

# Productivity improvement in Small and Medium Machine Manufacturing Industries in Kenya

B.N Njiraini, S.M Maranga and B.W Ikua

**Abstract**— Productivity determines an organization's competitiveness and consequently its growth. Kenya's development plan dubbed vision 2030 recognizes small and medium industries (SMIs) as key stimulants for the growth of industrial sector. Productivity improvement of SMIs is therefore critical for the achievement of vision 2030. This paper reviews factors that determine productivity and quality of products manufactured by SMIs. Subjective method is used in the survey to investigate productivity levels in SMIs and identify the factors that influence productivity. The relationship of productivity to the factors is determined using multiple regression analysis. In addition, the interaction between the factors is determined. The technique facilitates SMIs to achieve optimum results by prioritizing areas in which to improve and invest more capital. The results indicated that application of technology is the best for improvement of productivity since it has multiple effects on other factors.

**Keywords**—Productivity, SMIs

## I. INTRODUCTION

**P**RODUCTIVITY is defined as output per unit input. It is a measure of how well resources are utilized [1]. Increase of productivity occurs only if for the same level of input or less the output increases. There are three productivity measures commonly in use, namely, partial productivity, multi factor productivity and total productivity.

a. Partial productivity relates total output to one class of input. There are three commonly used partial productivity measure namely;

$$\text{Labour productivity} = \frac{\text{Output}}{\text{Labour input}} \quad (1)$$

$$\text{Capital Productivity} = \frac{\text{Output}}{\text{Capital input invested}} \quad (2)$$

$$\text{Material Productivity} = \frac{\text{Output}}{\text{Material input}} \quad (3)$$

b. Multi-factor productivity (MFP)

This is the ratio of the real value of output to the combined input of labor capital and energy. It measures how efficiently and effectively the main factors of production combine to generate output.

c. Total Productivity Measure (TPM)

This relates total output to the sum of all tangible inputs. This model can be applied to any manufacturing organization or service company.

$$\text{Total productivity} = \frac{\text{Total tangible output}}{\text{Total tangible input}} \quad (4)$$

where

Tangible output= Value of finished goods produced + Value of partial units produced + dividends from securities + interest + other income

Tangible inputs=Value of human+ material +capital + energy + other inputs) used

Improvement of productivity is the key to success of most organizations and benefits both the investor and employee. Although productivity improvement in the minds of the workforce means higher work load, more efforts, more profits to owners, unemployment and threat to their jobs, it is the productivity that integrates the objectives of the owners and workers. Fig. 1 shows the causal ripple effects of productivity enhancement. High productivity contribute to better living standards and leads to improvements in working and living conditions, higher real earnings and generally strengthen the economic foundation of human well being. Steady growth in productivity guarantees non-inflationary increase in wage as well as solves pressing problems of unemployment.

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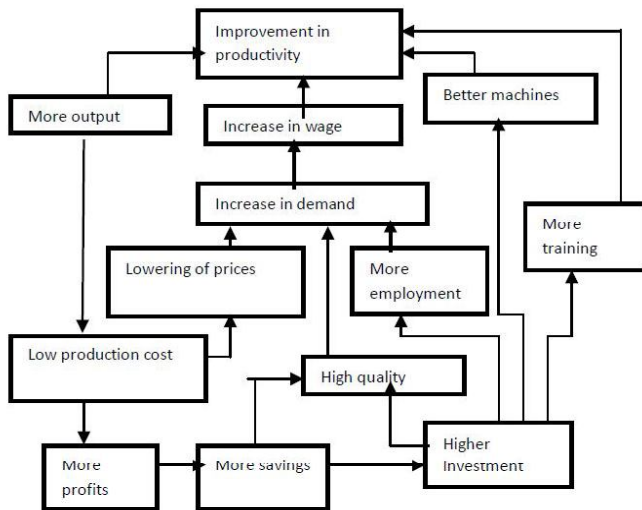


Fig 1: Causal diagram of dynamics of productivity change

## II PRODUCTIVITY IMPROVEMENT METHODS

Productivity is influenced by many different factors which can vary according to the nature of the company. A study showed that the different productivity improvement techniques can be categorized into five categories; technology, material, employee, products and processes [2]. To improve productivity many firms have developed strategies and adopted policies and mottos such as 'You cannot improve what you can't measure' to steer their organizations to higher levels. One of widely applied method is upgrading of equipment to modern technology equipment. A study on impact of information technology in telecommunication industry using Cobb-Douglas model showed a significant correlation of productivity to information technology [3].

