ST. MARY'S UNIVRSITY (SMU)

SCHOOL OF GRDUATE STUDIES

INSTITUTE OF QUALITY AND PRODUCTIVITY MANAGEMENT (IQPM)

PRACTICE AND CHALLENGES OF CALIBRATION SERVICE PROVISION: THE CASE OF THE NATIONAL METROLOGY INSTITUTE OF ETHIOPIA

BY

FEYISSA WORKU MESHESHA

ID.NO: SGS/0411/2012A

DECEMBER, 2021

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THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTERS OF SCIENCE IN QUALITY AND PRODUCTIVITY MANAGEMENT

ADVISOR: ABDU ABAGIBE (Ph.D.)

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APPROVED BY BOARD OF EXAMINERS

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External Examiner	Signature
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Internal Examiner	Signature

DECLARATION

I, the undersigned, declare that this thesis entitled “THE PRACTICE AND CHALLENGES OF CALIBRATION SERVICE PROVISION: THE CASE OF THE NATIONAL METROLOGY INSTITUTE OF ETHIOPIA”, is my original work, prepared under the guidance of my advisor Abdu Abagibe (Ph.D.). All necessary sources of materials used for the preparation of this thesis are appropriately acknowledged. Moreover, I want to confirm that the thesis has not been submitted either in part or in full to any other higher learning institution for the purpose of earning any degree.

Name: Feyissa Worku Meshesha Signature: _____

St. Mary‘s University, Addis Ababa, Ethiopia, December 2021

ENDORSMENT

This thesis has been submitted to St. Mary‘s University, School of Graduate Studies for examination with my approval as university advisor.

Advisor: Abdu Abagibe (PhD) Signature _____

St. Mary‘s University, Addis Ababa, Ethiopia, December 2021

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TABLE OF CONTENTS

Contents **Page**

LISTS of TABLES

LIST of FIGURES

ABBREVIATIONS AND ACRONYMS

AFRIMETS	Inter Africa Metrology Organization
BIPM	International Bureau of Weights and Measures
CABs	Conformity Assessment Bodies
DAKKS	Deutsch AKK/ German accreditation Body
ECAE	Ethiopian Conformity Assessment Enterprise
ENAO	Ethiopian National Accreditation Office
ESA	Ethiopian Standard Agency
FDG	Focus Group discussion
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
IEC	International Electric Commission
ILAC	International Laboratory Accreditation Cooperation
ISO	International Organization for Standards
MoSI	Ministry of Science and Innovation
MoTI	Ministry of Trade and Industry
MRAs	Mutual Recognition Arrangements
NMIs	National Metrology Institutes
NMIE	National Metrology Institute of Ethiopia
NQI	National Quality Infrastructure
NQIE	National Quality Institute of Ethiopia
OIML	International Organization for Legal Metrology
QI	Quality Infrastructure
QSAE	Quality and Standards Authority of Ethiopia
RMOs	Regional Metrology Organizations
SI	International System of Units
SOP	standard operating procedure
TBT	Technical Barrier to Trade
TII	Technology and Innovation Institute
UNIDO	United Nations Industrial Development Organization
VIM	International Vocabulary of Metrology

ABSTRACT

Experiences and research findings have depicted that a fully functional NMI is essential for maintaining national standards and improvement of calibration service in any country. The purpose of this study was to assess the practice and challenges of calibration service provision in NMIE. More specifically, the study tried to assess the extent of contribution of calibration services provided by NMIE to the overall performance of the firms and able to assist them in product and process quality; the extent of availability of the necessary resources that could promote the provision of calibration services in NMIE; the extent of stakeholders engaged in the activities being performed by NMIE; and identified the major challenges that affect the provision of calibration services in NMIE. In the study, both qualitative and quantitative research approaches were employed and data was collected using closed-ended and open-ended questionnaires, semi-structured interviews, and document analysis. To analyse the quantitative data, both descriptive and inferential statistics were used. The qualitative data was analysed through coding, transcription, putting into categories and Themes, and discussed. Finally, the results of the quantitative and qualitative data were triangulated to come up with the findings. The findings showed that the overall achievement of the provision of the calibration service of NMIE was found to be satisfactory. In general, results revealed that inadequate knowledge management, poor resource allocation, lack of equipment utilization as well as frequent failure, and inefficient maintenance activities have retarded the implementation of NMIE. In connection with these findings, it was recommended that NMIE need to improve coordination and provide resources to overcome the barriers that prevent the NMIE to perform its activities in an effective manner.

Key words; Calibration service, Measurement Standards, Practice, Challenge

CHAPTER ONE

INTRODUCTION

This chapter deals with the background of the study, statement of the problem, research questions, objectives, the significance of the research work, delimitations and limitations of the research, definition of basic terms, and organization of the study.

1.1. Background of the Study

Economic growth is the most powerful instrument for reducing poverty and improving the quality of life in developing countries like Ethiopia. The contribution of QI to the economic growth and its significance is often not well known or unnoticed for decades (UNIDO, 2019). The QI with all the building blocks in place standardization, metrology, accreditation, and conformity assessment, in particular, testing, certification, and inspection services play a fundamental role in supporting economic growth in any respect. The plat-form of the QI can help consumers make informed choices, encourage innovation, lead businesses and industries to take up appropriate new technologies and organization methods improve current practices, and support public authorities in designing and implementing public policies aligned with the Ethiopian government grand plan. Quality Infrastructure institutions like conformity assessment service providers, metrology, standard authority, and internationally recognized accreditation system can support other governmental policy objectives in areas such as competitiveness and trade facilitation, consumer protection, productivity, and innovation, in food safety, health, and the environment and climate change that were enacted in different Ethiopian Government Ministries and Governance. Under the concerted framework and direction provided by the NQIE, all component parts of the QI system act synergistically with each other and provide a valuable tool for defining, developing, and verifying quality requirements for products and services. The system components assist in the verification and demonstration that products and services actually meet specified requirements.

