Productivity Analysisand Improvementin Ethiopian Metal Manufacturing Industries

"A Case of Yesu Metals Manufacturing"

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Productivity Analysis and Improvement in Ethiopian Metal Manufacturing Industries

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DECLARATION

I hereby declare that the work which is being presented in this thesis entitled **"productivity analysis and improvement in Ethiopian metal manufacturing industries: a case of Yesu metals manufacturing"** is original work of my own, had not been presented for a degree of in any other university, in any projects by any means, and all the resource materials used for this thesis had been accordingly acknowledged.

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Tadiyos Derbe Date

This is to certify that the above declaration made by the candidate is correct to the best of my knowledge.

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Dr. Yitagesu Yilma (Advisor) Date

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ABSTRACT

Nowadays, due to high level of competition and survival request in a business world, that is a basic necessity that business firms to measure, analyze and improve their productivity level as they encounter increasing competition from an ever-changing business environment. Even though the word productivity is a common word to hear every day in, it is still confusing for many. However, the concept behind productivity is getting a better output from available resources and inputs. As productivity increases, firms and county as a whole will be benefited as investment expands and employment opportunity will also be created more. Even though there are so many types of models and mechanisms of productivity measurement and analysis, there is no decision can be made, as it is the first step to control and improvement of productivity.

Though the metal industry sub sector is the basic provider for the other sub sector industries & construction sector and also the Government of Ethiopia is promoting the sector as a priority area and for a huge potential in import substitution and economy development, its productivity level is at low level due to variety of problems. Hence the countries demand for metal and engineering products is met almost from export market. Thus, the research focuses to assess, analyze and improve the productivity practice of Ethiopian metal industries by identifying the critical problems and propose a firm level total productivity improvement method and suggest possible improvement directions towards low productivity.

To undertake this research, primary & secondary data were collected through a survey questionnaire, interviews and field visit/ physical observation in the case company as well as referring previous research works and case company records. To analyze and present the data, pie charts, bar graphs, and Pareto graph, cause and effect diagram are used. From the research, it is concluded that the metal industries constitute several sub processes that are being managed hindered by outdated machines, systems and techniques and poor skilled & knowledge employees are resulting low productivity and competitiveness. To alleviate the internal or firm level problems, an improvement method is proposed. In addition improvement knowledge transfer mechanism is also directed for the sector level productivity improvement.

Key words: Productivity, productivity measurement, productivity analysis, productivity improvement, production system, Ethiopian metal manufacturing industries, knowledge transfer

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LIST OF ACRONYMS AND ABBREVIATIONS

CCM- Continuous casting machine

CEO – Chief executive officer

CNC- Computer numerical control

CSA- Central statistics authority

GDP – Gross Domestic Product

GNP – Gross national products

GTP – Growth and Transformation Plan

KAIZEN – Ethiopian Kaizen institute

MIDI – Metal Industry Development Institute

MOI Ministry of industry

PLC –Programmable logic controllers

RC– Reinforcement concrete

R & D – Research and development

UNIDO- United nationsIndustrial development organization

WS- work stations

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

Productivity is a main factor in which business firm existence is based up on. The main objective of a business firm is providing consumers' satisfaction while making a profit. Business firms always attempt to maximize profit. But in order to maximize profit a business firm has to be efficient where efficiency is measured by the capacity of the business firm to raise the productivity of existing resources so that cost per unit production is reduced. Since cost and productivity are reciprocal of each other, a raise in productivity implies a fall in cost of production which ends in higher profit. [Kendrick .G. 1965**]**Productivity, productivity growth and improvement is a common issue for the business community, industrial firms, mangers, economists, media and politicians as the solution to improving living standards, yet there is a difference on what productivity actually is, how it is appropriately measured, what are the real factors affecting it and how can it be improved as well. [Joshep .P. 1999]

This is true for manufacturing industries as well;manufacturing industries are the backbone in the economic structure of a nation, since they contribute to both increasing gross national product and gross domestic product [GDP/GNP] and providing employment. The efficiency with which manufacturing firms/organizations and industries, convert inputs (labour, capital, and raw materials) into output is determine their Productivity grows when output grows faster than inputs, which makes the existing inputs more productively efficient.Since the level of productivity in manufacturing firms increases, the overall output value increases, resources are used efficiently and their contribution in the whole economy will increase.[Groover. 2008]

According to country's GTP II document, in the past decade the manufacturing sector has shown an average 5% growth rate. Meanwhile, the metal and engineering sub sector has been growing in number while observing several dynamics or changes in type and scale of products. Even though, the metal industry sector is provided a strategic focus by the government in the past five years as it is the mainbase for the development of other downstream industries& for the construction and there has been a continuous increase in demand for metal products. Several

studies have been conducted on the sector and yet the sector has not been appreciated regarding its national supply, import substitution& global competitiveness which is a direct result of poor productivity level and capacity utilization which is below 60%.

The research focuses on the productivity analysis and improvement on an Ethiopian metal manufacturing industry. Analysis of the production system and productivity play a vital role for the development of the manufacturing sector and the overall economy. It can assure the efficient resource utilization through systematic approach and techniques that can analyze and improve the specified manufacturing industries and address the inefficient and ineffective utilization of the production system. Therefore analyzing the productivity of the metal manufacturing sector can signify the sectors productivity level and thus lead to a better productive production and manufacturing environment.

1.2. Problem statement

In a world of high competition and dynamic business world, organizations, manufacturing firms should find a way of integrating their ways, techniques, procedures, inputs, materials, capital and over all resources in order to have greater products and services output (system productivity as a whole) in order to stay competitive with other organizations. Survival of any firm in the market is therefore depends on the effective use of these resources. The manufacturing Industries in Ethiopia are no exception to this fact.

According to the five year capacity utilization and productivity survey study conducted by the government, generally, the metal manufacturing industries are face the following major problems with regard to the issue of productivity and system efficiency;

- Since local production output is minimal nearly all machineries and equipments are imported or Import level 95% which also led to the low level of other sub sector development since metal and engineering is the base for others. The least Export level with respect to the other sub-sectors[MOI GTP II -2015].
- Low level of per capital consumption 20.36 kg/year which is very much less than even the African consumption of 42 kgs less than with a capacity utilization of just54% [CSA, GTP II.]

Generally the industries has also Low level of value addition, and, raw material availability (iron and iron ore) etc. In order to be competitive globally, domestic metal manufacturing industries will have to strive for maximum efficiency and high capacity utilization which is directly related to productivity[MIDI annual report].

Meanwhile based on the preliminary analysis the case company is similar with other metal manufacturing industries. The manufacturing system in the plant to be considered in this research uses complex processes involving various resources [hot Rolling machines, cold rolling and drawing machines, furnaces, PLC controlled systems, CNC machines, Hydraulic and pneumatic systems, printing machines, operators, etc.]. Based on the preliminary survey it is observed that Interactions and interdependencies between these activities make it difficult to monitor the processes and necessitate extra effort to analyze equipment and system efficiency which led to a low level of systems productivity as a whole.[Company report 2016]

Thus, for effective production control, identification of machine performance, cycle times and production data [(total parts, rejects, throughput, products /hr] becomes critical. It was identified that this production process required a long lead-time[due to the nature of process and downtime involved] and a lot of automatic and manual material handlings and transport systems are engaged in the process.[Company report 2016]

The production rate, particularly the smaller size reinforcement bars, was considerably low that it cannot supply the highly increasing demand of the market. It is also considered that the scrap, rework and work-in-process [WIP] inventory level was significantly high. The production process significantly disturbed due to the amount of time spent in the shop floor production counts, percent uptime, and downtime reasons. Supervisors and plant / production manager and engineers had to focus on scrap and downtime time monitoring and control of the manufacturing process. [Company report 2016]

The research contributesthe analysis of productivity and developing a productivity improvement tool that can effectively improve the metalmanufacturing industries productivity performance by identifying relevant inputs, key factors and intervention areas. The study assess the production environment in order that the metal manufacturing industries tobe competitive in global stage.

1.3. Research question

The major research question to be raised in the process of the research preparation could be generalized in the following areas.

- What is the existing productivity performance of the Ethiopian metal manufacturing industries?
- What are the key factors/productivity drivers responsible for the productivity of Ethiopian metal manufacturing industries?
- What are the firm level system and operational productivity problems and identify the root causes of the case company?
- What appropriate techniques should be used to maximize the system/operational productivity the case firm?
- How can the productivity of the Ethiopian metal manufacturing Industries be improved?

1.4. Research objectives

1.4.1. General objectives

The general objective of the study is to analyze the existing productivity performance and propose appropriate framework that can improve the Ethiopian metal manufacturing factories productivity.

1.4.2. Specific objectives

The specific objectives of this research are as follows:

1. Analyze the existing productivity of the Ethiopian metal manufacturing industries.
2. Identify the key factors/productivity drivers responsible for the productivity of Ethiopian metal manufacturing industries
3. To investigate the existing productivity measurement practices, identify and analyze the firm level system/operational productivity problems and the root cause of the case company.
4. Develop appropriate techniques to maximize the system/operational productivity of the case firm.
5. Suggesting possible solution to improve productivity of the Ethiopian metal manufacturing.

1.5. Significance of the study

According to the GTP II, despite the Ethiopian manufacturing sector is growing by more than 15 % per annum, theindustries are less competitive with imported goods and globally. This is due totheir production output, cost and quality which are caused by associated production efficiency, high production cost and hence low level of productivity**.** Therefore**,** identifying the problems and suggesting appropriate improvement method to improve the productivity performancewill increase their competitiveness level and generally the study could benefit the metal manufacturing industries in; by identifyingthe current productivity related problem areasand assert areas for improved productivity by designing improved productive manufacturing systems. It benefits the other sub sector manufacturing sector involved industries with poor productivity performance. And finallyit providesa sort of data and information sourcefor other researchers.

1.6. Scope and limitation of the study

The research is concerned in the productivity analysis and improvement in Ethiopian metal manufacturing sub sector in which the sector has the lowest level of important substitution, export performance and lower productivity among the other industry sub-sectors[MIDI annual report].Even though it assess, review and analyze their productivity performance, the research will only focus on the detail manufacturing system operational assessment, review, and analysis of YESU manufacturing as a case company. Since it is an educational research with limited resource, the research does not asses the details of other metal industries production system.

1.7. Organization of the thesis

This research isorganized into several chapters. The first chapter covers the introduction, the overall background & problems, objectives, scopes and importance of the research. Chapter two presents a literature review is done about manufacturing systems with respect to the concept of productivity, and after that Chapter three discusses the research methodology and then chapter four discusses the overview the Ethiopian metal manufacturing productivity profile and the next chapter five deals data collection, presentation and analysis of the Ethiopian metal manufacturing industries based on the survey questioner&the case company analysis and chapter six presents the proposed improvement system and finally the conclusion and recommendation are drawn.

CHAPTER TWO

2. LITERATURE REVIEW

The word Productivity and productivity growth is frequently lauded by the business community, media commentators and politicians as the solution to improving living standards, yet there is little agreement on what productivity actually is**.** [Gordon J.2015]

So what is productivity? Productivity isn't half the thing that people say it is. It does not mean

- working harder-unless people are being idle on the job
- cutting costs- unless it can be done without affecting the quality
- reducing staff and workers- unless the market is shrinking
- extra work for managers- it's the part of their job
- employing specialists-it's a job for everyone [Gordon J.2015]

Productivity is a matter of concern to business owners, industrialists ,government bodies, trade unions and other social institutions not minding the disagreements over its conceptualization by different groups and individuals. Productivity is complex and this is because it is both a technical and managerial concept. It is perceived that the more different are the goals of the different individuals, institutions and bodies that have a stake in productivity as a problem, the more different their definitions of productivity will be. [Hans G. 2012]

There is nothing new about productivity. Early writings on the subject go as far back as 400 BC and by AD 1400 and efficient assembly line working in Venice. By the 1800's the role of the worker in productivity had been recognized but it was not until early 1900's that the modern approach to the productivity of industrial processes really came into being. Since then the word productivity has become the best word used by managers and politicians. As a result it is even confusing for many people production and productivity[Gordon J.2015].

The following literature review discusses the concepts of production, production process, production process control, production/manufacturing system, productivity, productivity measurement and improvement in detail.

2.1. General features of manufacturing system

Manufacturing is "the step-by-step conversion of one form of material into another form through chemical or mechanical process to create or enhance the utility of the product to the user." Thus production is a value addition process. At each stage of processing, there will be value addition. [Rajender S. 2006]

The manufacturing company itself is a complex system. It is a complex, dynamics, and stochastic entity consisting of a number of semi-independent subsystems interacting in an attempt to make the overall system function productive. The complexity comes from the heterogeneous environment [both hardware and software], huge quantity of data, and the uncertainty of the external environment. The complex structure of the system and the complex relationship between the interacting semi-autonomous subsystems are also the affecting factors to make the system more complicated. [Groover. 2008]

A simple model of manufacturing system can be a black box that takes input material, energy, and information and gives output products. The internal details of the manufacturing system depends on the particular industry involved, but the key futures common to all manufacturing organizations are that the system processes both material and information. The general manufacturing system can be decomposed into seven levels of decision hierarchies. Decisions at the upper level are made less frequent intervals [but have implications for longer periods into the future] and are made on the basis of more abstract [and slower to change] information on the state of the system. Decisions at the lower frequency use much more detailed information on the state of the system. Three kinds of decisions should be made for any manufacturing company. [Groover. 2008]

1. What kind of product to be produced
2. what resources is needed to make the products
3. How to control the manufacturing systems

2.1.1. Production system

Production system basically implies making of goods or articles and providing services to meet the needs of mankind. It creates value by useful application of physical and mental-labor in the process. It is a chain of interrelated activities of production process and other support services activities of an manufacturing environment such as order processing, product design, design and manufacturing of tools, die, mould, jigs, fixtures and gauges, selection of material, planning, managing and maintaining control of the processes, production, and reliable quality of processed product in a systematic and sequential manner with proper coordination, cooperation and integration of the whole manufacturing system that will lead to economical production and effective marketing of proposed product in the minimum possible time.[Rajender S. 2006]

It is, therefore, evident that manufacturing today is not a one man activity as it was in the initial stages, wherein all the physical and mental inputs were applied by a single craftsman. These days it has become totally a team work which consists of several components interacting together in a dynamic manner. Production function is that part of an organization, which is concerned with the transformation of a range of inputs into the required outputs [products] having the requisite quality level. [Rajender S. 2006]

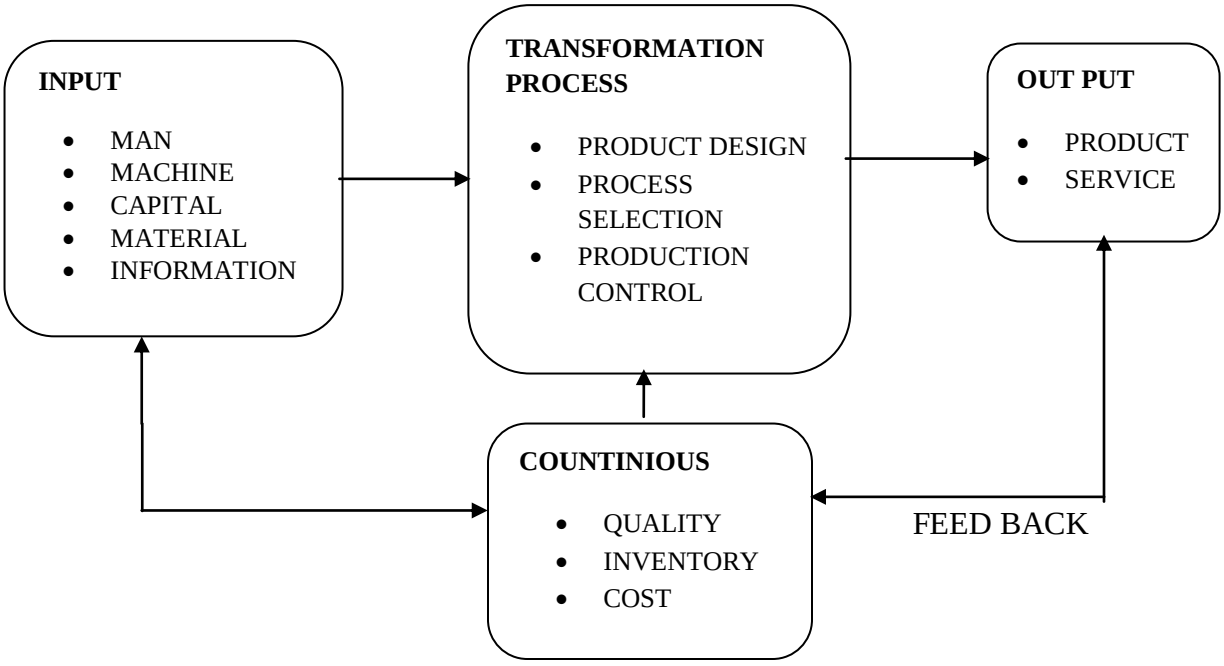

Figure.2.1. Schematic production system [Cheng .W 1998]

[Aggarwal, 1980]explains the production system of an organization is that part, which produces products of an organization. It is that activity whereby resources, flowing within a defined system, are combined and transformed in a controlled manner to add value in accordance with the policies communicated by management.

A simplified production system is shown above. The production system has the following characteristics:

1. Production is an organized activity, so every production system has an objective.
2. The system transforms the various inputs to useful outputs.
3. It does not operate in isolation from the other organization system.
4. There exists a feedback about the activities, which is essential to control and improve system performance.

Production systems can be classified as Job Shop, Batch, Mass and Continuous Production systems. [Groover. 2008]

2.1.2. Production process

The figure below shows a production process as a system with a set of inputs and output. The input x1, x2 ...xn are controllable factors, such as temperature, pressure, feed rate, and other processed variables. The inputs z1, z2 ….zn are uncontrollable (or difficult to control) inputs, such as environmental factors or property of raw materials submitted by the vendor. The manufacturing process transforms these inputs in to a finished product that has several quality characteristics. The output variable y is measure of process quality. [Aggarwal, 1980]

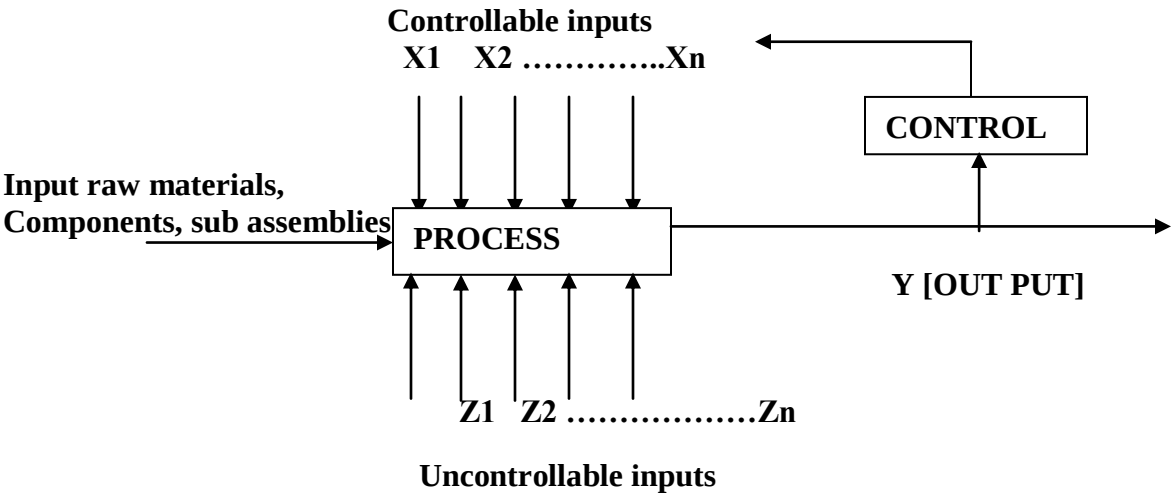

Figure: 2.2. Input, output and control [Aggarwal, 1980]

2.1.3. Production process control

If a product is to meet customer requirement, generally it should be produced by a process that is stable or repeatable. More precisely, the process must be capable of operating with little variability around the target or nominal dimensions of the product's quality characteristics.Generally, Process- is a chain of activities that turns inputs in to outputs. And Control- we use the data to adjust the process to achieve the desired results. Those results are dependent on customer requirements, efficiency, quality and reliability.Process Control is a system of controlling data on a process to predict the desired outcome. This can control the process so items being produced will conform more consistently to the design criteria. This process produces more usable items and reduces rework or scrapped parts. [Aggarwal, 1980]

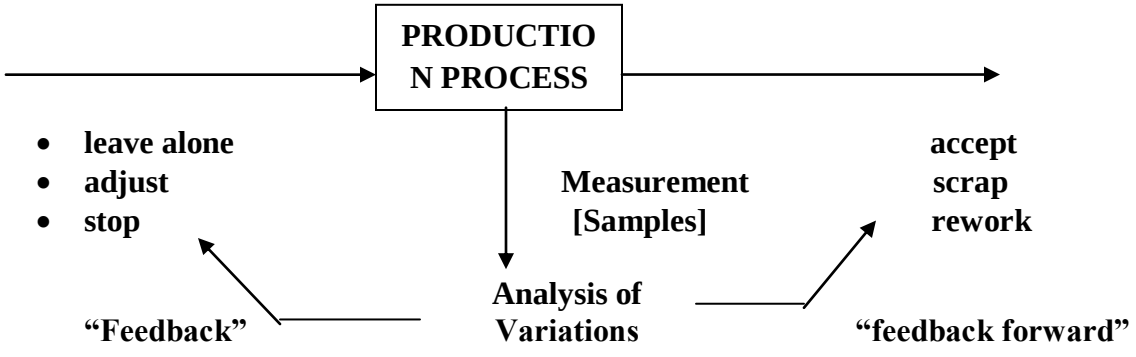

Figure: 2.3. Process capability analysis [Theodore T. 2006]

2.2. The concept of productivity

2.2.1. Definition of productivity

Several international scholars and organizations give different definitions and meanings of productivity;

The InternationalLabour Organization [ILO] summarizes the concept of productivity, thus some think of productivity as a measure of the economy as a whole. Others think of productivity in terms of individual industries or plants". Some businessmen in their public relations speak as though the whole matter of productivity had to do with the degree of application of the workers to their Jobs. At other times, the concept of productivity is used as though it were a measure of the degree of efficiency achieved in production.

The I.L.O. publication "Higher Productivity in Manufacturing Industries" has defined productivity as the ratio between output of wealth and the input of resources used in the process of production".[Hans G. 2012]

The organization for European economic cooperation (OEEC) has defined the concept of productivity as its widest sense it may be said that productivity; is the measurement of the economic soundness of the nations. [OECD 2012]

"Productivity is an attitude of mind. It is a mentality of a progress, of the constant improvement of that which exists. It is the certainty of being able to do better today than yesterday and continuously. It is the constant adaptation of economic and social life to changing conditions". [The European Productivity Agency [EPA]]

- It is the continual effort to apply new techniques and methods.
- It is the faith in human progress.

Mehta defines productivity as the "ratio of output to the corresponding labor"; He places the validity of this definition on its popularity. Salter accepts the measure of labor productivity as output per man hour because it has a perfectly respectable ancestry 6 July 15, 1987. [Hans G. 2012]

Kendrick also opined that "productivity" used to denote the ratio of output to any or all associated inputs in real terms. [Kendrick & Creamer 1965]

‘’Productivity is the quality, or state of being productive. It is a concept that guides the management of production systems and measures its success. It is the quality that indicates how well labor, capital, materials, and energy are utilized’’. [Kendrick & Creamer 1965]

“Productivity is the efficiency with which firms, organizations, industry, and the economy as a whole, convert inputs (labour, capital, and raw materials) into output. Productivity grows when output grows faster than inputs, which makes the existing inputs more productively efficient. Productivity does not reflect how much we value the outputs it only measures how efficiently we use our resources to produce them” [Hans G. 2012]

One thing common to all these concepts of productivity is the desire to portray some one's ability to produce or the rate at which production is carried. But today there appears to be a consensus of opinion that productivity is the ratio of output to input. Here it may be desirable to mention the difference between the productivity of enterprise as a whole or industrial productivity and the labor productivity. Whereas the increase in the 'productivity of the enterprise as a whole' is a simple function of the factors like technological advancement, improved managerial or organizational skills better entrepreneurial ability, positive attitude of all concerned, good industrial relations and the like. The productivity of labor depends on the stimuli or incentives available to human effort**.** [Kendrick & Creamer 1965]

Therefore, Increasing productivity is a goal advocated by business organized labor and Government. A change in productivity of a system results from the combined effect of all the factors contributing to the system’s performance.

2.2.2. Earlier and modern approaches to productivity

2.2.2.1. Earlier thinking of productivity

Earlier approach to productivity is related to the physical and technical aspects of the productive process. The Industrial Revolution brought significant changes in technical conditions of production. Before the advent of Industrial Revolution an individual made the complete product and there existed a simple and flexible relationship between the crafts man and his few assistants. The introduction of machinery and large scale production changed the structure of jobs and the nature of work process. After the industrial revolution mass scale production changed the structure of jobs and the nature of work process. [Gordon, J.2015]

Frederick Winslow Taylor (1856-1915) developed and proved the value of task system. New impersonal relationship came about between employers and workmen. The tendency was to fit the worker to the machine. He made it clear that if this approach is followed the gains to management may not be from extra efforts by workers but from elimination of waste, waste of worker's time and waste of machine time. The establishment of time study by Taylor and Motion study by Frank Gilberth were the root application of productivity. [Gordon, J.2015]

2.2.2.2. Modern approaches of productivity

It treats organization as a system of mutually dependent variables and illustrated them as socio-technical systems. Analysis of socio technical system is important to determine an optimum solution for process design which will produce the output most economically process design. It is concerned with selecting the work stations, and manages also have to give consideration to the behavioral consequences of arranging work situations.[Gordon, J.2015]

Managerial productivity lies in the better utilization of organization resources towards the attainment of the organization resources towards the attainment of the organizational objectives.A modern trend therefore is for all technical staff to be given some training in the principles of work study and for the design and layout of new plants and better processes to proceed with these principles in mind as well as purely technical considerations**.**[Joseph P. 1999]

2.2.3. Firm and national approaches of productivity

2.2.3.1. Productivity at the firm level

The generation and application of technological and organizational knowledge (innovation) are the main drivers of firm-level productivity growth. These determinants are broader than technology in an engineering sense. The choice of production technology and how production is organized, which are management decisions, play a crucial role in productivity performance.[Anthony & Gerhard 1992]

Improvements in firm level productivity translate directly into national economic growth, but productivity growth in the economy can exceed that of the individual firms. This is because competition favors firms that are more productive, and so these firms' market share expands, while that of less productive firm's contracts. In the process, the average level of productivity is increased. This process of competitive dynamics is important for keeping the economy close to its production possibility frontier. Policies and market behavior that undermine competition may cause the economy to slip below its potential. [Joseph P. 1999]

2.2.3.2. Productivity at the national level

Since productivity is one of the basic variables governing economic production activity national productivity concerns would be appropriate. As a matter of fact, productivity may be the most important variable governing economic production activity. It is the fundamental controllable factor in wealth production. Since other economic variables depend on it, increasing productivity tends to have a beneficial multiplying effect on other economic variables. This is generally true at every level of economic aggregation.[Joseph P. 1999]

Improving productivity is of national importance because, for a society to increase its standard of living, it must first increase productivity. Overall productivity for individual countries is calculated by dividing output, as measured by GDP or GNP, by the country's total population. Thus, productivity is measured as the monetary value per capita outputs. An increase in this measure of productivity means that each person in the country, on average, produced more goods and services. Also if productivity increases, then profits increase. The resulting profits can then be used to pay for wage increases (inherent in inflation) without having to raise prices. In this way, productivity gains actually help curb inflation. [Anthony & Gerhard 1992]

2.2.4. Productivity measurement

Measurement of productivity is a very difficult task because it depends on so many factors. If a concern is engaged in the production of a single product, output can be measured in physical terms, e.g., number of units produced, volume, weight etc. But it becomes very difficult when a variety of goods is being manufactured. The problem becomes more complicated when an industry produced some by-products. When the value of money does not remain stable due to price fluctuation, monetary measurements do not measure correctly changes in quantity. Thus, productivity measured in terms of monetary value may not reveal the correct position. Input factors are many and varied. Therefore, measurement of inputs poses similar problems. Some of them e.g. managerial skill, may not be measureable at all. They have to be converted into money terms. Productivity measurement is even more difficult in service enterprises. [Lieberman 2009]

Generally, the productivity of one factor may be affected by the productivity of another factor. For example, productivity of labour may adversely be affected by poor quality of management, defective tools and machinery, bad quality of materials. In spite of all these difficulties, it is desirable to measure productivity so that action may be taken for correction and improvement may take place. [Yitagesu .Y 2014]

Productivity measurement and analysis are also helpful in locating the shortages of a particular factor, which might have caused a decrease in productivity. The basic objective of analysis of productivity is to find out some ideas in relation to improve the efficiency and these ideas may be applied in the field of resources utilization. They are also used in determining the distribution of the product of industry and thereby in some sense they are relevant for collective wage-bargaining. At industry level also, such measurement are very helpful. Comparisons of productivity change within an industry over a period of time as also between two or more industries can indicate various interesting facts, regarding technical, economical and managerial aspects in the Industry**.**[Yitagesu .Y 2014]

The importance of productivity measures analysis is however computed, provide little guidance for both public or private economic policy andthat such measure only take on significance whenthe factors associated with the changes or differences shown have been analyzed.