Another method which indirectly affects productivity is quality improvement. Quality improvement means minimization of waste and defective products, which increases productivity and often leads to cost reductions [4]. A study by Deming [5] showed that improvement in quality creates corresponding improvement in productivity by reducing costs errors, rework and delays. Continuous Improvement (CI) popularly referred to as (KAIZEN) which is a philosophy that focuses on improvement through introducing small incremental changes help improve productivity. A case study found implementation of CI at the Boeing Company resulted in significant resource productivity improvements with important environmental improvement implications [6]. Lean manufacturing such as Just In Time (JIT) philosophies have shown improvement in productivity in SMIs [7]. A survey conducted by Dilworth [8] on use of JIT found performance improvement resulting from process changes, reduction of organization layers, increased teamwork and lower inventory levels. A good plant layout creates an efficient flow process and reduces both transportation time and cost thus improvement on productivity. A proposed layout in marble factory contributed to a 55 % time saving [9]. In a study of a company manufacturing lubricant, a proposed U shaped layout

improved space utilization and productivity [10]. Another method used is work study. Work study which involves both method and time study has been proved to improve productivity by various studies [11]. It is important for a company to compare its operation, products, and practices prices to a leading company referred to as benchmarking. The objective of using the practices learned as a guide and reference point for improving the practice or products of one's own organization.

## III METHODOLOGY

The study involved structured survey questionnaire, interviews and in-depth real-time observations of the production processes. The designed questionnaire used subjective methodology for assessment of productivity levels in SMIs where firms were asked to assess their productivity on a five point scale. The respondents were asked to name and rank the factors that improve productivity to get empirical correlations between productivity performance and the numerous factors. Productivity function was obtained using multiple regression analysis. To determine the constraints that they face a cause and effect diagram was done.

A sample frame of 100 firms were identified dealing with machine manufacturing sector and questionnaires were sent. Cluster sampling technique was used since the SMIs were scattered throughout the country. Four main cluster areas were identified to represent the entire sample population. Further stratification of firms into three strata was done in accordance with number of employees as follows; very small SMIs (1-9), small (10-19) and medium (20-50) employees. The three clusters were Kariobangi light industries, Nairobi's industrial area, and Gikomba area.

## IV. RESULTS AND DISCUSSIONS

### a. Response rate

Table 1 presents the number and distribution of SMIs that responded to the questionnaire out of the targeted 100 firms. 41% of the firms responded.

Table 1: No. of respondents per area

Region	No. of Respondents	Percentage
Kariobangi Area	17	41.46 %
Nairobi Industrial area	14	34.15 %
Gikomba area	10	24.39%
<b>Total</b>	<b>41</b>	<b>100%</b>

### b. SMI details

The data collected was based on information provided by the technical managers, personnel from the finance and human resource departments. From Table 2, the mean number of employees per firm was 12.7 with a minimum of 1 and

Table.2: Personnel details

	No of Employees	Education level				Firm's age	Main products	Respondents years of experience
		Engineers	Technicians	Craftsmen	Artisans			
N	41.0	41.0	41.0	41.0	40.0	41.0	41.0	
Mean	12.7	0.2	1.7	3.2	5.8	4.3	3.7	6.8
Mode	3.0	0.0	1.0	0.0	1.0	1.0	3.0	4.0
Std. Deviation	9.9	0.5	1.5	3.0	5.1	3.0	1.4	4.2
Minimum	1.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0
Maximum	40.0	2.0	7.0	12.0	16.0	15.0	7.0	20.0

maximum 40 personnel employed respectively. The average operational existence of SMIs was 4.3 years with maximum and minimum of 15 years and 1 year respectively. Many firms did not specialize and produce many products as demand changed, with a mean of 7 products manufactured per firm. From the data collected the bulk of the firms had their 30% personnel working as casuals and did not have formal education but acquired their skills through on job training. On training levels, 10% of the firms had employed technicians qualified with either diploma or certificates while 20% were craftsmen from village polytechnics. The study showed that 40% of the firms did not measure productivity but evaluated their performance through profit and loss accounting system.

