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Performance Evaluation for Productivity Management

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Abstract*: Productivity management is one of the major problems faced by many firms all over the world. Without identifying productivity influence factor it is difficult to manage the production cycle. The paper concentrates on the evaluation of management controls over the production. The day to day productivity must be measure and compare for to take corrective actions and to increase the productivity. This paper presents a project work done in a small scale footwear industry in south India. Few research efforts have specifically evaluated productivity in the context of the productivity management cycle. Consequently, there is still a lack of useful indicators for determining which items should be prioritized and improved upon in order to yield the highest benefits from productivity management. In an effort to address this issue, this study proposes a method for calculating productivity. Tool used for the project is Productivity Achievement Ratio (PAR), Regression analysis, Relative Importance Index (RII) etc.*

Keywords*: PAR, OP, AP, RII, Variable Ranking, Reduction Factors etc.*

I. INTRODUCTION

Productivity-one of the major factors used in measuring industry outcomes- is defined as the relation between a production system output and the input set in that system. The importance of managing productivity has long been emphasized in the manufacturing industry, and a considerable amount of research has been conducted on the issue. Both managers and employees should pay close attention to productivity management and that the productivity management cycle has four phases: measurement, evaluation, planning, and improvement. There have been many research efforts to examine productivity measurement and consequently contribute to the better productivity management However, despite yielding decent estimations of productivity, these studies have rarely identified which items require the most attention for optimal productivity management. Indeed, productivity has commonly been estimated by the ratio between system output and input without consideration of the particulars of each work item. Considering each work item when measuring productivity is a complex process. For instance, it must be taken into account that work items associated with low productivity do not always have high potential for improvement. As well, a minimal change in productivity does not necessarily signify the presence of a work item linked with a poor management performance. To deal with these complexities, an advanced productivity indicator, which can account for the unique characteristics of each item, is needed. This work is done for the enhancement of productivity and reduces the productivity fluctuations in a small scale footwear industry in Kerala, India (Footmate polymer Footwears India Pvt. Ltd- a LUNAR Group of company).

For example, Table 1 shows the labor productivity calculated using the data collected from FOOTMATE for the months of April and March in packing unit. As seen in Table 1, the productivity of the month March is 103.02, while that of the month April is 132.96. However, this fact does not directly indicate that the productivity management of the month April is better than that of the month March. It would also be inappropriate to conclude that the month April has higher potential for improvement than the month March. Instead, it must be determined which of the Month should be focused on during the planning and improvement phases of the productivity management cycle. These items should not be chosen merely by estimating productivity without considering the potential effects of management activity. Although conversion factors can be used to account for different labor resources and conditions required for the outputs, they still do not provide clear information regarding the potential effects of management activity. Thus, this research aims at developing a productivity evaluation indicator that takes management aspects into account so that the most appropriate items for management activity are selected, and so that the benefits of productivity are maximized.

Table 1: Labor Productivity of PACKING UNIT in FOOTMATE.

	WORKERS(A)	TOTAL UNITS(B)	PRODUCTIVITY (B/A)
MARCH	227	23385	103.02
APRIL	239	31778	132.96

II. LITERATURE REVIEW

A. Productivity

Prokopenko defined that "productivity is the relationship between the output generated by a production or service system and the input provided to create this output. Thus, productivity is defined as the efficient use of resource – labors, capital, land, materials, energy and information – in the production of various goods or services. Productivity can also be defined as the relationship between results and the time it takes to accomplish them. Time is often a good denominator since it is a universal measurement and it beyond human control. The less time taken to achieve the desired result is the more productive the system". Prokopenko also stated that "regardless the type of production, economic or political system, the definition of productivity remains the same. Thus, though productivity may mean different things to different people, the basic concept is always the relationship between the quantity and quality of goods or services produced and the quantity of resources used to produce them".

Eatwell and Newman (1991) defined productivity as a ratio of some measure of output to some index of input use. Put differently, productivity is nothing more than arithmetic ratio between the amount produced and the amount of any resources used in the course of production. This conception of productivity goes to imply that it can indeed be perceived as the output per unit input. Overall, productivity could be defined as the ratio of outputs to inputs

Productivity = Outputs / Inputs

B. Productivity improvement methods

There is several productivity improvement methods developed so far. Shruti Sehgal categorized the methods into seven basic categories namely, employee based, material based, task based, management based, technology based, product based and investment based. And any other techniques can be grouped in any of these categories [8]. Anton Soekiman summarized manufacturing system productivity improvement methods into operation research based, system analysis based, continuous improvement based and performance metrics based. [10] Shruti Sehgal represented the productivity improvement methods into the following categories: logistics, quality, production engineering and others [8]

C. Actual Productivity and Obtainable Productivity

Tae Wan Kim *et al* [1] assumes that there exists productivity yielded under an ideal situation. Such productivity is defined as Ideal Productivity (IP). In contrast, Actual Productivity (AP) is yielded in reality where various factors can prevent the attainment of IP. In addition to IP and AP, there exists Obtainable Productivity (OP). OP is the maximum productivity that can be attained through the adequate management of controllable variables.

D. Reduction Factors

A Reduction Factor (RF) is defined by Tae Wan Kim *et al* [1] as a factor that prevents productivity from reaching an IP value. Namely, an RF makes the difference between IP and AP. This idea is formalized in the following equation:

AP = IP – an amount of productivity loss caused by RF

Only a factor can be an RF, not an event. For example, although "overtime" causes productivity to decrease, it cannot be called an RF because it is an event. In this case, "insufficient time" is considered a factor and therefore an RF.

E. Factors affecting productivity

Mr. A .A. Attar et al [2] states that the Factors affecting labor productivity have been identified and are grouped into 15 categories according to their characteristics, namely 1)Design factors 2) Execution plan factors 3) Material factors 4) Equipment factors 5) Labor factors 6) Health and safety factors 7) Supervision factors 8) Working time factors 9) Project factors 10) Quality factors 11) Financial factors 12) Leadership and coordination factors 13) Organization factors 14) Owner/consultant factors 15) External factors

The top ten factors that affect the small and medium company: 1) Lack of material 2) Labor strikes 3) Delay in arrival of materials 4) Financial difficulties of the owner 5) Unclear instruction to laborer and high absenteeism of labors 6) Bad weather (e.g. rain, heat, etc.) 7) Non discipline labor and use of alcohol and drugs 8) No supervision method, design changes, repairs and repetition of work, and bad resources management 9) Bad supervisors absenteeism and far away from location of material storage, and 10) Bad leadership

There are various literatures that illustrate the relation between some of these factors and the productivity of the employee. There are different reduction factors identified by the authors of various literature and these reduction factors and variables were reviewed.

