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Identification and statistical analysis of performance parameters of it enabled supply chain management system

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Abstract

The increasing use and application of information technology in supply chain management can be attributed to the performance improvements and value creation in organizations. There has been a considerable evolution of scientific investigations over the past few years. From a comprehensive and updated literature review, it has been observed that use of IT systems have a great impact on performance of the organization. The application of electronic data interchange, enterprise resource planning systems, such as SAP and Oracle has been extended to supply chain partnership, enabling supply chain partners to plan and synchronize their processes**.** Effective performance measurement is key area for successful implementation of strategy. Individual firms must choose the performance measures that reflect the unique operations of their business. The performance parameters of strategic, tactical, and operational level were identified. To perform statistical analysis, principal component extraction method of factor analysis with varimax rotation was applied using SPSS software.

Key words: Natural convection solar hot water systems, Pressurized and non-pressurized solar water heating systems

1. Introduction

Any business is composed of three main activity namely input, processing and output. If we consider the manufacturing sector, the processing activity is performed the firm itself, the input to the firm are man machine and material and further the output is the product of the company. According to Sukati et. al. (2012), supply chain is the set of nodes or activities through which values are added and connects the enterprise's suppliers as well as its customer. As the size of the organization or business increases the number of the intermediate units or sub units also surges and the supply chain network become large and complex and this complex network is very difficult to manage or coordinate. But with the advent of the electronic information system or technology and computer it is become quite easy to handle or coordinate such complex network. Marinagi et al. (2014); Subramanian and Gunasekaran (2015) told that techniques of information technology and methods can help companies to become efficient, increase their productivity and thereby respond rapidly to customer needs. The implementation of information technology in businesses should be incorporated in active areas. Barros et al. (2015) proposed a model depicting the evaluation of the influences of the adoption of Information are Cost reduction, Operational efficiency and process improvement, Quality, reliability, and accuracy of information, Integration and collaboration. Premkumar G. P. (2000); Shaik M. N. and Abdul K. W. (2013) explained that the adoption of inter organizational information systems (IOS) for supply chain management has been proposed to enable external integration which include Electronic Data Interchange (EDI) networks, extranets, customer oriented strategic systems, electronic commerce (e-commerce) and electronic markets. Rylkova Z. and Bernatik W. (2013) emphasized that to obtain objectives or ensure continuous improvement, the performance of the processes must be measured

2. Literature Review

Sukati et al. (2012) told that a supply chain may be described as the set of values adding activities connecting the suppliers and its customers of the enterprise. Marinagi (2014) defines supply chain that a supply chain is a system that contains of dealers, producers, warehouses, distributors and retailers who

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coordinate their strategies and actions in order to translate raw resources to finished goods to deliver to the ultimate user. Gunasekaran A. and Ngai E. W. T. (2004) explored in their research that effective supply chain management is important to build and sustain competitive advantage in product and services of the firms. Barua et al. (2004); Rai A., Patnayakuni R. and Seth N. (2006); Huo et al. (2015) told that although information technology can potentially boost supply chain management, many firms fail to realize this potential due to the lack of supply chain coordination over information technology, or since their dealing associates may not have the capability to align with them.. Marinagi et al., (2011) and Torabizadeh et al. (2012), told that alignment of information systems with supply chain management strategies and explained how they affect on supply chain and performance of the organization. Jeyaraj A. and Seth B. (2010) and Subramanian and Gunasekaran (2015) demonstrate that the information technology of a supply chain refer to handling information flows in modern, global supply chains. Bayraktar et al. (2009) told that due to intensifying competition in global markets, today's most of the companies have been increasingly integrating supply chain management with information systems practices. In their research they found that there is a moderating impact with regard to the relationship between information systems practices and operational performance. Singh A. and Teng J. T. C. (2016) suggested that where Inter-organizational system empowered B2B e-commerce arrangements were found to reduce transactional costs.
Gunasekaran et al. (2001) explained the supply chain performance as its overall productivity and effectiveness. Beamon (1999) recommends three aspects for measuring supply chain performance, namely, assets measurement, productivity measurement, and flexibility. Singh et al. (2016), define supply chain performance for tractability, incorporation, and customer responsiveness**.** According to Kumar et al. (2015), performance measurement can be defined as the process of quantifying the effectiveness of various procedures being followed by the business.

