

DESIGN OF QUESTIONNAIRE TOOL FOR ANALYTICAL STUDY OF LEAN - GREEN MANUFACTURING PRACTICES IN PUNE (INDIA)

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ABSTRACT

Sustainability into their strategies and activities. In response to the growing sustainability concerns, manufacturing companies have to formulate measures to evaluate sustainable manufacturing performance, aiming at integration of sustainability aspects. Generally, sustainability is evaluated by environment, social, and economic; known as the three pillars of sustainability. Although literature on sustainability is abundant and growing, very few studies have actually integrated sustainability into manufacturing performance. Sustainability has been integrated into manufacturing management areas such as product development, supply chain management, lean manufacturing, and supplier evaluation and selection. In this research, attempt is made to integrate sustainability into manufacturing performance and design a tool to evaluate sustainability into manufacturing performance.

Keywords: Questionnaire, Lean, Green, sustainable, integration, manufacturing performance.

INTRODUCTION: NEW GREEN MARKETING APPROACHES

Taylor's theory states the any motion study of individual process and workers can lead increase in production efficiency and put strong control resource utilization, According to the demand from customer management can always choose the best way to do the job to obtain correct productivity level with ascertaining quality parameters. Taylor also encouraged workers on the shop floor to understand the process well and to suggest improvements to reduce the inputs. He also said, management should pay a responsible role for suggestions by workers. Taylor also strongly emphasize on active participation of workers and supervisor to bring effective change and fair look to suggested methods by an employee of organization will help develop easy and moderated adopting strategy. Even Taylor realized that effective changes in an organization are not possible without active participation of workers. Ford introduced moving assembly line in 1993 reducing lead time to 93 minutes from 750 min. This could be possible because of production line had specialized and only task to do.

Now it was the turn of Japan to shake manufacturing world. Toyota terminated large part of their work force at the end of 1949 as a result of collapse in sales. This gave birth to criticism Taylor's mass production system. And new manufacturing system came into existence as a replacement, called TPS. TPS is considered as the summation of Lean system and TQC. TPS was very aggressive on reduction of waste and production free from any defects. Hence TPS became popular very quickly.

In the studies carried out by Convis and Ohno showed clearly that TPS is not just collection of concepts and tools to be commanded to control rather it is a full-fledged Philosophy which can take care of manufacturing and service at all stages. It is further highlighted by Shingo [Shingo1989] that the reason for failure of TPS could be the misunderstanding of the companies that TPS is just a tool and technique not manufacturing philosophy. Shingo [Shingo1989] also said HR is the most important factor in developing processing TPS. This should not be misunderstood as the tool to make workers redundant. But tool to develop the man power and empower them [Drickhamer2004]. Subsequently 1990 gave birth to the term Lean which was till the date referred as TPS and credit goes to Warnack, Jones and Rose. Lean first of all said create new work instead of cutting manpower for

efficiency. According to Marchwinski and Shook [Marchwinski and Shook2004] lean production is a system for organising and managing product development, operations, suppliers, and customer relations that requires less human effort, less space, less capital, less material and less time to make products with fewer defects to precise customer desires, compared with the previous system of mass production. The concepts of both Ohno [Ohno1988] and Womack/Jones [Womack and Jones2003] search for ways to reduce lead time by eliminating waste it can be said that the terms Lean and Toyota Production System are synonymous. However one of the drawback of Lean is, do not deliver detailed tools on waste reduction in indirect areas such as marketing, sales, research and development, branding, servicing or others.

21st century business around the world is focused on sustainability. Global warming has become a global agenda now. Developed, Developing and under developed countries have shown collective efforts to face this challenge at various international conventions. Environment friendly business practices has become a necessity of ethical business.

Increasing concerns worldwide to sustainability have pushed manufacturing companies to keep sustainability as top agenda. Looking at the humanitarian perspective and in the interest of mother earth businesses must take initiatives. Previous study has revealed, many companies wish to go green but unfortunately do not find a way. This paper is an effort to develop a tool to measure the level of greenness of any company in any sector. And then quantify it further to design a solution. Any companies sustainable manufacturing performance can be highlighted, by environment friendliness of the business, social practices to protect environment, and economics of environment protection; known as the three pillars of sustainability.

