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Quantification of factors influencing productivity using AHP: An approach towards productivity improvement.

[1]Summaiya R Shaikh
[1]P.G. student at AGPIT, Solapur

[2]Satish R Dulange
[2]Assistant professor at AGPIT, Solapur

Abstract:

Improvement in productivity level plays a major role in the organisation success and securing the objectives of the organisation. The aim of this paper is to quantify the factors influencing productivity of power loom industry and suggest suitable improvement techniques for the same. By reviewing the literature based on factors affecting productivity and productivity improvement, factors from different scholars were listed.

Later experts were asked to identify and group the factors related to power loom industry. By utilizing the acquired factors from the experts a questionnaire was formed which was used as an input for AHP process.

Based on the results of AHP process in the form of weights of different factors, the most important factors were identified and prioritized using the ranking method. The important factors were the human resource factor which influenced 55% to productivity followed by process factor 20%.

The lean philosophy is best suited in order to control these factors and improve productivity [9] and [30].Hence suitable techniques from the lean philosophy which can be applied to power loom industry are identified. The application of these techniques can assure improvement in the productivity of power loom industry.

Keywords: Power loom, productivity, critical success factors, AHP.

1. Introduction:

The decentralised power loom sector is one of the most important segments of the Textile Industry in terms of fabric production and employment generation. It provides employment to 57.44 Lakh persons and contributes 62 percent to total cloth production in the Country. 60% of the fabrics produced in the power loom sector are of man-made. More than 60% of fabric meant for export is also sourced from power loom sector. The readymade garments and home textile sectors are heavily dependent on the power loom sector to meet their fabric requirement.

There are approximately 5.24 Lakh Power loom Units with 23.24 Lakh Power looms as on 30.09.2012. The technology level of this sector varies from obsolete plain loom to high tech shuttle-less looms. There are approximately 1, 05,000 shuttle less looms in this sector. It is estimated that more than 75% of the shuttle looms are obsolete and outdated with a vintage of more than 15 years and have virtually no process or quality control devices / attachments. [19]

India has only 2% shuttle-less looms as against the world average of 16%. Our competitors China, Pakistan and Indonesia have 15%, 9% and 9% respectively of shuttle-less looms. Large seasonal orders cannot be accomplished by the entrepreneurs due to inflexibility in labour laws.

In spite of favourable conditions, largest producer and availability of skilled labour the Indian textile industry is still lagging behind in export market share.

Hence the present study aims to find out the factors that influence the productivity through literature review and survey based questionnaire data along with quantification and prioritization of them using AHP in order to suggest corrective action or tool which would help in productivity improvement.

2. Literature review:

Chaudhuri et al. [2] have stated the role of productivity in explaining variation in investment growth suggests that there is a need to manage productivity improvements from growth point of view and not only for efficiency improvements; firms should also use the right mix of labour and capital and involve industry associations in educating industries on their needs. Firm size and firm-specific interest rate on long-term loans are the other factors significantly affecting investment growth.

Dolage et al. [4] investigates the influence of the adoption of Flexible Manufacturing Technology (FMT) on the Total factor Productivity Growth (TFPG) of Malaysia Manufacturing Industry using the two situations, one, including the industry fixed effects dummy variables and the other without these, are contrasted which account for the greater variation in FMT show positive and moderately significant relationship with TFPG.

Jain et al. [8] say that manufacturing flexibility is a critical component to achieve a competitive advantage in the market place. This paper presents a review of various issues related with manufacturing flexibility specifically concept, need, dimensions, measurement, relationship among various dimensions, implementation aspect in a company and management of manufacturing flexibility and its aim to contribute to the conceptual systemisation of the material.

Kottawata [10] in his research work has studied the apparel industry in Sri lanka. He has listed major attitudinal factors that affect job performance, such as absenteeism, Job satisfaction and organisational commitment which in turn affect productivity.

Liu & Li [13] have studied the growth factors in China's manufacturing industries, industrial productivity, technological progress and efficiency and concluded that China's industrial strength is based mainly in input growth, and the improvement in technical progress.

Murugesh et al. [16] have discussed the ignorance towards productivity during last two decades and how the recent developments in managerial philosophies Total Quality Management (TQM) & Business Process Re-engineering, Flexible manufacturing process (FMS), Computer integrated manufacturing (CIM) etc. and Information and technology (IT) innovations have made the traditional productivity improvement techniques obsolete by presenting a review on productivity consisting of analyses of literature on productivity and a survey of manufacturing enterprises.