2.1 Identification of performance parameters

Frohlich (2002); Rai A., Patnayakuni R. and Seth N. (2006), explained that for effective measurement of performance and improvement, goals of measurement must represent organizational goals and metrics selected should show an equal approach between financial and non-financial measures that can be related to strategic, tactical and operational levels of decision making and control. By the extensive literature review twenty seven parameters are chosen, as shown in Table-1.

2.2 Research Methodology

Research methodology in this work includes, development of questionnaire, data collection, and statistical analysis of the collected data with reference to the identified performance parameter.

2.3 Questionnaire Development

A questionnaire is developed on five point likert scale, in which '1' is taken for the least importance and '5' for the most importance. This questionnaire consists of three segments. In the first segment, the detail of industry was asked from field experts in which they are working. The second segment includes the twenty seven performance parameters of strategic, tactical and operational level in combined form. The third segment or the last segment of the questionnaire includes details of the profile of the field expert. This questionnaire is uploaded on the google in the form of google form for data collection. The respondents for questionnaire were the field experts, working in different industries in Delhi NCR mostly in automobile sector; however some field experts are from other industries. The Questionnaire is sent to two hundred seventeen number of the field experts, working in different organization located near about National Capital Region Delhi for their response. The mode of communication of the questionnaire was mainly email; however the responses were received on the google form. Total sixty responses were received. Hence the response rate is 27.64%

2.4 Statistical Analysis

The reliability test of collected data is done using SPSS software. The value of Cronbach's alpha (α) for the collected data comes as 0.932. According to Liu et al. (2013); Kumar et al (2015) and Nunnally (1978) the value of Cronbach's α, should exceeds the minimum requirements of 0.5 for an exploratory study. Hence on the basis of the Cronbach's α reliability test, our data may be utilized for further exploratory study.

3. Result and Discussion

The result of the reliability test shows that the collected data is fit for the exploratory study. To perform the factor analysis, principal component extraction method was applied with spss software support.

