-Meyer-Olkin and Bartlett's test at significance level of 0.000(sig ¼ 0.000 is rejected) for manufacturing practices are show in TableI. These results suggest that factor analysis was suitable for these statements.

Table. II Eigen values, variance percentage, and cumulative variance of factors identified after a varimax rotation

No	Questionnaire dimension	Factor	Extracted sum of squared loading		
			Eigen value	Cumulative %	Cumulative variance %
1	Tools and technology		4.999	71.409	71.409
2	Manufacturing Paradigms	Manufacturing tool and process	3.280	54.673	54.673
3		Method of production	1.233	20.547	75.219
4	Relationship With Customer		2.955	49.244	49.244
5	People Of Organization	Practices aspects of employee	2.307	38.448	38.448
6		Human resources	1.792	29.870	68.317

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According to Table. II, factors influencing effectiveness of manufacturing practices were summarized into six factors using the Principle Component Analysis (PCA) and varimax rotation methods. Finally, the six factors were named with the aid of the research. The factors and components of each factor are introduced in the following. Research findings showed that the following six factors were identified as "tools and technology", "Manufacturing tool and process", "Relationship with Customer", "practice aspect of employee" and "human resource".

Table.III factor loading of manufacturing practices.

Factor		Statement	Factor loading
Tools and Technology		Computer aided design and manufacturing	.956
		Total productive manufacturing	.926
		Total quality management	.894
		Material requirement planning	.877
		Concurrent engineering	.789
		Automatic storage & retrieval system	.722
		Productivity improvement program & waste elimination	.718
Manufacturing Paradigms	Manufacturing tool and process	Agile manufacturing system	.927
		Lean manufacturing system	.845
		Product quality & reliability	.781
	Method of production	Flexible manufacturing system	.851
		Batch production system	.802
		Mass production system	.741
Relationship With Customer		Trust based relationship with customer	.794
		Information accessible to customer	.732
		Involvement of Customer In Product Development Process	.717
		Customer satisfaction	.711
		On Time Delivery To Customer	.651
		Customer Feedback & Complaint System	.588
	Practices aspects of	Employee Satisfaction	.720

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People of Organization	Employee	Employee Trust On Management	.737
		Centralized Decision Making	.826
		Motivation Of Manpower	.641
	Human resources	Training and skill development of people	.854
		Appropriate Mix Of Youth And Experienced Employees	.831

All statements in the factor loading is higher than 0.5 which indicates that these statements can optimally explain corresponding variances and the questions are significant. Hence, these statements become suitable for determining manufacturing practices in this research.

2. Factor analysis on quality practices.

Table.IV Factor analysis, KMO, and Bartlett's tests for each research variable as regards quality practices

Statements	KMO	BT	DF	p-Value
practice of constantly maintaining the accuracy	0.732	249.339	45	0.000
keeping up the tolerance up to +/-0.025				
practice of maintaining high process capability tolerance				
practice of maintaining the surface roughness standard value 3.2µm				
practice of maintaining the coating thickness 25µm				
performing employees are properly trained and qualified				
practice of implementing the lean technique to improve the delivery & transportation				
practice of maintaining reduced lead time				
practice of avoiding delivery of defective part				
practice of maintaining reduced cycle time				

Results of the Kaiser-Meyer-Olkin and Bartlett's test at significance level of 0.000 for quality practices are show in Table. IV. These results suggest that factor analysis was suitable for these statements.

Table.V Eigen values, variance percentage, and cumulative variance of factors identified after a varimax rotation

No	Questionnaire dimension	Factor	Extracted sum of squared loading		
			Eigen value	Cumulative %	Cumulative variance %
1	Quality practices	Employee work performance	5.687	56.872	56.872
2		Delivery Time Management	1.297	12.969	69.841

According to Table. V , factors influencing of manufacturing practices were summarized into two factors using the Principle Component Analysis (PCA). Finally, the two factors were named with the aid of the research. Research findings showed that the following two factors were identified and as factors Employee work performance and Delivery Time Management.
All statements in the factor loading is higher than 0.5 which indicates that these statements can optimally explain corresponding variances and the questions are significant. Hence, these statements become suitable for determining quality practices in this research.