San et al. [20] by using the Taiwanese manufacturing industry as an example are able to confirm that labour quality is an important contributing factor in explaining Taiwanese manufacturing sector's changes in productivity.

Seth & Tripathi [21] say that a combined application of Total Quality Management (TQM) and Total Productive Maintenance (TPM) brings out significantly higher improvements than individual drives in the Indian manufacturing industry. The study is based on data collected through a questionnaire as a research instrument and statistical analysis using Microsoft EXCEL 2000.

Sharma & Mishra [24] have examined the interrelation between exporting and productivity performance by using a representative sample of Indian manufacturing firms over the period 1994–2006 and concluded that entering in the export market does not improve productivity performance but exit from the export market does have an adverse effect on the productivity.

Shayan & Sobhanallahi [25] suggest that significant improvements at very low costs are possible at managerial and other work force levels, by introduction of appropriate production management systems. This paper discusses some of the major factual results and discussions of the effects of implementation of a cellular manufacturing environment.

The factors discussed in the above literature can be represented in a tabular form as shown below:

Table 1 Literature review.

Sr No.	Source	**Research issues**
01	Brah and Chong (2004)	Total productive maintenance
02	Chaudhuri et al. (2010)	Right mix of labour, capital, education to workers i.e. training
03	Chummar et al. (2013)	Technology up-gradation
04	Dolage et al. (2010)	Manufacturing flexibility.
05	Homyun et al. (2009)	Labour technique, labour management, labour force and labour characteristics
06	Jain et al. (2013)	Manufacturing flexibility.
07	Kottawata (2007)	Attitudinal factors that affect job performance, such as absenteeism, Job satisfaction and organisational commitment
08	Kumar et al. (2006)	Lean philosophy
09	Lee and Johnson (2010)	Market demand fluctuation
10	Liu and Li (2012)	Input growth and technical progress
11	Murugesh et al. (2010)	Managerial philosophies like Total Quality Management (TQM) & Business Process Re-engineering, Flexible manufacturing process (FMS), Computer integrated manufacturing (CIM) and Information and technology (IT) innovations.
12	Propenko J (1993)	Production, technical changes and investment accumulation, human factor, innovation and creativity, improvement and correction of methods of performing duties, management style, training, labour culture, Technological changes, labour force capability, the amount of capital proportionate to the labour force unit
13	Propenko J and North K (1996)	General factors, organizational and technical factors, human factors
14	Salum (2000)	Cellular manufacturing
15	San et al. (2008)	Labour quality
16	Seth and Tripathi (2007)	Total Quality Management (TQM) and Total Productive Maintenance (TPM)
17	Shanmugasundaram and Panchanatham (2011)	Labour relation, training, motivation.
18	Sharma and Mishra (2010)	Export market
19	Shayan and Sobhanallahi (2002)	Appropriate production system (Cellular manufacturing)
20	Sumanth, D. J. (1995)	Physical factors, mental factors
21	Sutermeister, R.A. (1969)	Occupational performance of employees (physical conditions, social conditions, capability, development of technology, personal conditions of individuals, official and non-official groups, capability)
22	Tanuwidjaja and Thangavelu (2007)	Technological up-gradation

3. Identification of factors by experts for textile domain:

The above table shows the list of different factors influencing productivity as stated by various scholars. But out of these factors only those factors which are applicable to power loom industry are identified by a team of four experts, out of which two were academicians and two were from industrial background. There were about 24 factors classified into five groups which were considered as listed below:

Table 2 Factors identified by experts.

Name of factor	Meaning		Name of sub-factor
(A) Process factor	It comprises of all the factors which affect the main production process of the product.	A1	Maintenance
		A2	Lead time
		A3	Production standard
		A4	Level of technology
		A5	Management philosophy
		A6	Yarn quality
(B) Human resource factor	It comprises of all the factors related to attitude, managerial skills and professional practices of workers, supervisors and managers.	B1	Training
		B2	Motivation
		B3	Labour turnover
		B4	Labour relation
		B5	Absenteeism and lateness
		B6	Bonus
		B7	Wages
(C) Product factor	It comprises of all the factors that affect the final product.	C1	Flexibility
		C2	Quality
		C3	Optimum volume
		C4	Cost
(D) Control factor	It comprises of all the factors which can be controlled at the plant level.	D1	Inventory
		D2	Rejection level
		D3	Repair level
(E) External factor	It comprises of all the factors which are beyond the control of entrepreneur.	E1	Plant location
		E2	Market demand
		E3	Export destination
		E4	Worker education

The above listed factors are being taken into consideration while performing AHP. These factors can be expressed in a generalised hierarchical form as shown below.