The researcher is focused on finding the green factor present into manufacturing performance by incorporating Green Manufacturing Performance Indicators with sustainable manufacturing indicators will be the key variables to study. As a result of this study KPI will be generated to lead sustainable manufacturing evaluations. To confirm the finding research will be further referred to field expert and interview with professionals. The basic objective behind identifying manufacturing performance indicators is to learn the current state of manufacturing world and to derive the scope of improvement. This will help monitor and control operational efficiency, to drive improvement programme, and to gauge the effectiveness of manufacturing decisions as a result [Baumann2002]. Five of the most commonly cited indicators to evaluate manufacturing performance are quality, cost, delivery waste,, and flexibility [Connelly and Smith2003].

THE INITIAL KPI FOR EVALUATING GREENESS

Based on a review on previous studies of the manufacturing performance indicators and the sustainable manufacturing indicators, the authors have developed a set of initial KPIs for sustainable manufacturing evaluation in automotive companies. The initial KPIs have been constructed from the integration of manufacturing performance indicators and sustainable manufacturing indicators. The initial KPIs have adopted the triple bottom line of sustainability consisting of environmental, economic, and social performance factors. Five manufacturing performance indicators of quality, cost, delivery, waste and flexibility are incorporated into the initial KPIs as economic performance dimensions. The other dimensions are derived from the literature. Finally, the initial KPIs consist of three factors of environmental, economic, and social performance and further divided into nine dimensions. A total of 53 sub-dimensions was then adopted and modified from relevant literature as shown in Table 4.

RESEARCH METHODOLOGY

Many companies in India have adapted Lean Philosophy to become market leader. As it is reiterated time and again in the lean manufacturing it has very wide scope towards waste management and effective resource management in all the processes of the business. Every company has to or better must customize the tools and techniques of managing 8 MUDA of Lean philosophy. The list of companies mentioned above have achieved lean enterprise status by sustaining to continues pressure of cost reduction quality enhancement and delivering time reduction in highly competitive market. Traditional business approach says high price high profit. And this is what TPS do not agree with. Selling price is the only option to increase the profit is orthodox viewpoint, and has no validity in current era. Sole concentration on improving its own efficiency, with a relentless focus on cost-cutting, quality improvements and lead time reduction can also give a company good dividends.

Based on the theoretical discussion in the literature review the research objective are as follows

1. To validate the understanding about Lean Philosophy and principles
2. To validate the understanding about green philosophy and practices
3. To identify and to describe critical success factors of Lean to Green
4. To Design a Tool (questionnaire) to quantify Leanness and Greeness of company

5. Test and validate the tool (Questionnaire)

Table1: Initial KPI of Sustainable Manufacturing Evaluation

1. Emissions	4. Quality	6. Delivery	(47)Supplier flexibility
(1)Air emission	(16)Product reliability	(32)On time delivery	9. Employee
(2)Water emission	(17)Product durability	(33)Delivery lead time	(48)T and D
(3)Land emission	(18)Adhering to specific	(34)Delivery speed	(49)On Job health,safety
(4)Hazardous emission	(19)Customer complaint	(35)Delivery Cycle time	(50)Turnover rate
2. Resource utilization	(20)Scrap and rework	(36)Due date adherence	(51) Job satisfaction
(5)Energy utilization	(21)Reject rate	(37)Schedule attainment	(52)Community Satisfy
(6)Water utilization	(22)quality of Work life	(38)Delivery Route	(53) Social awareness
(7)Fuel consumption	5. Cost	7. Waste	
(8)Land used	(23)Material cost	(39)Solid waste	
(9)HR Utilization	(24)Setup cost	(40)Hazardous waste	
3. Flexibility	(25)Overhead cost	(41)Waste water Economy	
(10)Volume flexibility	(26)Inventory cost	(42)Waste Handling	
(11)Product flexibility	(27)Unit cost	(43)Waste Management	
(12)New prod perfo	(28)R and D Cost	8. Supplier	
(13)Technology flexibility	(29)Process Cost	(44)Supplier certification	
(14)Manpower Flexibility	(30)Technology Cost	(45)Supplier commitment	
(15)Process flexibility	(31)Labor cost	(46)Supplier Punctuality	