F. Productivity Achievement Ratio (PAR)

The Productivity Achievement Ratio (PAR) can be represented as the quotient of AP and OP. This value considers the potential effect of improvement and therefore can be used as a productivity evaluation indicator to determine the main items that should be focused on during production. The PAR formulated by Tae Wan Kim *et al* [1]. But these methods have lot of difficulties within that that was focused to review and suggest new method

and practically justify using the new method. The classification and the statistical method used in that paper was statistically irrelevant for the use.

G. Relative Importance Index (RII)

The aim of the analysis was to establish the relative importance of the various factors identified as responsible for production variation. The score for each factor is calculated by counting the scores from the observations. The relative importance index (RII) was calculated using the following formula.

$$RII(\%) = \frac{5 * n_5 + 4 * n_4 + 3 * n_3 + 2 * n_2 + 1 * n_1}{5 * N} * 100 \quad (1)$$

Where,

n_1 - n_5 is the no of observation results 1 to 5

N is the total no of observation.

III. DEFINITIONS

A. Productivity

This research assumes that there exists productivity yielded under an ideal situation. Such productivity is defined as Ideal Productivity (IP). In contrast, Actual Productivity (AP) is yielded in reality where various factors can prevent the attainment of IP. In addition to IP and AP, there exists Obtainable Productivity (OP). OP is the maximum productivity that can be attained through the adequate management of controllable variables. The differences between OP and baseline productivity (BP) are determined, as shown in Table 2.

Table 2: Comparison of Baseline Productivity and Obtainable Productivity.

Baseline productivity	Obtainable productivity
The maximal productivity (or top 10%) obtained within the project	Productivity obtained from the most controllable situation.
1:1 function to event	Focusing on factors, not events
Pre-set from existing data and therefore unchangeable over time.	Calculated by current site data. As time passes and data is accumulated, accuracy increases.

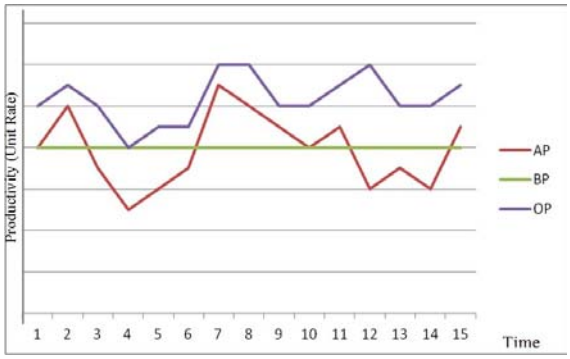

Figure 1: Comparing Baseline Productivity with Obtainable Productivity.

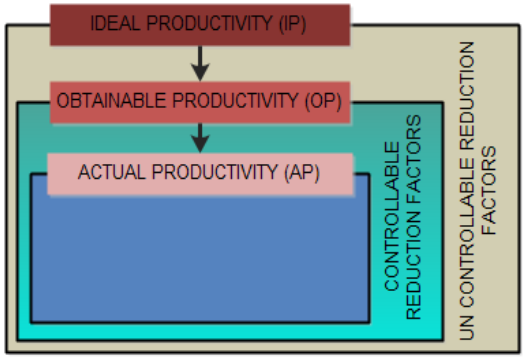

Figure 2: Relationship of Reduction Factors and Productivity.

Figure 1 illustrates those differences. Dots in the Figure represent the daily results of productivity (AP). The Y axis is productivity as a unit-rate. That is, if less amount of input is required for one unit-work, a higher productivity is yielded. The daily amount of productivity is constantly changing. Regardless of changes in project circumstance, baseline productivity is set by the median of the daily productivity values in the baseline subset which is 10% of the total workdays. However, OP is changing on a daily basis according to changes in project circumstances. It is notable that OP does not necessarily follow the same pattern as the actual productivity curve.

B. Reduction Factors

A Reduction Factor (RF) is defined as a factor that prevents productivity from reaching an IP value. Namely, an RF makes the difference between IP and AP. This idea is formalized in the following equation:

AP = IP – an amount of productivity loss caused by RF (2)

Can the RF be controlled by Anyone Working on the Site?

Managers can control factors, such as “site layout plans,” that can potentially obstruct AP from reaching OP. However, other factors, such as “weather conditions,” cannot be controlled or stopped, therefore preventing OP from reaching IP. While the former factor type is referred to as a Controllable-RF (C_RF), the latter is referred to as an Uncontrollable-RF (UC_RF). These concepts are presented in the following equations:

OP = IP – an amount of productivity loss caused by UC_RF (3)
AP = OP – an amount of productivity loss caused by C_RF (4)
Figure 2 visualizes the relationship between RFs and productivity
While some RFs, such as "worker faithfulness," change from day to day, other RFs, such as "Plant Lay out," remain unchanged over the course of production. The former RF type is called a Variable-RF (V_RF), while the latter is called an Invariable-RF (IV_RF). Previous researcher says that the Invariable reduction factors do not have an impact on the productivity. But, Invariable reduction factors have serious impact on the productivity and the invariable reduction factors effects are vary over time. KIM Tae Wan [1] classifies the variables into Invariable and Variable Reduction factors and excludes the invariable RF. In this study not classifies the reduction factors into the variable or invariable. In this study classify the variables into Controllable and Uncontrollable and then grouped the variables according to their characteristics. The Uncontrollable variables are classified separately.

IV. METHODOLOGY

A. Research Process

The research process consists of 7 steps illustrate in Figure 3. In step 1 define the research problem and conduct a detailed literature review. In next step determine a data collection method and develop a plan for data analysis. Through Literature review and pilot survey identify the variables affect productivity and short list it. In step 3 conducts a pilot survey to short list the variables affect the productivity and classify according to the characteristics of the variables. Next stage is to design the observation data sheet and collect the data through field observation. The scaling of the data is done with this step. In data analysis stage Conduct reliability analysis to find the data is significant or not. And a correlation analysis need to conduct because to identify any mutually exclusive relation between the variables. Through forming a regression equation calculates the value of obtainable productivity and then calculates the productivity achievement ratio. As part of that rank the variables with relative importance index, it help to prioritized problem solving.

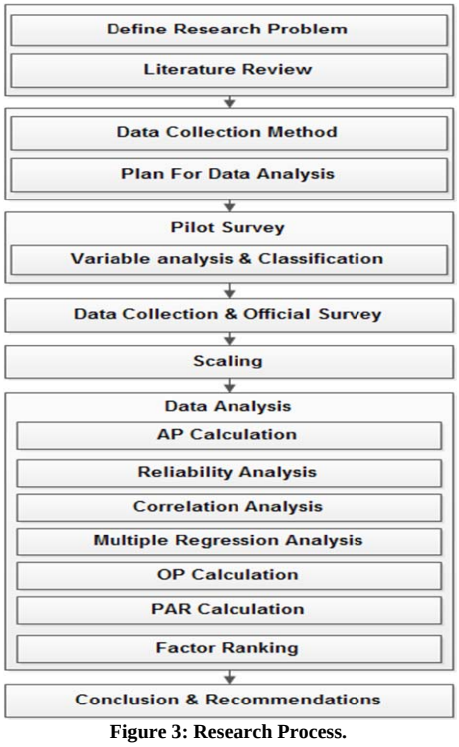

Figure 3: Research Process.