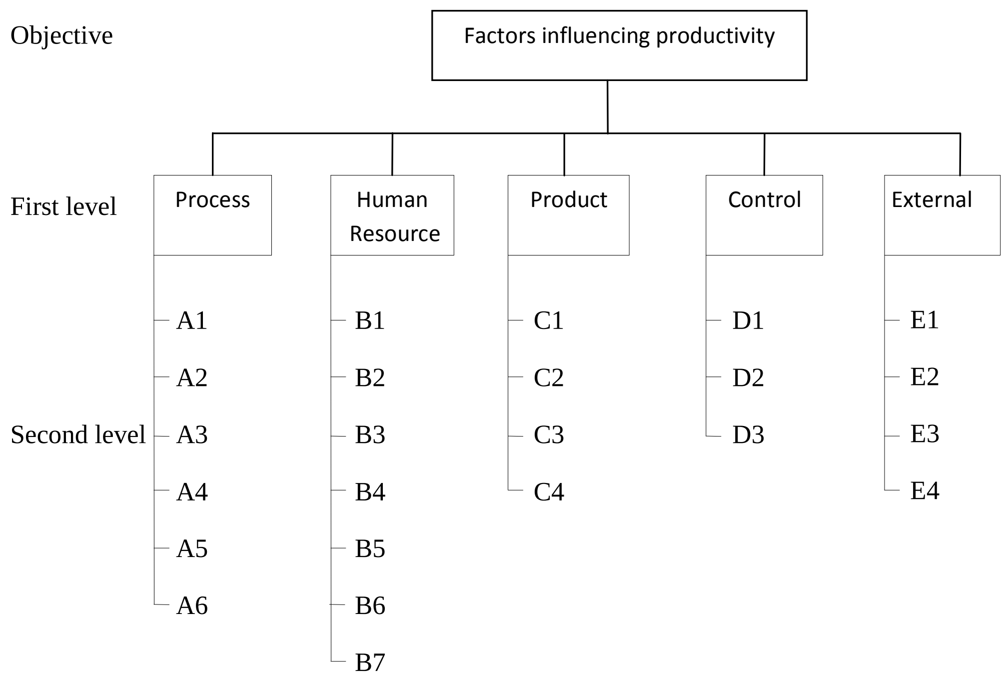

Fig 1: Generalised hierarchical representation of factors influencing productivity.

4. Analytical hierarchical programming (AHP):

4.1 Introduction:

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making approach and was introduced by Saaty (1977 and 1994). The AHP has attracted the interest of many researchers mainly due to the nice mathematical properties of the method and the fact that the required input data are rather easy to obtain. The AHP is a decision support tool which can be used to solve complex decision problems. It uses a multi-level hierarchical structure of objectives, criteria, sub-criteria, and alternatives. The pertinent data are derived by using a set of pair-wise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion. If the comparisons are not perfectly consistent, then it provides a mechanism for improving consistency.
Steps to perform AHP:

The AHP provides a means of decomposing the problem into a hierarchy of sub-problems which can more easily be comprehended and subjectively evaluated. The subjective evaluations are converted into numerical values and processed to rank each alternative on a numerical scale.

4.2 The methodology of the AHP:

***Step 1*: The problem is decomposed into a hierarchy of goal, criteria, sub-criteria and alternatives.
***Step 2*: Data are collected from experts or decision-makers corresponding to the hierarchic structure, in the pair-wise comparison of alternatives on a qualitative scale as described below.
Experts can rate the comparison as equal, marginally strong, strong, very strong, and extremely strong.
***Step 3*: The pair-wise comparisons of various criteria generated at step 2 are organised into a square matrix.
***Step 4*: The principal Eigen value and the corresponding normalised right eigenvector of the comparison matrix give the relative importance of the various criteria being compared.
***Step 5*: The consistency of the matrix of order *n* is evaluated.
***Step 6*: The rating of each alternative is multiplied by the weights of the sub-criteria and aggregated to get local ratings with respect to each criterion.