Productivity measurement, in itself, is not an end. It should be useful to meet management needs. Productivity measures are useful in the following management areas: [Lieberman 2009]

1.Goal setting;
2.Estimating Resources requirements;
3.Organizational improvement;
4.Operation Control;
5.Resource reallocation;
6.Responsibility Accounting; and
7.Motivation for improvement.

Company's productivity can be measured and analyzed in basically three types of productivity indices [Lieberman 2009]

1. Total productivity index = total output/all input factors
2. Total factor productivity index= net output /total factor input
   Where;
   - net output = output-intermediate goods and services
   - Total factor input = manpower input + capital input
3. Partial productivity index = output/one factor of input

In put factors are considered as labour, capital and materials and the partial productivity index, so obtained are referred to as partial productivity of labour, partial productivity of capital and partial productivity of materials. [Lieberman 2009]

TPM (Total Productivity Measure) = V/ M + Q + C …… (2.1)

Where,

- V = value of the total output
- M = input of manpower
- Q = input of materials
- C = input of capital

Total Productivity measure [Pt] = Qt/L +C+R+ Q …….. (2.2)

Where,

- Pt = Total Productivity
- Qt = Total output
- L = Labour input factor
- C = Capital input factor
- R = Raw materials and purchased parts input factor
- Q = other miscellaneous goods and services input factor

Productivity evaluation centre (PEC) Virginia polytechnic institute and state university has also contributed a model to measure company productivity. As per this model, TPF productivity index can be measured as [Gordon, J. & Ulrich K. 2015]

Pt = Output / Input……..…….. (2.3)

Output = Sales + Potential Sales

- Sales = Net sales
- Potential Sales = Change in Inventory X Sales/cost
- Change In inventory = Inventory of current period input - inventory of last period
- Costs = Cost of goods sold

Input = Costs + Implied costs of capital

= Costs + depreciation + opportunity + cost on invested capital

= Costs + Depreciation + (inflation rate + 3% (Net equity + debt)

Invested capital has been defined as comprising of net share holders equity and long term debts. The model presumes that opportunity cost interest rate is 3 per cent more than the prevalent inflation rate. [Gordon, J. & Ulrich K. 2015]

Models Based on Output as Value Addition

This concept believe that there is no contribution from production function to the cost of materials & other parts purchased and as such only the value addition is the true output.[Craig, C & Harris, C. 1973]

Total factor productivity (TFP) as an index of productivity

$$TFP = \frac{(S+C+MP) - E}{(W+B) + (CKW+KF)\ Fbdf} \quad \ldots\ldots \quad (2.4)$$

Where

S= sales (represents the sales billed deflated to a base year)

C = inventory (The inventory change is the difference between the closing and the opening of inventories of all the three types i.e., raw materials, work in progress and the finished inventory all deflated to the base year)

MP=manufacturing plant (covers maintenance, repairs, manufactured items for R & D etc all produced within the plant)

E= exclusions (represent items purchased (supplies, components etc.) which do not result from production efforts)

W= Wage and Salaries

B= Benefits

Kw= Working capital

Kt = fixed capital

Fb = investor contribution adjustment
df = price deflator factor (Factor fb represents capital after depreciation for each year weighted by the rate of return in the base year).[Craig, C & Harris, C. 1973]

2.2.5. Productivity models

Productivity models are available to measure productivity at micro-levels, say of a workman a small section or of a department. At macro level, models have been proposed for a plant or an organization or a multi-unit corporation or industry. The following major categorization is possible on the basis of approaches or concepts on which they have been constructed. [Gordon, J. &Gretton, P. 2015]

1. Production function models
2. Financial ratios as measures of productivity
3. Production based models
4. Surrogate models
5. Systems approach based models
6. Productivity accounting model
7. Economic utility models

1. **Production Function Models**

This approach represents one of the earliest attempts to measure productivity the model consider production as major activity of an organization and therefore infer that measurement of productivity is synonymous to measurement of productivity of the production function. Production function is perceived to be a function of several input factors. Cobb-Douglas Function expresses the function as;[Gordon, J. and Gretton, P. 2015]

$$Q = aL^{d}K^{t}e^{u\ldots} \text{……..……... (2.5)}$$

Where; Q = Output

L = labour

k = capital

U = Random measurement error a, d, f are constants.

Harry Ernst also proposed a model considering output to be a function of inputs as

Output = F (X1, X2, X3……..Xn) Where; X1, X2 X3 X4 …….are the inputs

2. Financial ratios as a measure of productivity

The financial ratios are used to assess the financial performance of a company. Although the financial ratios are generally useful to the measurement of financial performance of a concern, they seldom represent the measurement of productivity. Productivity depends to a great extent on the stability, solvency and activity of a concern. Therefore, areas such as liquidity, stability, profitability, and coverage, stock and creditors turnover can be studied for productivity measurement of a concern. If ratios regarding the above factors are more favorable, it will indicate the concern is more productive. For this purpose, acid test ratio, debtors turnover, creditors turnover, stock turnover. Assets turnover and return on capital employed may be considered s important ratios in this connection.[Gordon, J. and Gretton, P. 2015]

3. Production Based Models

Productionbased models may be categorized in two following classes: -[Kendrick and Creamer, 1965]

i. Models based on output as value of production
ii. Models based on output as value addition**.**

I. Models based on output as value of production

[Kendrick and Creamer, 1965] are considered to be propounded of this approach. They stated that there are three types of productivity indices to measure and analyze productivity of a company.

a. Partial Productivity Index i.e. Output/ One factor of input
b. Total Productivity index i.e. Total Output/ All Input.
c. Total factor productivity index i.e. Net Output/Total factor input.

Here, Net Output = Output – Intermediate goods and services

Total Factor Input = Manpower input + Capital input

II. Models based on output as value addition

[Cox, 1983]states Value added is "The increase in market value brought about an alteration in the form, location or availability of a product or services excluding the cost of brought in materials or service."The above models place too much emphasis on labour and have limitations.[Davis 1951] sates, the practice of using output per unit of labour time expended to answer all questions about productivity performance has led to confusion." Measure of valued added per man-hour also becomes a misnomer of productivity as value addition is generally the total cost of products minus the cost of purchases. Owing to this, high wages would automatically increase the value of products appearing as numerator and hence, increase productivity.

4. Surrogate Models

It is based on partial productivity approach. The model selects "Such measures which can be considered valid in place of measures which are either difficult to define or are unavoidable because of problems inherent in data collection etc." These models do not consider many factors which affect the productivity, so, these are used for small set-up in a highly restrictive way. Key activities' closely linked with the total productivity are suggested under this model. With the help of payroll records, productivity under this approach can be measured as:[Gordon, J. and Gretton, P. 2015]

"Productivity Index = Actual Pay/ Standard Pay

Here "Actual Pay" means the pay, paid to the worker

"Standard Pay" Hours worked *Standard rate of pay

5. Systems Approach Based Models

[Mason, 1984] says that "the exercise of productivity measurement is basically reduced to measuring the entire output a system has generated in relation to the input resources consumed during the production process." He has presented the productivity measurement concept in

details with each of the four types of environment which are based on conventional methodologies and output and input are considered in the traditional manner.

6. Productivity Accounting Model

It is a technique of measuring and analyzing productivity by the relation of total output to total input after both have been revalued to some appropriate scale of constant prices and it is grounded on basic accounts of a firm." Productivity analysis not contributes for the firm but also contributes in the development of the country by directing for better utilization of resources [Gordon, J. and Gretton, P. 2015]

According to [Sardana and Vrat,1984] "The model should be such that it may help management in analyzing areas of improvement, take into account all possible outputs and inputs used, keep out external factors such as price rise etc., from the calculation of productivity of the organization and the data should be available for the measurement of productivity." All the conditions mentioned about are not satisfied in all the models discussed above due to their inherent limitations but productivity accounting model is only the model under which all the above mentioned conditions are satisfied.

The present study is based on Productivity Accounting Model (PAM) because this model is based on accounting data and present study is also being conducted in the field of accounting. The Model is based on common price accounting and takes into account all outputs and all inputs. [Gordon, J. and Gretton, P. 2015]

7. Economic utility Models

Productivity measurement models under this approach recommended use of multi ratios, each ratio reflecting on a particular economic activity or utility function. The conventional ratio concept of output to input is not followed under this model. It may be more useful in measuring productivity at macro level instead of micro level.[Gordon, J. and Gretton, P. 2015]

Model of this approach is as follows

$$O = A+M+Y+K \quad (1)$$

Where, “O” Stands for gross output during the period.

“A” Stands for depreciation and replacement of stocks.

“M” Stands for current intermediate inputs.

“Y” Stands for national income.

“K” Stands for capital.

$$I = K+A+M \quad (2)$$

Here

“I” represents aggregate input of the factor cost for productivity “O” National income is the excess of “O” over I.

Analysis of National income is as follows:

$$Y=W+P+D \quad (3)$$

Where, “Y” Stands for National Income

“W” Stands for Aggregate wages

“P” Stands for Profits

“D” Stands for Differential rents

Hence, Y/A is the ratio of national income or net output to capital utilized and Y/L is the net output per worker in terms of rupee when L stands for working population of an economy. Y/L is used to measure overall productivity. [Gordon, J. and Gretton, P. 2015]

Table 2.1: Summary of productivity concept [Kannan G. 2014]

NO	***CONCEPT***	***SUMMARY***
1	productivity as an objective concept	It can be measured, ideally against a universal standard Organizations can monitor productivity for strategic reasons such as corporate planning, organizational improvement, or comparison to competitors Can be used for tactical reasons such as project control or controlling performance budget
2	productivity as a scientific concept	Can be logically defined and empirically observed It can also be measured in quantitative terms, which qualifies it as a variable and therefore, it can be defined and measured in absolute or relative terms It is much more useful as a concept dealing with relative productivity or as a productivity factor
3	productivity as a measure concept	Useful as a relative measure output of production compared to actual input resources, measured across time or against common entities As output increases for a level of input, or as the amount of input decreases for a content level of output, an increase in productivity occurs "productivity measure" describes how well the resources pf an organization are being used to produce input
4	productivity as an efficiency concept	Productivity is often confused with efficiency. Efficiency is generally seen as the ratio of the time needed to perform a task to some predetermined standard time. However, doing unnecessary work efficiently is not exactly being productive It would be more correct to interpret productivity as a measure of effectiveness(doing right things efficiently) which is outcome-oriented rather than output-oriented
5	**Productivity as a factor concept**	
5.1	Partial factor productivity	Considers a single input in the ratio Partial-factor productivity would be the ratio of total output to single input Output/labour, output/machine, output/capital or output/energy
5.2	Multi factor productivity	Utilizes more than a single factor Multifactor productivity is the ratio of total output to a subset of inputs A subset of inputs might consists of only labour and materials or it could include capital
5.3	Total factor productivity	Measured by combining the effects of all the recourses used in the production of goods and services (labour, capital, raw material, energy, etc) and dividing it into the output

2.2.6. Productivity improvement

The productivity improvement is a never-ending journey. Many people never take the first step because they do not see the end of the road. Productivityimprovement initiatives are often perceived as expensive, when one is not aware of the benefits that they achieve when executed with due diligence[Pradeep.P 2009]. There are varieties of factors which can affect productivity, both positively & negatively where some factors can be controlled & some cannot be due to natural limitations[Kannan.G 2014]. The following aspects are dealt for improving the performance of each element of production in order to ensure that productivity is improved.

2.2.6.1.Productivity improvement based on productivity indices

A. Design, Plant and Machinery

Design should be aimed at the production by optimum quality at minimum cost.Faulty designs lead to waste, bottle necks increase in cost and low productivity. There should be neither too small nor too large of heavy plant and machinery. The optimum nature and size of plant and machinery is to be decided so that high productivity is achieved. Further, the economics of work by manual labour is machines should also to be considered. [Kannan.G 2014]

B. Labour Efficiency

Labour is the most important factor affecting productivity. Placement of right man on the right job, Training of workers, Work study, fixation of rates and incentive and schemes for the purpose of payment of incentive bonus, production planning and control in order to ensure steady, flow of raw materials, proper maintenance of machines and better working conditions, Simplification and standardization of work, Utilization of suitable workers of the right type of skill, availability of work load, material, working tools, availability of power, work efficiency, level of motivation, level of training, level of working condition (comfortable or poor) and Avoidance of labour storage or excess of labor.[Kannan.G 2014]

Labour productivity = total output/labour input

- The productivity of labour can be increased by increasing efficiency of labour and reducing labour time.

C. Material Performance

Material productivity may be increased by Value analysis, Suitable designing with the intension of minimum consumption of material, Preparation of standard bill of materials so that excessive use of materials is prevented. The bill of materials should indicate the specified units of the various raw materials required for the manufacture of product, Purchase of right materials at the right time and at the right price from the right source, Improving the quality of materials, Removing defects in machines, Skilled labour is required so that defective work, scrap, wastage and spoilage are reduced, Efficient storage of materials and Finally efficient handling of materials. Material productivity depends upon how material is effectively utilized in its conversion into finished product. Material productivity depends upon percentage of rejection, creation of scrap, level of spoilage, obsolescence, work wastage etc. [Kannan.G 2014]

Material productivity = total output/material input

- Material productivity can be increased by using skilled workers, adequate machine tools, good design of product etc.

D. Machine Performance

Machine productivity may be increased by Optimum utilization of machine time, Proper maintenance including preventive maintenance, routine maintenance and major overhauls whenever required according to the maintenance schedule, efficient production planning and control, scheduling and work loading to avoid bottlenecks an idle time of machines as well as manual labour, Employment of skilled and efficient operatives, and Proper maintenance of machine tools**.** [Kannan.G 2014]

Machine productivity= total output/machine input

- Machine productivity depends upon availability of raw material, power, skill of workers, machine layout.

E. Capital productivity

For any production set-up, facilities of machines, tools,land etc. are required which are assets of organization. Capital is needed for such assets. Capital productivity depends on how effectively assets are utilized. Therefore decision is necessary to take about replacement of fixed assets.

Replacement of fixed assets brings down maintenance cost but requires capitalexpenses. And late replacement of fixed assets improves ratio ofproduction to capital expenditure, but it increases maintenance cost. Therefore proper balance is necessary. Organization spent large amount (direct expenditure) for assets like direct material, direct wages, land, building, equipment etc. But a production system incurs a lot of direct expenditure like salaries of manpower employed in planning, store keeping, record keeping, inspection etc. Indirect labour is also used for material movement, good housekeeping, cleaning etc. Indirect expenditure is incurred on indirect material like tools, oils, lubricant etc.[Kannan.G 2014]

Capital productivity = total output /capital input

2.2.6.2.Manufacturing system productivity improvement through operation research

Manufacturing system productivity measurement and improvement can be done using rigorous mathematical modeling, operations research (OR) based methods, control-theoretical methodsdriven by information systems, system analysis-based methods for productivity improvement and continuous productivity improvement methods. A survey of performance metrics-based methods and the motivation for a factory-level approach for productivity measurement and improvement comprises a survey of commercial tools available to measure manufacturing system performance [Muthiah, 2006].

2.2.6.3.Productivity Improvement through Work Study

Work study is an important management tool to achieve higher productivity. It is related to human work, method of doing work and standard of performance. The survival of any organization is dependent on use of latest technology and efficient methods of production. To improve efficiency of production it needs effective utilization of plant, equipment and labor. This can be achieved by using work study which studies method and evaluate the performance. It divides work into smaller elements, studies it, and rearranges it to get same or greater efficiency at reduced cost. International Labor Organization (ILO) defines work study as the technique of method study and work measurement employed to ensure the best possible use of human and material resources in carrying out a specified activity. [Kannan.G 2014]

As Productivity of an enterprise is affected by various factors such as Labour, Material, Land, Machine, Capital, Technology, product & Management, work study aims to improve productivity through the systematic analysis of existing operations, processes & work methods to improve their efficiency with little or no extra capital expenditure. To achieve this improvement it is extremely important to apply work study continuously andthroughout the organization. Thus, International Labour organization has clearly shown to what extent there is direct relationship of work study in raising the productivity. [Joseph P. 1999]

2.2.6.4.Productivity improvement through Production Control

Proper responsibility accounting, Simplification, standardization & specialization in product lines, application of work study techniques, Introduction of the system of production, planning and control (PPC), Integration of the functions of various departments, proper system of quality control, an efficient system of budgeting, standard costing, cost reporting &control, budgetary control, & efficient system of management information system, so that corrective action is taken on the responsible executives in respect of the controllable items. [Joseph P. 1999]

2.2.6.5.*Productivity improvement through technology transfer*

The three elements technology, management and human relations, appear to be of importance for developing countries. A well trained management and trade union with mutual understanding of each other's problems can create climate required for increasing productivity**.** Firms can improve their productive efficiency in three ways***:*** [Joseph P. 1999]

First Improvements in technical efficiency: increases in output can be achieved, at a given level of input, from more efficient use of the existing technologies. and secondly Technological progress and organizational change: as firms adopt technologies or organizational structures that are new to the firm, or develop and apply new technologies or approaches; they can expand output by more than any additional inputs might be required and thirdly Increasing returns to scale**:** as the size of the firm expands; its unit cost of production can fall as it becomes financially advantageous to adopt existing technologies.

Generally, productivity in industry can be increased by either developing new technologies, improving the comprehension and components of a given technology or both. Accordingly, productivity can be expected to be influenced by both technical progress and efficient use of the given technology.[Kannan.G 2014]

It has been estimated that technology was responsible for at least half of the growth in productivity in firms across the globe. It would appear, to continue to increase productivity, technology may be the key. Extensive attention has focused on the factory of the future, where factory workers are being replaced in order to improve flexibility and productivity. Apparently, the role and importance of productivity will not diminish any time soon. Technologies directly affect the recipients in the increase of production resources and the substantial growth in the productivity of utilization oflabor, capital and natural resources. [Joseph P. 1999]

[Gulilat. G 2011] stated that Knowledge, one of the elements of technology, contributes the major part to technology, and it is the key to control over technology as a whole. It is important that the understanding of explicit and tacit elements of knowledge will help identify the process of knowledge transfer. Knowledge transfer is a key tool of technology transfer, technology cannot be transferred, if there are no knowledge of what to be transferred. Therefore, knowledge & technology transfer work together at the same rate to achieve transfer of technology.

2.3. Literature gaps

To get enough information and best understand about the subject matter and the field of study many literatures are reviewed from different sources, among these journal, articles, reports, and thesis are the main one. Therefore in this research, Even though so many researchesare conducted on the sub sector they didn't provide the root causes for low productivity. Those researches are focused on determining and improving one area of productivity issue of one company.

The researches focus on the sector competitiveness issues not the case of productivity as a detail general concept. Those researches are compiled either for sectorial review or case company analysis, not for both at a time; which does not justify the practicality of the survey against the individual industries/companies operational situations.

CHAPTER THREE

3. RESEARCH METHODOLOGY

3.1. The research design

The overall desire of this research is to improve Ethiopian metal industries productivity after conducting a survey analysis on their productivity concept, measurement practice, the related problems and their improvement activities in the industries, after that investigation of the existing productivity practices using a case manufacturing company was carried out. In order to that, an appropriate way has been adequately devised, so that it can ensure its outcome as per Productivitymeasurement and analysis. Literatures were considered to discuss the concepts and identify reasons and gaps in analysis of manufacturing companies' productivity and both qualitative (to identify the nature of the causes of the problems)and quantitative (for quantification of variables)data were used.Integration of the following methods is used to achieve the objectives.

3.2. Literature review

An extensive literature review has been conducted where both theoretical and empirical views relating to productivity analysis of production system from different sources including academic sources; related articles books, & journals and official sources; government & no government studies & reports in order to understand productivity concepts, arguments, methods, advancements and existing productivity measurement and improvement activities with a particular focus on the problems and improvement activities of manufacturing industry.

3.3. Data collection methods

3.3.1. Data type

The primary and secondary (qualitative and quantitative) data collected from the manufacturing firms, several organizations, literatures, and the case company to examining the productivity level and the possible causes of unproductive environment mainly contains the following;

1. Types of products produced
2. The layout and arrangements of machineries

3. The production process
4. Break down time, and production failure
5. The productivity rate/factors
6. The inputs involved
7. The processing times Completion and delivery times
8. The output

3.3.2. Data collection

A. primary data

The major sources of the primary data gathering techniques used for this research were field visit, interviews, questioner preparation.

Field visit/ Physical observation

The researcher with MIDI & the KAIZEN institute expertise has conducted a physical observation on some metal manufacturing industries and there was also a continuous physical visit to the selected case company in order to understand best the operational productivity issues.

Survey questioner

A questioner containing several questions with respect to the research ideology, objective, area of coverage, research question and so on is prepared and distributed to metal manufacturing firms, the MOI, MIDI, KAIZEN institute, customer industries and the case company as well. Basically it was constructed in to four major parts with preliminary information about the organizations, their productivity concept and status, their method of productivity measurement and improvement practices. It was an important tool in order to get qualitative and quantitative data regarding the productivity status of the Ethiopian metal and engineering industries.

Interviews

The researcher conducts interview and discussions with technical mangers, supervisors, financial managers and factory workers of the case company and the MIDI, KAIZEN institute technical expertise & researchers. The interview was context free, face to face and it will be held by the

researcher itself with these people based on the researcher's main areas of coverage in the title and the objective described.

B. Secondary data

- Case company's previous records and documents on production data, productivity measurement, evaluation and improvement practices.
- The researcher tried to collectseveral written materials, detail recording, reportsseveral organizations such as MOI, CSA, UNIDO, MIDI and browsing related literatures, articles, journals and websites of different organizations in order to understand, assess, analyze and examine the current status of the Ethiopian (metal) industries productivity.

3.3.3. SAMPLING

The main sampling techniques is used in the research is;

Purposive sampling: this technique is used by the researcher to question predefined groups which are the Ethiopian metal industries (from medium to high level of production capacity), the Ethiopian KAIZEN institute, the MIDI and the ministry of industry [MOI. They are selected in order to understand the productivity related issues across the industries since they provide relevant information on the subject matter.

Data analysis and presentation

The collected primary and secondary data, are presented on bar-graphs, pie-charts, pareto chart and cause and effect diagrams via on MS-Excel & SPSS and the Data analysis is conducted (based on the survey conducted and on case company operational functions and productivity related activities) based on the concept productivity analysis in manufacturing system, through referring different books, publications, researches, articles, through discussion in the class room and experience sharing with qualified personnel who has working experience on different manufacturing system applications, the analysis is done to discuss, identify major productivityactivities & related problems, and improvement method were also proposed and finally conclusion and recommendation reached. The major data analysis tools considered in the research demonstration are; Layout analysis, Pareto analysis, Cause and effect analysis, productivity measurement, and Productivity analysis.

3.2.2. Sample Size

To get a representative and reasonable sample size that supports the research findings, the following equations are used. Equation (1) is applied to compute the initial sample size. Since the population is finite (less than 50,000), Equation (2) is used to compute the new sample size. These equations developed by Johnson et.al, (2009) and Freedman et al., (2007) according to (Othman, 2014).

$n_0 = \frac{z^2 * p(1-p)}{c^2}$ ……1 $n_f = \frac{n_0}{1+\frac{n_0-1}{N}}$……..2

Where:

n0 = initial sample size

nf= target sample size

Z = Z-values for confidence levels are (1.645 for 90% confidence level, 1.96 for 95% confidence level and 2.576 for 99% confidence level)

p = percentage picking a choice, expressed as decimal 0.5 used for sample size needed

c = confidence interval, expressed as decimal; 0.08 = ±8

N = Population = 379 workers

$n_o = \frac{1.96^2 * 0.5(1-0.5)}{0.08^2} = 150.063$ $n_f = \frac{150.063}{1+\frac{150.063-1}{379}} \approx 109$

Since, total sample sizes of 100 responses are considered form the industry and the targeted government organization as a whole to accomplish the analysis research work.