c. Productivity measurements systems

The study showed that firms apply different techniques for productivity measurement as shown in Table 5.3. Labor productivity was the most commonly used measure at 31%; and the productivity measure was rated second at 19%. Capital productivity measure had a 14% use. Material productivity measure was used by 10% of the firms interviewed. Energy productivity measure was used by 5% of the firms. Indirect method was also used where assessment of rejects and re-work quantities formed 5 % of the total productivity assessment techniques. Other techniques used accounted for 15 %.

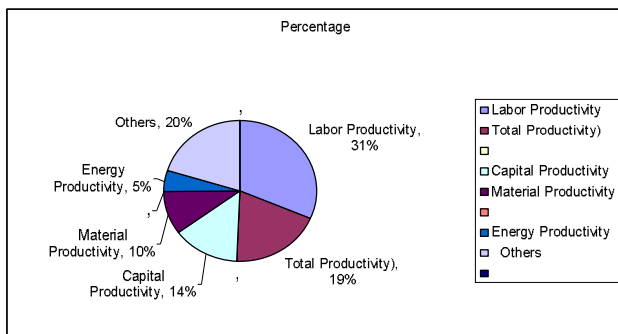


Figure 1: Productivity measurement used by various firms

d. Productivity levels and factors that improve Productivity in SMIs

Table 3 shows the results of productivity levels and factors that improve productivity. Based on a five point scale, the average productivity level was 2.71 indicating that firms felt that their productivity was slightly above the average mark. The result shows technology ranked as the best technique to have rapid impact on productivity with a mean score of (2.44). Skilled work force had a mean score of (2.22). Most firms interviewed felt that productivity could be enhanced through motivated workers with a mean score of (2.07). Availability of tools had a mean of (2.20) where most firms interviewed said special tools such as jigs and fixtures would shorten the work cycles hence improve productivity. Good management practice was rated at a score of (2.22). Safe working environment for workers was also necessary at a mean score of (2.15).

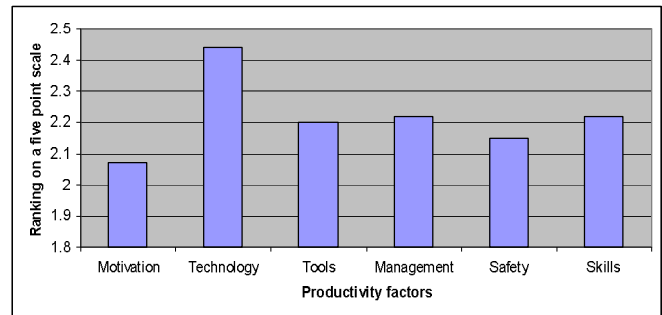


Figure 2: Factors that enhance productivity

e. Determination of productivity factors using regression analysis

To establish the nature of relationship between productivity and factors that enhance. Multiple regression analysis was done where productivity was the independent variable and the dependent variable: Application of technology, skilled manpower, good management practices, Availability of tools, safety of the working environment and motivated workers. Table 2 summarizes the results of regression. The fitted equation based on multiple regression becomes;

$$P = 0.268 + 0.288P_m + 0.29P_t + 0.258P_s + 0.308P_o \quad (5)$$

Where;

- $P_m$  = Motivation factor
- $P_t$  = Technology factor
- $P_s$  = Skill factor
- $P_o$  = Tool factor

The results indicate that application of technology has a positive and significant relationship with productivity ( $r=0.29$ ,  $p$ -value < 0.05). Figure 4 shows the relationship between productivity and Skills. The results indicate that firms that have improved their production machinery to semi automatic, improved their communication systems and quality control have higher productivity. There was a positive relationship ( $r = 0.258$ ,  $p$ -value < 0.05) between productivity and skilled

manpower. The trained personnel were easy adopt to the new job and could also be inducted to other closely related skills.