E) *Role of manufacturing and quality practices on the economic performance*.

Main objective of this study is to probe the role of manufacturing and quality practices on the economic performance. Manufacturing and quality practices as mentioned above were identified using the variables as component extracted for accessing the level of manufacturing and quality practices. In order to measure the economic performance we have taken value added as the main parameter, and value added are evaluated by the difference between industries gross output and the cost of intermediate inputs. The energy cost, labour cost and material cost are considered as the intermediate inputs. The regression equation was formulated by value added as the dependent variable and manufacturing and quality variable are independent variable. Regression analysis is done by using this regression equation.

$$\text{Value Added}=b_0+b_1x_1+ b_2x_2+ b_3x_{3+} b_4x_{4+} b_5x_{5+} b_6x_{6+} b_7x_{7+} b_8x_8$$

Table.VI Independent variable selected for multiple regression analysis

X1	Tools and technology
X2	Manufacturing tool and process
X3	Method of production
X4	Relationship with customer
X5	Practices aspects of employee
X6	Human resources
X7	Employee work performance
X8	Delivery Time Management

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The details of the regression analysis are given below.

Multiple regression analysis is used to predict the value of the value added based on the variables which identified from manufacturing and quality practices. Multiple regressions also allow determining the overall fit (variance explained) of the model and the relative contribution of each of the factors to the total variance explained.

Table. Ⅶ Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.891[a]	.794	.719	.192649	2.363

R-value represents the correlation between the value added and other (independent) variable. Since the R-value is greater than 0.4 it can be taken for further analysis. In this case, the value is .891, which is good. The R Square value for this modal was 0.794 that is 79.4% of the variance in value added was predictable from the quality and manufacturing practices. It shows a strong relationship between them.

Table. Ⅷ ANOVA

Model	Sum of Squares	Df	Mean square	F	Sig.
Regression	3.146	8	0.393	10.595	0.000
Residual	.816	2	0.037		
Total	3.962	30			

95 % confidence interval of the significant level is chosen for the study. The significant value in the above table is 0.000 which is less than 0.05.there for result is significant. The f- ratio in the table 3.30 represent an improvement in the prediction of the variable by fitting the model after considering the inaccuracy present in the model. Here the f- ratio is 10.595 which is greater than 1.hence this model was good.

Table.Ⅸ Significance of manufacturing practices and quality practices on value added

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
	Beta	Std. Error	Beta			Zero-Order	Partial	Part	Tolerance	VIF
(Constant)	-2.521	.729		-3.460	.002					
Tools and technology	.284	.103	.570	2.755	.012	.567	.506	.267	.219	4.575
Manufacturing tool and process	-.106	.109	-.215	-.975	.340	.399	-.204	-.094	.193	5.177
Method of production	.003	.112	.005	.031	.976	.681	.007	.003	.304	3.293
Relationship with customer	-.106	.183	-.100	-.579	.568	.461	-.123	-.056	.317	3.155
Aspects of employee Practices	.358	.158	.379	2.266	.034	.456	.435	.219	.335	2.982
Human resources	.219	.066	.454	3.334	.003	.642	.579	.323	.506	1.977
Employee work performance	.281	.145	.284	1.942	.065	.506	.383	.188	.438	2.285
Delivery Time Management	-.049	.138	-.042	-.351	.729	.232	-.075	-.034	.651	1.535

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The table X shows the significance of the manufacturing and quality practices in the model and magnitude with which it impacts the value added. The analysis suggest that manufacturing practices such as "tools and technology", "practices aspects of employees", "human resources" and "employee work performance" have significant positive relationship with value added.

IV. RESULTS & DISCUSSION

A) Level of manufacturing practices adopted in the firms.