Table: 3.1 Target respondents

No	***Department***	***Total staff***	***Sampling size***
1	Production	239	239x(101/379)=69
2	Maintenance &Technic	47	47 x(101/379)=17
3	Quality	10	10 x(101/379)=3
4	Human resource	18	18x(101/379)=5
5	Supply	21	21x(101/379)=6
6	Finance	24	24 x(101/379)=7
7	Sales	5	5x(101/379)=1
8	logistics	5	5x(101/379)=1

3.4. Research framework

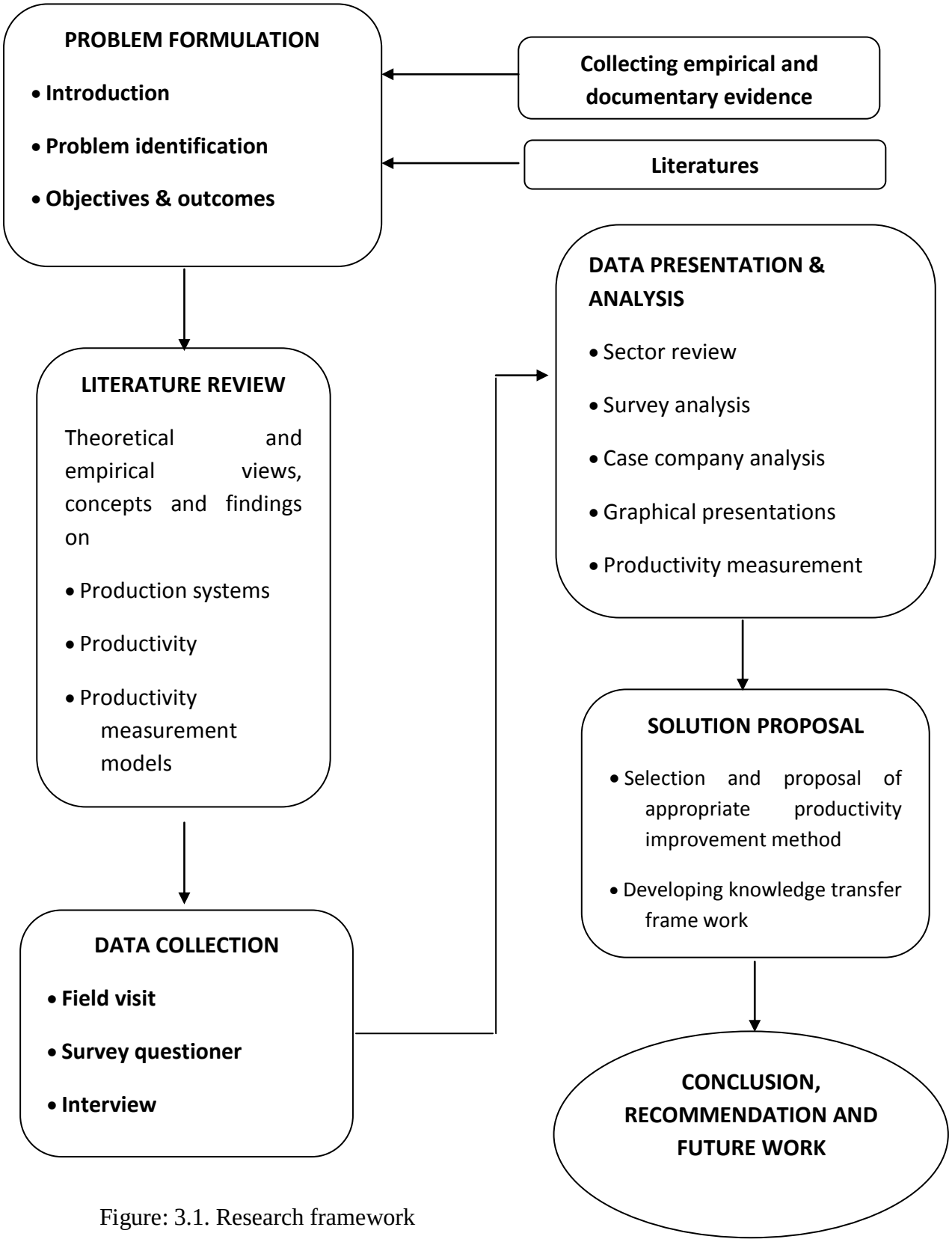

Figure: 3.1. Research framework

CHAPTER FOUR

4. OVERVIEW OF THE ETHIOPIAN METAL PRODUCTIVITY MANUFACTURING SUB- SECTOR

4.1. Overview of the Ethiopian metal manufacturing industries:

Metal manufacturing industries are considered to be as upstream technologies that are the base for the requirements of downstream technologies by providing the required raw material through acceptable quantity and quality. [Rajender Singh, 2006]When compared to this concept Ethiopian metal manufacturing industries could be considered as nonexistent as they lack crucial component of producing basic metals from ore or other process route. Table 4.1 demonstrates the overview about the Ethiopian metal industry with respect to the other industrial sectors;[MOI GTP II and MIDI annual report, CSA]

Table 4.1: Ethiopian industry sector review

No	***Industry sector***	***Number of factories***	***Number of employees***	***Worth of production [billion birr]***
1	Agro-processing	687	68,759	24
2	Textile and garment	77	19,214	1.84
3	Leather and leather products	141	14,101	3.5
4	Chemical products	183	10,926	4.67
5	***METAL AND RELATED PRODUCTS***	***243***	***13,431***	***6.62***

Source: [MOI, CSA 2015]

The Metals and Engineering Industries is a Sub-Sector within Manufacturing Sector, according to International Standard Industrial Classification (ISIC), the sub sector is divided into:

Basic Metal Industries:- Industries that deal with production of metal from ore, scrap and conversion of billet, slabs etc. into primary metal products such as metal sheet, tubes, bars, wires, cables and nails. This major group includes establishments engaged in processing ferrous and nonferrous metals from ore, pig or scrap and those engaged in rolling, drawing and alloy melting and casting primary products.

Engineering Industries:- These industries convert primary metal products into secondary products such as metallic structures, windows and doorframes, tanks, pressure vessels, machine parts, machineries, transport equipments, electrical and electronic equipment, measuring and control instruments.[Rajender Singh, 2006]

[GTP II] demonstrates that by the end of year 2015 the number of medium and higher manufacturing industries in Ethiopia reached 2,655, when compared to the year 2012 it show a 22.2% increment. Therefore, the metal industry sector as a whole, the Ethiopian metal manufacturing industry has been experiencing an increase in its complexity based on growth and improvements in manufacturing with products quantity, variety, processes, technologies &equipments over the past years.Product diversification ofthe metal and engineering industries sector;

- Machineries, machine parts , accessories, and spare parts producing industries
- Iron and steel producers
- Automotive industries

Accordingly, the range of products to be contained in the basic metal industries across the country mainly constitute plain reinforcement bars and hot rolled ribbed bars, wire rod, angles, cold rolled tubes of various profiles, cold rolled sheets, galvanized sheets and tubes etc.

Based on the [Ethiopian Ministry of Industry road map data 2016] and [CSA 2015], among the stated sectors of the industry,the Ethiopian metal industry sector constitutes more than 243 medium and high capacity manufacturing industries that employee more than 22,697 workersand these manufacturing industries produce products that worth around 7billon birr at that specific year which is the second largest next to the agro-processing industries in capital and there are also more than 20 big new and expansion projects of manufacturing industries.

Figure 4.1 shows the Ethiopian metal industries status with respect to number of industries, employment opportunity and worth of production.

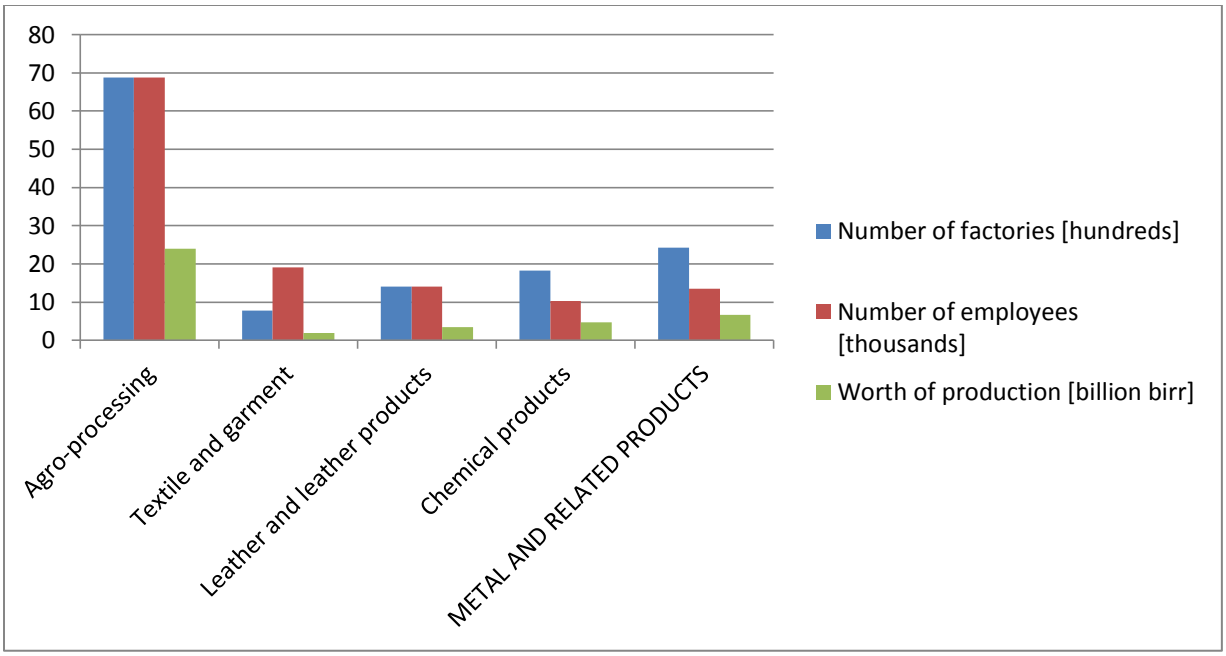

Figure4.1: Metal industries Vs. the Ethiopian manufacturing industries status

From the figure 4.1 it can be understood that the sector has the second highest worth of production among the manufacturing sectors however, the number of industries are far fewer than the agro processing and the upstream behavior of the sector and also it is the second lowest based on employment opportunity which shows that, even though it is increasing in the recent years, it is still needs to work on that area. The government has also established national Metal Corporation which is organizing activities in order to manage and organize several local workshops to produce input materials for the ongoing sugar, fertilizers, and hydro electronic dam electromechanical projects inputs.

4.2. Production capacity, technology transfer, skill and engineering technique.: [average utilization of 54%],

In 2005 E.C the Ethiopian metal industry constitutes 243 industries (38 basic metal industries, 194 fabrications of machineries and equipments, 11 automotive and body carriers) with annual production of 3.7 billon birr and 207 million investment capital.

Table 4.2: Value of Production (In Billion Birr) and Capacity Utilization of the sector

No	*Year [E.C]*	*Value of production [billion birr]*	*Planned capacity utilization*	*Average Capacity utilization [%]*	*Performance[%]*
1	2003	6.65	75	53	70
2	2004	12.0	80	61	76
3	2005	19.02	85	62	73
4	2006	30.14	90	54	60

Source: The ministry of industry GTP II plan

Table 4.2 demonstrates the production value of the metal industries with respect to their capacity utilization level and the actual performance which shows the industries goal against the capacity utilization is still behind the plan.The following figure demonstrates the gap between the actual capacity of firms and the intended plan to be achieved in the previous four years.

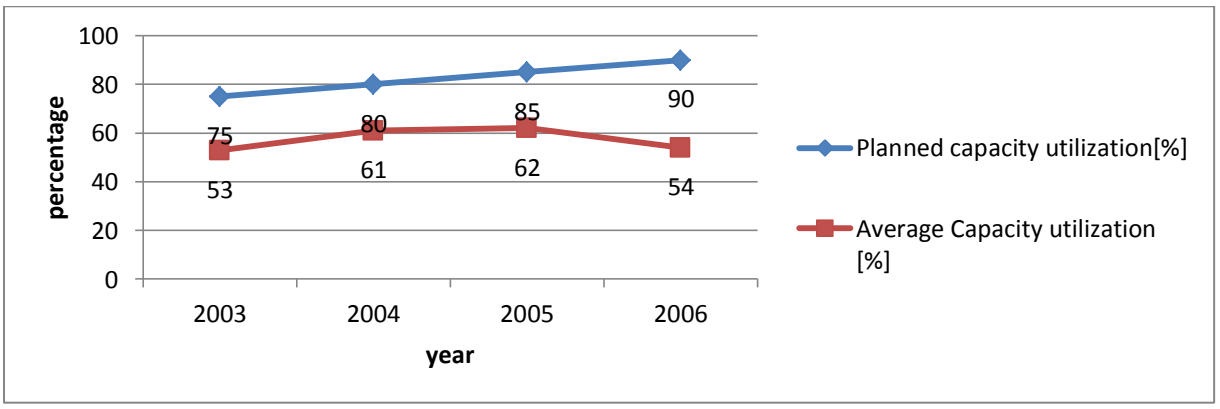

Figure 4.2: The actual metal industries capacity utilization

As it can be seen from figure 4.2 there is a significant difference between the attainable capacities of the major metal industries they are working below their installed capacity. On average the production capacity utilization lie between 50 – 60%. Although there are few factories that attain more than this percentage but this was due to production of however that most large metal industries work far from the designed capacity. The following table 4.3 further illustrates selected (tried to include different types products, and ranges production/design capacity) Ethiopian metal manufacturing industries overall status capacity utilization status.

Table4.3: Major Ethiopian metal industries products, production capacity, and utilization

No	Company Name	Installed Capacity (tons)	Working capacity (Tons)	Capacity utilization (%)	Types of products
1	Ethiopian crown &can factory	6607.2	3833	55.5	Corks , can
2	Adama Steel	26.8	25.8	90.0	0.20mm, 0.25mm, 0.32mm, 0.40mm Galvanized and pre painted sheets and Nail 3m-15mm
3	Akaki Metal Products	40,000	21,000	50	Galvanized iron sheet, Water pipe and Steel structure
4	AMCE Automotive Manufacturing	120	80	66.6	Trailer assembly, Cargo body and trailer and body manufacturing
5	Amio engineering	200	47	23.5	Rope washer pump, Tridle pump, Multi crop treasher, Pottery wheel, and Modern weaving machine
6	Dan lift technology	782.5	216.03	27.6	Passenger Lift 4P/320Kg, 6P/480Kg, 8P/640Kg, 10P/800Kg, 13P/1000Kg, and 16P/125
7	Ethiopian spring M.b profile	720	434.4	60.34	Different types of leaf springs
8	Walia steel industry	201,500	38,600	19.1	Hollow section, rebar and sheet metal
9	East steel	300,000	180,000	60	Reinforcement bars
10	Yesu manufacturing	200,000	140,101	70	Rebar and galvanized sheet metal

Source: MIDI industries profile [modified]

Table 4.3 shows the types of products that the metal industries are producing and production capacity trend, while the production capacity utilization (installed and Attainable capacity in 2016) shows a remarkable difference among the industries themselves. The table shows the maximum production capacity utilization among the metal industries (90%) and the minimum production capacity utilization (19.1%). As it can been seen from the table, steel manufacturing plants have relatively higher capacity utilization rate whereas engineering and basic metal industries has the lowest capacity utilizationrate.

Generally, the major problems associated with this low capacity utilization are;

- Raw materials and inputs availability
- Power and electric energy supply, fluctuation and interruption
- The machineries and technologies that the industries have
- Human power skill and particularly technical manpower unavailability
- Market competitiveness with the imported metal products
- Lower linkage with the recipient downstream industries
- Shortage of capital and foreign currency
- And the firms efficiency and productivity

4.3. Level of Value addition: Low level of value addition, per capital consumption with [20.36 kg/year]

Table4.4: Annual demand, per capital consumption and value adition of metal sector

No		***Year (E. C.)***			
		2003	***2004***	***2005***	***2006***
1	Population in millions	81. 7	83. 7	85. 7	87. 8
2	Average metal consumption [kg]	9.73	14.6	17.75	20.36
3	Demand for metals in [kg]	1,162,733	1,488,298	1,905,021	2,438,427
4	Ratio of value added to production	0.135	0.219	0.102	0.204
5	% of value added to manufacturing	6.49	8.07	8.94	6.89

Source: The ministry of industry GTP II plan &CSA

From table 4.4 it can be understood that, even though the demand for metal products show a significant amount increase, the average per capital metal consumption shows 20.36 kg per annum which is very low compared to the standard. The Percentage distribution of value added across industries describes value added in the national account at basic price by industries between across the stated years is also at minimal value. Whereas the ratio of value added to gross value of production describes the ratio of value added to gross value of production by the manufacturing sector over the period of the past shows years about 8 % of gross value of

production displayed by all industries over the same period. The subsector account for around 0.8 percent of GDP in Ethiopia, equivalent to 3.9 billion Birr of value added.Therefore, the contribution of the sector to the national economy is little as compared to the other sectors

4.4. Export performance: The least Export level with respect to the other sub-sectors and Nearly all machineries &equipments are imported or [Import level 95%]

The Ethiopia metals industries are categorized under the import substitution sector among the manufacturing industries in which the sector is subjected to replace the amount of import of metal raw materials, products and machineries. Import-substitution reduces foreign exchange dependency by advocating replacement of imports with domestic production of goods, products while it reduces foreign currency problems, creates indigenous technological capacity and employment opportunities and a more equitable income distribution However since 2006 E.C, the sector is given an additional direction to participate on the export since Export-oriented industries are aiming to speed up the industrialization process of a country by exporting goods for which the nation has a comparative advantage. Export-led growth implies opening domestic markets to foreign competition in exchange for market access in other countries. [MIDI report]

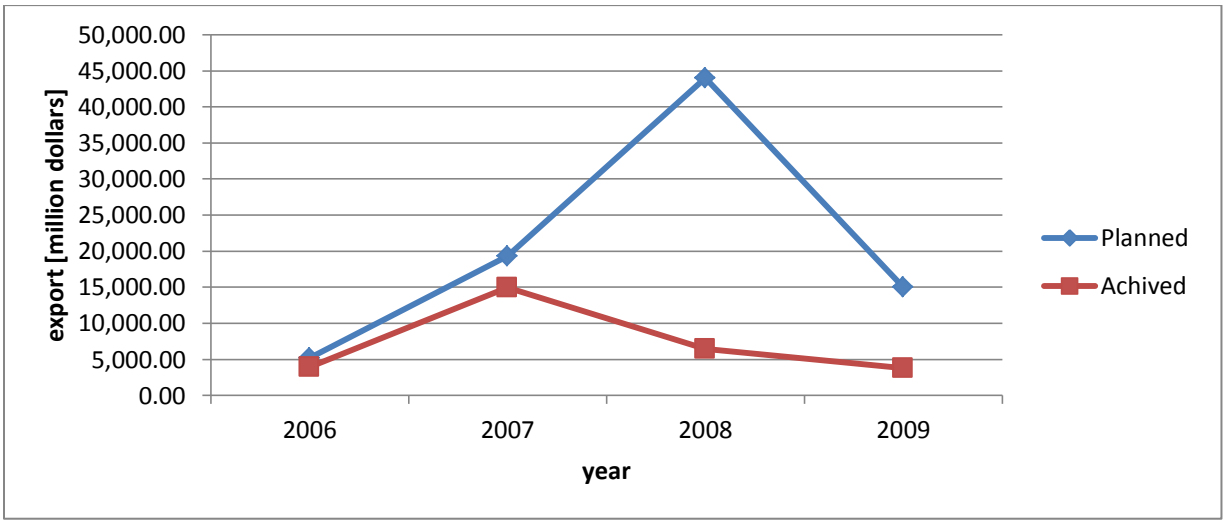

Figure 4.3: The Ethiopian metal industry export performance

When the Export performance of the sector is assessed, A total of about 83.46 million USD was planned for export from the metals and engineering sector up to 2009E.C however based on the Metal Industry Development Institute performance report, it was indicated that the achievement for the export for the metals and engineering industries was 3,090,717.87 USD which is 34.88% of the plan. This shows that the performance of the sector for export is low even with the standard of the plan.

As it can be seen in the figure 4.4, the metal sector industries export performance is also at a very low level when it is compared to other sectors export performance in the last four year. As it can be seen in the table below, the Ethiopian leather manufacturing sector is the best exporting sector among the manufacturing industries. Accordingly, the metal manufacturing industries are not capable of exporting products or good while competing with other countries metal industries.

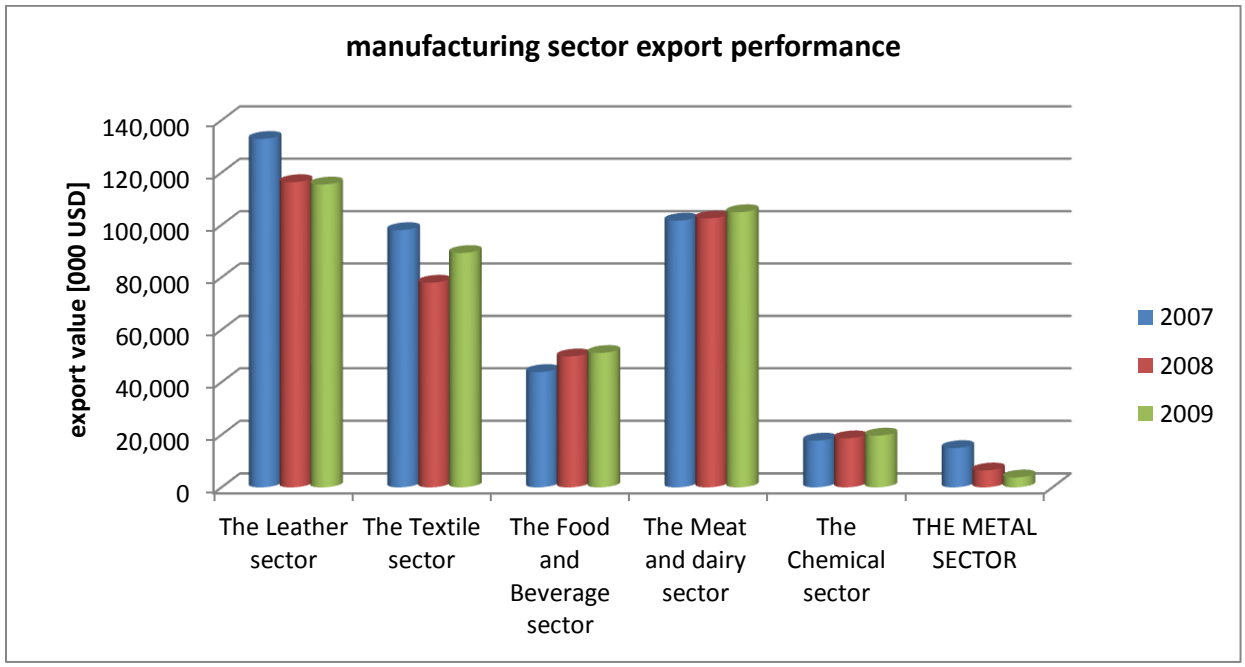

Figure4.4: The Ethiopian manufacturing sector export performance

According to The GTP II document, the government presented key the execution plan activities in order to that the sector imports substitution and boost the export as well;

- Enhancing the capacity of the usage of iron ore

- Establishing of furnaces, rolling mills, casting and foundry plants and Establishing high tech manufacturing firms in order to substitute the imported machineries and equipments
- Manufacturing of at least 40% of the country's spare parts
- Manufacturing and assembling of other sector industries to support the export market
- Manufacturing electricity, electronics and computer accessories and equipments in order to substitute the import and boost the export as well

4.5. The Ethiopian metal manufacturing sector productivity status

Despite the increments in number and variety of products in the Ethiopian metal manufacturing,does not guarantee the sectors productivity growth. [GTP II plan] The following table demonstrates the national productivity level of the Ethiopian metal manufacturing sector which was conducted in August 2015 by the ministry of industry by adopting the Japanese productivity index calculation.

Source: with the modification of the ministry of industry GTP II plan [2016]

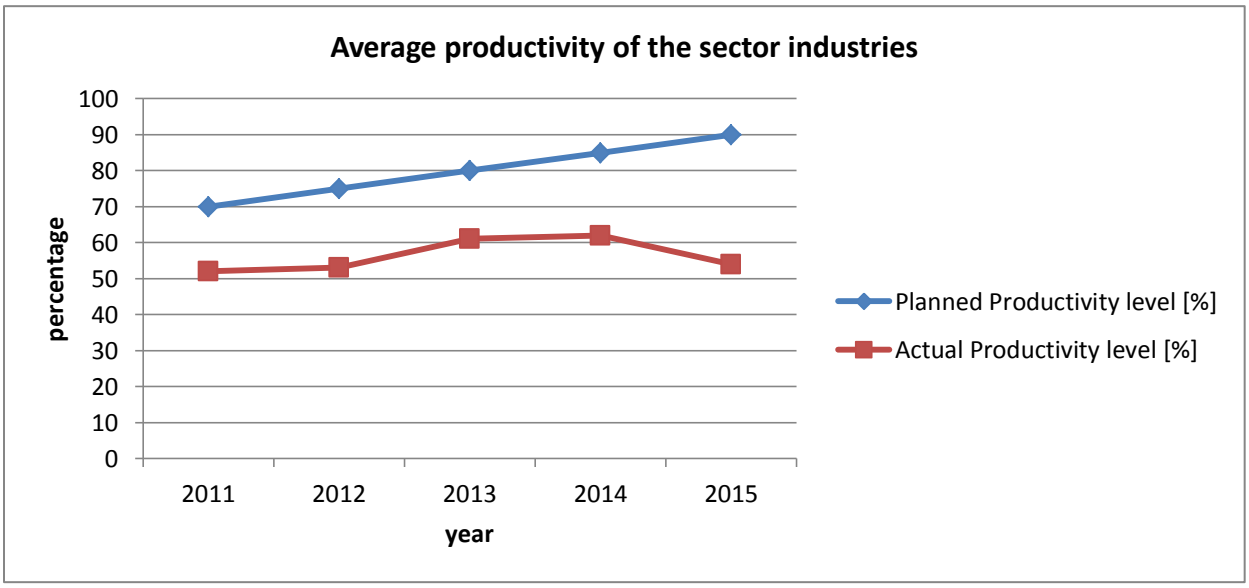

Figure 4.5: Ethiopian metal industry sector productivity index

As it can seen in the figure 4.5, there is the big difference between the government plans for the sector productivity status and the actual industries productivity level up to the end of year 2015.

Therefore the Ethiopian metal manufacturing industry can be marked as low productive and hence the wastage and related cost makes it highly uncompetitive at local market (import substitution) and at the international level

This shows that in today's world of high competition and very fast changing business world, organizations should coup up with the pace and dynamics of this environment. As part of a business organization, manufacturing firms should find a way of integrating their ways, techniques, procedures, inputs, materials, capital and over all resources in order to have greater output in their production of products and services and in order to stay competing with other organizations and do well in the above all business environment in other words in order to stay competitive with the rest of the world they should increase their productivity level.

As it has been discussed in the earlier, productivity, which directly affects the growth of GDP a nation, and the benefits from a manufacturing system, this makes productivity a highly important aspect of a manufacturing system.asMetal industries plays a great role in enhancing the economic development of countries and to be competent at the international levels.

Where competitiveness is determined by the productivity with which a nation uses its human, capital, and natural resources. Productivity sets a nation's or region's standard of living (income, returns to capital, and returns to natural resource gifts). Productivity in its turn depends both on the value of products and services as well as the efficiency with which they are produced. [Ethiopian association of basic metals &engineering]

Therefore analyzing the productivity of the metal manufacturing sector can signify the sector's productivity performance level and it will thus lead to a better productive production and manufacturing environment.

CHAPTER FIVE

5. DATA ANALYSIS, FINDINGS AND DISCUSSIONS

5.1. Results and Discussions on Surveyed Data for Productivity

The following section discusses the analysis of the data collected from different Metal manufacturing industries, capacity building institutions and stakeholders.After over viewing the metal industries in Ethiopia, it will focus at Yesu metal manufacturing industry to analyze the problems in detail. Questionnaire was developed to assess the productivity factors, practices, and level through collecting qualitative and quantitative primary data regarding the current productivity measurement and improvement practices in metal industries.

Productivity of the manufacturing system is therefore depends on the amount of capital invested on it, the technology adopted, the human resource involved and a detailed knowledge and skill of the production process involved. So far, with the advancement of the national economic growth which increases the demand of consumers for different materials, capital acquisition, manufacturing sector growth, technology advancement, makes the metal manufacturing industries to have been growing in number and variety, however, problems associated with the utilization of new technologies and as a result producing variety of high quality products, that enhance the productivity and contribute to the economic development of the nation is still lags behind.

Despite this progress, different problems affect the metal manufacturing industries productivity. Hence, the metal manufacturing industries in Ethiopia are assessed and presented in the following topics so as to devise a means to alleviate the problems on time and enhance their productivity so that the current import rate for metal products will be minimized, export will be higher and the industries will be competitive in the global market.

Discussion and interview were also made with different level of workers, stake holders that are participated directly or indirectly in the metal manufacturing industries. Responses from the respondents and the results from personal observation are summarized as follows:

According to the information obtained from MIIDI under MOI, Metal manufacturing industries are given due attention by the government. The investment and incentives mechanisms are being designed in such a way that import-substitution is to be highly promoted, so that the local metal manufacturing industries will be benefited out of such a system than other export-oriented sectors.

Based on the observations and the responses of the interviewed personnel, it is identified that capital, technology, technology/knowledge transfer activity, human resource (skilled man power), product/production quality, high scrap and rework rate, high amount of machineries and equipments break/down, electric and energy power problems, raw material availability and delivery time, lack of integration and bureaucracy among stakeholders and are the critical problems associated with the metal manufacturing industries that affect their productivity.