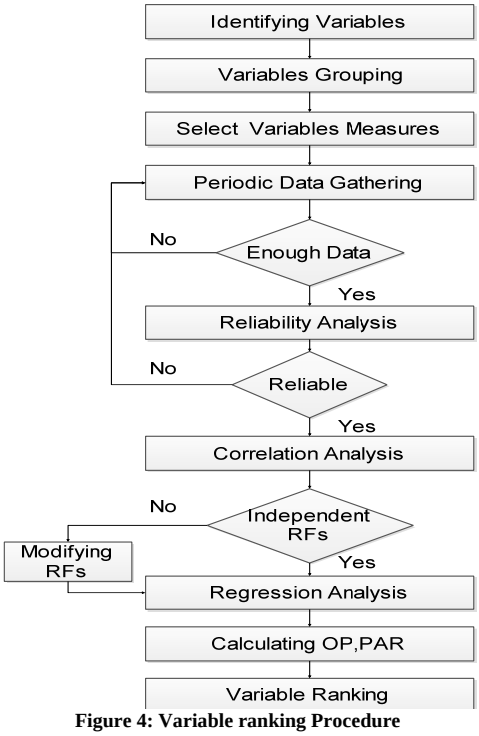

Figure 4: Variable ranking Procedure

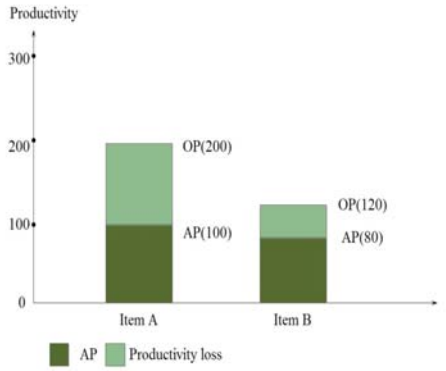

Figure 5: Comparison of Productivity between Item A and Item B

B. Sampling Design

In FOOTMATE Polymer Footwear's India Pvt. Ltd have four production units in their poly urethane footwear manufacturing factory namely cutting unit, stitching unit, molding unit & packing units. All these units are comes under the study. In this project choose total population sampling, necessary to study the entire population of FOOTMATE Polymer Footwear's India Pvt. Ltd because the size of the population that has the particular set of characteristics that we are interest in is typically very small.

C. Pilot Survey

There are two phases in research design step of this study are pilot survey and main survey. Pilot survey used collect the factors that observe in the field reduce productivity and site conditions. Pilot survey also helps to interact with the company officials to identify the variations in productivity. Main survey consists of the field observation. Based on the literature review identify the variables affecting productivity. Some variables are listed by the basis on the conversation with the employees. On the basis of the listed variables a pilot survey is conducted for short list the variables by the frequency of observation.

The variables short listed by observe the field and on the basis of opinion of the officials and employees. In summary, based on the previous research, pilot survey, refinement and discussion with experts, 46 Variables are selected and these are grouped to 7 Factors according to their characteristics, namely: Workforce, material/equipment, management, motivation, schedule, Safety and Work environment and supervision. Out of this Safety and Work environment is a group of uncontrollable variable and other factors are the group of controllable variables.

The observation data sheet designed for a natural field survey and the data sheet consist of the 38 controllable and 8 uncontrollable variables identified. The time scheduled to make this observation is from 8.00 am to 6.30 pm of every working day of the company. Company has only one shift and work time of employees except the stitching unit is 8.4 hour and duty time of stitching unit was 9.1 hour. RFs and productivity data are collected periodically.

D. Data Collection

The data collection method used in this survey is field observation. The reason why this method chosen because is FOOTMATE is a small scale industry and consist of uneducated workers only. So the questionnaire survey and interview method is not possible in this survey. Herbsman and Ellis (1990) have recommended that the minimum number of observations should be at least three times the number of the RFs involved in a specific item. For example, if there are 10 RFs, then 30 or more cases should be collected.

E. Data Analysis

In data analysis scales the collected data and conduct a reliability analysis, Correlation analysis. Next step is to calculate the productivity achievement ratio. Figure 4 shows the overall procedure for calculation of Productivity Achievement Ratio and Variable Ranking. An item with a high PAR indicates that the item's productivity has been managed effectively. On the contrary, an item with a low PAR should be carefully monitored and studied to improve on-site productivity. For example, in Figure 5, though the AP of item A is higher than that of item B, item A should be prioritized by site management because the PAR (PAR=AP*100/OP) of item A is 50%, while the PAR of item B is 67%. Managers should investigate the main culprit of the productivity loss and make efforts to reduce or minimize the cause. Since it is non-dimensional, the PAR can be used to compare the same items among different units with different C_RFs.

V. DATA ANALYSIS AND INTERPRETATION

The variables frequency of occurrence will be measured for forty days. The frequencies of occurrence of variables are used for the calculation of Relative Importance Index. The total of each variable group are used for

scaling for the calculation of OP. The identified variables and their classification is shown with RII rank in Table 16.

A. Scaling

Figure 6 shows the likert scale used for the scaling of collected data and the Table 3 shows the reduction factors and their quantification method used for this study.

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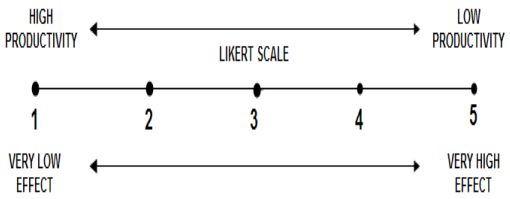

Figure 6: Likert Scale.

Table 3: Reduction Factors and Quantification methods.

RF No.	Reduction Factor	Quantification method
RF1	Workforce	Likert scale (1 to 5)
RF2	Material / equipment	Likert scale (1 to 5)
RF3	Management	Likert scale (1 to 5)
RF4	Motivation	Likert scale (1 to 5)
RF5	Schedule	Likert scale (1 to 5)
RF6	Safety & work environment	Likert scale (1 to 5)
RF7	Supervision	Likert scale (1 to 5)

The data from the four units of FOOTMATE are converted to five point likert scale and shown in Table 15. That is the independent variables used for the calculation of obtainable productivity using the regression model. The AP is the dependent variable used for the regression.