In this paper an AHP template by Klaus D Goepel is used for evaluation purpose. The AHP template works under Windows OS and Excel version MS Excel 2010 (xlsx extension). The workbook consists of 20 input worksheets for pair-wise comparisons, a sheet for the consolidation of all judgments, a summary sheet to display the result, a sheet with reference tables (random index, limits for geometric consistency index GCI, judgment scales) and a sheet for solving the Eigen value problem when using the eigenvector method (EVM).

4.3 Results

The result table will show all criteria with calculated weights and rank, using the EVM:

	Criterion	Comment	Weights	Rk
1	Criterion 1	First Criterion	27,9%	2
2	Criterion 2	Second Criterion	7,2%	3
3	Criterion 3	Third Criterion	64,9%	1
4				
5				
6				
7				
8				
9		for 9&10 unprotect the input sheets and expand the		
10		question section		

Principal Eigen value lambda and consistency ratios GCI (geometric consistency index) and CR (consistency ratio)

Eigenvalue			lambda:	3,000
Consistency Ratio	0,37	GCI: 0,00	CR:	0,0%

In the section below the comparison matrix along with the normalised vectors is displayed:

Matrix		Criterion 1 1	Criterion 2 2	Criterion 3 3	0 4	0 5	0 6	0 7	0 8	0 9	0 10	normalized principal Eigenvector
Criterion 1	1	1	5	1/3	-	-	-	-	-	-	-	27,9%
Criterion 2	2	1/5	1	1/7	-	-	-	-	-	-	-	7,2%
Criterion 3	3	3	7	1	-	-	-	-	-	-	-	64,9%
0	4	-	-	-	1	-	-	-	-	-	-	0,0%
0	5	-	-	-	-	1	-	-	-	-	-	0,0%
0	6	-	-	-	-	-	1	-	-	-	-	0,0%
0	7	-	-	-	-	-	-	1	-	-	-	0,0%
0	8	-	-	-	-	-	-	-	1	-	-	0,0%
0	9	-	-	-	-	-	-	-	-	1	-	0,0%
0	10	-	-	-	-	-	-	-	-	-	1	0,0%

4.4 Scale used:

Pair-wise comparisons are quantified by using a **scale**. Such a scale is a one-to-one mapping between the set of discrete linguistic choices available to the decision maker and a discrete set of numbers which represent the importance, or weight, of the previous linguistic choices.

In 1846 Weber stated his law regarding a stimulus of measurable magnitude. According to his law a change in sensation is noticed if the stimulus is increased by a constant percentage of the stimulus itself [31]. That is, people are unable to make choices from an infinite set. Psychological experiments have also shown that individuals cannot simultaneously compare more than seven objects (plus or minus two) [15]. This is the main reasoning used by Saaty to establish 9 as the upper limit of his scale, 1 as the lower limit and a unit difference between successive scale values. The values of the pair-wise comparisons in the AHP are determined according to the scale introduced by [31] as shown in table

Table 3: Scale used in AHP (Saaty 1980)

Intensity of Importance	Definition	Explanation
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one activity over another
5	Essential or strong importance	Experience and judgment strongly favor one activity over another
7	Demonstrated importance	An activity is strongly favored and its dominance demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals of above nonzero	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i.	

4.5 Consistency

Consistency ratios are calculated in all *input sheets* and in the *summary sheet*. With λmax the calculated principal Eigen value - either based on the priority eigenvector derived from RGMM in the input sheet or derived from EVM in the summary sheet – the consistency index *CI* is given as

$$CI = \frac{(\lambda_{\max} - N)}{N - 1}$$

The consistency *ratio CR* is calculated using

$$CR = \frac{CI}{RI}$$

The value of RI is taken from the table of random consistency index table as shown below for n number of experts.

n	1	2	3	4	5	6	7	8	9
RCI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

In the AHP the pair-wise comparisons in a judgment matrix are considered to be adequately consistent if the corresponding consistency ratio (CR) is less than 10% [31]. Hence if the CR value is greater than 0.10, then it is a good idea to study the problem further and revaluate the pair-wise comparisons.

5. Case Study on power loom:

5.1 Questionnaire formation

Considering the factors identified by the experts a questionnaire for AHP input was designed which is shown below: ***Please fill the following questionnaire judiciously.***

Part A: Compare the relative preference with respect to: main criteria < goal using the following **Saaty scale 1 to 9 where (1= equally important, 2= equally to moderately, 3= moderately preferred, 4= moderately to strongly, 5= strongly preferred, 6= strongly to very strongly, 7= very strongly preferred, 8= very strongly to extremely, 9= extremely preferred)**

Table 4: AHP Questionnaire.