Table 1: Performance parameters

S. N	Parameter	References	Remarks
1	Proper responsiveness to urgent orders	Bhagwat R. and Sharma M. K.(2007); Rossiter J. R. (2009); Joshi S. (2013); Qrunfleh S. and Tarafdar M. (2014); Huo B. et al. (2015).	Urgent orders are taken on priority as compared to the existing orders, and organization equipped with IT has to deal with this situation properly.
2	Forecast ease for market demand	Bhagwat R. and Sharma M. K.(2007); Tracht K. et al. (2013); Colin M. et al. (2015); Kumar R. et. al. (2015).	IT enabled supply chain helps for market demand forecasting i.e. to know about the near future sale or consumption.
3	Productivity improvement	Marinagi C. et al. (2014); Barros A. P. D. et al. (2015).	It means the number of item of required quality produced or amount of service given in a specified time.
4	Proper visualization of customer needs	Marinagi C. et al. (2014); Qrunfleh S. and Tarafdar M. (2014); Barros A. P. D. et al. (2015); Huo B. et al. (2015); Kumar R. et al. (2015).	IT enabled supply chain helps in understanding that what the customer wants.
5	Total lead time reduction	Tracht K. et al. (2013); Azfar K. R. W. et al. (2014); Colin M. et al. (2015).	It means the time elapsed between the moment customer places an order and get the delivery. IT enabled supply chain helps in reduction of total lead time
6	Total Inventory cost reduction	Tracht K. et al. (2013); Azfar K. R. W. et al. (2014); Qrunfleh S. and Tarafdar M. (2014); Kumar R. et al. (2015).	Less number of items for less time are stored in IT enabled supply chain.
7	Increase the level of Customer satisfaction	Tracht K. et al. (2013); Barros A. P. D. et al. (2015).	
8	Improve the relationships with suppliers and customer relation	Tracht K. et al. (2013); Marinagi C. et al. (2014); Barros A. P. D. et al. (2015).	In IT enabled supply chain it is very easy make fast and clear communication with supplier and customer hence improved relationship.
9	Proper visibility among the supply chain stages	Azfar K. R. W. et al. (2014); Qrunfleh S. and Tarafdar M. (2014).	IT enabled supply chain has proper visibility among its stages
10	Helps in enhancing the cooperation among the existing stages	Rylkova Z. and Bernatik W. (2014); Marinagi C. et al. (2014); Subramanian N. and Gunasekaran A. (2015).	Information Technology enhances the cooperation among the existing stages of supply chain
11	Helps in Maintaining the stability in the competitive market place	Marinagi C. et al. (2014); Subramanian N. and Gunasekaran A. (2015).	IT enabled sc helps to understand the strategy of the competitor and the decision are taken accordingly, which helps in Maintaining the stability in the competitive market place.
12	Easiness in Decision making	Luthra S. and Haleem A. (2015); Colin M. et al. (2015); Singh A. and Teng J. T.C. (2016).	As the required information for making a decision is received fast and correct, the manager feels easiness in Decision making.
13	Reduction in coordination cost	Marinagi C. et al. (2014); Colin M. et al. (2015); Singh A. and Teng J. T.C. (2016).	There is no need to go everywhere physically and the communication may be made easily and fast in IT enabled supply chain, which reduces coordination cost
14	Information processing capability	Marinagi C. et al. (2014); Colin M. et al. (2015); Singh A. and Teng J. T.C., (2016),	IT enabled supply chain enhances information processing capability
15	partnership structure enhancement	Marinagi C. et al. (2015); Barros A. P. D. et al. (2015); Singh A. and Teng J. T.C. (2016).	Due the transparency ease, clarity and proper visibility in the business, IT enabled supply chain enhances the structure of partnership
16	Helps in automation of exchange procedures	Singh A. and Teng J. T.C. (2016).	Automation means the no interfere of human for the activity and the IT enabled supply chain makes the automation of exchange procedures.
17	Reduction in uncertainty	Koh S.C.L. and Saad S. M. (2006); Bayraktar E. et al. (2009); Singh A. and Teng J. T.C. (2016).	Use of the Information Technology reduces uncertainty in any business activity.
18	Reduction of non-value added activities	Qrunfleh S. and Tarafdar M. (2014); Azfar K. R. W. et al. (2014).	IT enabled supply chain, non-value added activities are reduced
19	Improve the Reengineering capability	Denolf J. M. et al. (2015); Barros A. P. D. et al. (2015).	Use of the Information Technology, due to its vast application in the business sphere, its reengineering capability is improved.