Table 2: Regression coefficients

Model	Coefficients (r)	t-test (t)	Significance (p-value)
(Constant)	-0.268	-1.046	0.303
Motivation	0.288	2.141	0.039*
Technology	0.290	3.232	0.003**
Tools	0.308	2.216	0.034*
Management	0.035	0.394	0.696
Safety	0.162	1.497	0.144
Skills	0.258	2.855	0.007**

Dependent Variable: Productivity  
 \*\* p-value < 0.01,  
 \* p-value < 0.05

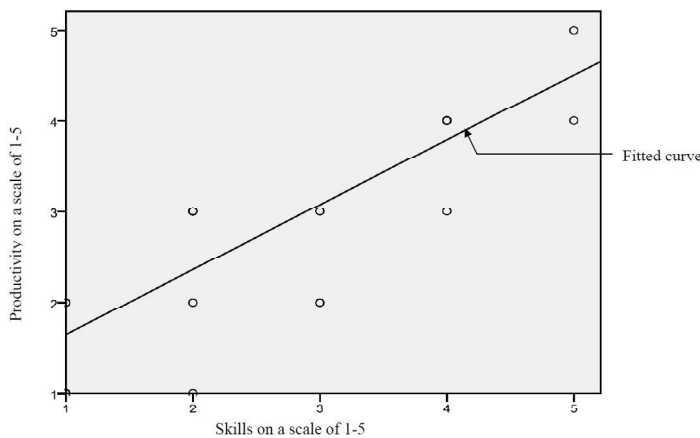


Figure 4: SMIs productivity level versus manpower skills

f. Correlation of productivity factors

With respect to motivation and productivity relationship, the results indicate a positive relationship ( $r=0.288$ ,  $p\text{-value} < 0.05$ ). Highly motivated workers through incentives such as better remuneration. The results of regression showed the relationship of productivity to availability of tools ( $r = 0.308$ ,  $p\text{-value} > 0.05$ ). It was noted that well established firms that had operated for more years had better tools and their productivity higher. Specialized tools and jigs and fixtures helped in reducing the production period thus reduced man hours, better quality and higher productivity. The modern management practices had their limitations in application at SMIs especially the very small firms. The research findings discovered that modern management techniques such as TQM,

JIT have no significant effects on productivity( $r=0.035$ ,  $p\text{-value} < 0.1$ ). This could imply that due to their low capacity adopting this concept will add additional cost in terms of personnel and capital inputs.

In order to evaluate the relationships between factors that influence productivity, A correlation matrix was obtained using SPSS. Table 4 shows the correlation matrix. The Guilford 5-level interpretative model was employed in interpreting the coefficients;  $r < 0.2 =$  Marginal correlation,  $r = 0.2\text{-}0.4 =$  Low correlation,  $r = 0.4\text{-}0.7 =$  Moderate correlation,  $r = 0.7\text{-}0.9 =$  High correlation,  $r > 0.9 =$  Extremely high correlation, The correlation matrix Table 4 showed that motivation is positively related to availability of tools ( $r = 0.773$ ;  $p\text{-value} < 0.01$ ) and to the safety ( $r = 0.633$ ;  $p\text{-value} < 0:01$ ). Availability of tools is positively related to skills( $r=0.603$ ;  $p\text{-value} < 0.01$ ) and technology ( $r=0.512$ ;  $p\text{-value} < 0.01$ )

Table 3: Correlation matrix

	Productivity	Motivation	Technology	Tools	Management	Safety	Skills
Productivity	1						
Motivation	.801**	1					
Technology	.664**	.499**	1				
Tools	.816**	.773**	.512**	1			
Management	.403**	.418**	0.217	.366*	1		
Safety	.647**	.633**	.424**	.532**	.389*	1	
Skills	.672**	.498**	.339*	.603**	0.266	.386*	1

\* Correlation is significant at 0.05 level (2- tailed)  
 \*\* Correlation is significant at 0.01 level (2- tailed)

g. Constraints that SMIs face in improving their productivity.

The causes that contribute to the low productivity in SMIs were identified after conducting an investigation using structured questionnaires. The investigation was based on the five 5Ms (Machines, Methods, Men, Materials an Measurement). Figure 5 shows the cause and effect diagram. Cause and effect diagram can be used to identify the area with the problem for rectification.