Sr no	Evaluation criteria	Numerical scale																	Evaluation criteria
1	Process	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Human resource
2	Process	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Product
3	Process	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Control
4	Process	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	External
5	Human resource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Product
6	Human resource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Control
7	Human resource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	External
8	Product	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Control
9	Product	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	External
10	Control	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	External

5.2 Result:

The above questionnaire was filled by 4 experts and the consolidated result for each factor is displayed in the form of following matrices in the form of weights and ranking.

5.2.1 Part A: For Goal (Main factors are considered)

AHP Analytic Hierarchy Process (EVM multiple inputs)
K. D. Goepel Version 12.08.2013 http://bpmsg.com
Only input data in the light green fields and worksheets!

n=	5	Number of criteria (3 to 10)	Scale:	1	Linear
N=	4	Number of Participants (1 to 20)	α:	0.1	Consensus: 99.5%
p=	0	selected Participant (0=consol.)	2	7	Consolidated

Objective To find out the factor that influences productivity the most.

Author S R Shaikh

Date 20-Jan-14

EVM check: 1.57341E-09

Table

	Criterion	Comment	Weights	Rk
1	Process factor		20.4%	2
2	Human resource		55.1%	1
3	Product		10.3%	4
4	Control		11.0%	3
5	External		3.3%	5

Result

Eigenvalue			lambda:	5.398
Consistency Ratio	0.37	GCI: 0.32	CR:	8.8%

Matrix

		1 Process factor	2 Human resource	3 Product	4 Control	5 External	normalized principal Eigenvector
Process factor	1	-	1/6	3	3	5	20.36%
Human resource	2	6	-	5	3 5/7	9	55.07%
Product	3	1/3	1/5	-	1	5	10.28%
Control	4	1/3	1/4	1	-	5	10.99%
External	5	1/5	1/9	1/5	1/5	-	3.29%

5.2.2 Part B: For sub-factors within the Process factor

AHP Analytic Hierarchy Process (EVM multiple inputs)
K. D. Goepel Version 12.08.2013 http://bpmsg.com
Only input data in the light green fields and worksheets!

n=	6	Number of criteria (3 to 10)	Scale:	1	Linear
N=	4	Number of Participants (1 to 20)	α:	0.1	Consensus: 69.4%
p=	0	selected Participant (0=consol.)	2	7	Consolidated

Objective To find out which subfactor from process influences productivity the most.

Author S R Shaikh

Date 20-Jan-14

EVM check: 2.02284E-10

Table

	Criterion	Comment	Weights	Rk
1	Maintenance		4.5%	6
2	Lead time		31.1%	1
3	Production standar		10.5%	5
4	Level of technology		14.5%	3
5	Mgt philosophy		11.3%	4
6	Yarn quality		28.0%	2

Result

Eigenvalue			lambda:	6.249
Consistency Ratio	0.37	GCI: 0.15	CR:	4.0%

Matrix		Maintenance 1	Lead time 2	Production standard 3	Level of technology 4	Mgt philosophy 5	Yarn quality 6	normalized principal Eigenvector
Maintenance	1	-	1/5	2/5	1/3	2/7	1/6	4.55%
Lead time	2	5	-	3	3	3 2/7	1	31.15%
Production standard	3	2 1/2	1/3	-	5/9	8/9	5/9	10.49%
Level of technology	4	3	1/3	1 5/6	-	2 1/4	2/7	14.51%
Mgt philosophy	5	3 4/7	1/3	1 1/8	4/9	-	5/9	11.31%
Yarn quality	6	5 1/6	1	1 5/6	3 3/5	1 5/6	-	28.00%

5.2.3 Part C: For sub-factors within the Human resource factor

AHP Analytic Hierarchy Process (EVM multiple inputs)

K. D. Goepel Version 12.08.2013 http://bpmsg.com

Only input data in the light green fields and worksheets!

n=	7	Number of criteria (3 to 10)	Scale: 1	Linear
N=	4	Number of Participants (1 to 20)	α: 0.1	Consensus: 99.0%
p=	0	selected Participant (0=consol.)	2 7	Consolidated

Objective To find out which factor from human resource mostly affects productivity.