20	Improve the Capability to integrate different business activities	Bayraktar E. et al. (2009); Marinagi C. et al. (2014); Barros A. P. D. et al. (2015); Colin M. et al. (2015).	Any business includes various smaller or sub activities and for a effective business all the sub activities are to be joined in proper manner.
21	Reduce the customer order path	Gunasekaran A. et al. (2004); Denolf J. M. et al. (2015).	Use of the Information Technology, reduces the customer order path i.e. the channels or the steps which have to approach by the customer to place an order.
22	Reduce the Purchase order cycle time	Gunasekaran A. et al. (2004); Colin M. et al. (2015); Kumar R. et. al. (2015).	Use of the Information Technology, reduces the Purchase order cycle time i.e. the time elapsed to place a purchase order; hence the IT enabled supply chain.
23	Flexibility capability Enhancement	Gunasekaran A. et al. (2004); Azfar K. R. W. et al. (2014).	Flexibility means to fulfill the varying demand of the customer without the major change in the existing setup of the organization.
24	Helps in Quality improvement	Gunasekaran A. et al. (2004); Qrunfleh S. and Tarafdar M. (2014).	IT enabled supply chain helps in Quality improvement
25	Improvement in the Effectiveness of scheduling techniques	Gunasekaran A. et. al. (2004); Tracht K. et al. (2013),	Scheduling means that the clock and calendar time fixed to do an activity and use of the Information Technology in scheduling techniques i.e. JIT, MRP and MIS etc improves the effectiveness of scheduling techniques
26	Reduction in customer query time	Gunasekaran A. et al. (2004); Qrunfleh S. and Tarafdar M. (2014); Kumar R. et al. (2015).	When a customer seeks the information about the product or service, the time elapsed for it is reduced by use of the Information Technology.
27	Helps the Top Management in taking Initiative for an activity	Luthra S. and Haleem A. (2015); Denolf J. M. et al. (2015); Kumar R. et. al. (2015).	IT enabled supply chain helps the Top Management in taking Initiative for an activity

Table 2: Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	10.250	37.962	37.962	10.250	37.962	37.962	3.764	13.941	13.941
2	2.275	8.425	46.388	2.275	8.425	46.388	3.423	12.676	26.617
3	1.854	6.865	53.253	1.854	6.865	53.253	3.227	11.952	38.569
4	1.634	6.053	59.306	1.634	6.053	59.306	3.036	11.244	49.813
5	1.422	5.265	64.571	1.422	5.265	64.571	2.399	8.884	58.697
6	1.369	5.071	69.643	1.369	5.071	69.643	2.378	8.806	67.503
7	1.113	4.121	73.764	1.113	4.121	73.764	1.691	6.261	73.764
8	0.976	3.615	77.380						
9	0.788	2.919	80.298						
10	0.675	2.501	82.800						
11	0.673	2.492	85.292						
12	0.543	2.013	87.305						
13	0.500	1.852	89.157						
14	0.421	1.559	90.716						
15	0.370	1.372	92.088						
16	0.342	1.268	93.355						
17	0.289	1.070	94.426						
18	0.265	0.983	95.409						
19	0.260	0.961	96.370						
20	0.221	0.820	97.190						
21	0.210	0.776	97.966						
22	0.161	0.596	98.562						
23	0.134	0.496	99.058						
24	0.096	0.357	99.415						
25	0.079	0.291	99.706						
26	0.047	0.173	99.879						
27	0.033	0.121	100.000						
Extraction Method: Principal Component Analysis.									

Table 3: Case Processing Summary

		N	%
Cases	Valid	56	93.3
	Excluded[a]	4	6.7
	Total	60	100.0
a. List wise deletion based on all variables in the procedure.			

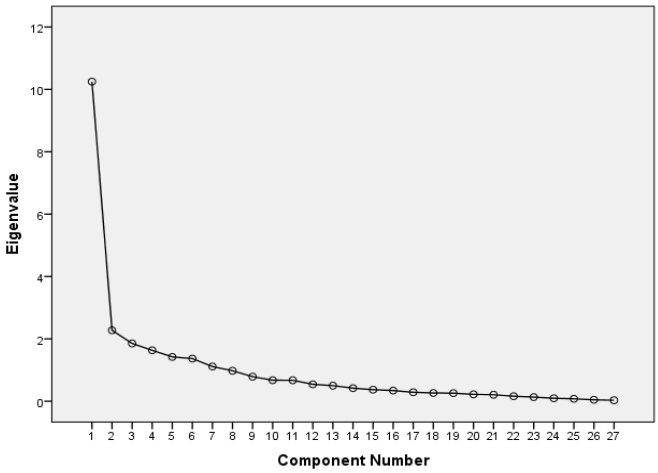

Figure 1: Variation of eigen value and component number

In the fig. 1 the scree plot is drawn, showing eigen values of the all of the twenty seven parameters. In this plot, the components are taken on the horizontal axis and the eigen value of the parameters are given on the vertical axis. It may be seen from the scree plot that there are seven parameters those have the eigen value more than 1.