As one of a pillar for NQI, the Metrology Institute is playing a fundamental role. Calibration laboratories help firms ensure that their equipment allows them to manufacture products in accordance with buyer requirements. By the virtue of Council of Ministers Regulation No. 194/2010, the NMI has been given the powers and duties to transform existing traditional measurement instruments into modernity through introducing an international system of units

and by enabling to use of other acceptable measurement instruments in the country. To determine and maintain national measurement etalons and to establish national metrology laboratory and provide calibration services, support industries in establishing their own calibration laboratories through providing theoretical and practical training and consultancy on metrology and others.

Calibration is the set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or a measuring system, or values represented by a material measure or a reference material and the corresponding values realized by measurement standards (John Webster, 1999). Calibration is very important in all fields of the industries and service providers' organizations. Ethiopia is progressing in development in the industrial sector, but there are only a few calibration laboratories in the country. There are two government-owned owned organizations that provide calibration service to the entire country, namely, NMIE and TII, Quality Engineering Management Centre, And a few private calibration laboratories which are not well established to address the need demands. The country has a wide geographical coverage and has a wide range of industrial parks at selected industrial corridors of the country. Accordingly, establishing a private calibration laboratory is very beneficial and it is also important to share the government burden in the calibration field. So that it is very crucial to design updated and modern calibration facilities which can be compatible and coup up with current industrial measuring instruments.

Calibration may be called for; a new instrument, after an instrument has been repaired or modified when a specified time period has elapsed, when a specified usage (operating hours) has elapsed, before and/or after a critical measurement, after an event, for example; after an instrument has had a shock, vibration, or has been exposed to an adverse condition which potentially may have put it out of calibration or damage it. Sudden changes in weather, whenever observations appear questionable or instrument indications do not match the output of surrogate instruments, as specified by a requirement, e.g., customer specification, instrument manufacturer recommendation. NMIE is conducting a calibration service at its permanent facilities in Addis Ababa, using mobile truck laboratory and at customer facilities. In spite of giving this service nationwide still more is expected to satisfy the calibration demand of the institutes. The 2018 annual report of the NMIE shows that the institute has enormous challenges in its infrastructure, human capital development, and financial capabilities. This study is intended to analyze the

types and extent of challenges that the institution is facing in the provision of calibration services.

1.2. Statement of the Problem

From various documents of NMIE, the researcher understand that the institute gives calibration service to different customers. The calibration service seekers are from various sectors like; manufacturing industries, construction sectors, health sectors, research institutes, universities & higher educations, regulatory and conformity assessment bodies, agriculture and agro-processing industries, export-import Trades, service giving & others in all parts of the country. The institute's end result for service users is a calibration certificate that is accredited or non-accredited and of scope letter for out-of-scope service orders. The calibration service registration document of NMIE shows that for the last six years, calibration service needs is increasing from year to year.

1.2.1: Table Calibration Service need of previous years

S/No	Fiscal Year	Number of Customer	Equipment Quantity	Remark
1	2014/2015	1,152	14,150	
2	2015/2016	1,328	15,236	
3	2016/2017	1,438	16,701	
4	2017/20184	1,537	21,269	
5	2018/2019	1,684	28,596	
6	2019/2020	1,937	29,889	

Source: NMIE Registration Log books (2014/2015 to 2019/2020)

Reports from the internal audit and management review of NMIE indicate that some challenges are being created from time to time in measurement traceability, inter-laboratory comparison, and maintaining laboratory accreditation performance. To understand the factors that can affect the NMIE service giving activities the researcher has analyzed the 2018 and 2019 annual reports and found that there is a noticeable problem in the institute with respect to quality service provision, management of system standards, stakeholders participation, and resource utilization.

Even though there is no census made on measuring equipment by CSA in the country, a report submitted to GIZ office Addis Ababa 23 December 2014 on testing, calibration, and verification need assessment study to create the enabling environment for private calibration and verification service indicates more than 350,000 measuring equipment, which is more than this at this time.

From this amount, less than one-tenth is addressed by the existing calibration laboratories. As the knowledge of this research writer, there is no research made on this title specifically concerning on NMIE locally, some works were done before are concerned with NQI cases totally. To fulfill this gap, the researcher intended to take a commitment and try to play its own role in assessing on Practice and Challenges of calibration service provision in the case of NMIE.

Generally, the identified problems indicate that there is an inefficiency of service delivery of the NMIE. Moreover, according to the customer satisfaction report of 2019, NMIE fails short of meeting the increasing demand from industries and suffers from weaknesses that hinder promoting and strengthening the use of calibration services among the private sector as tools to increase their competitiveness. These weaknesses include (i) Capability of service delivery of the institute; (ii) lack of consultation on calibration service development with industries; (iii) low level of understanding on the calibration services among the private sector and local consumers;(iv) lack of private calibration service providers; (v) weak coordination and collaboration in the implementation of technical regulations among the regulatory agencies.

As a result of these indicated problems and weaknesses, there seems to emerge a lack of competitiveness of Ethiopian products and services and which then affect the improvement and creativity in the country. Therefore, this study is dedicated to exposing and understanding the factors that can challenge the provision of the calibration service from resource utilization, management of system standards, services, customer satisfaction, stakeholder participation, and related issues in the institute.

1.3. Questions Research

In light of the above perspectives, the study was guided by the following basic questions;

1. To what extent do the calibration services provided by NMIE contribute to the overall performance of the firm and able to assist them in product and process quality?
2. What is the extent of availability of the necessary resources (manpower, finance & material) that could promote the provision of calibration services in NMIE?
3. What is the extent of stakeholders' engagement in the activities being performed by NMIE?
4. What are the major challenges that affect the provision of calibration services in NMIE?

1.4. Objectives of the Study

1.4.1. General Objective

The general objective of this study is to investigate the practices and challenges affecting the effectiveness of the provision of calibration services in NMIE.

1.4.2. Specific Objectives

1. To identify the contribution of NMIE to the overall performance of firms in the selected sectors.
2. To analyse the factors that can affect the development of calibration service in NMIE.
3. To assess the stakeholder engagement in the NMIE activities.
4. To investigate the challenges that affect proper and adequate calibration services in NMIE.in resource management.