Author S R Shaikh

Date 20-Jan-14

EVM check: 7.70852E-12

Table

	Criterion	Comment	Weights	Rk
1	Training		16.9%	3
2	Motivation		4.9%	7
3	Labour turnover		7.2%	5
4	Labour relation		6.9%	6
5	Absenteeism & late		29.4%	1
6	Bonus		7.7%	4
7	Wages		26.9%	2

Result

Eigenvalue			lambda:	7.726
Consistency Ratio	0.37	GCI: 0.32	CR:	9.0%

Matrix		Training 1	Motivation 2	Labour turnover 3	Labour relation 4	Absenteeism & lateness 5	Bonus 6	Wages 7	normalized principal Eigenvector
Training	1	-	3	1 5/7	2 1/4	1/3	4 2/5	1	16.88%
Motivation	2	1/3	-	2/9	1	1/5	1	1/5	4.94%
Labour turnover	3	3/5	4 2/5	-	3/5	1/5	1/3	1/6	7.18%
Labour relation	4	4/9	1	1 2/3	-	1/3	1	1/6	6.94%
Absenteeism & lateness	5	3	5	5	3	-	5	1	29.39%
Bonus	6	2/9	1	3	1	1/5	-	1/3	7.75%
Wages	7	1	5	6 3/7	5 8/9	1	3	-	26.94%

5.2.4 Part D: For sub-factors within the Product factor

AHP Analytic Hierarchy Process (EVM multiple inputs)
K. D. Goepel Version 12.08.2013 http://bpmsg.com
Only input data in the light green fields and worksheets!

n=	4	Number of criteria (3 to 10)	Scale:	1	Linear
N=	4	Number of Participants (1 to 20)	α:	0.1	Consensus: 98.8%
p=	0	selected Participant (0=consol.)	2	7	Consolidated

Objective To find out which subfactor from product factor mostly affects productivity.

Author S R Shaikh
Date 20-Jan-14 EVM check: 4.89702E-08

Table

	Criterion	Comment	Weights	Rk
1	Flexibility		6.4%	4
2	Quality		22.1%	2
3	Optimum volume		8.7%	3
4	Cost		62.9%	1

Result

Eigenvalue		lambda:	4.250
Consistency Ratio	0.37 GCI: 0.33	CR:	9.2%

Matrix

		1 Flexibility	2 Quality	3 Optimum volume	4 Cost	normalized principal Eigenvector
Flexibility	1	-	1/4	1/2	1/6	6.42%
Quality	2	4	-	3 3/4	2/9	22.06%
Optimum volume	3	2 1/5	1/4	-	1/8	8.67%
Cost	4	5 1/2	4 2/3	7 2/3	-	62.85%

5.2.5 Part E: For sub-factors within the Control factor

AHP Analytic Hierarchy Process (EVM multiple inputs)
K. D. Goepel Version 12.08.2013 http://bpmsg.com
Only input data in the light green fields and worksheets!

n=	3	Number of criteria (3 to 10)	Scale:	1	Linear
N=	4	Number of Participants (1 to 20)	α:	0.1	Consensus: 99.7%
p=	0	selected Participant (0=consol.)	2	7	Consolidated

Objective To find out which subfactor from control factor that mostly affects productivity.

Author S R Shaikh
Date 20-Jan-14 EVM check: 7.49239E-06

Table

	Criterion	Comment	Weights	Rk
1	Inventory		38.2%	2
2	Rejection level		11.9%	3
3	Repair level		49.8%	1

Result

Eigenvalue		lambda:	3.070
Consistency Ratio	0.37 GCI: 0.21	CR:	7.4%

Matrix

		1 Inventory	2 Rejection level	3 Repair level	normalized principal Eigenvector
Inventory	1	-	2 1/2	1	38.25%
Rejection level	2	2/5	-	1/5	11.91%
Repair level	3	1	5 4/9	-	49.84%

5.2.6 Part F: For sub-factors within the External factor

AHP Analytic Hierarchy Process (EVM multiple inputs)

K. D. Goepel Version 12.08.2013 http://bpmsg.com

Only input data in the light green fields and worksheets!

n=	4	Number of criteria (3 to 10)	Scale:	1	Linear
N=	4	Number of Participants (1 to 20)	α:	0.1	Consensus: 99.7%
p=	0	selected Participant (0=consol.)	2	7	Consolidated

Objective To find out which subfactor from external factor that mostly affects productivity.