The eigen value, extraction sum of square loading and rotation sum of square loading of the components are calculated in terms of the total, percentage variable and percentage cumulative using principal component analysis of extraction method. The component matrix is given in table 5, showing the factor loading of the components and on the basis of the factor loading, seven components have been extracted.

Table 4 Reliability Statistics

Cronbach's Alpha	N of Items
.932	27

Table 5: Component Matrix

	Component						
	1	2	3	4	5	6	7
VAR00022	0.784						
VAR00011	0.776						
VAR00026	0.775						
VAR00012	0.768						
VAR00020	0.751						
VAR00008	0.744						
VAR00003	0.674		-0.534				
VAR00019	0.670				-0.552		
VAR00024	0.654						
VAR00005	0.651						
VAR00021	0.624						
VAR00027	0.620						
VAR00014	0.604	0.509					
VAR00017	0.597						0.469
VAR00013	0.590						
VAR00007	0.589		-0.535				
VAR00015	0.567		0.465				
VAR00018	0.566	-0.475					
VAR00002	0.560						
VAR00004	0.549		-0.449				
VAR00016	0.545		0.418				
VAR00006	0.540				0.484		
VAR00009	0.537	-0.515					
VAR00025	0.496	0.565					
VAR00023		0.563	0.406				
VAR00001				0.771			
VAR00010	0.540					0.550	
Extraction Method: Principal Component Analysis.							
a. 7 components extracted.							

Table 6: Rotated Component Matrix

	Component						
	1	2	3	4	5	6	7
VAR00013	0.728				0.436		
VAR00005	0.707	0.440					
VAR00019	0.690					0.445	
VAR00020	0.575		0.491				
VAR00022	0.569						
VAR00012	0.510			0.419			
VAR00004		0.775					
VAR00003		0.749					
VAR00007		0.744					
VAR00026		0.544			0.419		
VAR00016			0.668			0.431	
VAR00027			0.660				
VAR00021	0.567		0.608				
VAR00006		0.441	0.579				
VAR00015			0.504	0.415			
VAR00010				0.814			
VAR00009				0.785			
VAR00011				0.627			
VAR00008		0.462		0.487			
VAR00024							
VAR00025					0.746		
VAR00023					0.743		
VAR00014	0.446				0.560		
VAR00018						0.784	
VAR00017						0.743	
VAR00001							0.795
VAR00002			0.533				0.541
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.[a]							
a. Rotation converged in 27 iterations.							

Table-7: Component Transformation Matrix

Component	1	2	3	4	5	6	7
1	0.508	0.445	0.445	0.414	0.259	0.313	0.095
2	0.230	-0.113	0.062	-0.396	0.722	-0.445	0.234
3	-0.178	-0.770	0.441	0.208	0.203	0.311	0.002
4	-0.368	0.115	-0.139	0.139	0.031	0.153	0.888
5	-0.654	0.361	0.507	0.100	0.126	-0.347	-0.199
6	-0.070	-0.083	-0.501	0.720	0.354	-0.246	-0.180
7	-0.298	0.216	-0.276	-0.284	0.478	0.634	-0.277
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.							