B. Reliability Analysis

The assessment of Scale Reliability is a measurement of the internal consistency of the produced items in this research in order to evaluate the reliability of each variable in measurement scales. Otherwise, the observed variables describe the common construct. For reliability analysis of data collected in this paper use the Cronbach's alpha. In generally, the value of Cronbach's alpha for acceptable reliability is 0.6 and any variables which have the value of Corrected Item-Total Correlation below 0.4 would be consider to be rejected. SPSS statistical software is used for the data analysis. Four unit's Cronbach's alpha was checked and alpha values are satisfies the internal consistency of the data collected. The reliability analysis results are shown in Table 4.

Table 4: Reliability Analysis.

UNIT NAME	NO OF ITEMS	CRONBACH'S ALPHA	N
CUTTING UNIT	7	0.685	40
STITCHING UNIT	7	0.672	40
MOLDING UNIT	7	0.798	40
PACKING UNIT	7	0.745	40

C. Correlation Analysis

The correlation analysis is a measure of linear association between two variables. Values of the correlation coefficient are always between -1 and +1. A correlation coefficient of +1 indicates that two variables are perfectly related in a positive linear sense; a correlation coefficient of -1 indicates that two variables are perfectly related in a negative linear sense, and a correlation coefficient of 0 indicates that there is no linear relationship between the two variables. If any mutually exclusive relation occurred the correlation between the variables are above 0.8. When an RF is dependent on another RF, a ripple effect can be generated, yielding an incorrect OP value at the end of the analysis. To solve this interdependency problem, RFs with similar constructs can be combined. Or, RFs can be gathered into a pattern to make new factors. The latter technique is known as factor analysis. For correlation analysis in this work chooses the person correlation because the relations between the variables are normally distributed. In this paper the correlation analysis satisfies the correlation analysis.Table5, 6, 7& 8 is shown the person correlation between the variables.

Table 5: Person Correlation – Cutting Unit.

Pearson Correlation-CUTTING UNIT							
	RF1	RF2	RF3	RF4	RF5	RF6	RF7
RF1	1	0.461	0.526	-0.173	0.436	0.381	0.205
Sig.(1-tailed	.	0.001	0	0.143	0.002	0.008	0.103
RF2	0.461	1	0.248	0.005	0.486	0.547	0.09
Sig.(1-tailed	0.001	.	0.062	0.487	0.001	0	0.291
RF3	0.526	0.248	1	0	0.397	0.329	0.177
Sig.(1-tailed	0	0.062	.	0.5	0.006	0.019	0.137
RF4	-0.173	0.005	0	1	0.104	-0.067	-0.082
Sig.(1-tailed	0.143	0.487	0.5	.	0.262	0.341	0.308
RF5	0.436	0.486	0.397	0.104	1	0.333	0.109
Sig.(1-tailed	0.002	0.001	0.006	0.262	.	0.018	0.251
RF6	0.381	0.547	0.329	-0.067	0.333	1	0.171
Sig.(1-tailed	0.008	0	0.019	0.341	0.018	.	0.146
RF7	0.205	0.09	0.177	-0.082	0.109	0.171	1
Sig.(1-tailed	0.103	0.291	0.137	0.308	0.251	0.146	.

Table 6: Person Correlation –Stitching Unit.

Pearson Correlation-STICHING UNIT							
	RF1	RF2	RF3	RF4	RF5	RF6	RF7
RF1	1	-0.005	-0.013	0.496	0.233	0.35	0.533
Sig.(1-tailed	.	0.487	0.468	0.001	0.074	0.013	0
RF2	-0.005	1	0.223	0.289	-0.23	0.059	0.136
Sig.(1-tailed	0.487	.	0.083	0.035	0.077	0.358	0.201
RF3	-0.013	0.223	1	0.229	-0.274	0.292	0.298
Sig.(1-tailed	0.468	0.083	.	0.078	0.043	0.034	0.031
RF4	0.496	0.289	0.229	1	-0.276	0.601	0.642
Sig.(1-tailed	0.001	0.035	0.078	.	0.042	0	0
RF5	0.233	-0.23	-0.274	-0.276	1	-0.136	0.084
Sig.(1-tailed	0.074	0.077	0.043	0.042	.	0.202	0.302
RF6	0.35	0.059	0.292	0.601	-0.136	1	0.52
Sig.(1-tailed	0.013	0.358	0.034	0	0.202	.	0
RF7	0.533	0.136	0.298	0.642	0.084	0.52	1
Sig.(1-tailed	0	0.201	0.031	0	0.302	0	.

Table 7: Person Correlation – Molding Unit.

Pearson Correlation-MOLDING UNIT							
	RF1	RF2	RF3	RF4	RF5	RF6	RF7
RF1	1	0.292	0.166	0.497	0.345	0.221	0.514
Sig.(1-tailed	.	0.034	0.154	0.001	0.015	0.085	0
RF2	0.292	1	0.467	0.384	0.308	0.305	0.579
Sig.(1-tailed	0.034	.	0.001	0.007	0.026	0.028	0
RF3	0.166	0.467	1	0.467	0.244	0.579	0.269
Sig.(1-tailed	0.154	0.001	.	0.001	0.065	0	0.047
RF4	0.497	0.384	0.467	1	0.292	0.444	0.514
Sig.(1-tailed	0.001	0.007	0.001	.	0.034	0.002	0
RF5	0.345	0.308	0.244	0.292	1	0.264	0.313
Sig.(1-tailed	0.015	0.026	0.065	0.034	.	0.05	0.025
RF6	0.221	0.305	0.579	0.444	0.264	1	0.191
Sig.(1-tailed	0.085	0.028	0	0.002	0.05	.	0.118
RF7	0.514	0.579	0.269	0.514	0.313	0.191	1
Sig.(1-tailed	0	0	0.047	0	0.025	0.118	.

Table 8: Person Correlation – Packing Unit.

Pearson Correlation-PACKING UNIT							
	RF1	RF2	RF3	RF4	RF5	RF6	RF7
RF1	1	0.282	0.271	0.344	0.197	0.466	0.083
Sig.(1-tailed	.	0.039	0.045	0.015	0.111	0.001	0.305
RF2	0.282	1	0.118	0.422	0.063	0.451	0.046
Sig.(1-tailed	0.039	.	0.234	0.003	0.349	0.002	0.389
RF3	0.271	0.118	1	0.563	0.43	0.316	0.382
Sig.(1-tailed	0.045	0.234	.	0	0.003	0.023	0.008
RF4	0.344	0.422	0.563	1	0.274	0.434	0.608
Sig.(1-tailed	0.015	0.003	0	.	0.044	0.003	0
RF5	0.197	0.063	0.43	0.274	1	0.058	0.205
Sig.(1-tailed	0.111	0.349	0.003	0.044	.	0.362	0.103
RF6	0.466	0.451	0.316	0.434	0.058	1	-0.042
Sig.(1-tailed	0.001	0.002	0.023	0.003	0.362	.	0.399
RF7	0.083	0.046	0.382	0.608	0.205	-0.042	1
Sig.(1-tailed	0.305	0.389	0.008	0	0.103	0.399	.