1.5. Significance of the Study

It is expected that in carrying out this study a deeper understanding of the limitations to the countries' engagement in calibration laboratories will be gained. Furthermore, it will make recommendations as to solve challenges of calibration laboratories and development can be conducted conduct in the field based on sound evidence derived from the population to which it concerns. It is expected from this study that the status of calibration laboratories will be identified, the solution for the challenges will be indicated and the customer requirements will be identified. It is also expected from this study to indicate the policymakers for possible intervention mechanisms to enhance calibration services in the country. Finally, since the research writer working in manufacturing industries and more for the last ten years on Legal Metrology and NMIE, this work benefits him to sum up his knowledge in a practical way.

1.6. Delimitation/ Scope of the Study

The target group for this study was selected from industries that have obtained calibration services from NMIE. The scope of the research focused on identifying and accessing the survey it was necessarily applicable to the selected population expected in the country. The study will assess selected calibration demand areas in Ethiopia. The study was focused on assessing the factors related to stakeholder participation, the extent of services provided to industries by NMIE, and factors affecting the development of calibration laboratories.

1.7. Limitations of the Study

There were some limitations that had to be set as this research completion was limited to a specified time frame and also there were some obstacles face during data collection that affected the outcome of the research. Some of them are; upon accessing the survey, it was not necessarily applicable to all of the population expected in the country. The coronavirus pandemic/COVID 19 was also expected to affect research during data collection. How well have virtual communication worked and how the expected financial stringency affect was the research.

1.8. Definitions of Key Terms

Metrology is "the science of measurement, embracing both experimental and theoretical determinations at any level of uncertainty in any field of science and technology," as defined by the International Bureau of Weights and Measures (BIPM, 2004).

Calibration is an "operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication. (VIM)

Traceability is a "property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty." (VIM),

Traceability Chain is a sequence of measurement standards and calibrations that are used to relate the measurement result to the reference. (VIM)

Uncertainty in Metrology is a parameter characterizing the dispersion of the values being attributed to a measurand, based on the information us (VIM)

Out of scope- anything that is outside the parameters of an initiative. (http://www.wrike.com)

1.9. Organization of the Study

This study is structured into five chapters. The first chapter, which is the introductory part, deals with the background of the study, statement of the problem, objectives and significance of the study, scope of the study and definition of the key terms used in the study. Chapter two presents the review of the related literature which treats the fundamental of the calibration service, the need for NMIE and detailed explanation on the Calibration service activities both in the international and national perspectives. Moreover, the literature review describes theoretical issues regarding relevance, challenge and opportunities in calibration services. The research design and methodology is explicitly presented in the chapter three of the research document. Chapter four is dedicated to discuss the results and the findings obtained from the study. Finally, the summary of major findings, conclusions and recommendations will be explained in chapter five.

CHAPTER TWO

REVIEW OF THE RELATED LITERATURE

The chapter deals with the details of the theoretical issues in the calibration service, the importance of National Quality Infrastructure in Ethiopia, the current status of the Ethiopian National Quality Infrastructure, Empirical Literature on Organizational Effectiveness, and the conceptual framework..

2.1. Introduction

Instrument calibration is one of the primary processes used to maintain instrument accuracy (CH. Aparna, Gowrisankar, 2015). Calibration is the process of configuring an instrument to provide a result for a sample within an acceptable range. There are three main reasons for having instruments calibrated are to ensure readings from an instrument are consistent with other measurements, to determine the accuracy of the instrument readings, to establish the reliability of the instrument that it can be trusted. The study includes information about the tests conducted for calibrating different instruments and acceptance criteria. Out of calibration is the major thing during analysis. It gives in detail about the out of calibration also. (Hazelton, N.W.J., 2009). Nowadays there are so many various measuring instruments that are involved directly in different work areas which need calibration.

2.2. What is Metrology?

Metrology can be defined as the science of measurement associated with the evaluation of its uncertainty. It includes all theoretical and practical aspects of measurements, whatever the measurement uncertainty and field of application (A. Jorio, M.S. Dresselhaus, 2016). Metrology activities may be divided into three basic subfields:

- Scientific or fundamental metrology: concern the establishment of quantity and unit systems, units of measurement, the development of new measurement methods, the realization of measurement standards, and the process to determine the equivalence of national measurement standards to those of other nations and the transfer of traceability from these standards to users in society.
- Applied metrology for voluntary applications, namely Industrial metrology: concern the application of scientific metrology to manufacturing and other technological processes

and their use in society, ensuring the suitability of measurement instruments, their calibration, and the quality control of measurements.

- Applied metrology for mandatory applications, namely Legal metrology: concerns measurements and measuring instruments for fair trade, the protection of health and environment, public safety, for enabling taxation, and for the protection of consumers.

Metrology is structured at international, regional, and national levels to handle the following missions: Definition of internationally accepted units of measurement, the realization of these units of measurement in practice. Application of chains of traceability linking measurements made in practice to reference standards and establishment of legal requirements for measurements and measuring instruments.

Measurement is fundamental to practically all the processes we carry out, both large and small (Anil Akdogan, 2018), from commodity trading, manufacturing, environmental and energy monitoring, health diagnostics, medical treatment, global navigation, sports performance, public safety, and law enforcement to just about every daily activity we perform. To ensure the accuracy of measurement in all these fields and to guarantee that measurements can be used repeatedly in time and space, the international community has set up an ensemble of standards associated with the international system of units and an ensemble of rules and specifications related to measuring instruments.

The organizations playing the main role at the international level are respectively:

The Bureau International des Poids et Measures «BIPM » (www.bipm.org): set up by the Convention of the Metre (treaty signed in Paris in 1875) and its mandate is to provide the basis for a single, coherent system of measurements throughout the world, traceable to the SI. The BIPM acts in matters of world metrology, particularly concerning the demand for measurement standards of ever-increasing accuracy, range, and diversity, and the need to demonstrate equivalence between national measurement standards.