In order to find out, whether organisations, which already have started implementing lean concepts, considered the theoretical aspects that have been explained, data was collected and theory was analysed regarding the application of the concepts in the sample. Data gathered from the sample was used to verify if organisations apply Green ideas in the original sense. Theory was tested against data, which is a deductive approach, in order to confirm or reject the applicability of the theory to the population. Therefore a quantitative method was used. The survey strategy is usually associated with the deductive approach. Using this method allowed the collection of a large amount of data, which afterwards was analysed.

Sampling technique and source

As described above, a survey-based research was used to make inferences from the sample to the population. In order to answer the research question, probability sampling was performed. Identifying a suitable sampling frame looking at the research question, the population consists of all organisations that are applying lean tools in order to improve their business processes and going Green. The sampling frame consisted of customers (continuous improvement managers and general managers) of the organisation. Therefore it can be said, that the sampling frame was relevant to the research topic. A sample taken out of this sampling frame was representative for the whole population, because these clients are organisations operating over the whole Pune. Companies from most of the industry sector as well as general industry were represented in the sampling frame, and it included cases, in which the lean implementation was very successful and further successfully implementing Green. Few cases where Lean implementation struggled, were also included. Hence it can be concluded, that the sampling frame was complete. It was moreover precise, because irrelevant cases were excluded as only organisations were represented which had made experiences with lean management applications.

PROPOSED WORK: PLOT STUDY

In order to investigate these KPIs of sustainable manufacturing in different companies, a questionnaire was developed. The questionnaire was divided into three main sections: (i) background information; (ii) perception of sustainable manufacturing; and (iii) perceived importance of the initial KPIs. The first section was intended to obtain some basic information, such as business size, types of certification gained, and experience in automotive industry as well as on sustainable manufacturing initiative. The second section on sustainable manufacturing perception provides the drivers, barriers, and benefits on which respondents were asked to rank their level of agreement. In the last section, respondents were asked to rank their level importance of the initial KPIs. These results will be used to develop a set of KPIs in evaluating sustainable manufacturing. A pilot study was conducted to validate and improve the questionnaire, in terms of the questions and statements content, wording, sequence, and also potential participant interest. A total of 16 forms were distributed to two groups of sustainable manufacturing experts: practitioners in automotive industry and professionals (academics and consultants). Nine responses were received, thus giving a 56 % response rate. The comments were generally concerned on questions and statements wording. For the initial KPIs, some terms were edited and corrected, for example, water emission was changed to water pollution, land emission was changed to land contamination, and due date adherence was

changed to due date compliance. One sub-element of cost element (i.e. unit cost) was removed, and rework cost was added as a new sub-element. In this way, the questionnaire was greatly improved. The questions and statements were corrected and improved in order to make them more clearly and accurate. In short, the questionnaire was validated through pilot study and provided improvement opportunities for the researchers before conducting the full survey. The survey will be conducted to Pune (India) Manufacturing sector companies which manufacture parts and accessories.

After performing reliability analysis using Cronbach's alpha method it is found that the items are having alpha value in the range greater than 0.6. Inter item correlation matrix was also showing the acceptable results. Therefore, no need to delete any item among the identified elements. Table shows the reliability result (Cronbach's Alpha value) for each success factor and performance measure.

Table2: Reliability Test for Input Factors

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.975	0.978	9

Normality Test:

Normality testing on the obtained data is performed in order to know that the data is normally distributed. The test is performed in SPSS software. Following results shows that the distribution of data is normal as 90 percent readings are coming under normal distribution curve. Each success factor is tested for the normality distribution of its responses.