Author S R Shaikh

Date 20-Jan-14

EVM check: 5.62548E-08

Table

	Criterion	Comment	Weights	Rk
1	Plant Location		10.6%	3
2	Market demand		64.7%	1
3	Export destination		19.0%	2
4	Worker education		5.7%	4

Result

Eigenvalue			lambda:	4.197
Consistency Ratio	0.37	GCI: 0.26	CR:	7.2%

Matrix

		1 Plant Location	2 Market demand	3 Export destination	4 Worker education	normalized principal Eigenvector
Plant Location	1	-	1/7	3/8	3	10.56%
Market demand	2	6 4/5	-	5	7	64.72%
Export destination	3	2 2/3	1/5	-	3 1/2	19.03%
Worker education	4	1/3	1/7	2/7	-	5.68%

5.3 Quantification of the factors:

After the AHP process we obtain the local and global weights for each factor and sub-factor as shown in below table:

Table 5: Weights (global and local) of different factors

Sr. No		Name of the factor/ sub-factor	Local weight	Global weight
A		***PROCESS***	**0.204**	**0.204**
	A1	Maintenance	0.0460	0.0098
	A2	Lead time	0.3110	0.0635
	A3	Production standard	0.1050	0.0213
	A4	Level of technology	0.1450	0.0296
	A5	Management philosophy	0.1130	0.0230
	A6	Yarn quality	0.2800	0.0571
B		***HUMAN RESOURCE***	**0.550**	**0.550**
	B1	Training	0.1688	0.0928
	B2	Motivation	0.0494	0.0272
	B3	Labour turnover	0.0718	0.0394
	B4	Labour relation	0.0694	0.0381
	B5	Absenteeism and lateness	0.2938	0.1616
	B6	Bonus	0.0774	0.0426
	B7	Wages	0.2694	0.1482
C		***PRODUCT***	**0.103**	**0.103**
	C1	Flexibility	0.0642	0.0066
	C2	Quality	0.2206	0.0227
	C3	Optimum volume	0.0867	0.0089
	C4	Cost	0.6285	0.0648
D		***CONTROL***	**0.11**	**0.11**
	D1	Inventory	0.3825	0.0421
	D2	Rejection level	0.1191	0.0131
	D3	Repair level	0.4984	0.0548
E		***EXTERNAL***	**0.033**	**0.033**
	E1	Plant location	0.1056	0.0035
	E2	Market demand	0.6472	0.0214
	E3	Export destination	0.1903	0.0063
	E4	Worker education	0.0568	0.0018

6. Conclusion:

From the above analysis it is observed that out of the total factors influencing productivity, human factor has the greatest impact of about 55% on the productivity followed by Process factor with 21% and Control factor with 11%. This can be depicted in the form of a pie chart for better understanding. The textile industry is labour based industry. It is observed that many of the firms do not provide training to the workers and lack direct communication with the workers [22]. The attitudinal factors affect the job performance [10]. This means human resource factor and process factor must be stressed in order to improve the productivity of a power-loom.

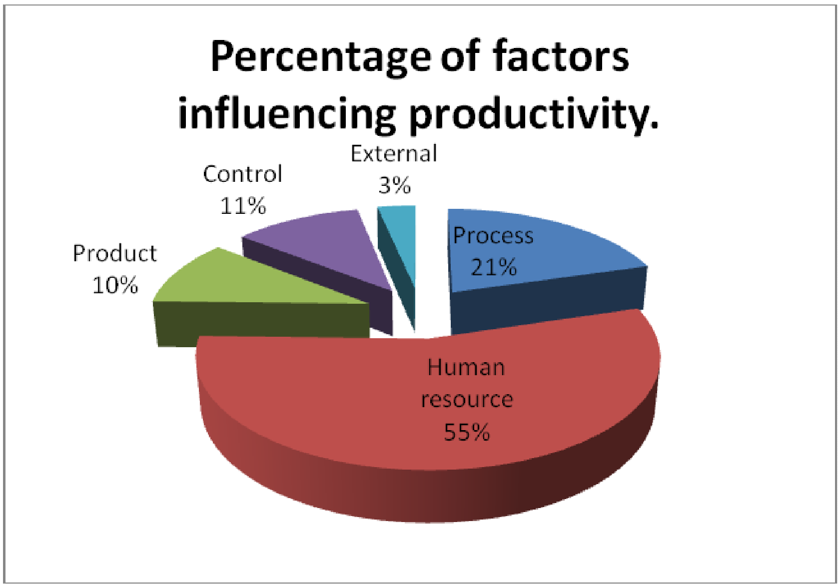

Fig 2: Percentage of factors affecting productivity.