The International Organization of Legal Metrology «OIML» (www.oiml.org): an intergovernmental treaty organization established in 1955 and has a mission to enable economies to put in place effective legal metrology infrastructures that are mutually compatible and internationally recognized, for all areas for which governments take responsibility, such as those which facilitate trade, establish mutual confidence and harmonize the level of consumer protection worldwide. At regional and continental levels, the RMOs are coordinating the cooperation of NMIs. For instance, in Africa “AFRIMETS” (www.afrimets.org) is the RMO of

Africa. Its mission is to “Promote metrology and related activities in Africa with the view of facilitating intra-African and international trade and to ensure the safety, health, and consumer and environmental protection of its citizens.”

2.3. Calibration and its Relevance

A calibration is a basic tool in ensuring the traceability of measurement, measuring instrument, measuring system, or reference material. Calibration determines the performance characteristics of an instrument, system, or reference material. It is usually achieved by means of a direct comparison against measurement standards or certified reference materials. The main reasons for having an instrument calibration are: To establish and demonstrate traceability, to ensure readings from the instrument are consistent with other measurements, to determine the accuracy of the instrument readings, and to establish the reliability of the instrument

Calibration is one of the most important aspects when we are engaged directly or indirectly in manufacturing a certain product in terms of measurements. Almost all of the industries require this service mainly because of quality and safety (and of course including auditor’s requirement). Because of this, the internal calibration laboratory is established and many 3rd party calibration laboratories exist to provide their services. Calibration service allocates a significant amount of a company’s budget and therefore it is a big plus if you consider having an internal calibration laboratory also called in-house calibration to be implemented. By calibrating measuring and monitoring equipment we achieve so many benefits like; restoring the accuracy of the instrument, adjusting or repairing an instrument that is out of calibration, minimizing uncertainty or error, ensuring the reliability and consistency of the instrument, keeping measurements within specification limits, building trust, confidence, and reliability in measurements and establishing traceability of the measurement to a National/International Standard, which is a mandatory requirement for most standards. To summarize, calibration quantifies and controls errors and uncertainties within measurement processes and brings them to an acceptable level (Peter H.Sydenham and Richard Thorn, 2005).

2.4. Basic Requirements for Calibration Service

2.4.1. What determines the frequency of calibration?

The frequency of calibration is influenced by several factors: In-house or external calibration program usage of the instrument, behavior of the instrument – frequent out-of-tolerance results, accuracy and precision requirements, environmental conditions, overall calibration program and

policy, instrument manufacturer-recommended calibration interval, and also unscheduled calibration due to accidental dropping, or mishandling that leads to non-conforming results. (ISO/IEC 17025:2017)

2.4.2. Practical tips for calibration program

Here is a list of practical tips for a calibration program: All instruments used in the manufacturing, testing, and related processes must be calibrated at all times during the life cycle of the instrument. Design and document an SOP for calibration, Conduct calibration training, create a master list of all equipment and instruments needing calibration, including details of equipment ID, make, location, etc.

Define frequency or the intervals of calibration; weekly, monthly, quarterly, bi-annually, annually

Define calibration range which covers the operational range of the instrument.

Design a Calibration Plan with dates and timelines for performing calibration.

Implement the program: Monitor and maintain all records of calibration and verification, making them easily available at the point of use.

Plan what is to be done in case of deviations: Affix calibration status labels which identify the date and due date of calibration, providing control to ensure that only calibrated instruments are used. After reviewing them carefully, store your Calibration certificates, with the process owner approving and signing them. Once calibrated, do not adjust the instrument, as adjustments may invalidate the measurement result. Protect equipment used in measuring and monitoring from damage and deterioration during handling, maintenance, and storage.

A basic tool in ensuring the traceability of measurement is the calibration of a measuring instrument, measuring system, or reference material. Calibration determines the performance characteristics of an instrument, system, or reference material. It is usually achieved by means of a direct comparison against measurement standards or certified reference materials. The main reasons for having an instrument calibration are: To establish and demonstrate traceability, to ensure readings from the instrument are consistent with other measurements, to determine the accuracy of the instrument readings, and to establish the reliability of the instrument

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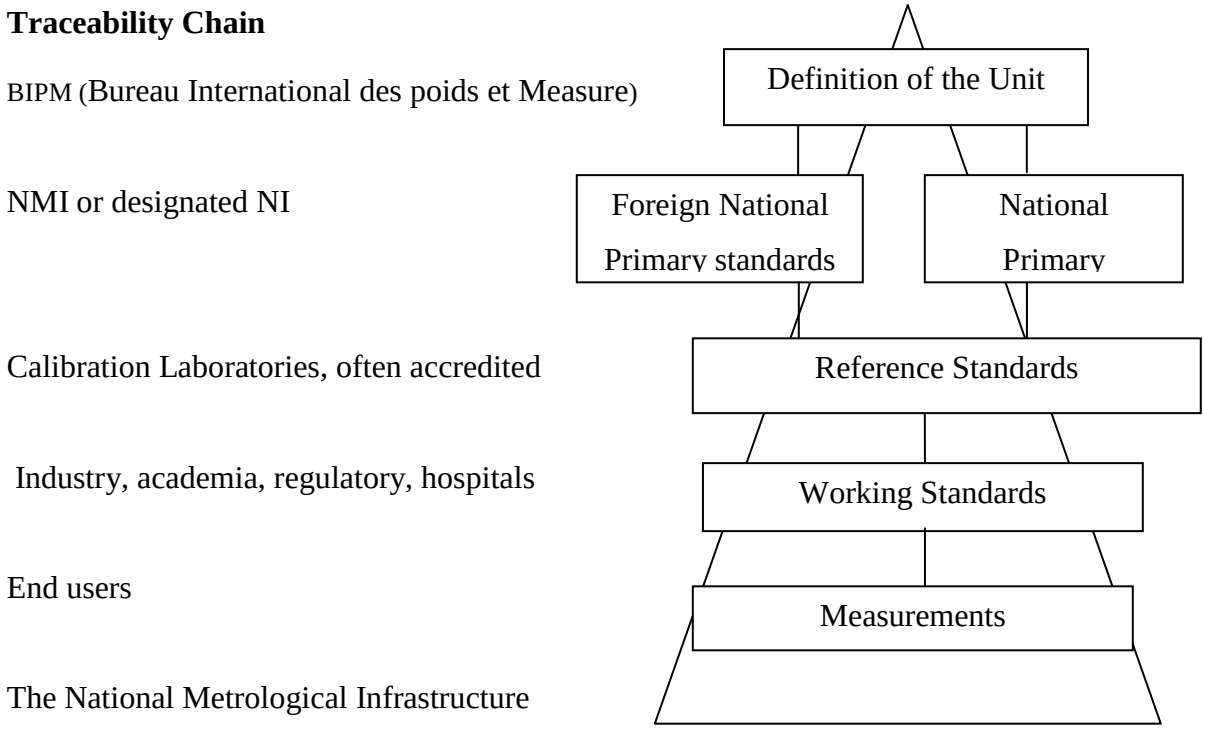
laboratories exist to provide their services. Calibration service allocates a significant amount of a company's budget and therefore it is a big plus if you consider having an internal calibration laboratory also called in-house calibration to be implemented