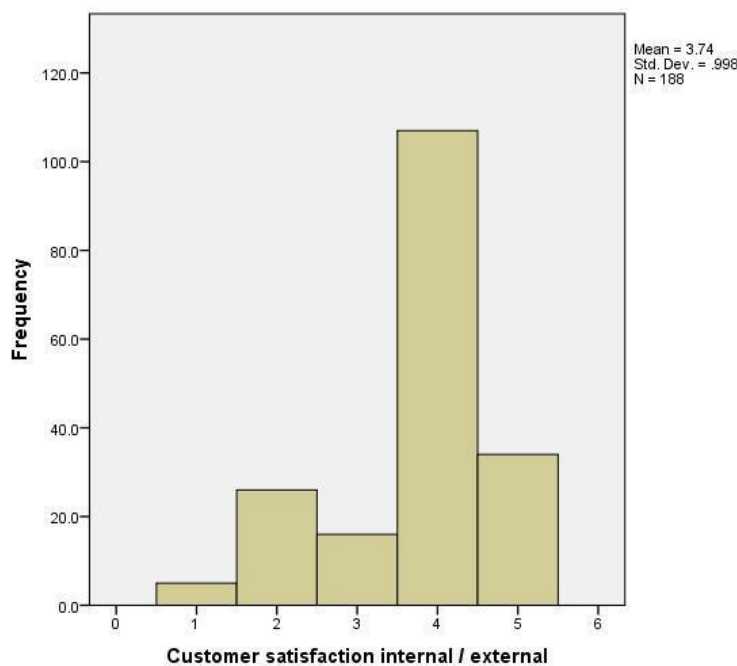


Figure1: Normality Test Result

Only two model graphs are shown to test the normality of the variables under this study. Likewise all the 12 critical success factors and 6 performance measures are tested for its normality. From the above graphs it can be said without any hesitation that 90 percent of the data is falling under normality curve. Hence, the obtained data follows the normal distribution and it is fit for performing statistical analysis on it.

Validity

The validity of a measure refers to the extent to which it measures what it was intended to measure. Based on the previous studies three different types of validity are considered:

1. Content validity,
2. Criterion-related validity and
3. Construct validity

Content Validity:

A Success factor has content validity if there is general agreement that the factor has items that covers all aspects of the variable being measured. Content validity is not evaluated numerically. It is subjectively judged by the researchers. Since the twelve measures of green supply chain management were developed based on exhaustive review of literature and detailed evaluation by the top level practitioners, they were considered to have content validity. Content validity depends on how well the researchers created the measurement items to cover the content domain of the variable being measured [P2000]. In this study the literature review is carried out in order to select the factors, as well as academia and industrial experts are also consulted for the same. Therefore chapter 2 specifies the content validity of the data obtained.

Construct Validity:

A factor has construct validity if it measures the theoretical construct that it is designed to measure. Muttar [Pickett1995] stated three methods of determining construct validity: multi-trait multi-method analysis, factor analysis and, correlation and partial correlation analysis. Out of these three methods, factor analysis is usually used to identify items, which should be included in a consistent measuring instrument [Pickett1995]. Given that one of the objectives of this study is to develop items/variables to assess each performance measure, factor analysis is chosen to evaluate construct validity, which is consistent with the literature [Baylis and Flynn1998]; [Angell2001]; [Quazi1999]; [Digalwar2004].

Criteria Related Validity:

Is concerned with the extent to which a measuring instrument is related to an independent measure of the relevant criterion. Criterion-related validity of the factors was evaluated by examining the multiple correlation coefficients computed for the twelve measures and the organizational performance. The multiple correlation coefficients obtained in most of the cases were above 0.5 ($p < 0.05$), providing strong evidence of criterion related validity [Azzone and Noci1998]. Table 4 3 gives the results for criterion related validity of the obtained data.