In the rotated component matrix, it is shown that which factor contributes a component significantly. Factor loading above 0.6 is taken as the significant loading. The factors having loading less than 0.6 will be eliminated from the further study. Also, using the rotated component matrix, the remaining factors are grouped into the seven components based upon the factor loading. For example, factors 13, 5, 19, 20, 22, 12, 21 and 14 have loading 0.728, 0.707, 0.690, 0.575, 0.569, 0.510, .567 and 0.446 respectively, for component 1. So, the factors 20, 22, 12, 21 and 14 may be considered as eliminated and the factors 13, 14 and 19 will be considered as the part of the component 1 for the further study. Similarly, component 2 comprises of factors 4, 3 and 7, component 3 comprises factors 16, 27 and 21, component 4 comprises of factors 10, 9 and 11, component 5 comprises of factors 25 and 23, component 6 comprises of 18 and 17 and component 7 comprises of factors 1. The retained factors are given in table 8.

Table 8: Retained Factor

S. No.	Parameter Number and Name
1	(5) Total lead time reduction
	(13) Reduction in coordination cost
	(19) Improve the Reengineering capability
2	(4) Proper visualization of customer needs
	(3) Productivity improvement
	(7) Increase the level of Customer satisfaction
3	(16) Helps in automation of exchange procedures
	(27) Helps the Top Management in taking Initiative for an activity
	(21) Reduce the customer order path
4	(10) Helps in enhancing the cooperation among the existing stages
	(9) Proper visibility among the supply chain stages
	(11) Helps in Maintaining the stability in the competitive market place
5	(25) Improvement in the Effectiveness of scheduling techniques
	(23) Flexibility capability Enhancement
6	(18) Reduction of non-value added activities
	(17) Reduction in uncertainty
7	(1) Proper responsiveness to urgent orders

4. Result and Discussion

(i) Twenty Seven Performance Parameters as per the table 1 were identified based on the literature review and the discussion held with the field experts of the supply chain.

(ii) Reliability test is performed, in which the value of Cronbach's alpha (α) for the data collected of these twenty seven parameters was calculated 0.932 and the data is found fit for an exploratory study.

(iii) Communalities initial and after extraction of all the parameters are calculated. Total variance, the eigen value, extraction sum of square loading and rotation sum of square loading of the components are calculated in terms of the total, percentage variable and percentage cumulative using principal component analysis of extraction method.

(iv) The Scree plot for the components is given in the figure 1, which shows that there are seven components having Eigen values greater than 1.Scree plot is drawn, which shows there are seven components having eigen value greater than 1.

(v) Based the statistical analysis the parameters having poor loading extracted from further study and remaining are grouped into seven components as per the table 2.

In the rotated component matrix, it is shown that which factor contributes a component significantly. Factor loading above 0.6 is taken as the significant loading. The factors having loading less than 0.6 will be eliminated from the further study. Also, using the rotated component matrix, the remaining factors are grouped into the seven components based upon the factor loading. For example, factors 13, 5, 19, 20, 22, 12, 21 and 14 have loading 0.728, 0.707, 0.690, 0.575, 0.569, 0.510, .567 and 0.446 respectively, for component 1. So, the factors 20, 22, 12, 21 and 14 may be considered as eliminated and the factors 13, 14 and 19 will be considered as the part of the component 1 for the further study. Similarly, component 2 comprises of factors 4, 3 and 7, component 3 comprises factors 16, 27 and 21, component 4 comprises of factors 10, 9 and 11, component 5 comprises of factors 25 and 23, component 6 comprises of 18 and 17 and component 7 comprises of factors 1. The retained factors are given in table 8.

5. Conclusion

For the performance evaluation of the IT enabled supply chain, twenty seven performance parameters were identified based on the literature review and the discussion held with the field experts of the supply chain. Reliability test is performed, in which the value of Cronbach's alpha (α) for the data collected of these twenty seven parameters was calculated 0.932 and the data is found fit for an exploratory study. Communalities initial and after extraction of all the parameters are calculated. Total variance, the eigen value, extraction sum of square loading and rotation sum of square loading of the components are calculated in terms of the total, percentage variable and percentage cumulative using principal component analysis of extraction method. Based the statistical analysis the parameters having poor loading extracted from further study and remaining are grouped into seven components.

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