2.4.3. Traceability to SI Unit

A traceability chain is an unbroken chain of comparisons all having stated uncertainties. This ensures that a measurement result or the value of a standard is related to references at the higher, ending at the primary standard. An end user may obtain traceability to the highest international level either directly from NMI or from a secondary calibration laboratory, usually an accredited laboratory. As a result of various mutual recognition arrangements, internationally recognized traceability may be obtained from laboratories outside the user's own country. (ESCC Basic Spec. No. 21500)

Traceability Chain



Uncertainty increases down the traceability chain

Figure 1: Traceability chain

2.4.4. Resource for Calibration

According to ISO/IEC 17025: 2017 the calibration laboratories shall have available resources which are: personnel, facilities, and equipment, systems, and support services necessary to manage and perform its laboratory activities.

2.5. Types of Calibration

The process of testing and calibration can be performed on a number of products and types of equipment, across multiple sectors. Following are some of the most common types of calibrations services used today;

Pressure Calibration is a widely used calibration process in which gas and hydraulic pressure are measured across a broad spectrum. A number of pressure balances and calibrators are generally used, along with a variety of pressure gauges. The ISO 17025 UKAS accreditation is often taken into consideration when calibrating pressure and national standards must also generally be adhered to. Examples of pressure equipment that can be tested for calibration include; Barometers, analog Pressure Gauges, Digital Pressure Gauges, digital Indicators, transmitters, and test gauges.

Electrical Calibration is used to measure voltage, current frequency, and resistance. Electrical calibration often has to adhere to UKAS accredited standards. The process also monitors resistance and thermocouple simulation covering process instrumentation. Examples of electrical equipment that can be tested for calibration include; Multi-meters, counter timers, insulation testers, loop testers, clamp meters, RCD, data loggers.

Mechanical Calibration, mechanical calibration housing facilities will be temperature controlled. A number of dimensional, mass, force, torque, and vibration elements will be calibrated during the testing process. Examples of mechanical equipment that can be tested for calibration include; weight & mass sets, torque wrenches & screwdrivers, Scales/Balances, micrometers, verniers, height gauges, accelerometers, load cells & force Gauges

Temperature and Humidity Calibration

Temperature calibration usually takes place in a controlled environment. A number of different types of equipment can be tested using temperature calibration, including the following; thermometers/Thermocouples, Dial Thermometers, PRTs and Thermistors, Thermal Cameras, Infrared Meters, Chambers/Furnaces, Weather Stations, Data Acquisition Systems Again; humidity calibration will usually take place in a controlled environment and will generally cover a range of 10 - 98% RH. A variety of instruments can be tested for humidity calibration, including the following; Humidity Recorders, Humidity Generators, Digital Indicators and Probes, Transmitters, Psychrometers, Thermo hygrographs, Tiny tag Sensors. The calibration processes listed above are perhaps the most commonly used and more widely known methods. However, calibration is used on a much wider scale in many industries. A few additional

examples of calibration types are; water flows Calibration, Oil flow Calibration, Air Velocity Calibration, and Air Flow Calibration.

2.6. Uncertainty in Metrology

In metrology, uncertainty has a special meaning which is created by the need for accurate measurement. Accurate measurement, which implies the existence of standards of measurement and the evaluation of uncertainties in a measurement process are essential to all areas of metrology. It includes the identification, analysis and minimization of errors and the calculation and expression of the resulting uncertainties. Evidently, accuracy and uncertainty are inversely related: high accuracy implies low uncertainty; and low accuracy implies high uncertainty (Preben Howarth and Fiona Redgrave, 2008).

When reporting the result of a measurement of a physical quantity, it is obligatory that some quantitative indication of the quality of the result be given so that those who use it can assess its reliability. Without such an indication, measurement results cannot be compared, either among themselves or with reference values given in a specification or standard. It is therefore necessary that there be a readily implemented, easily understood, and generally accepted procedure for characterizing the quality of a result of a measurement, that is, for evaluating and expressing its uncertainty.

The concept of uncertainty as a quantifiable attribute is relatively new in the history of measurement, although error and error analysis have long been a part of the practice of measurement science or metrology.

It is now widely recognized that, when all of the known or suspected components of the error have been evaluated and the appropriate corrections have been applied, there still remains uncertainty about the correctness of the stated result, that is, doubt about how well the result of the measurement represents the value of the quantity being measured.

Just as the nearly universal use of the International System of Units (SI) has brought coherence to all scientific and technological measurements, a worldwide consensus on the evaluation and expression of uncertainty in measurement would permit the significance of a vast spectrum of measurement results in science, engineering, commerce, industry, and regulation to be readily understood and properly interpreted. In this era of the global marketplace, it is imperative that the method for evaluating and expressing uncertainty be uniform throughout the world so that measurements performed in different countries can be easily compared.

The ideal method for evaluating and expressing the uncertainty of the result of measurement should be:

Universal: the method should be applicable to all kinds of measurements and to all types of input data used in measurements.

The actual quantity used to express uncertainty should be:

internally consistent: it should be directly derivable from the components that contribute to it, as well as independent of how these components are grouped and of the decomposition of the components into subcomponents;

transferable: it should be possible to use directly the uncertainty evaluated for one result as a component in evaluating the uncertainty of another measurement in which the first result is used.