D. Regression Analysis

The main task of statistic analysis is applied in the Multiple Linear Regression in order to study the correlation and measure the prediction level of independent factors (Productivity Reduction Factors) on dependent factor (Actual Productivity). Because IP cannot be attained through efforts at the project level, the OP and AP should be calculated for the purpose of a practical productivity evaluation. Based on the labor productivity calculation, AP is measured as follows:

$$AP = \frac{Output(quantities)}{Workers * Worktime} \quad (5)$$

Actual Productivity of the four units will be calculated and shown Table 15.

A multiple linear regression analysis yields an OP value. In each case, RFs are explanatory variables and APs are dependent variables. The stepwise multiple linear regression coefficients summaries are collected from regression output of the SPSS statistical software and shown in Table 9.

Some variables are excluded because of insignificant P value or higher partial correlation. The table for p value and partial correlation for all variables are shown in the Table 10. The excluded variables P values and partial correlations are highlighted with red color. The excluded variables effects on the dependent variables are explained by the other independent variables.

Table 9: Regression Summaries

	REGRESSION SUMMARY							
	CONSTANT	RF1	RF2	RF3	RF4	RF5	RF6	RF7
CUTTING UNIT	56.153	-3.249	-1.742			-2.127	-2.624	
STITCHING UNIT	12.943	-0.483			-0.39		-0.528	-0.458
MOLDING UNIT	14.705	-0.328	-0.481			-0.36	-0.601	-0.468
PACKING UNIT	23.333			-1.043	-0.888	-1.54	-0.937	

Table 10: P value and Partial correlation.

	P VALUE						
	RF1	RF2	RF3	RF4	RF5	RF6	RF7
CUTTING UNIT	0	0.042	0.446	0.105	0.008	0.009	0.585
STITCHING UNIT	0.02	0.589	0.797	0.085	0.233	0.025	0.052
MOLDING UNIT	0.023	0.007	0.069	0.333	0.023	0	0.008
PACKING UNIT	0.063	0.941	0.001	0.007	0	0.004	0.83
	PARTIAL CORRELATION						
CUTTING UNIT	-0.32	-0.171	-0.131	0.275	-0.227	-0.226	0.094
STITCHING UNIT	-0.381	-0.093	-0.044	-0.287	-0.204	-0.369	-0.322
MOLDING UNIT	-0.377	-0.443	-0.311	-0.168	-0.377	-0.664	-0.433
PACKING UNIT	-0.313	0.013	-0.519	-0.439	-0.545	-0.465	0.037

Table 11: R square and Adjusted R square

	R	R Square	Adjusted R Square
CUTTING UNIT	0.877	0.77	0.743
STITCHING UNIT	0.839	0.704	0.67
MOLDING UNIT	0.909	0.826	0.8
PACKING UNIT	0.891	0.794	0.771

Table 12: ANNOVA

		Sum of Squares	df	Mean Square	F	Sig.
CUTTING UNIT	Regression	1349.469	4	337.37	29.223	0
	Residual	404.06	35	11.545		
	Total	1753.529	39			
STITCHING UNIT	Regression	56.025	4	14.006	20.802	0
	Residual	23.566	35	0.673		
	Total	79.592	39			
MOLDING UNIT	Regression	71.429	5	14.286	32.247	0
	Residual	15.062	34	0.443		
	Total	86.491	39			
PACKING UNIT	Regression	271.089	4	67.772	33.753	0
	Residual	70.276	35	2.008		
	Total	341.366	39			

The Table 12 shows the f value and significance level of test. The p value is less than less than .001, so the relationships are significant. The R^2 values for the four units are shown in Table 11. The R^2 value is 0.77, and the adjusted R^2 is 0.743 in cutting unit. R^2 value is called the coefficient of determination and is the percentage of the total variation in y, which is explained by regression. In this case study, this means that 77%of the total variation in AP is explained by the regression model. Similarly 70.4%, 82.6% & 79.4% of variations in AP were explained using the Regression Model. The regression equation is as follows:

$$AP = A - \sum_{n} B_{1,n} * C\_RF_n - \sum_{l} B_{2,l} * UC\_RF_l \quad (6)$$

Where,

A is the y-intercept;
$B_{1,n}$ is the regression coefficient for C_RF_n;
$B_{2,l}$ is the regression coefficient for UC_RF_l.

Table 13 shows the equations formed using the regression coefficients and the above AP equations. OP during a certain period t is calculated in the equation below:

$$OP = A - \sum_{l} B_{2,l} * UC\_RF_{lt} \quad (7)$$

Where,

$UC\_RF_{l,t}$ is the value of UC_RF_l at the period t.

That is, OP is the productivity value when the C_ RFs have not yet occurred. Mathematically, the value of the C_RF is 0. Table 5.9 shows OP equation after excluding the controllable reduction factors. We first grouped the RF6 as uncontrollable because it only enters in the OP equation. Using the above equations the op values are calculated and shown in Table 15.

Table 13: AP Equation.

CUTTING UNIT	AP=56.153-3.249*RF1-1.742*RF2-2.127*RF5-2.624*RF6
STITCHING UNIT	AP=12.943-0.483*RF1-0.39*RF4-0.528*RF6-0.458*RF7
MOLDING UNIT	AP=14.705-0.328*RF1-0.481*RF2-0.36*RF5-0.601*RF6-0.468*RF7
PACKING UNIT	AP=23.333-1.043*RF3-0.886*RF4-1.54*RF5-0.937*RF6

Table 14: OP Equation.

CUTTING UNIT	OP=56.153-2.624*RF6
STITCHING UNIT	OP=12.943-0.528*RF6
MOLDING UNIT	OP=14.705-0.601*RF6
PACKING UNIT	OP=23.333-0.937*RF6

E. PAR Calculation

The Productivity Achievement Ratio (PAR) can be represented as the quotient of AP and OP. This value considers the potential effect of improvement and therefore can be used as a productivity evaluation indicator to determine the main items that should be focused on during production. The PAR is formulated as follows:

$$PAR = \frac{AP}{OP} * 100(\%)(\text{where, } 0 \le PAR \le 100) \quad (8)$$

The PAR value calculated also shown in Table 15. The first five observation PAR value comparison chart is shown in Figure7. The chart shows that the comparison of PAR between units easily. It is the better way to compare productivity than the previous methods. The process for determining the OP value becomes increasingly accurate as more data are collected. If the variables considered are explain fewer amount of total variations in AP. That leads to OP less than AP. This will reason for the PAR higher than 100%. So consider maximum variables affect the productivity in the site.