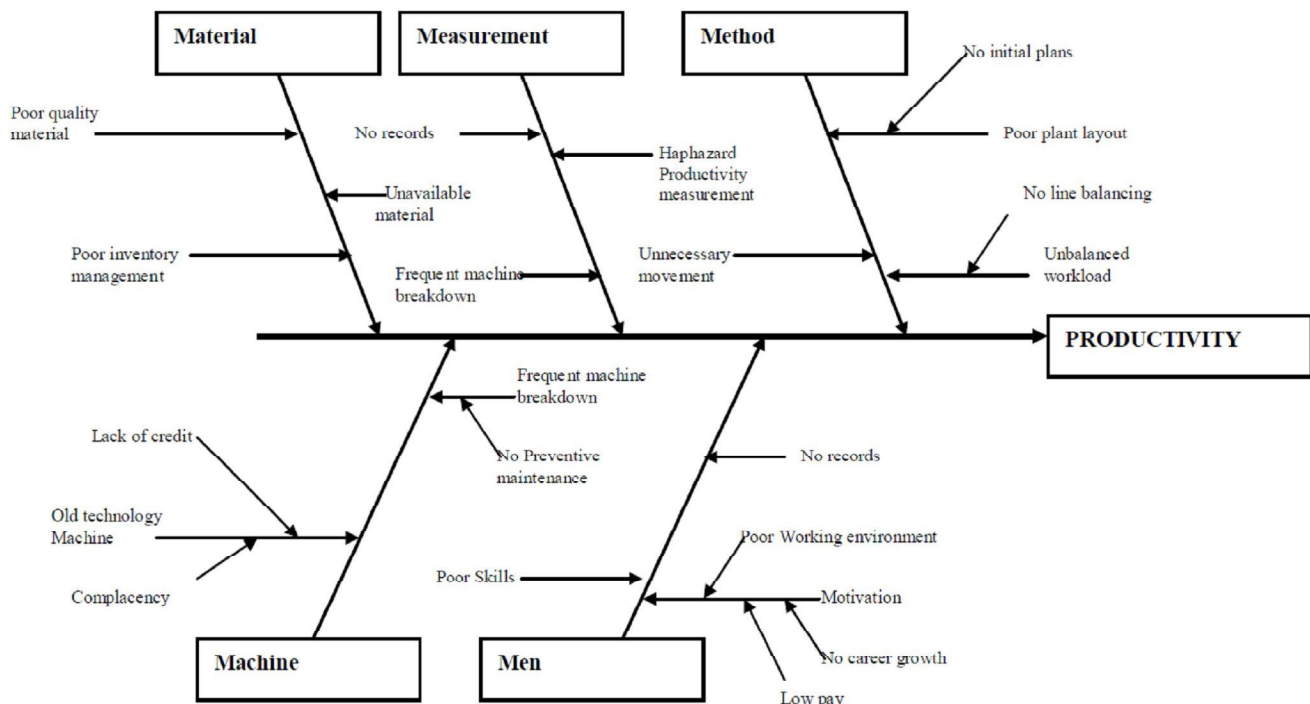


Figure 5: Cause and effect Diagram

### V CONCLUSIONS

Subjective method to evaluate the productivity levels was used based on a scale of 1-5. The results showed that the mean productivity was 2.71. The firms indicated that five factors namely; Application of technology, motivation, skilled manpower and availability of tools play the most important role in their productivity levels. Application of technology was ranked as the best method for improvement of productivity as for example, it influences other factors as well. Analysis using cause and effect diagram showed that that the major constraints facing SMIs falls under the five Ms, namely Materials, Men, Machines, Method and Measurement.

#### Recommendations

a. Due to the limited source of data from SMIs the study used subjective method for assessing the productivity level on a scale of 1-5 it is recommended that measurement of the above parameters be based on actual productivity measurements techniques to eliminate the error occasioned by interviewee perception.

b. The higher number of SMIs studied produce machines intermittently depending on demand for orders. The study Of these SMIs assumed the process as a continuous process. There is a need to study productivity where production is continuous and where there is interruptions to determine the relationship.

c. The SMIs studied produce a variety of products with different manufacturing processes thus complexity of

assessment of productivity. It is recommended that a study be based on SMIs that closely relate and produce similar products.

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