2.7. Status of NMIE

The function of the national metrology institute was begun when Ethiopia adopted a metric system according to the “weights" and measures Proclamation No. 208 of 1963 since 1962 under the Ethiopian Standards Institute which later changed to the Ethiopian Authority of Standardization. At a time EAS was mandated to promote Standardization, Quality control, Quality assurance and Certification, and Metrology activities as a sole government organ at the national level. EAS was further transformed into QSAE in 1998. One of its objectives was stated as establishing “a sound national metrology system as a basic structure for economic development.”EAS" was taken the responsibility for enforcing and administering the weights and measures proclamation in 1972. Even though, there was a national metrology laboratory at the time Ethiopia has been a member of OIML since 1974. However, Ethiopia was removed from the list of member states in 2008 as a result of remaining in arrears with its contributions for the last years.

Based on the study of NQI approved in 2009 and Business Process Re-engineering (BPR) under the former MoST the QSAE was divided into different autonomous entities. Like ESA, ECAE, NMIE, and ENAO which is actually a newly established NQI organization. Accordingly, the NMIE was established by the council of Ministers Regulation No 194/2010 as an autonomous organ as of February 2011. The NMIE has been established comprising all the activities that were carried out under QSAE related metrology, scientific and industrial metrology-related related activities that were performed by the Ethiopian Radiation Protection Authority, and all the activities and mandates that were owned by the former Ethiopian Scientific Equipment Centre.

NMIE has the following core objectives.

- Develop a national metrology system compatible with the international metrology system and ensure technology transfer in the sector.
- Establish and implement a system that enable to comparison Ethiopian national measurement etalons and certified reference material with international etalons and to maintain and disseminate them.
- Support education and research activities in the field of metrology. Building national capability for maintenance of scientific instruments and provides maintenance services.
- Support scientific equipment users to carry out their duties effectively by providing technical, training, consultancy and information services on scientific equipment.

Besides the objectives NMIE has the following duties and responsibilities.

- Transform existing traditional measurement instruments into modernity through introducing international system of units and by enabling to use other acceptable measurement instruments in the country;
- Determine and maintain national measurement etalons; Establish national metrology laboratory and provide calibration services;
- Support industries in establishing their own calibration laboratories through providing theoretical and practical training and consultancy on metrology;
- Based on other countries best practices, provide support in building the capacities of universities and research institutions in curriculum designing and implementation process and conducting research in the field of metrology;
- Publish and declare to the public measurement units to be used in the country, symbols of the measurement units and national measurement etalons;
- Represent the country's interest in international forums regarding metrology and follow up the implementation of treaties to which Ethiopia is a party;
- Participate in the calibration result inter comparison program with other national, regional and international metrology institutes intended to ensure the reliability of calibration services;
- Work in cooperation with the relevant stakeholders to ensure the existence of an integrated support for strengthening the national quality infrastructure;
- Conduct research in the field of metrology in collaboration with universities and research institutions and disseminate the results to industries;

- Establish a documentation and information centre for the provision of metrology related information;
- Provide the necessary technical and professional support so as to make the legal metrology activities effective;
- Provide consultancy services on selection and acquisition, handling and use, maintenance, repair and disposal of scientific equipment;
- Provide training for scientific equipment users on procurement, handling and use, maintenance, repair and disposal of scientific equipment;
- Support scientific instrument user institution in establishing their own maintenance workshops through providing training and support and issue certificates for trainees;

Since its formation in 2011 as a separate NQI Institution, the NMIE has consolidated and expanded its offered services and supplemented them with two mobile calibration laboratories and two vans supported by the National Quality Infrastructure Development Program (NQIDP) with the World Bank loan. Many of its key calibration services have already been accredited by the German accreditation body DAkkS. Furthermore, NMIE is also benefitting from a World Bank loan taken out by the Ethiopian Government for strengthening and further developing its NQI through a project which started in July 2017 and is scheduled to continue until June 2022. It has also under taking the construction of laboratory and administrative buildings with the government budget. In addition to the above-mentioned developments, the institute also has been undertaking the transformation of organizational structure.

2.8. Calibration Services given by NMIE

Length Measuring Instruments - Micrometre, Steel Graduated Rule, Penetrometer, Displacement transducer, Vernier Calliper, Steel Tapes/Tape Meter, Dial Gauges.

Standard Weights - Set OIML class F1 and lower, Single Weight, Weights of free nominal value

Weighing Instruments – Non-automated Weighing Scales, Automated Weighing Scale

Temperature Measuring Instruments - Moisture Tester, Liquid In Glass Thermometer, Digital Thermometer, Platinum Resistance Thermometer, Clinical Thermometer, Thermocouple, Dry Oven, Water Bath, Furnace Pyrometer

Pressure Measuring Instruments - Oil medium Pressure balance, Barometer, Gauge Pressure Indicator with both oil and gas medium, Absolute Pressure Gauges, Vacuum Pressure Gauges, Pressure Transducers Hydraulic Dead Weight Pressure Testers

Force, Torque, and Hardness Test Measuring Instruments - Marshal Testing Machines, CBR Testing Machines, Universal Strength Testing Machines, Tensile Strength Testing Machines, Compressive Strength Testing Machine. Torque Wrench, Torque Transducers, Hardness Probes.

Volume Measuring Instruments - Flask, Pyknometer, Pipettes, Burette, Graduated Cylinder, Metal Prover, Under/Above Ground Tanker, Beaker and Liquid Flow meter.

Electrical, Time and Frequency Measuring Instruments - AC Voltage Calibrator, AC Voltage Generator, AC Voltmeter, DC Voltage Calibrator, DC Voltage Generator, DC Voltmeter, AC Current Sources, AC Ammeters, DC Current Sources, DC Ammeters, Four Terminal Resistor, Ordinary Resistor, Ohmmeter, Resistance bride, Multi-meter meter Power Supply 380v, Frequency Generator and Time & Frequency meter.