Based on the responses, lack of technology/knowledge transfer system and very low innovation trends were mentioned frequently.According to the respondents there is lack availability of skilled manpower in which training and capacity building activities and budgets are low, and conducive working environment for workers does exist. Problems related with inputs, raw materials, and machineries, technologies and quality and waste system problems, insufficient trends on research and development are seriously affect the sectors productivity.

Metal manufacturing industries are the basic inputs for the manufacture of other sectors machineries, equipments, products and construction. Hence, linkage among industries and developmental institutions and all stakeholders associations should be strengthened further to solve the problems.

Meanwhile the metal manufacturing industries need to develop practices to improve the above challenges and give solutions that put them at a better productivity level and developmental institutions should create strategies, provide special trainings and skill development programs on areas of metal manufacturing, productivity improvement techniques, shall be arranged with common effort of industries, developmental partners, government, and educational institutions. So that it would help for the existing industries to improve their productivity and make them competent at the international standard, and boost up the economic growth of the nation.

5.2. Research Sample/response rate

A preliminary survey was conducted, on Yesu metal manufacturing industry and other similar industries in corporation with the Ethiopian metal industries development institute [MIDI] and the Ethiopian Kaizen institute.

The study gives emphasis to the metal manufacturing industries, the distribution and collection of the questionnaire was done mainly with more attention on those factories and it is also tried to include the medium scale metal factories through direct contact and E-mail. A detailed production process, production, output, inputs, scrap and rework rate data was received directly from Yesu metal manufacturing. In addition questioners were brought to Ethiopian metal industry development institute technology experts, the Ethiopian Kaizen institute professionals, other customer industries of the metal industry such as food processing factories. Accordingly, a total of 51 questionnaires were distributed and 36 (71%) of it was returned. The major reason to do not receive all the dispatched questionnaires was because some private metal industries were reluctant to answer the questioners on time and some companies were not voluntary to provide information, some answers a portion of the questioner due to some misconceptions. [See appendix III]

5.3. Respondents Profile

Most of the respondents were higher and middle managers, production and operation managers, finance manager, factory manager, production and technical manager, quality control manager, production planning and control engineer, industrial engineer, with different fields and customers with different educational backgrounds. And senior technology experts, team leaders and directors with qualification of B.Sc. B.A, M.Sc, so that their job positions and experience indicate that they are responsible to involve and participate in the measuring, analyzing and formulation of strategic plans and evaluation of activities with regard to productivity. [See appendix IV]. The questionnaire is analyzed using Microsoft excel spreadsheet and SPSS the results are discussed and presented as follows.[See appendixIV]

5.4. Analysis on Surveyed Data for Productivity in the firm/s

A survey questionnaire were prepared and used to assess the productivity of Ethiopian metal manufacturing industries. As it is stated above, the purpose of the survey is to identify the important practices and activities to analyze and enhance productivity of the industries. Data has been collected from selected metal manufacturing industries, workers of Yesu metal manufacturing, from customer industries (other sector industries), from different capacity building institutions and from the different organizations and stakeholders such as the Ministry of Industry, Ethiopian Metal Industry Development Institute, the Ethiopian Kaizen institute, Central Statistic Agency, from the Ethiopian Customs and Revenue authority, and other organizations. The organizations were selected based on the following productivity indicators and their involvement with the metal manufacturing industries:[John r. S 1993]

- the manufacturing/production system
- the value and range of products and services provided,
- production outputs and inputs volume,
- investment involved
- the technology adopted
- human resource/skilled manpower development
- providing different supports to the metal industry
- a center of technology development and
- willingness to cooperate

The questionnaire contains a total of thirty seven questions (see Appendix I) which requires contain a range of scale from [1= low/slightly; 2= medium; 3=highly] and [A= Least significant/ E=extremely significant] and questions that requires Yes or No answers, brief explanations and personal expertise opinions.

The questioner has four sections as shown in appendix I in which the first part is about preliminary information about the industries and respondent. In the second section, it is tried to assess how metal industries understanding and interpretations of Productivity is and in which the industries interpret productivity and the result shows that most of them interpret productivity in terms of high profit, good quality and higher capacity utilization. Some of them also include cost

and high production in their productivity interpretation and they also describe the major drivers as machineries &equipments, technology and human resource. From the result it can be drawn that Metal industries have awareness to what good productivity is though they are at low level.

The third part constitutes factors affecting the productivity of the productivity of Metal industries and therefore, it tried to assess from general reasons to specific firm level factors including to the capital, manpower, technology and quality cases.

Finally the fourth part contains questions that deal about productivity measurement, problems and improvement practices in the firms. In which they find it to difficult to measure the real productivity of their firms even though they are engaged in some productivity enhancing activities based on individually and as a management approach.

Generally the questionnaire was to assess the parameters and influencing factors for evaluating, measuring, and enhancing the productivity of Ethiopian metal manufacturing industries. The main points to be analyzed are:

- Productivity factors: this section includes questions which were used to assess the existing practices of productivity factors that affect the productivity of the Ethiopian metal manufacturing industries/the firm as well as the main reasons that responsible for the firms low productivity.
- Low Productivity related problems: this section includes questions which were used to assess the main problems that related to the low productivity of the Ethiopian metal manufacturing industries.
- Productivity measures: this section includes questions used to assess the main challenges of productivity measures, the Productivity measurement practices of the firms, methods and outputs of the result and so on.
- Productivity improvement practices: this section includes questions which were used to assess the activities that are practiced in order to improve the productivity of the firms as well as stakeholders involvement of the Ethiopian metal manufacturing industries.

5.5. Results of Productivity performance in the firms

5.5.1. Factors influencing productivity in the firms

Based on the surveyed questionnaire the productivity factors which are influencing the productivityof the Ethiopian metal manufacturing industries are analyzed. The table below summarizes the ratings from the respondents given to each factor.

Table 5.1: Respondents rating on factors influencing productivity

No	***Factors influencing Productivity***	***3***	***2***	***1***	***Total score***	***% share***
1.1.	Input Materials utilization *(raw materials & accessories -availability, quality, timeliness, import substitutes etc)*	48	26	7	81	8.6%
1.2.	Machineries &equipments*(relevance, quantity, accuracy, speed, maintainability, age, etc)*	57	22	6	85	9.0%
1.3.	Investment capital	36	26	11	73	7.8%
1.4.	Technology *(innovation, research & development, automation, information technology, etc)*	39	28	9	76	8.1%
1.5.	Human resource *(Labor force -availability, management, knowledge, skill, attitude, mixetc),*	60	20	6	86	9.1%
1.6.	Management *(plans & schedules, instructions, ability to adjust staff size & duties, coordination & balancing of material flow, supervision etc)*	27	34	10	71	7.6%
1.7.	Organizational structure and culture	24	26	15	65	6.9%
1.8.	Physical environment or working condition	12	16	24	52	5.5%
1.9.	Infrastructures *(transport facilities, means of communication etc)*	24	22	17	63	6.7%
1.10	Energy	33	36	7	76	8.1%
1.11	Marketing conditions	21	16	21	58	6.2%
1.12	Lack of coordination in the supply chain	12	18	23	53	5.6%
1.13	Government regulations , policy and strategy	21	24	17	62	6.6%
1.14	Demographic & social impact	0	6	33	39	4.1%

In Qn.16 (appendix I), about 14 factors influencing productivity (from several literatures) were assessed whether these factors are really appear in Ethiopian metal industries and how is their effect on sector is expressed.

Based on the responses results, human resource (skilled man power, skilled labour force, knowledge, management, attitude, skill, mix etc) is influencing the most about the productivity of Ethiopian metal industries and Machineries and equipments (relevance, quantity, accuracy, speed, maintainability, age, etc) were the second highly influencing factor and Input Materials (raw materials and accessories -availability, quality, timeliness, import substitutes etc) comes at third most influencing factor and then capital investment is at fourth place, and after that technology (innovation, research and development, automation, information technology, etc) came as the fifth most influencing factor and Management (plans and schedules, instructions, ability to adjust staff size and duties, coordination & balancing of material flow, supervision etc) Physical environment or working condition, Energy, Infrastructures (transport facilities, means of communication etc),Organizational structure and culture, Lack of coordination in the supply chain, Government regulations , policy and strategy, Marketing conditions and Demographic & social impact came thereafter respectively.

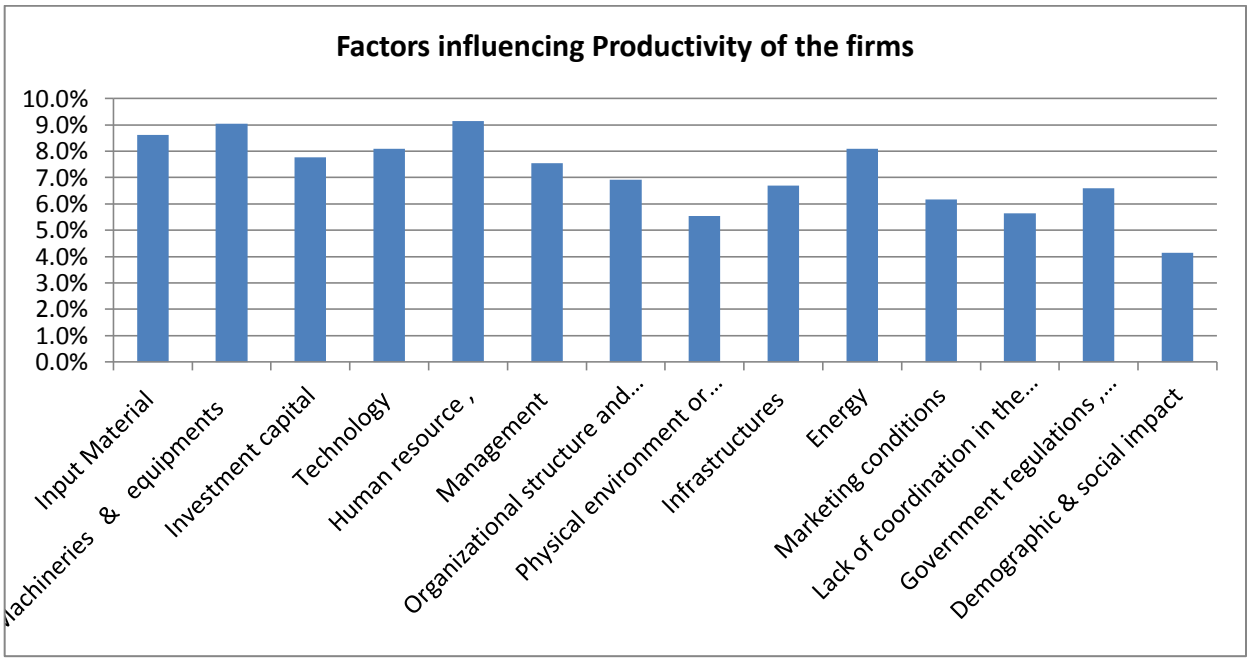

Figure 5.1: Factors influencing productivity in the firms

The above figure 5.1 shows the ratings five of the factors (human resource, machines and equipments, input materials, energy and technology) which account about 35% of the total factors in number result in about 43% of the total influence/effect on the productivity of the Ethiopian metal manufacturing firms.

5.5.2. Problems related to low productivity in the firms

Based on the surveyed questionnaire, the main reasons or problems that are related to low productivity in Ethiopian metal manufacturing industries are analyzed. The table below summarizes the ratings from the respondents given to each related problems.

In Qn.16 (see appendix I), about 9 major reasons (from literatures) that are responsible for low productivity in Ethiopian metal industries were assessed how is their effect on sectors productivity is expressed.

Table 5.2: factors responsible for low productivity

No	***Reasons for low Productivity***	***3***	***2***	***1***
1	Input related problems	15	11	10
2	Capital related problems	4	12	20
3	Machineries and equipment related problems	21	13	2
4	Planning and management problems	6	8	22
5	Process related problems	9	8	19
6	Skill and labor related problems	19	15	2
7	Technology and innovation related problems	16	17	3
8	Energy related problems	10	12	14
9	Quality and higher production cost related problems	26	9	1

Based on the responses from the firms, one of the main reasons (highly affects) behind Ethiopian metal manufacturing industries to a low productivity are Quality and higher production cost related problems, Machineries and equipment related problems and the other is the problems Skill and labor related of the human resource. The assessment shows that the reasons behind are shown in the following figure

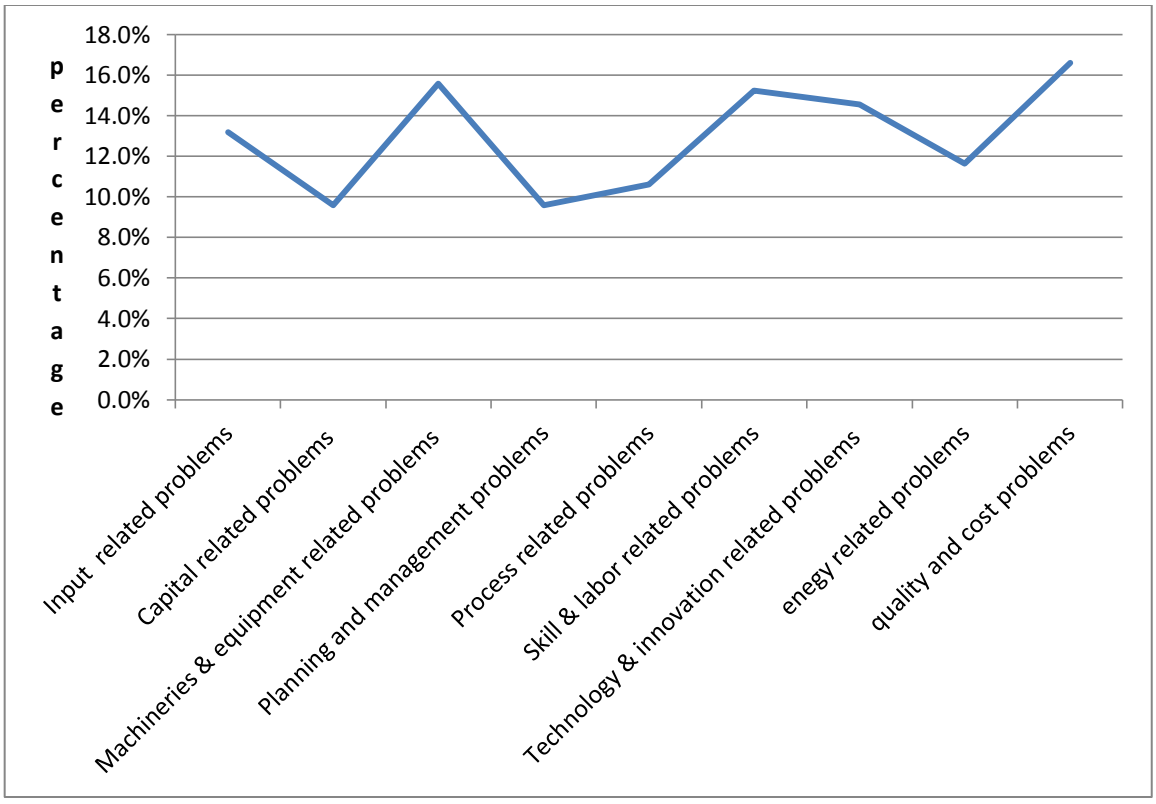

Figure5.2.: problems related to low productivity in the firms

As it can be seen from the figure 5.2, the two main reasons (Quality and higher production cost related problems) and (Machineries and equipment related problems) accounts about 33% and (Skill and labor related problems) and (Technology and innovation related problems) accounts about 29 % and while Input related problems take about 13% share. In addition, it can be seen that reasons (such as energy related problems) that are not specifically/directly related to the production process/systems were also specified by respondents towards not working at high productivity.

The above mentioned problems could further be analyzed as follows:

5.5.2.1. Quality and high production cost related problems

In Qn. 17, 35 & 36 (see appendix I), about 12 major reasons that are responsible for low quality of the products and higher manufacturing cost of the firms which affect the productivity in Ethiopian metal industries were assessed how is their effect on sectors productivity is expressed.

(Eph. Y. 2017) sited, the existence of wasteful manufacturing processes decreases the quantity and quality of products which may arise from inefficient processes. Moreover, it increases not only failure costs incurred for useless products but also increases the appraisal costs related to defective products. Hence increases the total production cost of the manufacturing firm. Most quality improvement initiatives are commonly targeted towards the elimination of waste and variation as a result of which productivity can be increased.

Based on the results Lack of skilled labor/expert in operation and maintenance, and lack of efficient machines &equipments constitutes about 54 % of the problems related to quality of products. While Lack of quality raw material such as scrap metals shares about 18% lack of technology (IT, R&D, automation, innovation) and lack of investment capital constitutes the remaining share. The cost of quality is largely related to the cost of waste, scrap and rework of sub standard products, the cost is incurred mainly due to inefficiency of machineries, production systems, operators and maintenance human resource skill and sometimes the cost incurred due to poor scrap raw materials in casting and foundry industries. Since it is affecting their productivity, firms struggle to compete in local and global market.

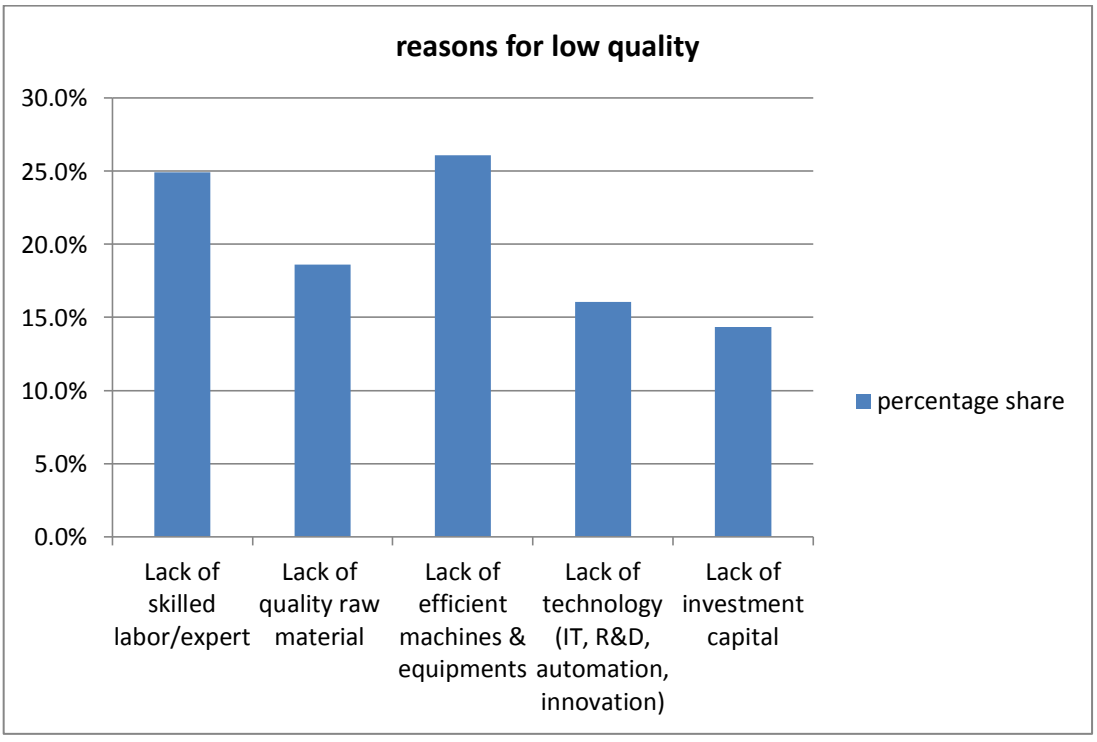

Figure 5.3: Reasons to low quality and high cost of production

Accordingly, Qn. 36 deals the cost of production rises due to the reasons high cost of raw material, high cost of spare part and accessories and high rework and scrap high cost of trainings, high cost of wages and salaries and high cost of investment. As it can be seen from the figure beside the raw material, cost related to spare part and inefficient machineries constitute much of the production costs

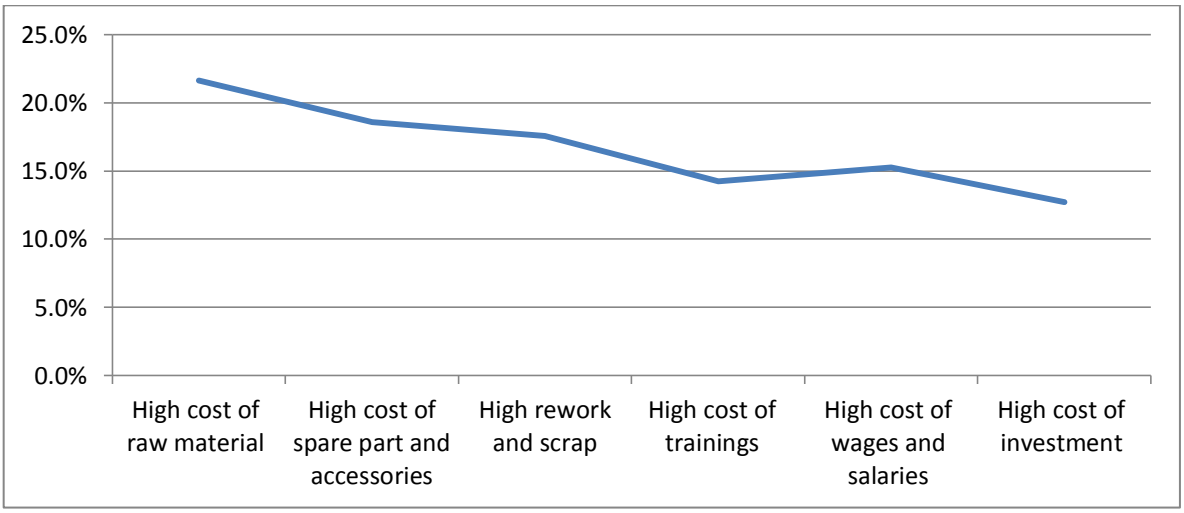

Figure 5.4.: Reasons for high cost of production

5.5.2.2. Machineries and equipment related problems

The above analysis shows that the firms experience regarding their low productivity performance due to machineries and equipments. The main problems related to machineries and equipments are mainly of problems associated with Machineries and equipment breakdown and the higher manufacturing cost sustained. Whenever breakdown/s occur production stops, production defects are occurred and outputs are delayed and therefore production and overhead costs rise which leads to low productivity of the system. This is usually happens due to;

- Machineries and equipment age
- Machineries and equipment operation
- Manuals and procedures followed
- Skills and handling of machineries and equipments
- Preventive and scheduling maintenance systems
- Availability and cost of Machineries and equipment spare part
- Poor Machineries and equipment Condition

- Outdated Machineries and equipment technologies
- Higher cost of Machineries and equipment import, installation and maintenance

Generally, the causes of Machineries and equipment breakdown are mostly due to lack of skills associated with operation and handling improper planning and performance of maintenance that reduce machinery down time and the age, speed, accuracy, durability and technology status decreases the total productivity the firms.

5.5.2.3. Human resource development and administration problems

As it can be seen from the above analysis, Qn. 32&33 (see appendix I), firms are experiencing low productivity performance due to human resource skill and labor development related problems, the main problems related to machineries and equipments are mainly of problems associated with issues that arise from education and training, recruitment, payment and incentives scale and system, morale, motivation and employee satisfaction, and generally development and management of proper human resource. These issues directly or indirectly affect labour productivity which in turn affects the total productivity of the firms. Generally;

- The installation, commissioning activities are done by foreigners therefore knowledge transfer a gap persist among the local employees since the activities are not done properly and depends on willingness. After all the knowledge sharing activity is not usually monitored during the project phase which directly affects the operation, maintenance, understanding and management of the manufacturing system and its components hence decreases the labour productivity.
- Technicians, operators, production workers does not get proper on job/out of job training and education therefore their output shall decrease.
- Unsatisfactory payment/wage structure, lack of performance based position/salary promotion, unsatisfactory incentives/bonus systems in the firms does not exist constantly which directly affects the satisfaction of employee that determines their motivation towards being productive.
- Management and employee handling problems exists, the discussions with some of the workers of the firms show that there is lack of regular work progress meeting and discussion

with management towards the good working environment and happening problems. This generally creates poor communication and working environment between workers and managers.

Proper knowledge sharing schemes, Employee capacity building activities, competitive salary and incentive systems and Performance based evaluation system, employee motivation activities, and creating good working environment are the basic issues that needs to be addressed regard in the productivity output of employees in the firms.

4.5.3.4.Input utilization related problems

(Eph. Y. 2014) stated that Inputs/resources are all organizational entities or activities. Some of the inputs can be consumed for producing products that customers require, however, majority of organizational resources and activities are non-value adding (or waste). This implies that resources are consumed not for the purpose of satisfying the customer.

In Ethiopian metal manufacturing industries the most inputs are the raw materials are mainly sourced from abroad (GTP II) and only few quantities are supplied locally in which the local source of raw materials (which are manly scrap metals) are usually provided for casting and foundry industries with melting furnaces while most industries use both local and imported raw materials as well. Qn.8 (appendix I) discusses the type and source of Inputs and raw material usage of the firms and the figure below shows the industries uses of inputs and raw materials.

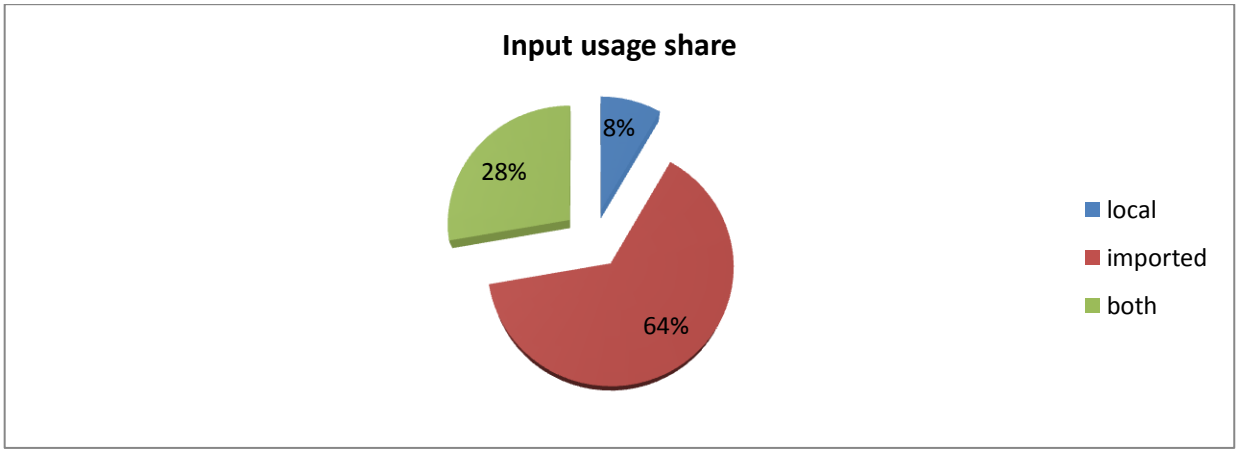

Figure5.5: The major source of raw materials in the firms

Despite the fact that Inputs and raw materials are availability is the issue, based on the analysis, the major problems associated with Inputs and raw, that affect the productivity of the firms are Input quality where the output is largely affected as they directly determines the output cost, inputs availability, source, reliability, lead time, higher cost, optimum/required quantity, transportation and logistics, foreign currency, working capital shortage are also affecting the firms productivity performance.