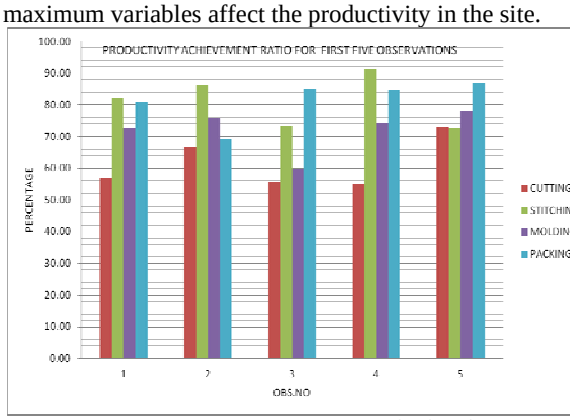

Figure 7: Productivity Achievement Ratio for first five observations.

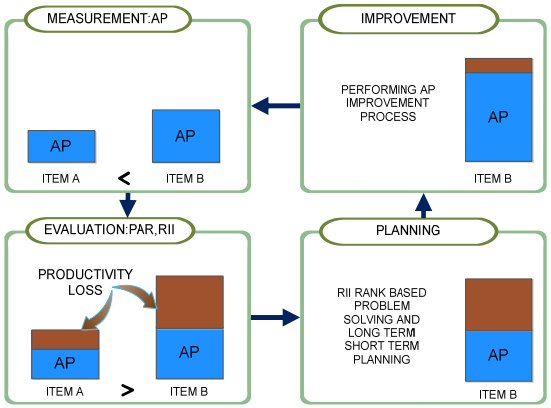

Figure 8: Productivity Management Model using PAR.

F. Relative Importance Index (RII)

Relative importance index was used here for the ranking of variables affect the productivity. In this work each of the 46 variables RII will be calculated and for four units separately using equation 1. The results are shown in table 16. From the ranking managers can identify which variables are most affected in the factory. RII was calculated using the frequency of occurrence of variables in the factory.

G. Productivity Management Using the PAR and RII

As a productivity evaluation indicator, the PAR can assist managers in identifying the management items that require productivity improvement the most. The PAR does this by focusing on an item's potential for improvement. In Figure 8, although item B has a better productivity value than item A, more intensive management is required for item B. Therefore, causes of the productivity loss of item B can be investigated and short-term and long-term plans can be established to reduce the productivity loss. Then, the process for improving the actual productivity of item B can be performed to acquire higher PAR. Likewise, the PAR can be used for a comparison of the same items from different units and for a comparison of different items at the same units.

Table 15: OP and PAR Calculation.