Table3: Coefficient of Correlations Outputs

		1	2	3	4	5	6	7
1	Customer satisfaction internal / external							
2	Waste Reduction	.828						
3	Productivity improvement	.736	.889					
4	Health and Safety	.453	.568	.516				
5	Goodwill	.106	.464	.535	.301			
6	Carbon Footprints mapping	.913	.741	.718	.617	.113		
7	Profit	.209	.379	.596	.327	.794	.223	

Table4: Coefficient of Correlations in Input Factors

Sr No		1	2	3	4	5	6	7	8	9
1	Leadership Vision and mission									
2	Feasibility Study of Green Business practices and policies	.846								
3	Gap analysis through competent agency for Green policies	.788	.869							
4	Employees Involvement through awareness campaign	.950	.931	.851						
5	Demand Analysis of Green Business	.932	.860	.889	.928					
6	Total Waste Management Study	.899	.908	.873	.980	.914				
7	Green Business Competitors Study	.952	.841	.854	.890	.929	.849			
8	Beneit analysis of Green Business	.635	.667	.503	.789	.603	.829	.456		
9	Study of suppliers in Green Business	.958	.813	.744	.925	.949	.883	.896	.667	

CONCLUSION

The tool designed for testing the Leanness and Greenness factor of any business as a whole is found to be working satisfactory. The validity tests, Normality tests and correlations test also has given good satisfactory results. The Questionnaire covers widely 9 input factors and 7 out factors (KPI). The questionnaire constitutes of 109 questions. Results obtained are very promising and validates the questionnaire to be used for further research before

commercial usage.

REFERENCES

- [Angell2001] Angell, L.C. (2001). Comparing the environmental and quality initiatives of badrige award winners. *Production and Operations Management*.
- [Azzone and Noci1998] Azzone, G. and Noci, G. (1998). Identifying effective pmss for the deployment of green manufacturing strategies. *International Journal of Operations Production Management*, 18(4), 308335.
- [Baumann2002] Baumann, H., B. F. B.A. (2002). Mapping the green product development field: engineering, policy and business perspectives. *Journal of Cleaner Production*, Vol. 10.
- [Baylis and Flynn1998] Baylis, R., C.L. and Flynn, A. (1998). Sector variation and ecological modernization: towards an analysis at the level of the firm. *Business Strategy and the Environment*, 7(2), 150161.
- [Connelly and Smith2003] Connelly, J. and Smith, G. (2003). *Politics and the environment*. Routledge Taylor and Francis Group.
- [Digalwar2004] Digalwar, A.K., M.B. (2004). Performance measurement framework for world class manufacturing. *International Journal of Applied Management and Technology*, 3(2), 83-101. ISSN: 1554-4740(www.ijamt.org).
- [Drickhamer2004] Drickhamer, D. (2004). *Lean manufacturing: The third generation*. Industry Week, March 2004.
- [Marchwinski and Shook2004] Marchwinski, C. and Shook, J. (2004). *Lean lexicon a graphical glossary for lean thinkers*. Second Edition, Version 2.0; Brookline, MA, USA.
- [Ohno1988] Ohno, T. (1988). *Toyota production system, beyond large-scale production*. Productivity Press, Portland, Oregon, USA.
- [P2000] P, C. (2000). Effects of best practices of environmental management on cost advantage: The role of complementary assets. *Academy of Management Journal* 43(4), 663680.
- [Pickett1995] Pickett, G.M., K. N. G.S. (1995). *An examination of the conserving consumer: implications for public policy formation in promoting conservation behavior*. *Environmental Marketing: Strategies, Practice, Theory, and Research*, The Haworth Press, New York, NY.
- [Quazi1999] Quazi, A.H. (1999). Implementation of an environmental management system: the experience of companies operating in singapore. *Industrial Management Data Systems*, vol. 99, ED-7, 302-311, 1999.
- [Shingo1989] Shingo, S. (1989). *A study of the toyota production system*. Productivity Press, Portland, Oregon, USA.
- [Womack and Jones2003] Womack, J.P. and Jones, D.T. (2003). *Lean thinking banish waste and create wealth in your corporation*. Free Press, New York, USA.