4.5.3.5.Technology related problems

Based on the Ethiopian ministry of science and technology, technology can be categorized in four major areas

- Techno ware [equipments, devices, machineries, tools etc. which enhance human physical process and control for all necessary transformation, operation/scale of operation, scope and of output, safety of environmental soundness],
- Orga ware [organizational structure, methods, techniques, networks, practices, which coordinate all productive activities of the enterprises for achieving purposeful results)
- Human ware [skill, knowledge, expertise, creativity etc which contribute to actual utilization of available natural and technological recourses for [productivity purpose/level of general education, appropriateness of training and retraining, relevant experience motivation of personnel],
- Info ware, [Design parameters, specifications, blue prints, and maintenance and service manuals which enable quick learning and help time resource saving].

Qn.30 (see appendix) was included for the analysis of the technological related problems of the Ethiopian metal manufacturing industries for their productivity has been assessed. The major problems related were age, condition technological level, affordability, suitability, accessibility, maintainability of the technology and the research and development activities of the firms in terms of innovation and technology development were affecting the productivity of the firms.

5.5.3. Productivity measurement trend

(Yitagesu. 2017) stated that due to the high level and variety of productivity applications, the use and selection of appropriate measurement techniques and interpretation of the productivity analysis makes difficult. Whatever productivity measurement approach pursued, understanding the concept of productivity and its measurement at the desired level becomes a crucial element. Productivity measurement and analysis can be done at individual level, working group, process or subsystem level, firm level, industry level, sectoral level, national or international economy levels.

Questions from no 18-26 (see appendix I) dealt about the firms trend their interest/approach and trend to measure Productivity, assessment of value of productivity measurement output for strategic decision making, methods/kinds and period of Productivity measurement conduction and the challenges that the company faced while conducting productivity measurement.

Based on the surveyed questionnaire the productivity measurement issues on Ethiopian metal manufacturing industries are analyzed;industries conduct productivity measurement but only few do the measurement as a company policy. Most of the industries answered they were challenged to measure the productivity correctly and regularly rather they conduct financial measures/analysis for strategic decision making and due to poor attitude about measuring the productivity, data and skill unavailability and time and cost sensitivity. They usually don't use the result of the measurement for critical strategic decisions, instead they use the conventional approach of increasing the selling price, decreasing the workers number, decreasing the benefits of the employees and increasing their profit margins rather than working to make the system efficient and productive, when they get the total cost of production higher which is main reason that they are not being competitive in global market even in local/import substitution.

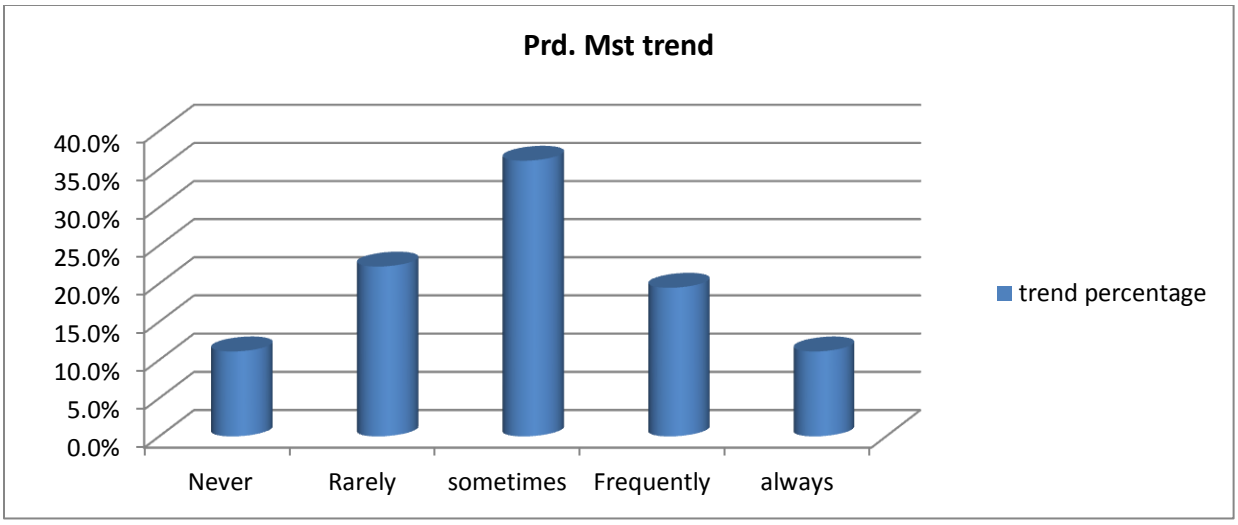

Figure 5.6: Productivity measurement trend in the firms

5.5.4. Productivity improvement practice

The last section of the questionnaire was developed for assessing the productivity improvement activities, performances, practices and related problems faced in Ethiopian metal manufacturing industries. Accordingly,

- The firms give on job trainings training programs, and occasional trainings (participate on training opportunities provided and sponsored by other stakeholders or organizations), however they don't conduct scheduled trainings and capacity building activities based on their workers skill, knowledge and attitude gap or by conducting gap analysis survey.
- Metal industries are the most hazardous industries were accidents happen frequently so that the manufacturing firms supposedly exert extra effort in order to make the working environment safe and conducive however there were no record of program schedules and, allocated budget for this activity.
- In firm level productivity improvement methods/tools, some firms are practicing such as KAIZEN (5S), but most of the industries are not active operationally and have poor perception on the improvement methods.
- Some industries are performing employee moral boosting practices such as paying annual and holiday bonus,employee learning, satisfaction, and innovation in order to raise the commitment of employees.

- Stakeholders such government institutions [MIDI], the Ethiopian kaizen institute have been engaged in educate and train employees of different metal industries with different skill development areas and capacity building activities; the MIDI provide product development, technology transfer, prototype manufacturing technical services, they are also performing some activities in creating university-industry linkage activities, benchmarking and twining programs. The institute is also trying to create supply chain and market linkage, market promotion (however it is limited with some opportunities in international market exposure) trade exhibition. They also have been working alongside the industries in order to solve/facilitate the issues regarding bureaucracy, power and infrastructure with offices like the Ethiopian power authority, commercial and developmental banks, and financial institution, the Ethiopian tax and revenue authority etc. Some NGOs and organizations have also been giving several capacity building training, seminars, consultations, research and development activities and few international exposures as well which are important in order make the industries and their manufacturing system strong, efficient and productive.

Generally, problems associated or affecting and influencing productivity, even the crucial ones may not be associated with direct firm's production (inherent to the system), they could also be problems which are related to such as supply, and marketing activities that means problems could arise external to the firms in the sub sector and internal to the firm level problems. Therefore, enhancing productivity of sector is the result of the effort exerted by all the stakeholders involved.

5.6. Productivity analysis of case company: Yesu metal manufacturing

In the previous section, it was tried to assess and analyze the productivity, the productivity related problems of Ethiopian metal manufacturing firms, productivity measurement and improvement practices and that helped to understand their productivity level and the problems currently facing the sub-sector. However, for a complete study of the research, it is needed to further analyze a metal manufacturing industry's internal situation (production system, working environment, productivity status, problems, and improvement practices) through the use of primary data. Because, in order to bring a total productivity in metal manufacturing firms, the whole manufacturing system elements has to be at a good productivity level.

Therefore; the main reasons to select the case company are:

1. It is one of the largest metal factories with automated and semi automated manufacturing system, PLC and CNC controlled/operated machineries, mechanized material handling system, high amount of employee number (more than 500 permanent & contract workers), and a secondary manufacturing firm (very high capacity induction furnace) , etc so that it will help to understand a complete system of metal manufacturing.
2. Even though the company's manufacturing system is modern and well equipped, based on preliminary survey and (company production report), it is observed that there is high amount of system inefficiency (high amount of scrap & rework and high amount of break down time), high amount of employee turnover and accidents, poor technical & managerial practices and generally poor working environment.
3. Easy access of Data availability and information.

Therefore, company overview, production process overview, assessment and analysis of the current productivity level/status, productivity measurement and practices, the causes for low productivity performance and related problems, productivity improvement practices is conducted. Summary and analysis of problems was conducted mainly with respect to the concept of productivity analysis (productivity measurement based on primary data, production cost, break down, scrap & rework cost analysis), Pareto analysis, cause and effect analysis, and finally the findings are summarized.

5.6.1. Background of the company

Yesu private limited company is one of the biggest manufacturing companies in Ethiopia. It was established in 1993 E.C with a capital of 955,000,000 br and the factory is located around Gelan Industrial site [about 30 kms south of ADDIS ABABA] and it has two major plants. Generally the plants can be considered as cold rolling mill and hot rolling mill plants. The company has 621 workers in both plants.

The cold rolling mill plant produces with the capacity of 220, 000 mt of steel coil per annum which is the raw material for the galvanizing line and then the line produces galvanized corrugated steel sheets with different varieties of final product steel sheets of with sizes [0.6 mm, 0.18mm, 0.2mm, and 0.23mm] galvanized coil which are used for covering roofs.

In 2002 E.c the company took an expansion of hot rolling mill project with a capital of 400,000,000. The hot rolling mill plant produces several types of reinforcement bars as a final or customer products which are used for construction and industrial purposes. In the hot rolling mill plant, the factory has two sections of production lines.

1- Steel mould production section and
2- Rolling mill section

The steel mould production section of the plants basically consists of a 25 tones induction furnace and a continuous casting machine. The furnace uses an electric power source with a copper coiled base which converts the eclectic source/ energy to heat energy that has a capacity of melting 25 tons of scrap/types of metal with average time duration of 3 hrs and it is located about 70 meters far from the continuous casting machine. The continuous casting machine [CCM] uses water as a main coolant material to cool the hot melted metal and it has an output/ capacity of, at one operation with average time of 1.2 hrs, casting average 56 respective moulds [mild steel bars] that have a cross section area of 12 cm*12cm and has a length of 4 meters. These mild steel bars are used as a raw material for the rolling mill section of the factory.

Vision: To be one of the leading metal manufacturing companies in Africa

Mission: To contribute and support the Ethiopia construction and metal industry sector

Main types of products service delivery its products to

- Corrugated steel sheets [4 types]
- Reinforcement steel bars [6 types]
- Distribution and delivery of its products for different section of the retailers and customers.

The production of the reinforcement bars uses moulds that are produced at the [CCM] continues casting machine as an input. These moulds are produced through casting of melting metals, for melting metals the major resources are scrap metals, and electricity.

5.6.2. Process description of the manufacturing of reinforcement bar

Scrap-based melting technology

Steel making has to be seen as part of a chain which leads from raw materials to semi-fabricated products to finished products. The traditional steel making processes in industries are listed below and the factory uses classical process route for electric steelmaking which are or include;scrap charging, melting, tapping, secondary metallurgy, slab casting, cold rolling, hot rolling, treatments and delivery.

There are several innovations concerning the actual steel making it also has to be pointed out that the subsequent steps are undergoing reconsideration and innovation, for steel products. It can be claimed that in the area of carbon steels the success of the electric arc furnace is linked to its joint operation with. Productivity increase in the electric steel making process can be taken as a reduction of the tap-to-tap times and the consumption of energy and other materials.

5.6.3. The production process at Yesumanufacturing: Hot rolling mill

The production process of the RC bars can be summarized as follows;

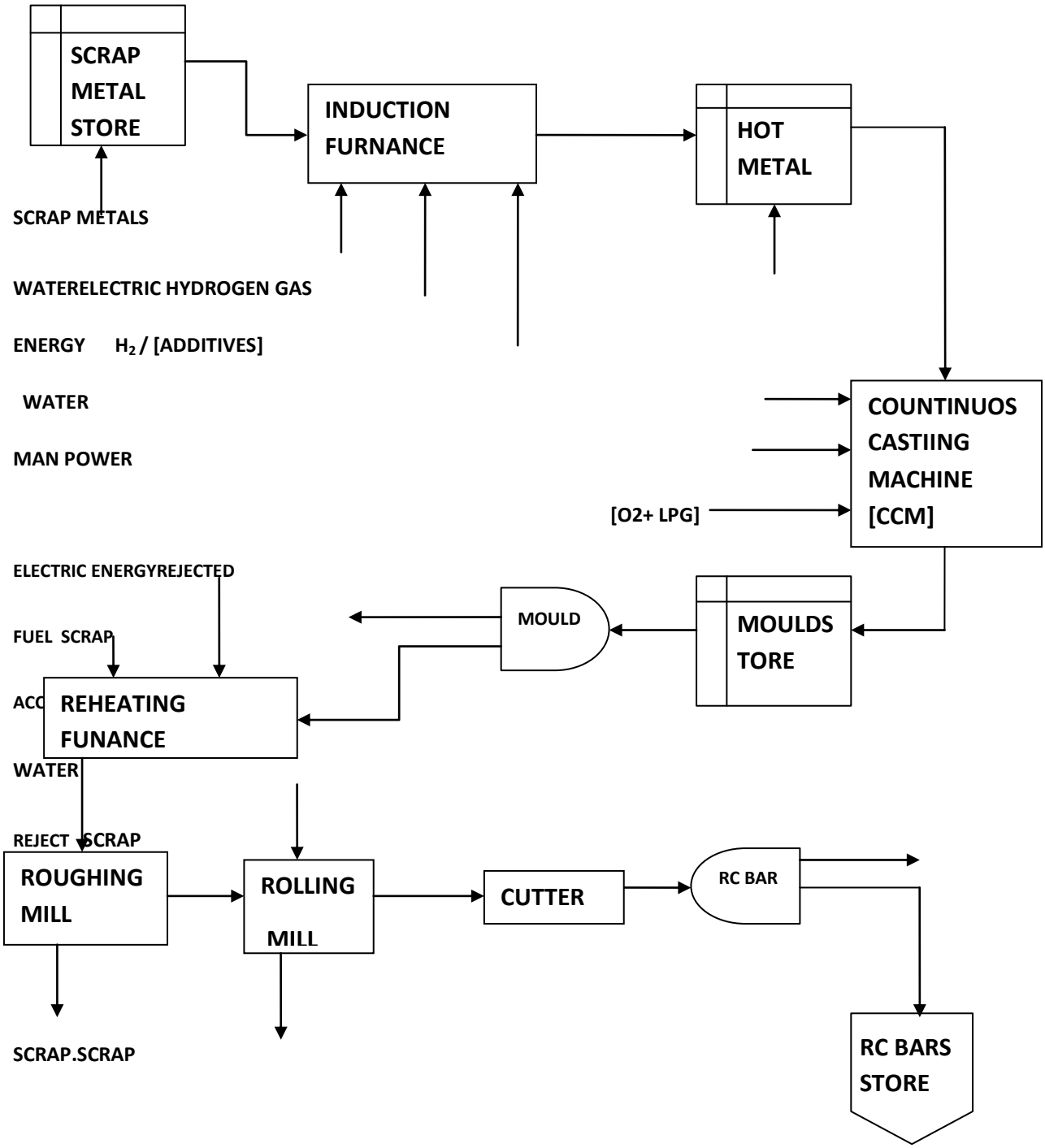

Figure 5.7: Process flow chart of reinforcement bars production

5.6.4. Productivity analysis based on Quantitative data for the case company

5.6.4.1. Level of Company productivity measurement and analysis definition

In the company, Productivity is defined traditionally based on the concept of factory profitability, in which the company understands and measures the total sales values with respect to the costs deployed for the total factory operation. Therefore the required resources including the labour force (employee number) are acquired and determined traditionally. Hence there has been a frequent labour force fluctuation across the working years. However the factory report discloses that the factory has been earning profits during the past six years. This is due to that the factory has a comparative advantage to determine a local selling price against similar industries because it has its own continuous casting machine to make input moulds for rebar production while other competitor industries import billets with foreign currency, (company report).

The measurement and analysis of a company has traditionally be determined byemploying Kendrick and Creamer, (1965) in which the productivity index is applied for total productivity value where the productivity index is measured usually based on sales values only or physical counts of the outputs are represented through selling values and input factor are determined with the total cost of production. There is no recorded any value of productivity measurement result during the last six years of production. However following this productivity measurements approach, is usually used by firms for monitoring and development of the daily operations and long term strategic considerations.

However Productivitymeasurement and analysis practice is not being accustomed in the company yet, employees are participated to some productivity improvement practices such as attaining capacity building trainings inside and outside the company when other organizations provided them the opportunities. Despite the above illustrations, the company provided modern up-to-date technology equipments and machineries where the productivity of machines is believed to be higher (since there is no partial and multifactor productivity measurement is not practiced, it is difficult to determine the share factor of the machines productivity based on the current practice of the company)

5.6.4.2. Company Productivity analysis based on productivity measurement

Definition of the level,output & input types and characteristics of the production function or system under quest are important step before measurement and analysis techniques are dealt with. Because, the characteristics of the inputs and outputs are different for different types of production system and the concept of production and application for different production type, careful considerations for selection of productivity measurement technique, analysis and result interpretation need to be searched for. Primarily, the outputs are usually expressed in different forms to the inputs. Outputs are often measured in physical words [OECD 2001] such as units (e.g. number of bottles produced, tones of sugar, kilowatts of electricity, etc) or values such as Ethiopian birr. However the inputs are usually physically different and include measures of people (numbers, skills, hours worked or costs) or materials (tonnages and costs). Secondly, the ratio by itself tells a little about performance. A ratio of 0.8 is of little importance unless it is compared with previous time periods, or a benchmark, or the potential productivity of the operation unit. Third, many different ratios can be used (both financial and nonfinancial, that can be used) to create productivity ratios [OECD 2001].

1. Gathering relevant data

(Yitagesu 2017) explained about data for productivity measurement, implementing a measurement model requires gathering any two of quantity, price, or value of each input and output. Inputs are categorized as material, labor, energy, capital, and miscellaneous resources. Outputs are categorized into product lines. Then, a "typical" period or optimal data base line is chosen for the base period. To measure the productivity performance of a particular period, the same type of data is gathered for that period. These data are then used in the model to obtain the productivity, profitability, and price recovery contributions of each element and category in monetary terms. The data required is dependent on the model chosen. The frequency of data gathering also depends on the situation. Organizations may want to monitor performance monthly, quarterly or yearly. The data may have to be collected manually or it may be available on a computer in a proper format for the measurement system to use it. Once the data are fed into the measurement system, the results should be computed by the system.

2. Base year selection

In order to measure the productivity increase and analysis, there should a base year be selected and the associated cost and related sales of the company should be described. The base year for the measurement of the productivity growth of the firm has been defined to be the [2006 E.C]. Because, this year has got a relatively demonstrated average performance, higher amount of net profit value and fully advocated by the interview result from the company's managers and experts for using as base period.

3. Determination of inputs and outputs values

On the previous sections it is seen that Productivity is the ratio of inputs over outputs whatever the measurement system applied however the nature of inputs and outputs used for the analysis may be different one type of production process to the other. Depending on the type of the process, outputs could be in the following forms; Units produced, sales volume, valueadded,labor hour /standard hours, number of, purchases/purchase orders processed, number of projects completed on time and machine run time/ uptime[Yitagesu. Y. 2014]

Similarly, depending on the type of the process, the inputs of a process can be expressed in different forms including the following:Number of employee, man or labor hour available/ working hour,labour cost, machine hour, unit of energy consumed, monetary value of a single or aggregate production factors[Yitagesu. Y. 2014]

Hence, for productivity measurement and analysis and to develop the company productivityindex, appropriate input and output expressions or units, compatible to one another has to beused.

A. Determination/ Quantification of out put

Production and sales trend

Yesu metal manufacturing has one of the highest production capacities among the Ethiopian metal & engineering firms with a designed capacity of manufacturing 200,000 tons of metals per annum. However, currently, it is performing under capacity about 40% due to several reasons.

The following figure and table demonstrates the annual production (performance with respect to plan), and annual production rate, total production, total production cost, sales value and the profit earned in birr during the past six years of operation respectively.

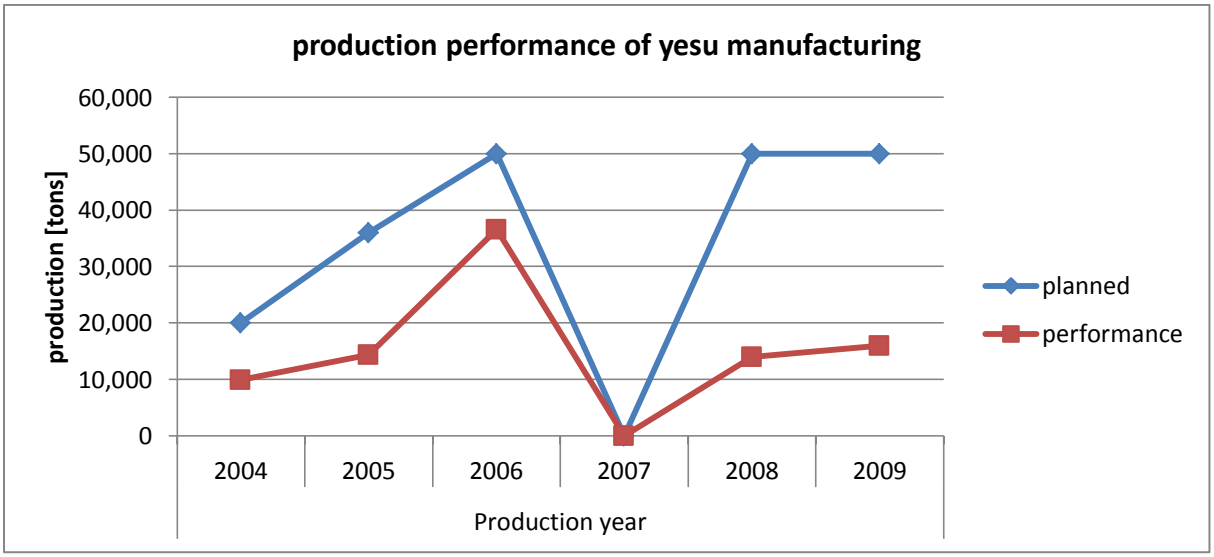

Figure 5.8: Annual Production trend of Yesu metal manufacturing

The above Figure 5.8 shows the past six year's production trend with regard to the firm's plan. Accordingly, the average six year production performance of the company compared to its yearly plan of total production is ***58%.***

Table 5.3: Production and sales of the company [2004 – 2009 E.C]

Item	***Unit***	***Production year [000birr]***					
		2004	***2005***	***2006***	***2007***	***2008***	***2009***
Total prod.	Tons	9,869	14,358	36,543	-	14,015	15,943
Prod. cost ('000)	Birr	190,840.1	277,645.4	706,644.2	-	271,012.7	308,295.1
Total sale ('000)	Birr	225,297,149	289,935,408.00	805035304.3	-	297465588.7	326139731.7
Profit ('000)	Birr	34,457	12,289.9	98,391.2	-	26,452.8	17,844.7

[Source: summarized from annual factory reports]

Table5.3shows the past six year's production, sales and profit trend of the firm. Accordingly, the five year trend is inconsistent.

B. Determination/Quantification of inputs

- **Total Cost of Production in Yesu metal manufacturing**

The data, presented below helps to calculate the amount of the Total cost of production and main costs constituted under the production process. In order to produce a reinforcement bar products, the following common production costs are involved for the overall operation of the industry, namely; raw material cost, auxiliary and input costs, labor cost, overhead cost. And the operating expenses are generally administration cost and selling & distributing costs. The amount of total cost of each type for 2009 E. C. is taken from the annual report of the company and tabulated as follows.

Table 4.4: Total cost of production at Yesu metal manufacturing for 2009 E.C

No	***Type of Costs***	***Cost in Birr***
1	Production cost	248,032,286.26
2	Operating expense	12,338,195.31
3	Maintenance cost	19,842,582.90
	Total cost	***280,213,064.47***

With this total production cost of the company described above, the following table and pages demonstrates the detail of associated total labour cost, material & input costs, cost of scarp & rework and cost of down time/breakdown.

- ***Labour and factory overhead costs***

Table 5.5: labour cost and factory overhead costs of Yesu metal manufacturing [2009 E.C]

No	***Cost Item***	***Total labour cost [Birr]***
1	Direct labor	6,892,681.43
2	Indirect Labor	8,059,113.56
3	FOH	13,130,225.47
	Total	**28,082,020.46**

- ***Cost of input and material***

Table 5.6: Revised total annual cost of material and input reinforcement bar production. [2009 E.C]

No	***Item***	***Total Qty***	***Unit Cost***	***Total Cost***
Direct Raw Materials [ton/ton]				
1	Scrap metal	15,943	12,500	199,287,500.00
Auxiliary materials [Kg /Ton]				
2	Ferro silica	317.81	30,393	9,659,199.33
3	Ferro Manganese	142.38	21,978	3,129,227.64
4	Sodium Silicate	59.49	4,752	282,696.48
5	Graphite Powder	198.32	15,840	3,141,388.80
6	Limestone	4,373.10	324.3	1,418,196.33
7	Silica Sand	118.989	3,960	471,196.44
8	Oxy-acetylene gas	2700	2,237	6,039,900.00
				223,429,305.02
Energy and utility				
9	Furnace Oil [furnace and reheating]			3,625,453
10	Electricity (Kwh)	144,000,000		6,848,054.00
11	Water [Ltr]	862,000		1,111,971.20
12	Lubrication [kg]	9,834		455,625.00
13	Fuel and gas [ltr]	8,976		679,400.00
				12,720,503.20
Transport and insurance				
14	Custom clearance and Transportation			823,200.00
15	Freight and Insurance			1,500,000.8
				2,323,200.8
All Taxes				
16	Taxes			***9,559,277.24***
Total cost = 248,032,286.26				

Source [compiled from company material acquisition bills]

- ***Maintenance cost***

Regarding maintenance, though there is a preventive maintenance schedule every Sunday of the week. However it is not applied with a defining consistency/ properly instead only for selected

machines and mostly failure maintenance is used while with minimum documentation and inventory procedures. The maintenance cost comprises cost of employee wage, cost of overtime, spare parts & lubrication costs and other relevant related costs.

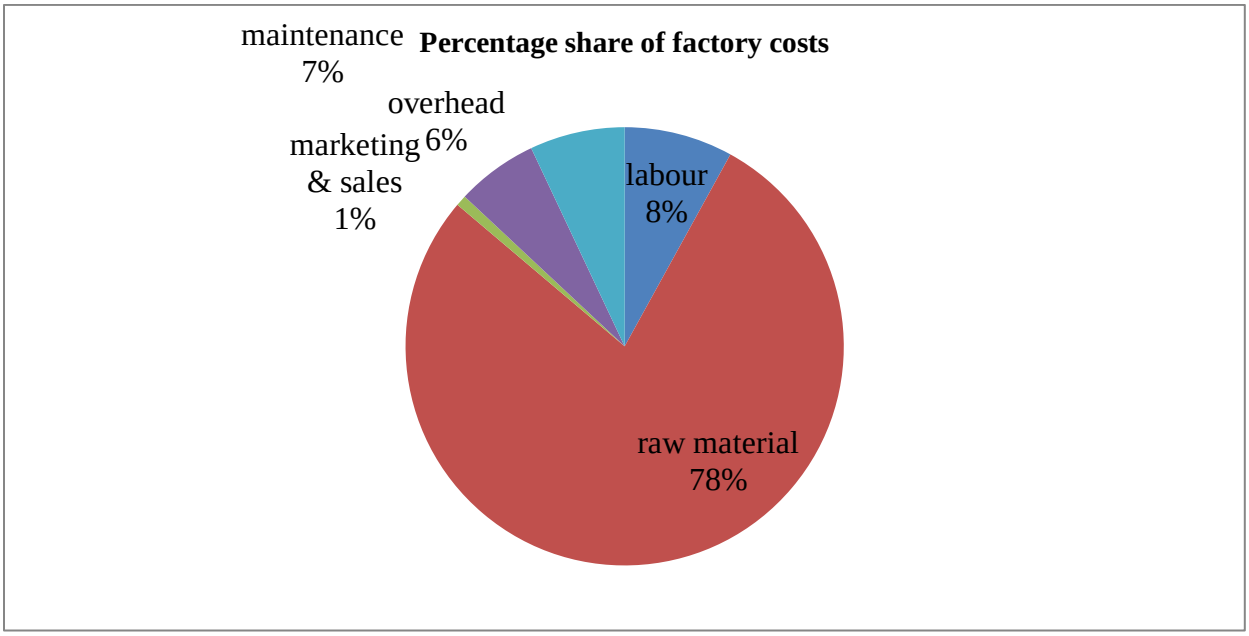

Figure 5.9: Percentage shares of costs in Yesu metal manufacturing

Note: input raw & auxiliary material cost takes 78% of the total cost

C. Rebar Production process productivity Measurement

Measuring productivity has been a common practice of organizations [Dahlgaard J. 1998]. Because it helps to know the position of the company with respect to its previous performances, to benchmark a company compared to its competitors, and to oversee a company's next pride and it can also be set as a strategic measure and indicator of improvement and success [David E. 1993]. For these and other many more reasons, measuring and improving productivity will be conducted in the preceding points.