Obs. No.	CUTTING UNIT										STITCHING UNIT										MOLDING UNIT										PACKING UNIT									
	AP	LIKERT SCALE 1 - 5							OP	PAR(%)	AP	LIKERT SCALE 1 - 5							OP	PAR(%)	AP	LIKERT SCALE 1 - 5							OP	PAR(%)	AP	LIKERT SCALE 1 - 5							OP	PAR(%)
		RF1	RF2	RF3	RF4	RF5	RF6	RF7				RF1	RF2	RF3	RF4	RF5	RF6	RF7				RF1	RF2	RF3	RF4	RF5	RF6	RF7				RF1	RF2	RF3	RF4	RF5	RF6	RF7		
1	28.93	2	3	2	2	3	2	1	50.9	56.8	9.313	2	2	1	2	2	3	2	11.4	81.99	10.23	3	2	1	2	3	1	3	14.1	72.53	16.63	2	1	1	2	2	3	1	20.52	81.02
2	33.93	3	2	3	2	2	2	1	50.9	66.7	9.794	2	1	1	2	2	3	2	11.4	86.22	9.81	1	2	2	3	2	3	2	12.9	76.01	14.81	0	2	3	2	3	2	2	21.46	68.99
3	26.95	2	4	2	2	4	3	2	48.3	55.8	8.338	3	3	2	3	3	3	3	11.4	73.4	8.08	3	3	2	3	4	2	4	13.5	59.84	18.21	2	1	1	1	2	2	0	21.46	84.88
4	26.48	3	3	3	1	3	3	2	48.3	54.8	11.33	1	1	1	0	3	1	1	12.4	91.29	10.00	1	2	1	2	3	2	2	13.5	74.06	19.71	1	1	0	1	2	0	2	23.33	84.49
5	37.08	2	2	2	3	2	2	0	50.9	72.8	8.227	2	3	1	3	1	3	2	11.4	72.43	10.52	3	1	2	2	2	2	2	13.5	77.94	18.64	1	2	1	2	1	2	1	21.46	86.88
6	34.58	3	2	1	1	2	2	2	50.9	67.9	8.313	3	2	1	2	2	2	3	11.9	69.93	9.08	2	3	2	1	3	2	3	13.5	67.21	13.39	2	2	1	2	3	2	1	21.46	62.41
7	33.45	2	3	2	2	2	3	2	48.3	69.3	8.675	3	2	2	3	2	3	3	11.4	76.37	9.03	3	2	1	2	3	2	2	13.5	66.89	11.25	1	2	3	4	3	2	3	21.46	52.43
8	39.49	2	2	2	1	1	2	1	50.9	77.6	8.535	3	2	2	2	2	2	3	11.9	71.8	12.80	1	1	0	1	2	2	1	13.5	94.78	13.51	1	2	3	3	2	1	2	22.4	60.31
9	29.00	3	2	3	3	3	3	2	48.3	60.1	8.832	3	2	1	2	2	2	2	11.9	74.3	11.50	1	2	2	2	2	1	1	14.1	81.54	17.71	0	1	1	1	2	1	0	22.4	79.1
10	40.60	2	1	2	1	1	1	1	53.5	75.8	9.198	1	2	2	2	1	3	2	11.4	80.98	11.11	2	1	1	1	1	2	1	13.5	82.25	11.26	2	2	3	4	2	3	3	20.52	54.88
11	29.38	3	3	3	2	3	2	2	50.9	57.7	10.12	2	1	1	1	2	1	1	12.4	81.54	7.14	3	3	2	3	4	4	3	12.3	58.01	12.39	1	1	2	2	1	3	1	20.52	60.38
12	40.42	1	1	1	1	1	2	2	50.9	79.4	9.386	2	1	0	2	2	2	2	11.9	78.96	12.30	0	2	1	1	2	2	1	13.5	91.08	13.91	1	2	1	3	2	2	1	21.46	64.81
13	33.48	3	2	2	1	0	2	1	50.9	65.8	6.697	2	1	1	3	3	3	4	11.4	58.96	8.30	3	2	2	1	3	3	2	12.9	64.3	12.16	2	1	3	3	2	2	1	21.46	56.69
14	31.45	3	2	2	2	2	2	2	50.9	61.8	11.2	1	1	1	0	3	1	0	12.4	90.22	10.42	2	3	2	1	2	2	2	13.5	77.17	14.91	1	1	3	2	3	2	2	21.46	69.5
15	42.50	1	1	1	2	1	3	2	48.3	88.0	7.912	2	2	1	3	1	2	2	11.9	66.56	8.80	3	3	1	2	2	3	4	12.9	68.23	11.18	2	2	3	3	2	4	1	19.59	57.08
16	29.33	3	2	3	2	3	3	2	48.3	60.8	6.971	4	1	1	3	2	3	2	11.4	61.37	9.40	3	2	2	3	2	3	2	12.9	72.84	16.47	0	1	2	3	2	2	3	21.46	76.76
17	38.04	1	2	0	2	2	2	0	50.9	74.7	6.951	4	1	2	3	2	3	3	11.4	61.19	7.82	4	3	2	4	3	4	2	12.3	63.55	9.264	3	2	3	2	3	3	1	20.52	45.14
18	26.74	3	3	2	2	3	3	3	48.3	55.4	7.395	2	2	2	2	2	2	3	11.9	62.21	8.21	2	3	2	3	2	3	3	12.9	63.61	17.95	2	1	1	1	2	0	2	23.33	76.95
19	37.62	2	2	2	3	2	2	1	50.9	73.9	7.94	2	2	2	3	1	3	3	11.4	69.9	8.05	2	3	3	3	3	4	2	12.3	65.47	11.73	3	2	3	3	3	3	2	20.52	57.14
20	24.17	3	4	3	2	3	3	2	48.3	50.1	9.835	3	1	1	2	2	2	3	11.9	82.74	11.38	2	2	1	1	2	2	1	13.5	84.27	9.113	2	1	3	4	3	2	3	21.46	42.46
21	53.13	1	2	1	3	1	1	2	53.5	99.2	9.535	2	2	1	3	1	3	2	11.4	83.94	10.70	2	3	2	3	2	1	3	14.1	75.87	13.45	1	0	2	2	3	1	1	22.4	60.07
22	37.11	2	2	2	2	2	3	2	48.3	76.9	7.569	3	2	2	2	2	3	3	11.4	66.63	6.98	3	3	2	3	2	3	4	12.9	54.11	9.156	2	2	3	3	3	2	2	21.46	42.67
23	36.79	3	2	1	2	2	2	1	50.9	72.3	10.45	2	3	1	1	2	1	1	12.4	84.15	7.80	2	3	3	2	4	4	2	12.3	63.42	12.66	2	2	1	2	3	3	1	20.52	61.68
24	29.67	2	3	1	2	3	2	1	50.9	58.3	9.121	3	1	1	3	2	2	3	11.9	76.73	8.36	2	4	3	3	2	3	3	12.9	64.76	11.61	1	0	3	2	3	2	3	21.46	54.12
25	36.99	1	2	1	3	1	1	2	53.5	69.1	7.658	2	2	2	2	2	2	3	11.9	64.42	8.07	3	4	2	2	2	3	3	12.9	62.57	11.43	1	2	3	2	3	2	1	21.46	53.26
26	32.02	2	3	2	1	2	3	1	48.3	66.3	8.772	2	3	2	2	2	3	3	11.4	77.22	8.47	4	3	2	4	3	4	3	12.3	68.88	16.08	1	1	2	0	2	1	1	22.4	71.81
27	37.59	1	2	1	2	1	2	2	50.9	73.8	9.934	2	2	2	3	1	2	2	11.9	83.57	9.26	3	2	1	3	2	2	3	13.5	68.6	8.823	2	1	3	3	3	2	3	21.46	41.11
28	32.29	3	3	2	1	2	2	2	50.9	63.4	7.854	3	2	1	3	2	2	3	11.9	66.07	7.94	4	3	2	3	3	2	2	13.5	58.81	11.25	2	1	2	2	3	3	1	20.52	54.82
29	53.13	1	1	2	3	1	1	2	53.5	99.2	9.251	1	2	2	2	1	3	2	11.4	81.45	7.09	3	3	2	4	4	3	4	12.9	54.93	12.73	1	1	3	2	3	2	1	21.46	59.31
30	24.38	3	4	2	2	2	4	2	45.7	53.4	6.755	2	2	2	4	2	3	3	11.4	59.47	10.14	3	2	2	3	2	1	3	14.1	71.93	10.43	2	3	2	3	3	3	2	20.52	50.82
31	42.62	2	2	1	2	1	2	3	50.9	83.7	5.817	3	3	1	4	2	3	3	11.4	51.21	10.41	2	2	1	2	2	1	2	14.1	73.78	15.14	1	2	1	2	2	2	1	21.46	70.57
32	29.64	3	3	2	2	2	3	2	48.3	61.4	5.687	4	2	2	3	2	3	3	11.4	50.06	6.67	3	4	2	3	4	2	3	13.5	49.43	13.72	2	1	3	2	2	2	1	21.46	63.95
33	24.88	4	4	2	3	2	3	2	48.3	51.5	7.802	3	1	2	3	2	3	3	11.4	68.69	7.43	2	3	3	3	2	4	3	12.3	60.39	9.476	2	2	3	4	3	2	3	21.46	44.16
34	39.46	2	2	1	2	1	3	1	48.3	81.7	10.01	2	3	2	3	1	1	2	12.4	80.61	10.41	2	3	0	2	2	1	2	14.1	73.78	11.05	3	2	3	4	2	3	3	20.52	53.83
35	30.19	3	1	2	1	2	2	3	50.9	59.3	7.977	2	3	2	3	2	2	2	11.9	67.1	8.24	2	2	2	3	2	4	3	12.3	66.95	10.42	2	2	2	3	3	3	1	20.52	50.78
36	36.82	2	3	2	2	1	3	2	48.3	76.3	10.4	1	1	3	2	1	2	2	11.9	87.49	8.82	4	3	2	3	2	3	3	12.9	68.4	12.64	1	2	3	2	2	3	1	20.52	61.6
37	39.46	2	2	1	1	2	2	2	50.9	77.5	8.234	2	2	2	2	1	3	2	11.4	72.49	9.63	2	1	2	3	2	3	1	12.9	74.62	17.17	1	1	0	1	1	2	2	21.46	80
38	28.69	2	3	3	1	1	3	2	48.3	59.4	7.509	3	3	2	3	2	3	3	11.4	66.11	9.35	3	2	1	2	2	1	3	14.1	66.26	15.5	2	2	1	2	2	3	1	20.52	75.52
39	33.36	2	3	1	2	1	3	1	48.3	69.1	6.41	3	1	2	3	2	4	2	10.8	59.18	9.49	1	3	2	2	1	2	2	13.5	70.26	11.73	2	1	3	2	3	2	1	21.46	54.64
40	33.45	3	4	1	1	2	2	2	50.9	65.7	6.037	3	2	2	3	2	3	4	11.4	53.15	7.85	3	4	2	3	2	3	3	12.9	60.84	10.11	3	2	4	3	2	3	2	20.52	49.26

It must be taken into account that the prioritization of PAR improvement can be affected by factors other than productivity itself. For example, when it is relatively expensive to improve the PAR of an item, the current production system might be kept in place for the sake of cost-effectiveness. From an organizational perspective,

an RF can be understood as a monitoring object. In other words, once RFs seriously affecting the PAR of an item are identified, companies can monitor values of the RFs and company-wide effort to reduce them. In addition, in the process of indentifying RFs, tacit knowledge about influential factors on each item can be turned into explicit knowledge. This output could be used to establish a comprehensive productivity management manual for industries. The combination of PAR and RII will help the management to concentrate on the fields which are immediate actions.