Descriptive statistics are used to describe the features of the manufacturing and quality practices in the study. The mean value in the descriptive statistics table is used to describe the level of the manufacturing and quality practices in the manufacturing industry.

Table. X Descriptive Statistics of manufacturing practices

Manufacturing practices	N	Range	Minimum	Maximum	Mean	Std. Deviation
Tools And Technology	31	2.622	1.000	3.622	1.79339	.729553
Manufacturing tool and process	31	2.637	1.306	3.943	1.86413	.732964
Method of Production	31	2.619	1.670	4.289	2.91213	.570734
Relationship With customer	31	2.036	2.964	5.000	3.66877	.340935
Practices aspects of employee	31	1.780	3.220	5.000	3.62210	.383948
Human resources	31	1.715	1.185	2.900	1.82990	.434352

Among the manufacturing practices, the factor "Relationship with customer" was having the highest mean score of 3.66877, whereas the factor "Tools and technology" has the least mean score of 1.79339. Among the manufacturing practices the modern technology such as "tools and technology", "manufacturing tools and process" and "human resources" has the low level of implementation due to lack of development on modern technologies in these small scale industries. The factors "method of production", "practice aspect of employees" and "relationship with customer" has the high level of implementation.

B) Level of quality practices adopted in the firms.

Table.XI Descriptive Statistics of quality practices

Quality practices	N	Range	Minimum	Maximum	Mean	Std. Deviation
Employee work performance	31	1.769	3.231	5.000	4.06626	.367061
Delivery time management	31	1.000	3.000	4.000	3.70603	.314798

This Result show that, among the quality practices "the employee work performance" has the highest level of implementation with mean score 4.06626, while "the delivery time management" has the least implementation with mean score 3.70603.

C) Role of manufacturing and quality practices on economic performance.

The regression analysis with value added as dependent variable and manufacturing and quality practices are the independent variables revealed with following facts.

1. The significant value of factor tools and technology is 0.012, which is less than 0.05. It shows this factor is statistically significant.
2. Similarly the factor Practices aspects of employee has value of significant is 0.034. Also shows statistically significant.
3. The significant value of factor Human resources has the significant value 0.003, which shows more statistically significant.
4. The significant value of factor Employee work performance has the significant value 0.065 which is close to 0.05, so it also taken as significant.

These results show that for a unit increase in the factor Tools and Technology the value added (Dependant variable) will increase 0.284 units. Since the unit of value added is crore (rupees), Value Added will increase by 28.4 lakh as the factor Practices Tools and Technology increase by one unit. The value added will increase by 0.358 units for the increase of factor Practices aspects of employee by one unit. That is value added will increase by 35.3 lakh as the factor Practices aspects of employee increase by one unit. The value added will increase by 0.219 units for the increase of factor Practices Human resources by one unit. That is value added will increase by 21.9 lakh as the factor Practices Human resources increase by one unit. The value added will increase by 0.281 units for the increase of factor Employee work performance by one unit. That is value added will increase by 28.1 lakh as the factor Employee work performance increase by one unit.

V. CONCLUSION

Main objective of this study was to probe the impact of manufacturing and quality practice on economic performance in manufacturing industries. The exploratory factor analysis done on the manufacturing practices revealed the factor "Relationship with customer" has the highest level of performance, whereas the factor "Tools and technology" has the lowest level

implementation. The remaining factors such as "tools and technology", "manufacturing tools and process" and "human resources" have almost high level of implementation. The exploratory factor analysis was done on the quality practices and it revealed "the employee work performance" has the highest level of implementation while "the delivery time management" found to be lowest level implementation. By analysis of multiple regressions, the study identified "tools and technology", "practices aspects of employees", "human resources" and "employee work performance" to be most significant factors influencing the value added. It was also concluded that these significant factors are positively related with the value added.

VI. ACKNOWLEDGMENT

This work was supported by the production management in manufacturing industry SIFL Trissur and production management in subcontracting industries. The work also supported by the guidance from department of mechanical engineering.

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