For the analysis of the company productivity total productivity and partial productivity measurement are selected, as an appropriate measurement approach for the case of this research to determine the total productivity of the firm, according to the rationales below;

1. The company operations are composed of several sub-processes, mainly ;
   - Supply and procurement process
   - Rebar Production process
   - Marketing process
2. The total productivity calculation error will be minimized since the results are determined based on each sub categories
3. The partial contribution of inputs the productivity and will be identified for improvement

Labor productivityof the firm

The standard measure of productivity reported in metal industry is tons of metals produced per worker-hour (or conversely, man-hours per ton). This measure requires a physical measure of output (tons) [Lieberman & Johnson, 1999]. And it is more general and can be computed for a range of industries.

Table5.7: Labour productivity of the firm based on [labour hour]

Item	***Unit***	***Production year [000birr]***					
		2004	***2005***	***2006***	***2007***	***2008***	***2009***
[Y] Total prodn.	Tons	9,869	14,358	36,543	-	14,015	15,943
[X] No of employee	No	376	434	567	254	289	328
Labour hour [L]	Hr	90240	104160	136080	60960	69360	78720
Productivity [ratio Y/L]		109.5	137.8	268.4	-	202.1	202.6
Index		0.41	0.51	1.00	-	0.74	0.75

Capital productivity

The measure of capital productivity is output per unit of capital stock. The estimate of a firm's capital stock is the value of its net property, plant, and equipment, as reported in its financial statements, where those figures may be subject to accounting biases. The biases may vary among firms and countries, particularly when inflation is a factor. To minimize these biases, real capital stock is used to estimate. This series can be computed for a given firm, starting from the initial year of data, using the equation:[Lieberman, Lau and Williams (1990)]

Real Capital Stock= Kt= (1-d) Kt-1+ It…….(5.1)

Where Kt is the real capital stock in year t, d is the annual rate of economic depreciation, and It is the firm's gross investment in year t adjusted for inflation. It is assumed that d, the real depreciation rate, was equal to 8.6 % (2009 E.C average) [CSA]

Capital Productivity = total output / Real Capital Stock……. (5.2)

Material productivity

The measure of material productivity is output per unit of all material inputs. The estimate of a firm's Material productivity depends upon how material is effectively utilized in its conversion into finished product. Material productivity depends upon percentage of rejection, creation of scrap, level of spoilage, obsolescence, and work wastage.

Material productivity = total output/material input……. (5.3)

Energy productivity

The measure of energy productivity is output per unit of capital stock. The estimate of a firm's energy productivity depends upon how the energy inputs are effectively utilized in order to produce outputs for sale (no defective products).

Energy productivity = total output/energy input……. (5.4)

The following table demonstratesthe calculation of the above discussed partial productivity factors for year (2009 E.C) with respect to their quantity, monetary values against the base year (2006 E.C) value.

Table5.8: Base year, quantity, value, productivity ratios and index of Rebar production process

No	***DESCRIPTION***	**Base year [2006 E.C]**		**2009 E.C**		**Productivity**		
		Quantity [tons]	***Value 000'***	***Quantity***	***Value 000'***	***Ratio***		***Index***
						2006 E.C	***2009 E.C***	

1	TOTAL OUTPUT							
	Rebar products	36,543	706,644.2	15,943	308,295.1			
2	INPUTS							
	Material	-	412,123	-	223,429.3	1.7	1.4	0.80
	Labour hour	136,080	28,772.8	78720	14,951.7	37.6	20.6	0.84
	Energy	-	39,156.7	-	12,720.5	36.9	24.2	1.34
	Capital	-	502,726.4	-	744,310.0	1.4	0.4	0.29
	Miscellaneous	-	17235.7	-	11,882.4	41.0	25.9	0.63
	TOTAL INPUTS							0.78

From the table 5.8 it can be understood that all the index values are showing there is a decline the partial productivity of inputs.

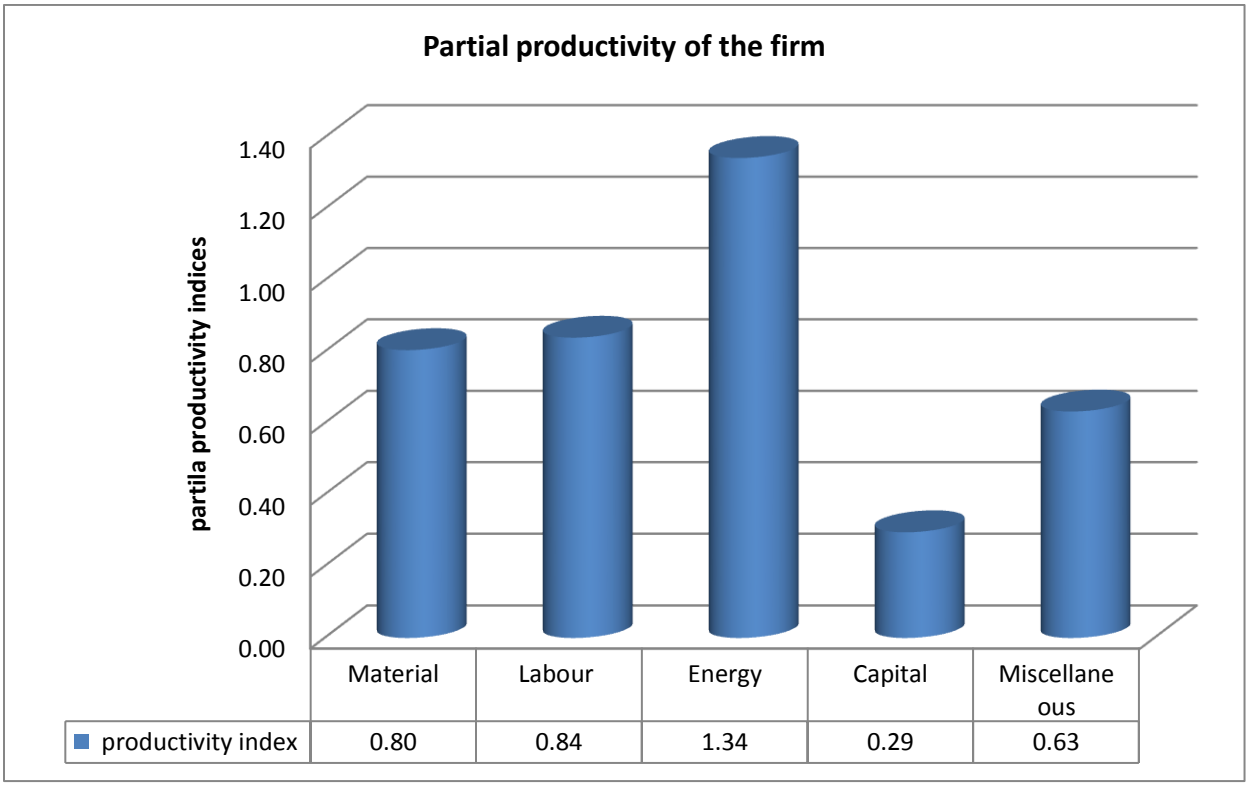

Figure5.10: Partial input productivity indices of Rebar productions

Based on the partial productivity index values, it can be concluded that all the input factors show a decreasing productivity with respect to the base year value. The high downtime of capital resources affects productivity measurement. It can also be noted that the existence and extent of wastes and reworks in the production system affects the level of productivity of the organization.

Total productivity measure of the firm

Calculating labor productivity, capital productivity, material productivity or energy productivity alone does not give an overall picture of a firm's efficiency/productivity. The total productivity calculation of the firm attempts to measure the change in output net of the changes in all inputs, and it is commonly regarded as a more appropriate measure (Lieberman & Johnson, 1999).The following standard formula is used to compute the total factor productivity of the firm

Productivity = total input values / total output values…… (5.5)

Similarly, using the above formula, the total productivity indices of the Rebar production process for the years 2004, 2005, 2008,and 2009 are presented in the following figure;

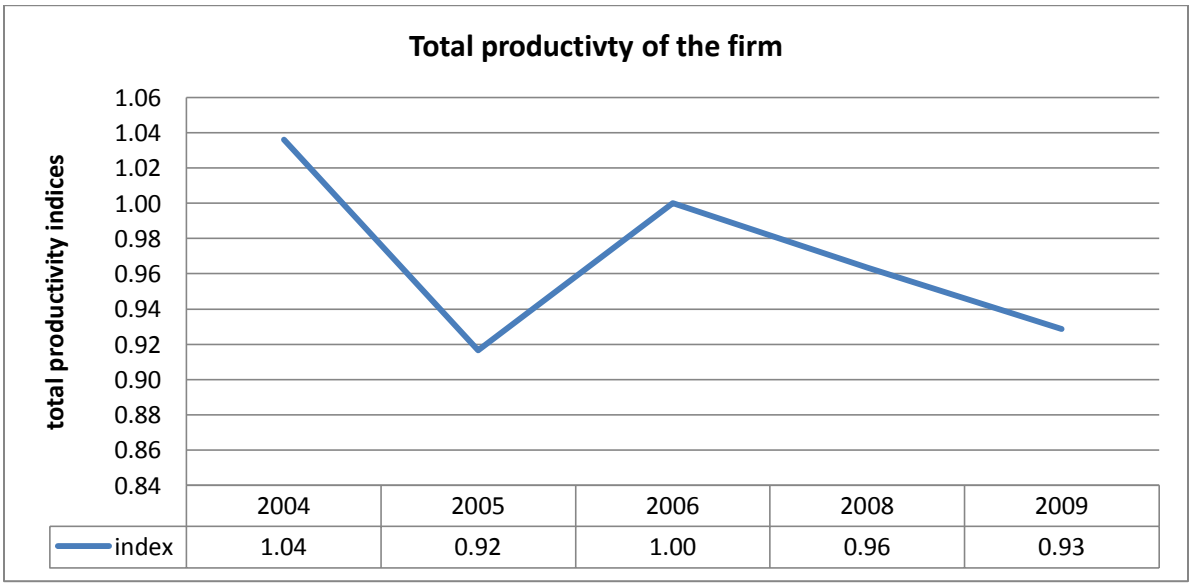

Figure5.11: total productivity of the firm with respect to the base year

From the above quantitative data analysis, the total productivity of the firm shows a decreasing trend and hence the factory losses high amount of capital resources.

5.6.5. Illustration of low productivity profile of the company

5.6.5.1. Cost of scrap/ rework

The quality control practice in the firm is conducted in two main scenarios. The first activity is conducted while at Furnace where some portion of the melt is taken into the laboratory and based on the result there would be made adjustments at melting stage and the second and activity is conducted on the reinforcement bar where products are checked and inspected to be sold or scrapped/reworked. The final product is checked against the standard and the product will be then be said conforming to be sold or rejected based on the following parameters.

The major Defects [non-conformities] and non sellable products in Yesu manufacturing are;

- Length - under cut [size]
- Weight - over weight [kg/m]

  - Under weight

- Strength – brittleness, hardness
- Structure - shape of the teeth and pitch

Therefore based on the company measures; due to poor quality concept, implementation & management, the scrap level measures (3%) and rework (23%); however in which there is no corrective actions can be taken at that stage. The scraps are waste materials that cannot be res melted because they affect the final melt composition & behavior whereas, reworks are those can be re melted and subsequently casted. Thus, the cost of quality in rework is very high which increases the total cost of production and hence reduces production efficiency.

Based on the given data;

- Given: rework = 23%;
- Labor cost= 3.427 million per year and factory overhead = 3.02 million/year
- Rework cost = 6.447 million birr year
- Scrap cost = 3% of total production cost = 9.25 million birr year

Total scrap & rework cost = 15.66 million/ year

The company uses two shifts of operation and four hours of OT for each shift i.e. it uses 8 hours OT per day, therefore, the reworks are done on regular and OT work period and the firm on average will lose 537,250 birr monthly or annual cost of 6.447 million birr due to rework or quality problem. However, if there is overtime rework in all days of the month, the company will lose 68,250 birr monthly. The firm works in a double shift and mostly uses overtime; however, it faced with high overtime cost (up to 250,000 birr per month), and its cost (30% of OT cost).

5.6.5.2. Cost of down time

(Ephrem G 2014) quoted, the status of a machine operating is known as availability. When machines stop operation they are known to be down – downtime. The total working hours of the company under research during the year was***43,200hours*** (considering the 6 major processing/workstations working hour measurement) out of which ***25,185.6 hours***has been recorded as downtime ***(59.3%).***The measurement of downtime has its impact on productivity, which is a measure of the efficient utilization of all organizational resources to produce required outputs [Butterworth 1990]therefore the higher downtime of capital resources significantly affects productivity. When machinery becomes down resources are being utilized less.

As the case of Yesu metal manufacturing, one of the biggest and modern industries in the country, is equipped with several set of modern machineries and equipments that are arranged to produce reinforcement bars. The machineries are arranged in operationally series arrangement, where the breakdown of one machine affects the whole production processes particularly for the bottleneck machines.

In the Factory, downtime hours are collected when problems that stop the production process in manufacturing plant. Based on that, the downtime hours compared with the available up times of respective processes, the major problems associated with the break downs, their occurrence levels happened at each workstation of the manufacturing plant and are presented in Table provided below.

Whenever downtime cost is considered, the factory loses the desired profits when the factory is down, labor costs are paid, depreciation occurs and only direct materials are not consumed when the factory is down. Therefore the losses incurred whenever the plant is down are assumed to be

associated with these. The plant has a uniform yearly demand for products (The total downtime hours that resulted due to the lack of orders were zero) and there is 1 day (every Sunday) preventive maintenance schedule (therefore, the total downtime hours that resulted due to preventive maintenance should not be considered). The total hours used for the purpose of preventive maintenance can be calculated using equation below.

Preventive Mnt. Time = (Mnt. working hour/day)*(Mnt. working days required /year)……. (4.6)

=12 hrs/day*52 days/year*6

= 3,744 hours/ year

Hence, the downtime hours that resulted in the loss of company resource are:

- Total Downtime = ***25,185.6*** hrs – 3,7444hrs = ***21,441.6hrs***

During up times production, the net operating profit which was transferred to retained earnings of the year was 17,844,646.73 birr. The profit was gained from the products which were produced during the uptime (21,758.4hrs). Hence, the amount of lost profit resulted from plant downtimes other than preventive maintenance will be:

Amount Lost = total downtime / Total uptime * Profit……. (4.7)

= 21,441.6hrs * 17,844,646.73 /21,758.4

= 17,584,830.56 birr

The other costs spent when the plant was down are salary payments for direct, indirect labors and other overhead costs. However other supporting departments would not be idle when plant machineries were down. Activities such as customers handling, processing orders, product supplies and other office works will be done. Therefore assuming that plant downtime also affects the performance of the other support functions, a 10% loss is assumed to exist. Thus, the costs resulting from direct, indirect, and overhead are;

Total downtime cost = 17,584,830.56 birr + 2,808,202.04 birr = ***20,393,032.6birr***

Therefore, 6.25 % of the additional profit from the total sell could have been found in the year if zero breakdowns were recorded, and which means the total efficiency of system lose 6.25 % so as the productivity. If this is the case; what are the root causes of this breakdown and what should be done to minimize it? The following points discuss in detail.

4.5.6.3 Causes of Breakdowns/Downtimes

The above breakdown cost analysis shows that much work should be done on breakdown to minimize the cost associated with it so that the system will be efficient and productivity would be improved or increased. Breakdowns are the root for many associated problems, [Butterworth 1990] because when they occur, production stops, deliveries are delayed, and production defects are created and whenever a single breakdown happens, it can affect the whole production processes. That is why it is necessary to discuss in detail about their existence and identifying their root causes.

The data provided above is collected at the manufacturing of reinforcement bar site for the year 2009 E.c. at major sections with their relative number and percentage of production interruption, break downs, break down times, defects and associated problems investigated under both working shifts [day and night shift] by considering the following points;

- The data presented considers the basic work stations of the factory; the induction furnace, continuous casting machine [CCM], reheating furnace, roughing mill, rolling mill and the cutter work stations.
- A process under this research is the conversion of scrap metals to moulds and 1 mould into several pieces of reinforcement bars (12 meter length by 8-32mm cross sectional diameter.
- The production data provided below investigated under the factory`s working days [Monday to Saturday].
- Since the factory`s data management and manufacturing system is very poor the format and the organization of the data, for break downs and non conformity products/rework and scrap are prepared by the researcher.

As it can be seen from the table, an estimation of the total down time is recorded and summarized under each work stations with respect to the available up times, the required

maintenance types, and possible causes of breakdowns. This can help the company to give focus and deal with the associated problems that create the breakdowns so as it minimize the products from being rejected and move to scrap metal store thereby optimizing time and resources and minimizing cost and expenses.

4.5.6.4.Description and analysis of Breakdown/downtime causes

Based on the conducted interview, factory observation and survey, the major problems/reasons that are associated with the system breakdowns/ inefficiency of the production process and their number of occurrence at each work station can be summarized as follows;

1. Mechanical maintenance:
2. Electrical maintenance:
3. Power interruption
4. Input & raw materials problems
5. Spare part and accessory problems
6. Operator or man power problem
7. System Set up
8. Others

1. **Mechanical maintenance**: One of the major reasons that are responsible for the breakdown in the production process of reinforcement bars at Yesu metal manufacturing is failure of mechanical parts. These mechanical problems or failures are break down of production machines such as boilers, compressors and failures of mechanical parts such as bearings, piston-cylinder arrangements, wear of cutting [shear] blades, and roll alignment adjustment and Rpm[revolution per minute] compatibility etc problems are assigned under this category. Therefore the system used to stop for the maintenance of mechanical failures/problems.
2. **Electrical maintenance**: Failures of electrical components such as motors and electronic components such as breakers, encoders, switches, electrically operated buttons usually happen during the production. Therefore the system used to stop for the maintenance failures/problems changeover of electrical equipments.

3. **Power interruption: D**uring the production period, power interruption and fluctuation or electrical failures occur unexpectedly lead to the termination of the system PLC activity and at this stage product on process are automatically rejected. The system frequently used to stop because of this.
4. **Input an raw materials related problems:** These forms of problems stop the factory operation and those are mainly related to the input & auxiliary materials (which includes scrap metals, auxiliary inputs, fuel, water, different types of hydraulic and machinery lubrication oils and other problems related to input material)accessibility, supply fluctuation, shortage and handling &quality management. When they become out of inventory and a gap appears with order and supply lead times.
5. **Spare parts & accessory problems: t**he factory requires different types of consumable and non consumable material and component for smooth operation. Among these, there are many types /different mechanical and electrical machine element spare parts and components which are necessary to conduct maintenance operations so as the process to continue. These include bearings, gear, and electrical equipments.
6. **Man power & operator problems:** the rolling mill section of the plant constitutes series of automatically and manually operated machineries&equipmentsthat require direct operations/activities of skilled operatorsand therefore the plant operation could seize wheneverproblems that are related to errors, faults and mistake commuted by operators. As soon as the faults happen during one operation, machines will stop, equipments need change, and dies would be adjusted for the next operation which leads a significant production line to stop.Sometimes these could problems happen when operators absent, lacks motivation, and being inefficient.
7. **Over all system set up times:** the production process atfactory constitutes several set of subsequent operations and activities performed at a time that involve exchange of system setup changes, machineries &equipments reorganization,operating system change (activation of respective PLC programs), and testing of the new setup. Whenever a new product is going to being manufactured, these activities are always performed for each type of products. Therefore this makes the factor to stop from operating normally.
8. **Others**: These are general type of problem responsible for additional factory operation downtimes. These problems are observed by the researcher during the factory stay and they

are reflected through the lack of coordination among the production department and the other departments. Organizational structure, general management, organizational culture, employee motivation, integration, orders placement, problems related to storage space area management and many other may break the factory operations.

Table 5.9: Downtimes hours of major break down problems at each work station

No	*Causes of breakdowns*	*Down time at each work stations*						*Total*
		Furnace	*CCM*	*Reheating*	*Roughing*	*Rolling*	*Cutting*	
1	Mechanical Maintenance	370.2	226.7	687.6	1851.1	1586.7	423.1	5289.0
2	Electrical Maintenance	141.0	100.7	261.9	705.2	604.5	161.2	2014.8
3	Power Interruption	229.2	163.7	425.6	1145.9	982.2	261.9	3274.1
4	Input & raw materials problems	264.4	188.9	491.1	1322.2	1133.4	302.2	3777.8
5	Spare part and accessory problems	211.6	151.1	392.9	1057.8	906.7	241.8	3022.3
6	Operator and man power problem	317.3	264.4	589.3	1586.7	1360.0	362.7	4533.4
7	System set up times	88.1	63.0	163.7	440.7	377.8	100.7	1259.3
8	Others	52.9	37.8	98.2	264.4	226.7	60.4	755.6
	Total down time	1674.8	1,196.3	3110.4	8374.2	7177.9	1914.1	***25,185.6***

Downtime measures the number of hours the company has not been working. Smooth Machine operations can be monitored and damaged equipments can be signaled out through unusual vibrations, noises, heat, smoke and other signs/signals. Operators, technicians and workers could see this signs and respond accordingly. From the table it can be seen that, the major causes for the factory's downtime wereMechanical maintenance, Operator or man power problem, Input &raw materials problems and Power interruption. And Spare part and accessory problems. The figure below shows the main reasons for the downtime with their perspective/contribution percentage share of breakdown time hours.

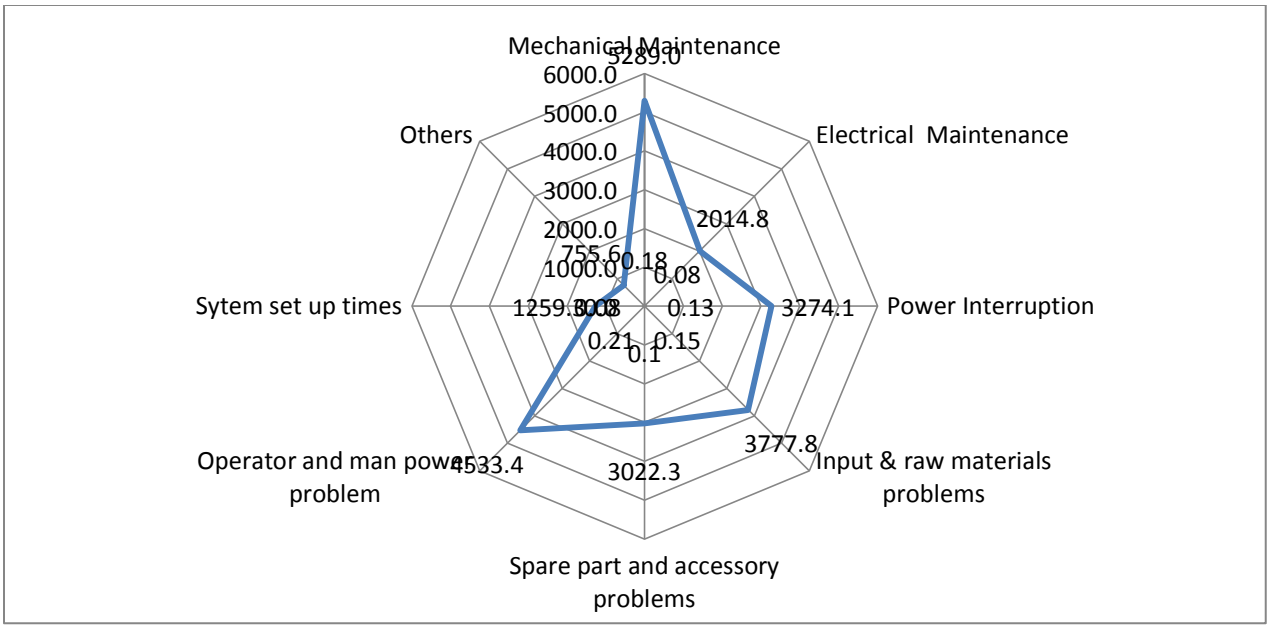

Figure 5.12: Major causes of factory break down

The figure shows the major reasons/problems for breakdown Mechanical maintenance, (21%), Operator or man power problem, (18%), Input & raw materials problems (15%), and Power interruption. (13 %) and the others constitute the rest. Since the above discussed problems are the major causes for the overall system inefficiency, the next part is going to discuss in detail their occurrence, frequencies, and their root causes. Thus it will analyze them in detail by using the two most common tools; Pareto and cause and effect analysis.

4.5.6.5.Pareto Analysis/ the 80/20 rule

Pareto Analysis can be applied to almost anything: [Theodore T. 2006]

- 80% of customer complaints arise from20% of your products or services.
- 20% of your product or services account for 80% of your profit.
- ***20% of a systems defects cause 80% of its problems.***

By using Pareto analysis, the major/the vital few problems that causes most of the effect on the system breakdown are identified and will be analyzed further by using cause and effect analysis to identify the root and the major causes of these problems so that they can ahead for solution making. Therefore, calculating for the sum of frequency of each workstation into one group is

done, based on the data provided at each workstation, so that their relative percentage occurrence to each other was obtained.