Table 16: Variables and Ranking

VARIABLE CODE	FACTORS	VARIABLES	CUTTING UNIT		STITCHING UNIT		MOLDING UNIT		PACKING UNIT	
			RII(%)	RII RANK	RII(%)	RII RANK	RII(%)	RII RANK	RII(%)	RII RANK
1.1	Work force	Lack of skill and experience of the workers	19	8	18.5	14	11.5	26	10	21
1.2		Lack of empowerment (Training and Resourcing)	20	7	13	25	15.5	20	9.5	22
1.3		Co workers attitude & Behavior	18	10	11	28	18.5	16	10.5	20
1.4		Difficult work methods	15	13	13	25	14.5	22	0	NIL
1.5		Low labor morale/commitment	12.5	15	20	10	24.5	10	12	18
1.6		Poor relations among workers	12.5	15	25.5	3	21	13	12	18
1.7		Labor frustration	7.5	21	11	28	12.5	25	8.5	23
1.8		Increase of labor age	6	23	8	31	9	29	5	26
2.1	Material / Equipment	Material shortages	15	13	7	33	7.5	32	9.5	22
2.2		Lost time to find material because of poor arrangement	30.5	1	17	17	25	9	13	17
2.3		Equipment, tools shortages and condition	22	6	21.5	9	31.5	2	13.5	16
2.4		Low quality of raw material	25	3	13.5	24	29.5	4	13	17
2.5		Unsuitable material storage location	18	10	14.5	22	21	13	11.5	19
2.6		Machine breakdown	12	16	12	27	15	21	8	24
3.1	Management	Poor relations between labor and superintendents	17	11	12	27	12.5	25	21.5	8
3.2		Bad leadership skill	24.5	4	19	13	27	7	36.5	1
3.3		Lack of labor surveillance	28.5	2	21.5	9	27	7	32	2
3.4		Lack of periodic meeting with labor	15	13	13.5	24	14	23	20.5	10
4.1	Motivation	High work discipline	9.5	19	14	23	8.5	30	12	18
4.2		Amount of pay	7.5	21	10	30	16	19	16	13
4.3		Little or no welfare	19	8	15.5	20	17	18	13.5	16
4.4		Little or no financial rewards	19	8	24.5	4	24	11	21	9
4.5		Lack of labor recognition program	16	12	27	2	25.5	8	22	7
4.6		Poor condition of camping	10.5	17	22.5	7	20.5	14	17.5	12
4.7		Lack of facility for relaxation and transportation	9	20	7.5	32	8	31	13	17
5.1	Schedule	Frequency of working overtime	9.5	19	12.5	26	14.5	22	20.5	10
5.2		Shift work	18	10	16.5	18	28.5	5	24.5	5
5.3		Internal delay because of change/cancel work order	22	6	23.5	5	42	1	29	4
5.4		Poor work planning	20	7	18	15	30	3	31	3
5.5		Overcrowding	14	14	16.5	18	9	29	17.5	12
6.1	Safety & Work environment	Accidents & Physical fatigue	5.5	24	10.5	29	8.5	30	7	25
6.2		Lack of labor responsibility	12	16	13	25	15	21	9.5	22
6.3		Product complexity	17	11	19	13	10	28	19.5	11
6.4		Ignore rules and regulations	22	6	28	1	27.5	6	14	15
6.5		Power failure	22.5	5	22	8	17.5	17	22	7
6.6		Unsafe working conditions	18.5	9	17.5	16	21	42	23	6
6.7		Weather condition.	7	22	0	NIL	18.5	16	14	15
6.8		Age of plant and equipment	12.5	15	16	19	13	24	7	25
7.1	Supervision	Poor or no supervision method	3.5	26	6	34	9	29	4	27
7.2		Incompetent supervisors	7.5	21	13	25	8	31	3	28
7.3		Changing of supervisor	9	20	23	6	14.5	22	7	25
7.4		Changing order	14	14	19.5	12	22.5	12	11.5	19
7.5		Incomplete layout	15	13	21.5	9	25.5	8	14	15
7.6		Inspection delay	10	18	15	21	20	15	15.5	14
7.7		Rework	12.5	15	20.5	10	14	23	8.5	23
7.8		Supervisors' absenteeism	4.5	25	7.5	32	11	27	10	21

VI. CONCLUSION AND FUTURE WORK

This thesis concentrates on the evaluation of management controls over the production. The day to day productivity must be measure and compare for to take corrective actions and to increase the productivity. From the present study, total 46 variables were identified which affects labor productivity in FOOTMATE classifies into 7 factor groups. Forty observations were made with the help of observation data sheet designed. The collected data is scaled and check the reliability and correlation between variables to identify validity of collected data. Stepwise linear Regression used for the calculation of the OP. The AP calculated from the observations is the dependent variable and the reduction factors are the independent variables for the Regression Analysis. So from the regression the OP value is calculated. From AP & OP the PAR was determined. From the frequency of occurrence of collected variables RII rank of every variables in the factory was determine and the most affected variables are Lost time to find material because of poor arrangement, Lack of labor surveillance, Low quality of raw material, Bad leadership skill and Equipment, tools shortages and condition.

The PAR & RII are used to define the obtainable productivity and operations to make productivity manageable, identify critical reduction factors, productivity indicators, productivity factors and intervention areas, and for productivity target setting, measurement and analysis. The PAR & RII can improve productivity by enhancing

effective utilization resources like human, capital, material, energy and miscellaneous inputs; it directly or indirectly improve quality by minimizing rates of rejection, rework and scrap; similarly increase capacity by increasing human hour utilization and machine hour utilization; increase both internal and external customer satisfaction; and reduce cost by minimizing waste of resources. For academicians and researchers, the PAR & RII can be used as guideline how to develop a method that supports productivity improvement of manufacturing company.

Despite that performance measurement has been a very popular research topic during the last decades; there are still many issues in the field that have not yet been solved to a satisfactory degree. Considering the scope of this research, it is suggested that the following areas should be further explored. Manufacturing organizations are basic economic elements of a nation. Therefore, developing a generic method that supports productivity improvement of both manufacturing and service giving industries of India is the research area that should be considered in the future

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