Density Measuring Instruments: - Hydrometer, Sacharimeter, Alcoholmeter, and Baume.

Secondary Standard Dosimeter Measuring Instruments - Radiation Measuring Instrument (Survey Meter), Irradiation of Thermo Luminous Dissymmetry.

2.9. Challenges faced by NMIE?

The national metrology institute of Ethiopia has the responsibility of maintaining national measurement standards and disseminating the international system of units nationally. NMIE is recognized internationally and is part of an international system that facilitates the recognition of national measurement standards and measurement capabilities. To perform these duties in full package NMIE faces the following challenges;

- Limited laboratory facilities;
- The limited scope of calibration service;
- Lack of educated and skilled manpower in the metrology area;
- Out-dated organizational structure to hold experienced personnel in NMIE;
- Very few commercial calibration laboratories cover all calibration demands in the country;
- Unable to participate in regional and International Metrology Conferences and Annual Seminars;
- Foreign currency for the traceability of National Standards at internationally recognized laboratories abroad.

CHAPTER THREE

THE RESEARCH DESIGN AND METHODOLOGY

This chapter presents the research design; the research method employed in it and discusses the research technique used in the study and the reasons for selecting such a technique. It includes the research design, sample size and sampling technique, data source and collection method as well as reliability and validity tests of data gathering instruments, method of data analysis, and ethical considerations.

3.1. The Research Design

The study employed a mixed approach as a research design is a procedure for collecting, analysing, interpreting, and reporting data in research studies. It is the overall plan for connecting the conceptual research problems with the pertinent and achievable empirical research. The importance of the mixed type of research design sets the procedure on the required data, the methods to collect and analyse data (Grey, 2014). In this study, both qualitative and quantitative methods were employed.

3.2. The Research Method

To increase the efficiency and accuracy of the study descriptive survey method was used for investigation. This method is important to describe and interpret what exists at present in the form of conditions, practice processes, trends, effects, attitudes, beliefs, etc. (Creswell & Plano Clark, 2011).

3.3. Source of Data

The necessary data for this study were collected from both primary and secondary sources. The primary data were collected through questionnaires from managerial and non-managerial staff which would contain a mixture of close-ended and open-ended questions. The open-ended question enables to discover the feeling, opinions and practical experiences of respondents. As to the secondary data, both published and unpublished sources are books and reports used after evaluating their relevance. Among other, various documents like reports, proceedings, internet (online) sources, and books were reviewed in order to seek information about previous activities.

3.4. Samples and Sampling Techniques

On designing samples (Copper & Schindler, 2008) suggested that the target population, parameters of interest, sampling frame, appropriate sampling method, and the required sample size of the sample should be clearly described. The target population of this study was management members and experts from NMIE and the quality and laboratory managers of selected industries from various sectors: (1) manufacturing industries (2) construction sectors (3) health sectors (4) research institutes, higher education & universities (5) regulatory and conformity assessment bodies (6) agriculture & agro-processing industries (7) export-import trades (8) service giving and others in all parts of the country. The sample was taken from the target population being researched. As a sample, the senior technical staffs of all institutions were selected using purposive sampling techniques. Creswell & Plano Clark, (2011), stated that purposive sampling involves the identification and selection of individuals or groups of individuals that are proficient and well-informed with a phenomenon of interest. The reasons for this purposive sampling were that the researcher believes that these people can satisfy and reliable because of the following criteria. Firstly, they are working directly on specialized assignments on selected institution core issues and are experts in the field of a quality system. The sampling number was including all members of the Industrial and scientific Metrology Directorate from NMIE and 15% of the population of selected industries.

Table 3.4.1: Population Sampling Frame and Number of Respondents from NMIE.

No	Organization	Experts	Management	Total	Selected Dept. for sampling	Total sampling
1	NMIE	53	12	65	Industrial and scientific Metrology Directorates	65

On the other hand, based on the customer registration data of the NMIE for the last five years it was obtained that about One Thousand Two Hundred (1,200) different companies from different sectors were getting direct calibration service per year. As shown in the tables below from a total population one hundred eighty organizations were taken using stratified sampling techniques. Then, the samples from each industry were selected using simple random sampling technique applied on the selected organization. Then two representative samples were drawn using purposive sampling technique.

Table 3.4.2: Population Sampling Frame and Number of Respondents from Selected Industry

No	Group of Organizations/Sector	Number of Organization	Number of Organization using proportionate	Selected Department	Target Respondent in Selected organizations related to quality
1	Agriculture & Agro processing Industries	140	21	Quality and laboratory	21*2=42
2	Construction Sectors	100	15	Quality and laboratory	15*2=30
3	Export-Import Trades	240	36	Quality and laboratory	36*2=72
4	Health Sectors	180	27	Quality and laboratory	27*2=54
5	Manufacturing Industries	300	45	Quality and laboratory	45*2=90
6	Regulatory and Conformity Assessment Bodies	80	12	Quality and laboratory	12*2=24
7	Research Institutes, Higher Education & Universities	40	6	Quality and laboratory	6*2=12
8	Service Giving and Others	120	18	Quality and laboratory	18*2=36
Total		1,200	180		360

3.5. Instruments of Data Collection

In this research, the researcher used both questionnaires and interviews to collect optimum data.

3.5.1. Questionnaire

The questionnaire was developed on the basis of the basic questions of the study. For this study, both closed-ended and open-ended questionnaires for all respondents and semi-structured interviews for all interviewers were employed. A Liker Scale, which is a five-point scale was used to allow the individual to express how much they agree or disagree with a particular statement in the questionnaire. Questionnaires were distributed to the selected samples from both the NMIE and Industries.

The structured questionnaire consists of four parts:

1. The extent of calibration services provided by NMIE contributes to the overall performance of industries.
2. The extent of availability of the necessary resources that could promote the provision of calibration services in NMIE
3. The extent of stakeholders' engagement in the activities being performed by NMIE.
4. The major challenges that affect the provision of calibration services in NMIE.