Table 5.10: Breakdown problems with their percentage frequency

No	*Problems*	*Frequency*	*Cumulative frequency*	*Percentage*	*Cumulative percentage*
1	Mechanical failure	892	892	44.2	44.2
2	Input & raw materials	367	1113	18.2	62.4
3	Electrical Power	221	1225	11.0	73.3
4	Spare part & accessory	112	1592	7.9	81.3
5	Operator or man power	160	1691	5.6	86.8
6	System	99	1851	5.2	92.0
7	Storage & material handling problems	62	1913	4.9	96.9
8	Others	105	2018	3.1	100.00

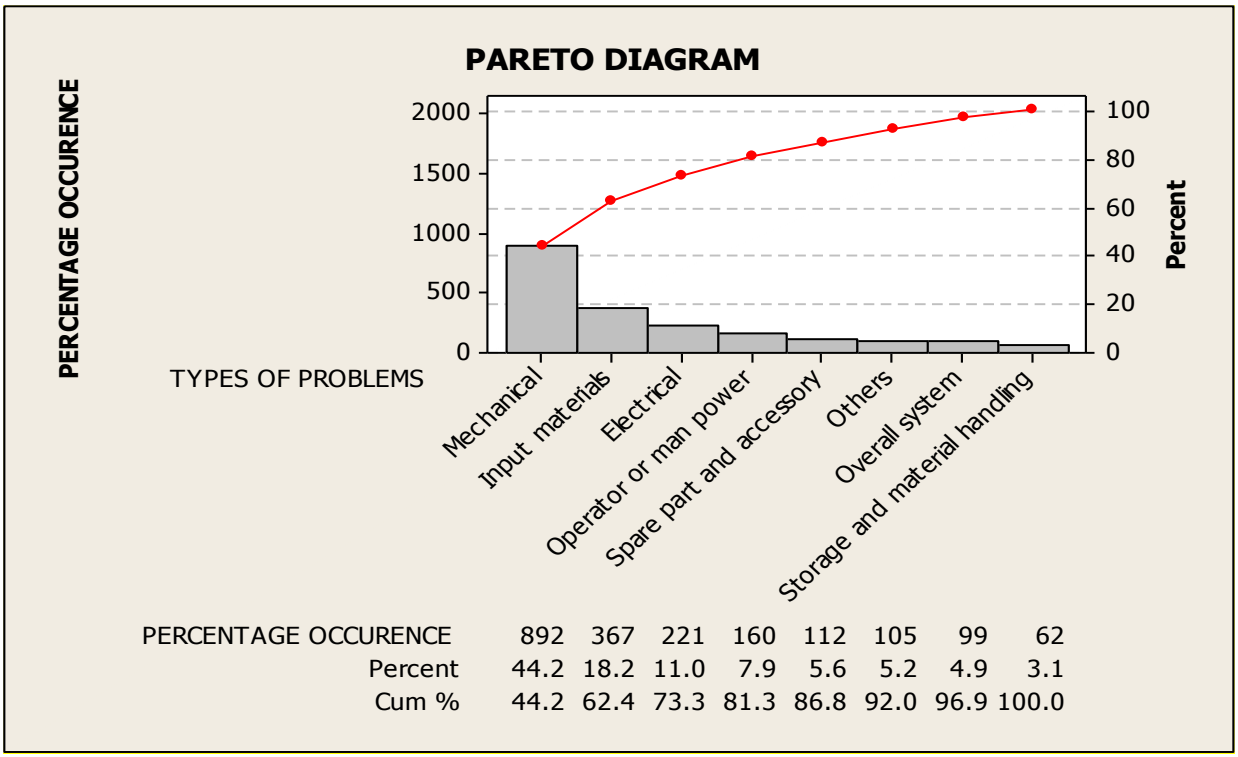

Figure5.13: Pareto graph for the major reasons of break downs

From the above Pareto graph it can be concluded that the mechanical problems constitute about 45% of the overall problem and together with problems that are related to input materials they constitute more than 60 % of the overall problems that happened and were responsible for the overall system breakdown and inefficiency. So analyzing and solving one or two of these major problems responsible for the system efficiency and productivity.

4.5.6.6.Cause and Effect analysis

Cause and effect analysis is an effective tool to see the relationship between factors to study [Theodore T. 2006]used in manufacturing includes Equipment, Process, People, Materials, Environment, and Management. Therefore; the figure 5.14 shows how the inputs/capital input factors such as labour skill, motivation, materials, machines &equipments spare parts, organizational system setups, and so many other factors are responsible for productivity issues or respective low productivity problems.

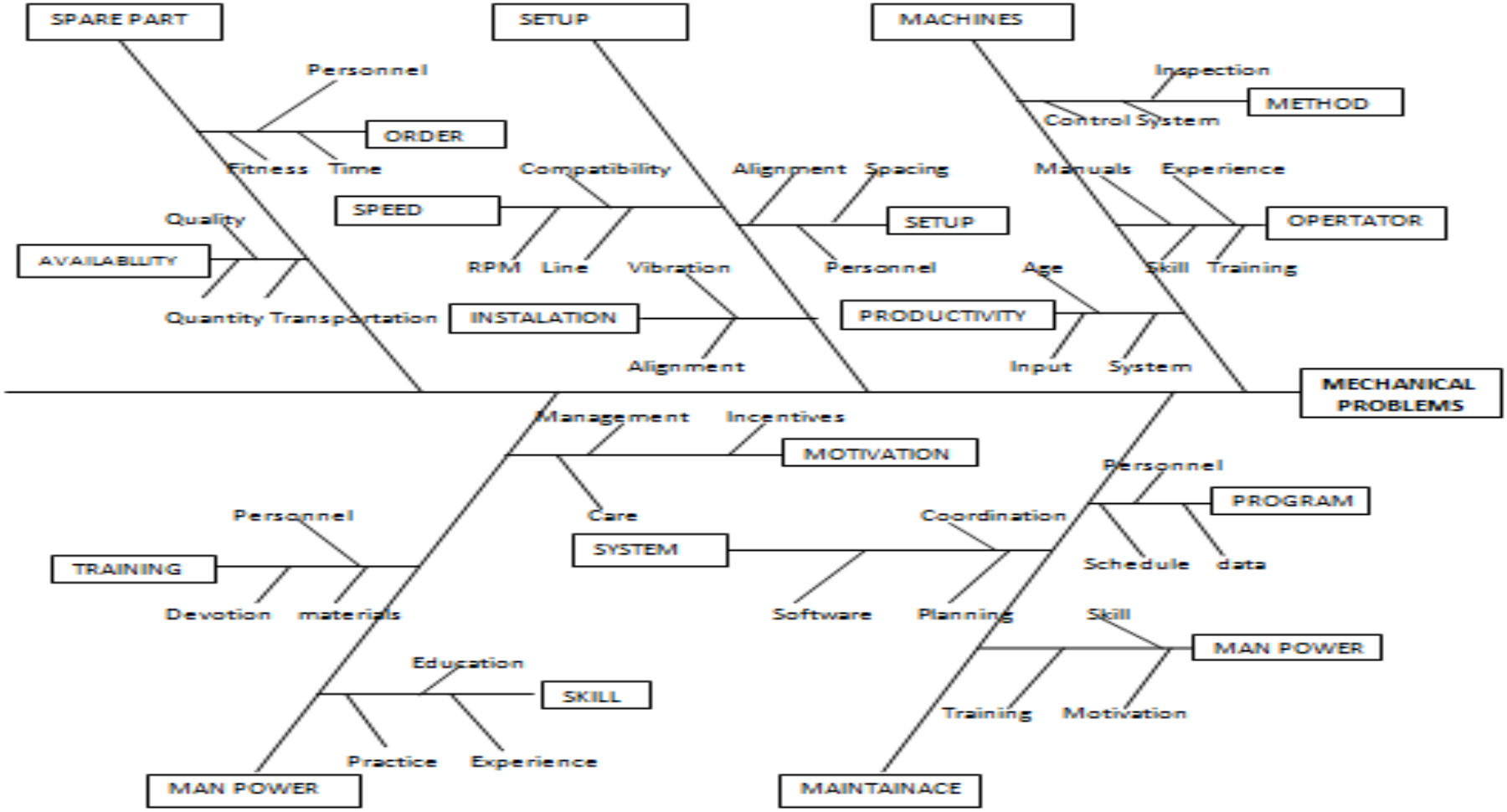

Figure 5.14:Cause and effect diagram for mechanical maintenance

5.7. Summary of the findings

From the above analysis it can be seen that productivity (understanding, measurement, analysis & improvement) level/practiceof the Ethiopian metal industries is at minimal level due problems both internal/firm level and external factors (based on the survey result). Generally problems associated with low productivity of the industries are mainly skilled man power, high production cost, low quality level of products, technology& machineries and equipment. These external problems need an integrated approach & participation of different stakeholder's as government, educational institutes, associations and different organizations involvement.

However, based on the case company analysis, the firm has a decreasing productivity feature during the past years due to several problems. The organizational low productivity related problems arise from the behavior of the metal manufacturing process where the metal manufacturing operation by itself constitutes a multi stage processes, operations, modern technologies, high level of employee skill in which the system requires an approach how activities/ processes should be linked to obtain the desired output and make the system efficient and productive. However from the analysis, it can be summarized that, the production environment consists of old methods/systems, low level of employee skill & motivation, that create inconsistencies including high level of scraps & reworks, high amount of machine breakdowns/high downtime cost and events resulting in disruption of production system &equipments.

Therefore; the inputs/capital input factors such as labour skill, motivation, materials, machines &equipments spare parts, organizational system setups, and so many other factors are responsible for respective low productivity problems.

The focus should therefore be to the firm level problems because these problems can be solved by the firm using its own potentials, resources and appropriate methods to improve the organizational as well as the country's industries productivity.

CHAPTERSIX

6. SOLUTION PROPOSAL

6.1. Selection and proposal of productivity improvement method

This chapter presents the basic means of productivity improvement and the development of a knowledge transfer framework and implementation guideline for the Ethiopian metal industries. The development of this model/ frame work is based on the literature review, the survey questionnaire findings of the Ethiopian metal industries &the case company analysis.

Before selecting a particular productivity improvement or management tool/framework or approach, it needs to be clear in what, why and how it is trying to achieve and this will involve raising several related questions, such as;[Joseph P.1999]

- What is aiming to change, improve and what outcome to look for?
- What are the key driver for change; review, change of staff , system, setup etc
- What is the timescale for the change and what resources are required/ available?
- Does the improvement be holistic on organizational activities or designed for a specific task/activity?
- What is the level organizational staff involvement?

As it is conducted in the previous chapters, a research is to be undertaken to decide on the approach or balance of approaches that would best suit situations, environments organization, sub-sectors and sectors. It is unlikely that a single approach would address all the associated problems and it does not aim at providing definite information on each approach however it is about to choose the best to address the strategic objectives and the vital/main problems that are responsible for low productivity in this context.

The following framework is drawn mainly from the metal manufacturing industriesgap, experiences, failures and problems found from the questionnaire, critical observation and interviews. The framework can assist its users in evaluating the strengths and weaknesses on their productivity system, targeting their improvement areas, setting up an action plan for improvements, and tailoring a special part to the needs of their firm.

Productivity improvement is not just doing things better; it is doing the right thing better [Joseph P.1999]. Productivity can be improved by utilizing the resources effectively. Thus the resources can be grouped in to human and capital resources. The following points will briefly discus each elements of the framework.

1. Identifying the Objectives

To start any productivity improvement program, management has to identify the area where improvement is necessary and achievable. And it has to identify the specific elements of productivity that are critical to the enterprise's success such as labour, technology, quality and capital investment etc.

2. Setting a Productivity Improvementprogram

The structure of the organization must be carefully examined in order to identify the changes to be aimed at the productivity improvement program. In spite of the difference in enterprises goal and approach, the following checklist for establishing a productivity improvement program is suggested: [Amanda W. 2006]

- Top management has a key role in determining the need for a maintenance program and initiating, developing and adopting of a productivity improvement policy.
- A team which includes all parties concerned or outside consultant has to be formed.
- A small unit can be established to carry on a productivity program
- Educating management and supervisors in productivity improvement is crucial.
- Personnel at any level should be involved through group meeting and informal discussion at the plant, departmental or office level.
- The program should provide for a periodic review and evaluation of results. This requires the establishment of measurement and goal for each organizational unit.
- It is vital to raise the awareness level within the organization of the entire factor that will influence the productivity and of the system for improving it.

3. Organizational awareness

People/employee is the key factors to bring in any change. Generally, organizations that commit to productivity improvement rely heavily on its most valuable resources i.e., employee. It must have good people execute the improvement framework that has been laid down. Awareness, participation, recognition and encouragement are the key factors in keeping people involved and participate in team member and assign responsibilities and accountabilities.

4. Productivity improvement team setup

The productivity improvement is made through the use of a team by participating individuals and employees. Without their participation, the development of a flexible and effective improvement will not be fully functional. Therefore, development of the team consists members of the top management, workers composed of multi-departmental members by selecting a productivity improvement professional leader. This implementation task force has to be empowered to all accesses of the organization.

5. Establishing Productivity Measuring and analysis System

One of the most important steps in productivity improvement is establishing a productivity measurement system within the organization. This in itself brings some improvement in productivity by making people more aware of the meaning of productivity. The measurement system must consider cost effectiveness, and determine the range and terms of measurement system tasks. It must be easy to use and serve to identify the reasons to organizational changes.

6. Selecting a productivity improvement tool

Productivity is an integration of all resource involved, whatever the technique used depending on each organizational context, as in a case of our metal industries, the key success factors for a process improvement program are continuous improvement, commitment from top management, and a sustainable improvement organization. As it is described in the previous chapters productivity improvement can be functional though different contextual activities. However,

based on the previous analysis, for the case of the Ethiopian metal industries productivity improvement through human resource development is going to be established on this research.

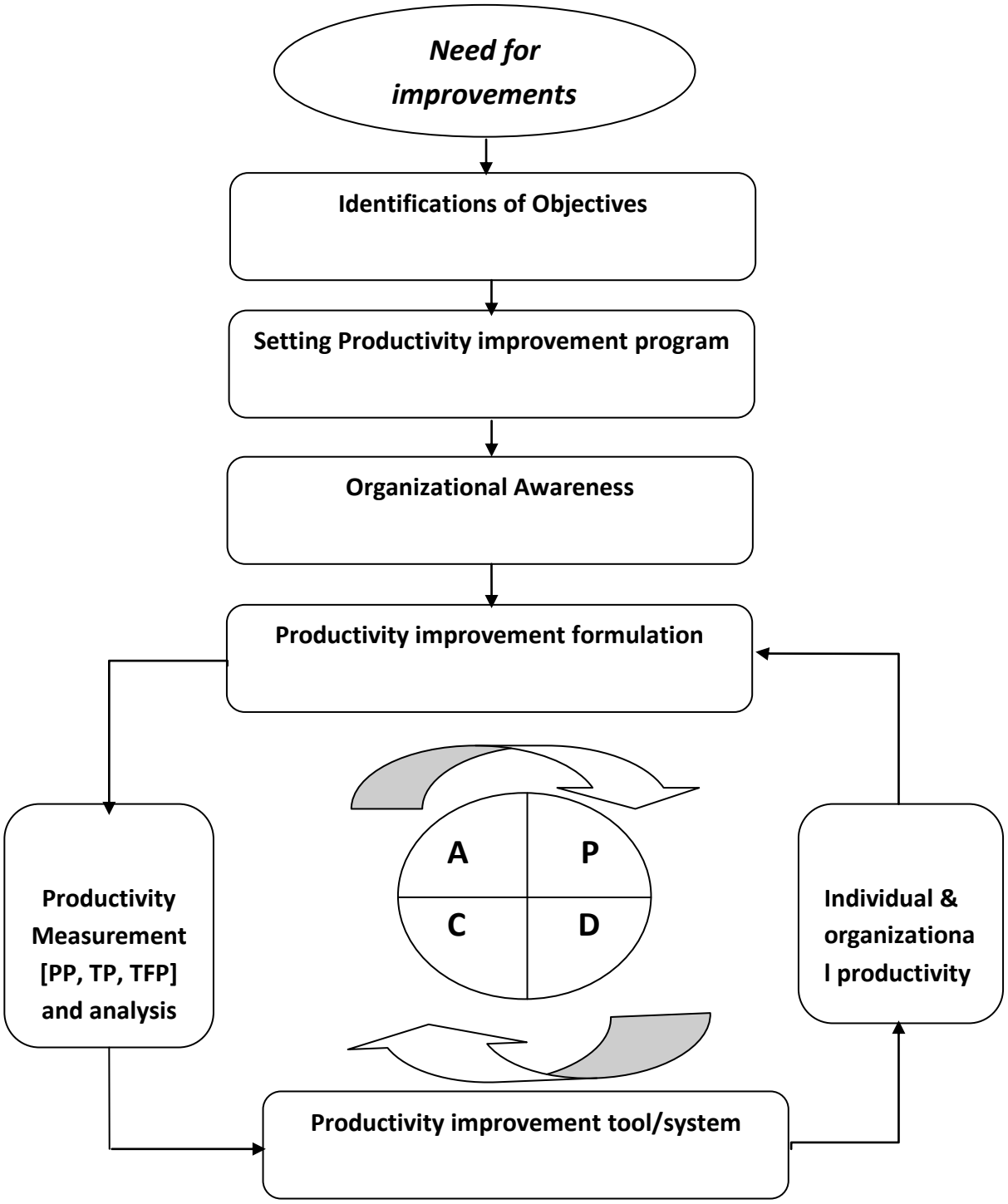

Figure6.1: proposed productivity improvement implementation system for Ethiopian metal industry [modified & drawn based on the concept from Amanda W. 2006]

6.2. Productivity Improvement through Human Resources development

The productivity issue of resource utilization includes another significant concern in today's world of strong social values- the way people are treated as human resources in the workplace. Human resource is the most important and potential area of productivity improvement [Pradeep.P and Sunitha B 2009].Ideally, productivity is achieved through high performance with a sense of satisfaction by the people doing the work. The term quality of work life is an indicator of the overall quality of human experiences in the work place. Managers are increasingly expected to facilitate productivity for the organization while maintaining the quality of work life for its members. The main management responsibilities in a productivity drive are to identify the objectives, to setup a productivity improvement program and to establish a productivity measurement system

6.2.1. Education and training

The education and training are the basic for enhancement tools for employee productivity. Therefore the government should continue to provide practical & theoretical trainings by integrating the respective organizations such as the federal TVET's, MIDI, KAIZEN institute and other organizations. The training program could be given from level I-V, certificate, short term skill development training based on the need of the customers metal industries to improve the productivity of labour. Meanwhile, the firm plants shall also provide practical training and education for internship trainees and students.

6.2.2. Capacity building

Capacity building & technical development services shall be provided to improve the laborproductivity of the sub sector. Skills associated with CAD/CAM, designs, prototype development, and incubation centers shall be included.Organizations like MIDI should provideproduct development service of by which value adding on semi-finished products would enables the metal industries to be competitive in the international market. Benchmarking and twinning programs should be activated sincebenchmarking implementation is the key for technology transfer& provide qualified staffs. Coordinated activities of stakeholders are important for the successful capacity building service to the metal industries.

6.2.3. Knowledge transfer

Technical knowledge applications, particularly for metal manufacturing technologies, have changed greatly in the last few yearsand they expected to change rapidity. Because of varying behavior of the sector towardsnew technology, new materials, old machines, old methods, outdated systems, high level of competition and variable demand are being replaced. As it has been discussed in the previous chapters, in the context of the Ethiopian metal & engineering industries where almost all technologies are being imported, there is no doubt there should be some means of transferring the technologies and knowledge.

6.2.4. Analytical knowledge gaps Analysis Framework

While analyzing knowledge gaps associated with productivity performance of the Ethiopian metal industries, elements associated with companywide activities that are basically starting from inputs, process activities and output must be considered; inputs, such as the labor and raw materials, technologies, Process factors and output factors such as markets and overall productivity measurement are considered.

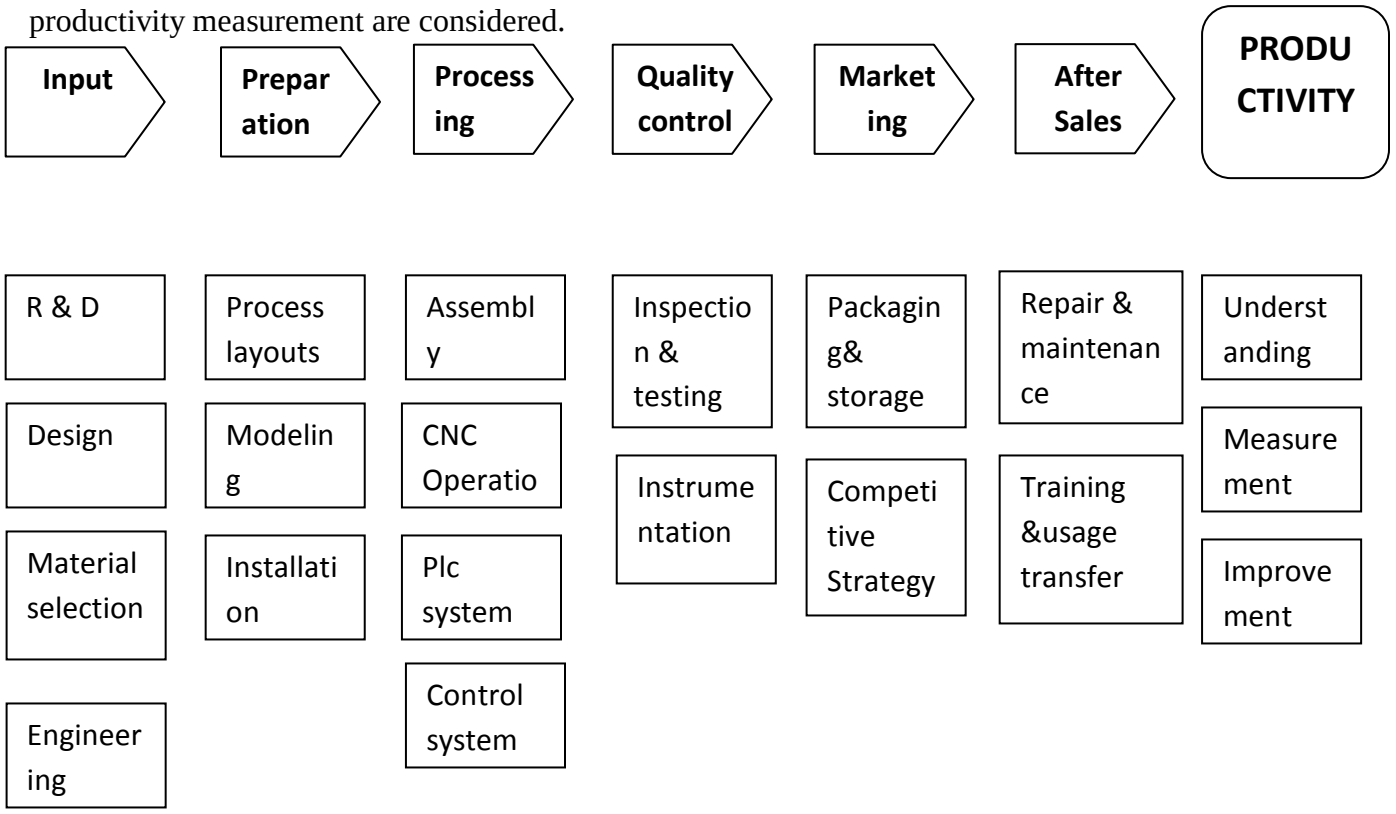

Figure 6.2: Analytical knowledge gap analysis frame work

6.2.5. Knowledge transfer framework[adapted from Robert .P. Alaska University 2012]

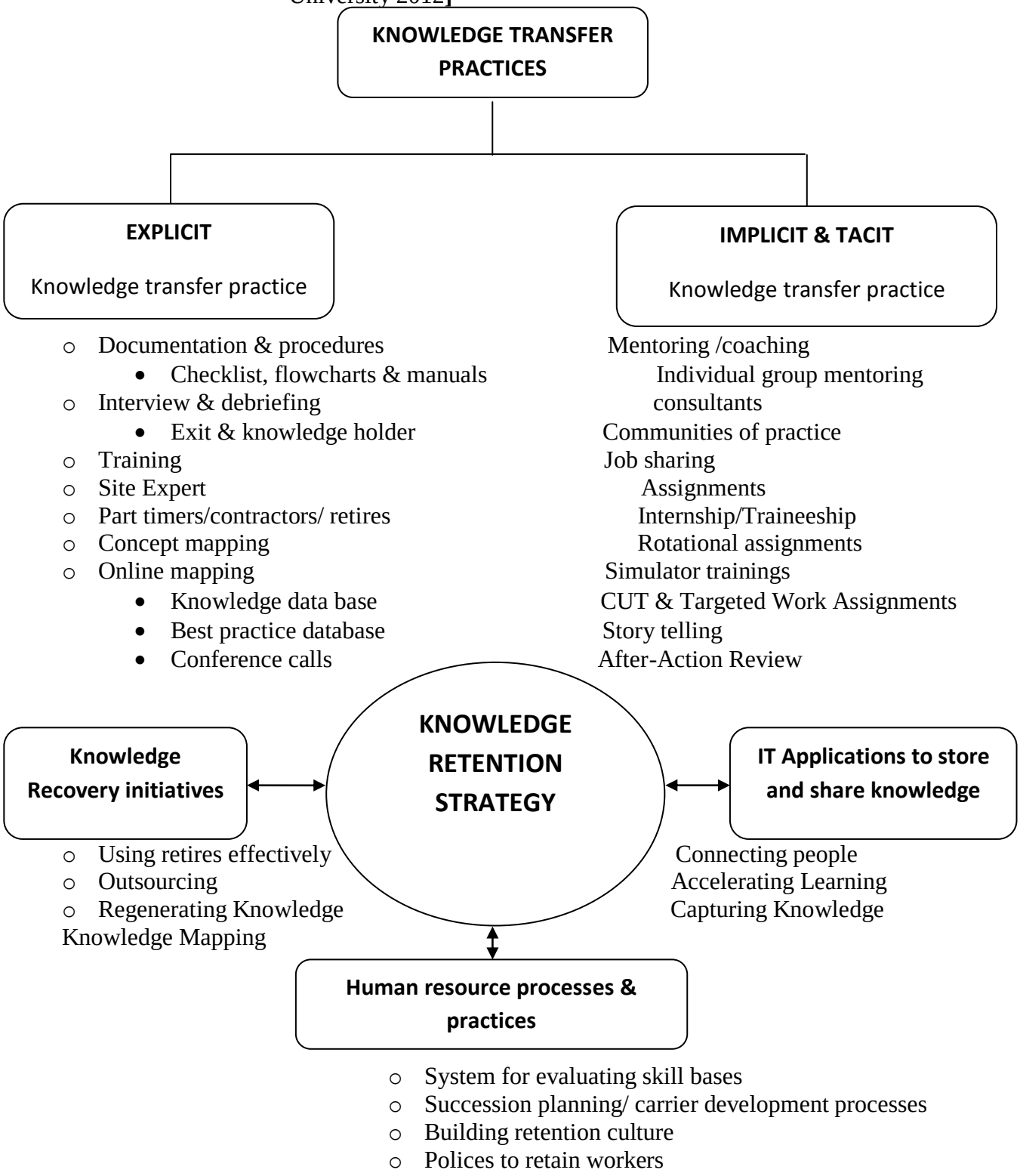

Figure6.3: Knowledge transfer framework

6.2.6. Development of knowledge transfer implementation guideline

This section describes how to start the knowledge transfer scheme and bring it to a state where the process of continuous improvement is institutionalized in the metal factory. Primarily the implementation of framework to any organization requires organization wide commitment andinvestment. Since organizations differ in their orientation, the application of one system may not generally provide the expected results of the cultural change to others however, the following general steps (based on the concept of knowledge transfer) could be applied to the metal industries.

A knowledge transfer plan allows managers & employee to target the knowledge and expertise that should be shared with the staff. It also allows mangers to evaluate how critical a task is to the mission of the organization. In addition, having an employee complete a knowledge transfer tool provides a positive framework for employee to look back over their career and document their accomplishments and worth to the organization. It also provides a mechanism for the employee to give honest feedback on the necessity of actual tasks and activities.

Metal industries therefore shall adapt and use the following information and tools necessary within their organizations. Itis provided to be a starting point for sharing knowledge and experience, allowing organization to continue providing quality products &services.There are three simple steps to complete the worksheet/guideline.

1. Identify critical tasks and activities.
2. Define each task and activity.
3. Develop a knowledge transfer plan

STEP 1: Identify critical tasks and activities

There are probably some aspects own to the organization itself, in this step developing a list of those tasks and activities. It is necessary to go into detail and the questions below can be raised to discuss tasks and activities;

- What are the specific tasks/activities in the organization to be transferred?
- Who is responsible for to do those tasks/activities?

- Which tasks/activity should be given focus?
- Which tasks/activity isn't done on plan?
- What is the associated knowledge shared across the tasks/activities?
- Who is to be responsible/ rely to receive the knowledge?