In human resources factor, absenteeism and lateness affects 29% to the productivity of power loom followed by wages 26% and training 16%. In process factor, lead time affects 31% to productivity, Yarn quality 28% and Level of technology 14%. In control factor, Repair level affects 49% to the productivity, Inventory 38% and rejection level 11%.

All these factors should be controlled in order to improve the productivity. The above listed factors belong to different departments such as human resource, process etc. But lean philosophy or lean production is the best suited technique to improve productivity. The table shown below enlists various lean production methods that can be employed in various departments to improve productivity.

Table 6 Cluster of Lean Production methods by their suitability for different enterprises. [

Type	Lean Production methods	micro	small	medium	large
Machinery and equipment	Low Cost Automation	◔	◕	●	◑
	OEE Overall Equipment Effectiveness	○	◔	◕	●
	Preventive Maintenance	◔	◑	●	●
	Setup Time Reduction (SMED)	◔	◕	●	●
	Total Productive Maintenance	○	◔	◕	●
Material flow and layout	Cellular Manufacturing	○	◕	●	◕
	First in first out (FIFO)	●	●	●	●
	One-piece-flow	○	◔	◕	●
	Simulation software (e.g. MatFlow)	○	○	◑	●
	Optimization of the supply chain	○	◕	●	●
	Value Stream Mapping	○	◕	●	●
	Work station design	◔	◕	●	●
Organization and staff	5S	◔	●	●	●
	Autonomous work groups	○	◕	●	●
	Benchmarking	●	●	●	●
	Ideas Management	●	●	◕	◕
	Job rotation	◔	◕	◕	●
	Lean Office (Administration)	○	◔	◑	●
	Kaizen (CIP-Meetings)	◑	●	●	●
	Standardisation	◑	◕	●	●
Production planning and control	Just in Sequence	○	◔	◑	●
	Just in Time	◑	●	●	●
	Kanban	○	◕	◕	●
	Line Balancing and Muda reduction	○	◔	◑	●
	Milkrun	○	◔	◑	●
	PPS Simulation software	○	○	◑	●
	Economic (optimal) lot size	○	◑	●	●
	Visual Management	◑	●	●	●
Quality	FMEA	○	○	◑	●
	Poka Yoke	◔	◕	●	●
	Quality Circles	○	◑	●	●
	Quality Function Deployment	○	○	◑	●
	Six-Sigma	○	○	◑	●
	Statistical Process Control (SPC)	○	◔	●	●
	Supplier Development	○	◔	◕	●
	Total Quality Management	○	◔	◕	●
	Zero Defect (Jidoka)	○	●	●	●

unsuitable ○ less suitable ◔ suitable ◑ well suitable ◕ very suitable ●

Small firms have the advantage to be more flexible than large companies. Once they decide to introduce Lean Production methods, small business managers can often bring change more quickly in small firms than is generally possible in larger firms because they have less bureaucracy, have shorter communication lines and are less bound by tradition. The informal nature of smaller businesses and leadership of owner/managers can make implementation of Lean Production programs therefore easier in small firms than in large [19].
Even if not all methods from the cluster are applicable in small enterprises we can deduce a selection of suitable/recommendable methods [14] such as:

- 5S (Seiri, Seiton, Seiso, Seiketsu, Shitsuke)
- Benchmarking
- Kaizen - Continuous Improvement meetings
- Just in Time delivery
- Pull-principle and Kanban
- Visual Management in Production
- Idea Management to utilize the worker's Know-How
- Setup Time Reduction to reduce waste
- Value Stream Mapping
- Efficient and ergonomic work stations
- Poka Yoke and standardisation in product and process
- Low Cost Automation ("keep it smart and simple").

Hence by applying the required techniques from listed above in the power loom industry improvement in productivity can be achieved.

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About the authors:

Miss. S R Shaikh is currently pursuing Master's Degree at A.G.Patil Institute of Technology, Solapur. She can be reached at: shaikhsummaiya10@gmail.com

Mr. S R Dulange is currently pursuing Fellow (Doctoral) programme at the National Institute of Industrial Engineering (NITIE), Mumbai. He is working as Assistant professor at A.G.Patil Institute of Technology, Solapur. He can be reached at: srdulange@yahoo.co.in