STEP 2: Define each task and activity

Tasks/activities will be identified in more detail based on the essence of the knowledge and experience required to complete each task or activity therefore defining/focus the particular task/activity to be transferred in more detail, the information, the knowledge and experience needed to have in order to carry out this responsibility or task. The following main points should be considered for proceeding;

- Knowing key contacts (customers, universities, other organizations, contacts, federal government contacts, people request through the process, business contacts, etc.)
- Having strong relationships with key customers or coworkers
- Knowing logistics or locations (training rooms, field offices, etc.)
- Knowing past history (gaps, customer requests, business decisions, etc.)
- Knowing locations of critical files or information
- Knowing how to carry out a task or responsibility

Go through the steps necessary to complete the task and work to uncover the parts that are critical to the organizational success & customer satisfaction through the knowledge transferred.

STEP 3: Developing a knowledge transfer plan

Start by inserting all the critical tasks and activities identified in Step 1. Answer the questions for each area. Use the details developed in Step 2 to help you think about the questions.Complete the matrix with your based on the importance and impact of the tasks on the organization, the current importance, and availability. For the tasks identified as critical, it is essential to develop a strategy to address the work as it is critical for the organization.

KNOWLEDGE TRANSFER TEMPLATE[N.Y University 2014]

Employee Name			
Supervisor Name			
Job Title			
End Date			

1. Attach a Project/Active Work Status Report, outlining all projects, ongoing tasks, tips and other open items on which you are currently working.
2. Are there key people (internal/external contacts) other than those identified in the Project/Active Work Status Report to whom we should be introduced before you leave the organization? If yes, please list and indicate when we might plan for such introductions.
3. Do Standard Operating Procedures exist for your role? If yes, are they up to date, and please provide the location and last date of revision.
4. Identify any internal units/groups or external agencies and regulatory groups (i.e. state, federal) with whom it is necessary for us to interact in order to fulfill the duties of your position.
5. Are there specific files/records related to your current or past projects that should be retained over a defined period of time? If yes, please list, identify the location of each, and include the retention period.
6. List important historical/reference documents, if any, in your possession.
7. Reminders: Discussion Points Confidentiality obligations, Proprietary information & Intellectual property, Guidelines regarding Public Disclosures &Other
8. What equipment was assigned to you for your use? Where is the equipment?
9. We may contact you if we have additional questions. Please provide a contact number should we need to reach you.
10. Is there other information not requested on this form that you feel it would be helpful for us to know? If yes, please provide.

Project/Active Work Status Report

Project	Client contact Information	Key Contacts with Knowledge of Project	Status of Project	Timeline for Delivery	Special Concerns	Location of Working Files	Comments

CHAPTER SEVEN

7. CONCLUSION AND RECOMMENDATIONS

7.1.Conclusion

Although productivity and productivity measurement are the common practice for firms, the research asserted that implementation of measurement and analysis of productivity system calls for companies' is carried out employing process approach where a process has got input and output values and productivity is the ratio of output to input considering the manufacturing firms perspectives of a composite of interrelated are value adding sub processes. Where the higher productivity is approached based on high amount of output.

In this research, any investigation has been conducted on the Ethiopian metal manufacturing industries and it can be concluded that firms has a misconception about what productivity is and how it is measured. The metal manufacturing firms are functioning at lower productivity due to many associated, problems. Although the crucial problems may not be associated with direct firm's production (inherent to the system), they could also be problems which are related to such as supply, and marketing activities that means problems could arise external to the firms in the sub sector.

The sub sector has faced several internal problems for low productivity Capital related problems, Machineries and equipment related problems, planning and management problems, Process related problems, Skill and labor related problems, Technology and innovation related problems and Energy related problems and Quality & high production cost related problems**.**

However, based on the case company analysis, the firm /organizational productivity related problems arise from behavior of the manufacturing process where the manufacturing operation by itself constitutes a multi stage processes, operations, modern technologies, high and level of employee in order where the system requires an approach how activities/ processes should be linked to obtain the desired output and make the system efficient and productive. The production environment consists of old methods and systems that create inconsistencies including machine breakdowns and events resulting in disruption of equipments.

- The firm shows a decrease in partial and total productivity index valuesthat are calculated with relative to the base year.
- The firm spends an annual cost of 6.447 million for (23%) rework and (3%) due to scrap rate of products
- The firm loses 20,393,032.6birrannually due to the breakdown of its manufacturing process
- Problems such as Mechanical maintenance, Electrical maintenance, Power interruption, Input & raw materials problems, Spare part and accessory problems, Operator or man power problem are the main causes for breakdown.
- Low level of employee skill and lack of knowledge transfer activities has hindered the productive level of the firm as well as the sub sector.

The intervention areas identified in one or another way reveal that they are problems for low level of productivity output/performance these problems can be addressed based on the proposed productivity improvement method in a continual manner. While technical and engineering skill gaps for employees, technicians and operators are going to be addressed based on the suggested knowledge transfer framework with the assit of the transfer guidelines and controlling templates.

7.2. Recommendations

From the research finding results in Ethiopian metal manufacturing, the following points are worth important to be recommended for the firms;

1. Productivity is the basic for the firm's survival and competitiveness capability at local & global stage, therefore, companies should be able to manage and utilize efficiently their resources in order to have a productive manufacturing system and ensure that to keep its sustainability growth.
2. The firms should have a clear definition, measurement, modeling, analysis and improvement of productivity and productivity practice since the concept of productivity is applicable at different level and its use and selection approach and model is difficult. Therefore, companies need to first define the level at which productivity measurement, analysisand improvement is going to be undertaken.

3. Since organizational productivity is achieved with harmonization the parties/individuals involved in the system, productivity should be understood as a task of everyone. However the role of management in productivity growth is vital or largely depends on their need and commitment of towards their way of productivity conception, measurement, analysis and improvement strategies and techniques.
4. Since most of the metal industries are imported from global market as well as the metal & engineering require high level of technical & engineering knowledge/skill, the researcher recommended that the Ethiopian metal manufacturing firms should effectively use the knowledge/transfer framework to develop their employee's skills and knowledge, from the technology providers.
5. Finally, the government should continues its support for the sector by comprising different stake holder & organizations on the areas capacity building, technical support, research & development, product development, infrastructure & facilitation support, investment incentives and capital funding in order to alleviate the problems responsible for low productivity which hindered the growth & competitiveness level of the firms at local & global market

Regarding the case company [Yesu metal manufacturing], the following points are recommended based on the major findings;

1. The company should understand productivity and being profitable are two deferent concepts
2. It should practice periodic and continual productivity measurement & analysis systems
3. Since the production system in the company comprises different sub processes, the company should integrate these activities in order to have a better output.
4. Since there is high level of scarp & rework level in the production process which consumes the capital resource inputs, the company should practice quality management system
5. The company should minimize the total down time by taking major actions to minimize the problems associated with high don time since they are responsible for high amount of high down time cost which directly affects the productivity level of the company.
6. Finally, since the firm employs several foreign workers, it should transfer the knowledge to the local workers in order to minimize the total cost of production and increase local labour productivity.

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APPENDICES
Appendix I

Research Questionnaire

ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY (AAiT)

MECHANICAL ENGINEERING DEPARTMENT

GRADUATE PROGRAM IN INDUSTRIAL ENGINEERING

Questionnaire for the PRODUCTIVITY ANALYSIS AND IMPROVEMENT IN ETHIOPIAN METAL MANUFACTURING INDUSTRIES

Prepared by: TadiyosDerbe Mobile: +251-961088074 E-mail: tadu25der@gmail.com

Advisor: Dr.YitagesuYilma Phone: 0111232439 Fax: 0111239480

At present I am conducting a research in the Ethiopian metal manufacturing companies, at Addis Ababa University Institute of technology, department of Mechanical Engineering towards Masters in Industrial Engineering. The title of the study is **"*PRODUCTIVITY ANALYSIS AND IMPROVEMENT IN ETHIOPIAN METAL MANUFACTURING INDUSTRIES*".*The main objective of the questionnaire***isto assess the current productivity status and the key factors or problems that affect productivity of Ethiopian metal manufacturing firms.

I would like to appreciate and express my gratitude if you complete the attached questionnaire or direct it to the person in charge. Moreover, *your response isvery crucial to the success of the survey*. All information will be treated in the highest confidentialand the respondent's name (optional information) will not be revealed. For further information you can contact me through the above mentioned address.

Thank you for your committed cooperation, time and consideration!!!

April 2018

Section I: Preliminary Information

Respondent Profile

2. Current position in the company:_____
3. Qualification level: ☐ College diploma ☐ BA/BSc ☐ MA/MSc & Above
4. Company Work experience in this:_____

Company Information

5. Name of your company_____
6. Year of establishment _____
7. Owner ship ☐ Public ☐ Private
8. Type of Business Domes☐ Foreig☐ Joint ven☐
9. Main products of the company_____
10. Capital (Birr)_____
11. Number of employees currently working in the firm: permanent _____ contract_____
12. Contact Person Tel._____ Email_____

Section II: Understanding and Interpretations of Productivity in the Firm

13. Select and circle (more than one is possible) among the following in which your company interpret good productivity? It is in terms of.....
    a) High production volume b)Capacity utilization c) high sale
    d) high profit e) Low rework/ scrap f)good quality g) fast delivery time h) Customer satisfaction i)Specify if any.....
14. At what Productivity level (in terms of *capacity utilization, production etc*) is your company compared to other Metal manufacturing factories?
    a) Low Productive b) Average Productive c) high Productive
15. Rate how the following issues drive Productivity in your company: [**1= low/slightly; 2=medium; 3=highly**] [Please, put an **Xmark** on the number that applies]

No.	***Productivity Drivers***	***1***	***2***	***3***
15.1.	Management intervention			

15.2.	Investment in machinery and equipment			
15.3.	Education and training of employees			
15.4.	Proper utilization of raw materials			
15.5.	Technology, Innovation and Research & Development			
15.6.	Government spending (initiative, policy, strategy...)			

16. Which of the following ***Major Metal manufacturing sub processes*** faced frequently with problems which in turn affect the Productivity of your company?

Rate their **impact [*1 = medium; 2 = high; 3 = Critical*]**

No	***Manufacturing processes***	***1***	***2***	***3***
16.1.	Supplies and procurement process			
16.2.	Research and development process			
16.3.	Production planning and control			
16.4.	Metal manufacturing process			
16.5.	Sales and marketing process			

***Section III*: Factors Affecting the Productivity of the Company**

17. How do you rate the effect of the following factors on the Productivity of your company [Please, put X mark on the number that applies]

Rating scale: **[Low Effect=1 Medium Effect=2 High Effect=3]**

No	***Factors affecting Productivity***	***1***	***2***	***3***
17.1.	Input Materials utilization *(raw materials & accessories - availability, quality, timeliness, import substitutes etc)*			
17.2.	Machineries &equipments*(relevance, quantity, accuracy, speed, maintainability, age, etc)*			
17.3.	Investment capital			
17.4.	Technology *(innovation, research & development, automation, information technology, etc)*			
17.5.	Human resource *(Labor force -availability, management, etc)*			

	mix, knowledge, skill, attitude,			
17.6.	Management *(plans & schedules, instructions, ability to adjust staff size & duties, coordination & balancing of material flow, supervision etc)*			
17.7.	Organizational structure and culture			
17.8.	Physical environment or working condition			
17.9.	Infrastructures *(transport facilities, means of communication etc)*			
17.10.	Energy			
17.11.	Marketing conditions			
17.12.	Lack of coordination in the supply chain			
17.13.	Government regulations , policy and strategy			
17.14.	Demographic & social impact			

18. Rate the **impact** of the following ***major reasons not to work at high Productivity*** in Ethiopian Metal Manufacturing Industries.

[***1 = medium; 2 = high; 3 = Critical***]

No	***Reasons to do not work at high Productivity***	***1***	***2***	***3***
18.1.	Input related problems			
18.2.	Capital related problems			
18.3.	Machineries and equipment related problems			
18.4.	Planning and management problems			
18.5.	Process related problems			
18.6.	Skill and labor related problems			
18.7.	Technology and innovation related problems			
18.8.	Quality and higher production cost related problems			
18.9.	Others (Please specify)_____			

Section IV*: *Productivity Measurement, Problems and Improvement Practices

[Please circle the appropriate response/s]

19. How would you describe your organization's interest approach to measure Productivity?[consider the last five years]

a) Falling interestb) unchanged interest c) interested d) increasing interest e) high interest

20. What is your assessment of value of Productivity measurement to the organization?

a) Waste of time b) Limited value c) Effective d) high value e) strategic output

21. Does your organization use Productivity measurement to identify areas that require strategic focus?

a) Never b) Rarely c) Sometimes d) Frequently e) always

22. How often does your company conduct Productivity measurement?

a) Never b) Rarely c) Sometimes d) Frequently e) always

23. What kind of Productivity measurement do you use for strategic decision making? Please specify if any

a) Total productivity b) partial productivity c) total factor productivity d) If other please specify …….

24. How often do you prepare your formal Productivity measurement reports?

a) Monthly b) Quarterly c) twice a year d) annually e) If other please specify.....

25. What kind of Productivity measurement do you use for strategic decision making? Please specify if any

_____

26. How did your company get conducting Productivity measurement?

a) Very Easy b) Easy c) normal activity d) difficult e) extremely difficult

27. What is/are the challenges that your company faced while conducting productivity measurement?

a) Data b) cost c) skill d) time e) management concern

28. Please indicate [with an X mark] the **general trend** of productivity in your enterprise. [consider the past 5 years]

No	*Productivity areas/types*	*Decreasing*	*Constant*	*Increasing*	*Seasonal*
28.1.	Labour/Employee Productivity				
28.2.	Financial Productivity				
28.3.	Machinery Productivity				
28.4.	Production/ manufacturing system Productivity				
28.5.	Total productivity				
28.6.	Customer satisfaction				
28.7.	Product quality				
28.8.	Supply productivity				
28.9.	Other.....				

29. Based on the Productivity measurement report please indicate the following information [consider the last five years]

No	*Productivity Item*	*Unit*	*2005 E.C*	*2006 E.C*	*2007 E.C*	*2008 E.C*	*2009 E.C*
29.1.	Production capacity	Ton					
29.2.	Production volume	Ton					
29.3.	Capacity utilization	%					
29.4.	Level of scraps and rejects	%					
29.5.	Unfinished production order due to lack of material	%					
29.6.	Production cost	Birr					

29.7.	Sales volume	Ton					
29.8.	Sales value	Birr					
29.9.	Market share (local/foreign)	%					
29.10.	Export volume	Ton					
29.11.	Export value	Birr					
29.12.	Operating profit / profit margin	Birr					
29.13.	New product models introduced	Qty`					

30. Have you introduced any method (model) or Productivity improvement program to ***measure &improve****Productivity* ***within*** [put ***X*** mark][consider the 3 years]

No.	***Productivity types***	***Yes***	***No***	***If your answer is "Yes" please specify***
30.1.	Labour/Employee Productivity			
30.2.	Financial Productivity			
30.3.	Machinery Productivity			
30.4.	Production/ manufacturing system Productivity			
30.5.	Total productivity			
30.6.	Customer satisfaction			
30.7.	Product quality			
30.8.	Supply productivity			

If your answers are 'No', please indicate the reason(s)

---

31. Does your company have a well organized<u>research and development (R & D)</u> department to find and introduce innovative methods and technologies that can improve Productivity?

☐ Yes ☐ on the way ☐ No

32. Does the company identify problems of Productivity improvement?

☐ Yes ☐ No if your answer is yes, please list them;

_____

_____

_____

33. Does the company have ***training program*** to improve productivity? ☐ Yes ☐ No

If the answer is yes, provide the number of employees involved in training per annum and list type of training_____

34. Does the organizational structure create suitable working environment?

☐ Yes ☐ if your answer is "yes", please list them

_____

_____

_____

35. What are the reasons to Ethiopian Metal manufacturing industries for not being fully operational or work at full capacity? (You can circle more than one).

a) Raw material shortage b) Shortage of spare parts c) Frequent machinery breakage
d)Lack of market d) Working capital shortage e) Management problem
g) Lack of skilled man power h) other please specify

_____

_____

36. Rate the **impact** of following possible reasons to Ethiopian Metal factories to **have highmanufacturing cost**compared to the standard. [***1 = medium; 2 = high; 3 = Critical***]

No	*Reasons to high manufacturing cost*	*1*	*2*	*3*
36.1.	High cost of raw material			
36.2.	High cost of spare part and accessories			
36.3.	High rework and scrap			
36.4.	High cost of trainings			
36.5.	High cost of wages and salaries			
36.6.	High cost of investment			
36.7.	Other (please specify).....			

36. Rate the **impact** of following possible reasons to Ethiopian metal factories to produce **low quality products** which cannot be competitive globally. [***1 = medium; 2 = high; 3 = Critical***]

No	*Reasons to low quality*	*1*	*2*	*3*
36.1.	Lack of skilled labor/expert			
36.2.	Lack of quality raw material			
36.3.	Lack of efficient machines &equipments			
36.4.	Lack of technology (IT, R&D, automation, innovation)			
36.5.	Lack of investment capital			

37. In your opinion, what can be done by the following stakeholders to enhance Productivity of Metal manufacturing companies' in Ethiopia?

a) Government

_____

_____

_____

b) Manufacturing firms

_____

_____

_____

c) Academic/ research institutes

_____

_____

_____

d) Associations/trade unions

_____

_____

_____

e) Any other agency (please specify)

_____

_____

_____

THANK YOU FOR YOUR COOPERATION AND VALUABLE TIME!

Appendix II

INTERVIEW QUESTIONS

ADDIS ABABA UNIVERSITY, INSTITUTE OF TECHNOLOGY SCHOOL OF MECHANICAL & INDUSTRIAL ENGINEERING GRADUATE PROGRAM IN INDUSTRIAL ENGINEERING

Thesis Title: **PRODUCTIVITY ANALYSIS AND IMPROVEMENT IN ETHIOPIAN METAL MANUFACTURING INDUSTRIES**

Prepared by: TADIYOS DERBE [TEL- 0961088074, E-mail: tadu25der@gmail.com]

Interview Date: _____ Time: _____

Name: _____ Sex_____Position_____Educational Level _____ Experience _____

1. Existing production capacity and future expansion plan (when)?
2. How do you define, measure and analyze productivity of the firm?
3. What factor is the most significant for your company's productivity (labour, capital, Technology, machineries and energy)?
4. What are the major problems responsible for the company poor productivity status?
5. What are the major productivity improvement activities in your company?
6. What activities are being done to make the plant productiveand hence competitive in local and the global market?
7. What is your strategy to sell your metal products in the local and international markets?
8. What opportunities does your company have in the current business environment?
9. What kinds of supports do the company needs from the Government to improve its productivity?

Appendix III

Table: survey questioner response rate

No	***Respondents' Organization***	***Number of Distributed Questionnaire***	***Number of Responses***	***Response Rate (%)***
1	Metal & engineering Industries	23	14	61%
2	MIDI	10	8	80%
3	KAIZEN institute	8	6	75%
4	MOI	6	4	67%
5	Customer industries	4	3	75%
	Total	51	35	71.5%

Appendix IV

Table: Major respondent contact profile

No.	***Name of organization***	***Type of establishment***	***Respondent's profile***		
			Name	***Education level***	***position***
1	Yesu metals	PLC	AdissBerhe	B.Sc.	Pant Manager
2	MIDI	GOV	EndashawShanko	B.Sc	Product design & development director
3	KAIZEN	GOV	Fitsum G/medihin	B.Sc.	Senior KAIZEN auditor
4	MOI	GOV	Sisaytamrat	M.Sc.	Industrial Projects control team leader
5	Ethiopian steel	Private	BeleteRade	B.Sc.	Plant manger

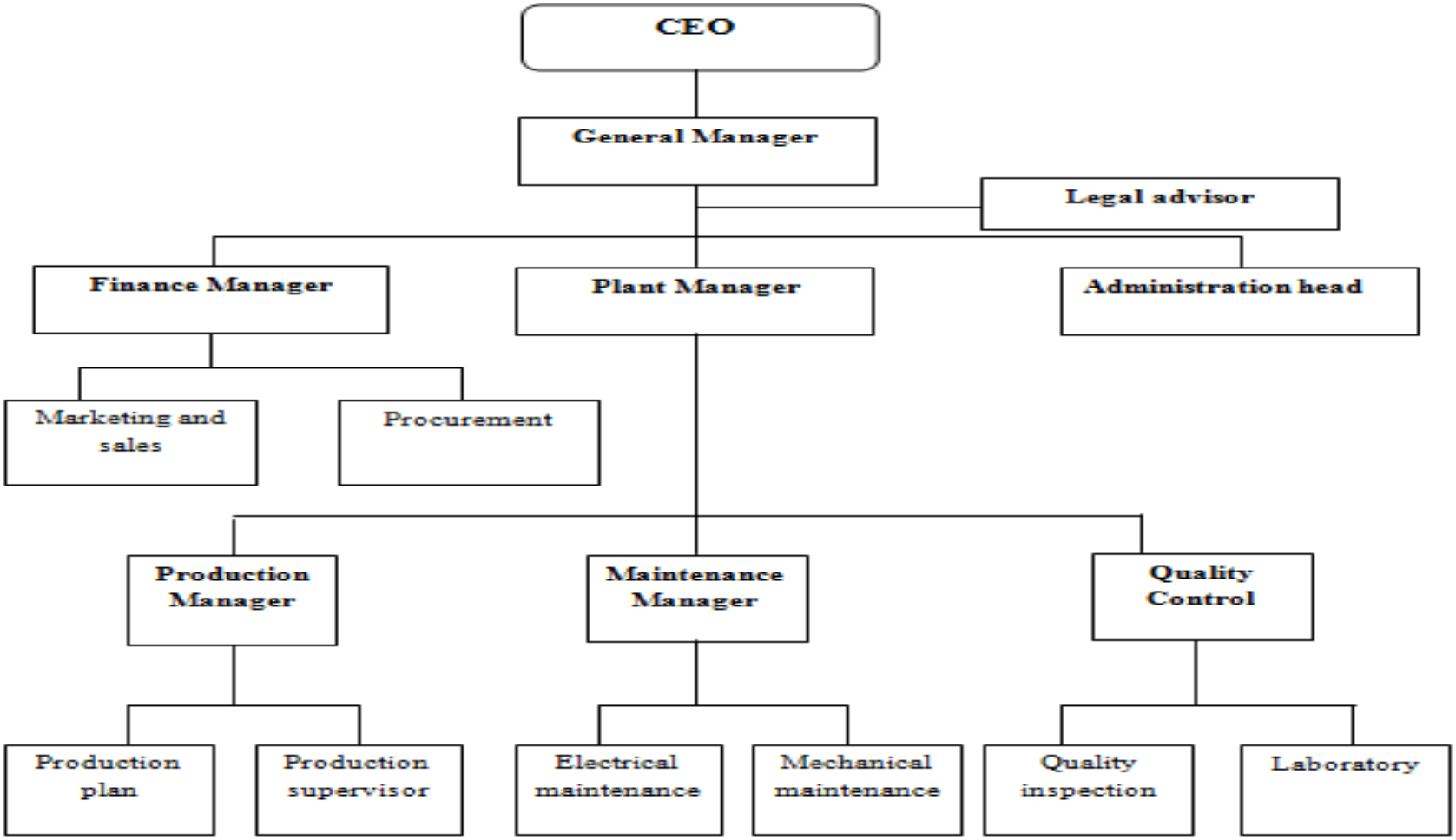

Figure: organizational structure of Yesu metal manufacturing

Appendix VI

INPUT MATERIALS AND PROCESS DESCRTIPTION OF FOR RC BAR PRODUCTION AT YESU METAL MANUFCTRUING

SCRAP METAL

The source of the scrap metals is among the different places of sources and hence, the company is using these scrap metals as a raw materials for the rolling mill section in the production of steels bars, the sources could be revised as follow. The company generates scrap metals from the following sources.

1. **Home scrap** – these scrap metals are mainly generated from the cold rolling mill plant [corrugated steel sheet] of the company which is from steel mill production and constitutes about 30 % of the overall scrap quantity [characterized by low carbon steel scrap metal].
2. **Process scrap** - about 20 % of the factory's general scrap quantity, and mainly generated from scraps in the production of consumer and production goods and it is earned from outside market [characterized by medium carbon steel metal].
3. **Obsolete scrap**- these scrap metals are developed after discharged materials or products at the end of their services or life, and it is the major contributor for the company's scrap metal source and covers about 50 % of the total scrap that the company is using that is eared from outside source [characterized by high carbon steel metals].

WATER

Water is one of the most important raw materials for the production of steel which is usually used for input material steam production/processing, and as a coolant media for hot metal cooling and for other related supplementary purposes.

ELECTRIC ENERGY

As any type energy is important in the steel production plants. The total energy consumption of steel and the proportion of electric energy the tap-to-tap times of the electric arc furnaces. It is evident that other energy sources are important, too, in particular in carbon steels, but electric energy remains the major source. In general electric steelmaking is ecologically very beneficial

since it uses energy effectively to produce valuable material from scrap and hence not only conserving energy but also reduces the waste burden by and increases productivity roughly. Other energy sources such as fuel energy is important and they used in the plant.

FUEL

Fuel is necessary for the purpose of reheating the moulds that are come out of the continuous casting machine and about 60 barrels of gasoil is consumed in 24 hours production and it can reheat about 75 tons of steel moulds.

OTHERS

Other input materials and technologies such as the necessary man power, the programmable control programs [PLC], different types of CNC and automatic control machines, different machineries, electrical and mechanical parts, different grade and type of hydraulic oils for piston-cylinder arrangements and many more others.

THE PRODUCTION PROCESS AT YESU MANUFACTURING: HOT ROLLING MILL

The existing production process of reinforcement bars at Yesu metal or steel manufacturing plc starts with the charging of scrap metals at the electric induction furnace by using over head crane as a material handling system and by subsequent production process systems these scrap metal is going to be transformed into mild steel casts or moulds and these moulds will be further transformed into a reinforcement bars thus these bars are available for the market and therefore they important mainly for reinforcement concrete and construction.

The production process of the RC bars can be summarized as follows;

INDUCTION FURNACE: This induction electric has a capacity of melting 25 tons of scrap metal within 3-4 hours of working time. The furnace uses electric energy to which is changed to heat energy up to 1600oC by the copper wire coil plates. The scrap metal is charged by using an over head crane through balancing different types scraps metals with relative to their carbon content and the hot metal is going to be ready at this temperature and it will be transported to the casting machine.

CONTINUOUS CASTING MACHINE [CCM]: The CCM is a casting machine which produces mild steel through cooling of the melted hot metal at about a temperature of 1400-1500oC by using water as a cooling media. After testing is made by taking the sample, the moulds will be having across sectional area of [12cmX12cm] and it will be cut manually at a length of 4 meters which is an input for the reinforcement bar.

REHEATING FURNACE: This furnace is rectangular metallic container and having a capacity holding and heating 265 moulds at a time it has primarily a function of reheating of moulds that comes out of mould store. The furnace is mounted with roller conveyors and hydraulic pusher and it uses fuel/gasoil for generating the heat [up to 1200^{o}C] and it will make ready the moulds to the roughing mill at a necessary temperature of 1040^{o}C.

ROUGHING MILL: In this section, the cross-sectional area of the reheated metal [with that specific temperature] will be reduced to a considerable size after it is being moved back and forth up to 8 times on roller conveyors and it will pass through different dimensions of holes that are created by pairing 3 adjacent rolls.

ROLLING MILL: This section is the most important section of the plant. At this stage, the reduced mould will be further reduced stage by stage and the mould will have a shape of reinforcement bar. There are 7 pairs of rolling stands [one pair for reduction and the other for making the shape] that are adjusted at different RPM for adding the value. After the bars are produced, they will be cut in to a length of 60 meters and collected into batches for further processing.

CUTTER: This cutting section of the plant, which is semiautomatic, is having a function of cutting these 60 meters of reinforcement bars into a standard or marketable size of 12 meters and that will be handled in rounded or bend shape for the easy of handling and transportation