3.5.2 Interviews

In order to triangulate the data obtained through the questionnaire, most of the interview questions conducted are similar to the questions in the questionnaire. Senior management staffs from both NMIE and industries were interviewed for 20 to 30 minutes besides the questionnaire. For conducting the interview, the researcher listed areas to be discussed, make the appointment with the interviewees, and arrange the time and place finally, the interview was conducted using both Amharic and English language, but the questionnaire was prepared in English.

3.5.3. Document Analysis

Document analysis is a form of qualitative research in which documents are interpreted by the researcher to give voice and meaning around an assessment topic (Bowen, 2009). Analyzing documents incorporates coding content into themes similar to how the focus group or interview transcripts are analyzed (Bowen, 2009). There are three primary types of documents (O' Leary, 2014):

Public Records: The official, ongoing records of an organization's activities.

Personal Documents: First-person accounts of an individual's actions, experiences, and beliefs.

Physical Evidence: Physical objects found within the study setting (often called artifacts). Examples include flyers, posters, agendas, handbooks, and training materials.

3.6. Standardization of Data Gathering Instruments

3.6.1, Validity

Validity is the term that describes the accuracy of a questionnaire how far it really measures the concept (Babbie, 2007). The literature review was conducted and exhaustively examined to make sure that the content of the questionnaire is relevant to the study. Moreover, before the formal data collection was undertaken, preliminary studies in the form of interviews and pilot testing of questionnaires were conducted. The purpose of the pilot test was to determine the feasibility of the study in terms of the reliability and validity of the instrument. During the designing of

questionnaires, relevant experts' opinion from the sample industries was asked to ensure the validity of instruments prepared by the researcher. The pilot sample consisted of 10 respondents in the area of quality and/or laboratory from industries who were purposively selected. Therefore, the drafted questions were analysed for their comprehensiveness and completeness to ensure that meaningful data were collected.

3.6.2. Reliability

Reliability refers to the extent that the instrument yields the same results over multiple trials (Livingston, S. A. 2018). The reliability of the tools was checked using Cronbach's alpha values. The descriptive statistics help to determine uni-dimensionality and construct validity of the measures and the Cronbach's alpha values of the factors helped to show the reliability of the factor affecting the NMIE effectiveness and its performance scales. The Cronbach's alpha measures the internal consistency of a group of items by measuring the homogeneity of the group of items. "It is an indication of how well the different items complement each other in their measurement of different aspects of the same variable or quality" (Litwin, 2003). Cronbach's alpha ranges in value between zero and one. Values closer to one indicate a higher internal consistency; values closer to zero indicate a lower internal consistency (McMillan & Schumacher, 2001). Suggest that groups of items with an alpha below 0.70 should be used with caution. The internal consistency of a scale can also be examined with item-to-scale correlations and inter-correlations of items within a scale (DeVellis, 2003). Finally, the Pilot test was conducted on ten selected respondents from industries that were not included as participants in the main study. According to Tavakol & Dennick (2011) reliability refers to the ability of the data to produce the same result consistently and the reliability of the data was calculated by using the Cronbach alpha coefficient (Pallant, 2007). It is a measurement of internal consistency among the items, and its range is from zero to one with a minimum of 0.7.

Table 3.6.2: Case Processing Summary and Reliability Statistics for Pilot-Test

Case Processing Summary			
Cases		N	%
	Valid	10	100.0
	Excluded	0	0
	Total	10	100.0
a. List wise deletion based on all variables in the procedure.			

Reliability Statistics		
Tests	Cronbach's Alpha	N of Items
Questionnaire Part Two	.875	9
Questionnaire Part Three	.751	10
Questionnaire Part Four	.859	12
Questionnaire Part Five	.727	11

Likewise, the reliability statistics were calculated for all parts of the questionnaire. The result is described as follow:

- Pilot-test to understand NMIE's contribution to the overall performance of the firm = 0.875;
- Pilot-test for understanding the availability of the necessary resources that could promote the provision of calibration services in NMIE = 0.751;
- Pilot-test that was done to know Stakeholder's engagement in the activities being performed by NMIE = 0.859;
- Pilot-test that was done to know the major challenges that affect the provision of calibration services in NMIE = 0.727

And these show that there is a high internal consistency among the variables.

3.7. Procedures of Data Collection

After checking and conducting the validity and reliability tests, data was collected by the researcher. Accordingly, the researcher had set up respondents for the research individuals, groups, and a panel of respondents whose opinions might seek on specific issues. Interviewing and questionnaires were the two main data collection methods in survey research.

3.8. Methods of Data Analysis

The most common forms of mixed research approaches method studies entail using different data components to complement or build on what might have been learned from any of those data types independently (Johnson and Onweugbuzie, 2004). The quantitative data were organized and put into tables to suit for analysis. Then the data were analysed using descriptive statistical methods (mean, standard deviation, and percentage) that can be done using statistical package for the social sciences (SPSS) version 20. Moreover, from inferential statistics, the independent T-test test was used to see idea differences between the groups of respondents.

The qualitative data were transcribed and then coded and put into categories. Then after the two types of data were triangulated and discussed.

3.9. Ethical Consideration

The principle of respect for people states that participants' thoughts and decisions must be honoured; all participants provided their consent via the informed consent process. In order to ensure the application of this principle, a form was provided to the participants who are outlined, for the participants' clarification, the study's purpose, potential risks, and benefits of participating in the study, as well as statements about confidentiality. Participants who intended to participate were asked to read the form. The study was designed to minimize all potential risks to the participants. The information provided by the participants remained anonymous. All collected data was absent of identifiable markers and stored on the researcher's personal computer. The researcher was the only person with access to the data. The computer files had password protection.

CHAPTER FOUR

RESULT AND DISCUSSION

This chapter presents the demographic characteristics of the respondents, the analysis of the extent of contribution of calibration services provided by NMIE to firms, the analysis of the extent of availability the necessary resources in NMIE, the extent of stakeholder's engagement in the activities being performed by NMIE and the major challenges that affect the provision of calibration services in NMIE.

4.1. Demographic Characteristics of the Respondents

A total of 339 (male=282, female=57) respondents were participated in the study. From this, 65 participants were from the NMIE and 274 participants were from the selected industries. Thus, Table 4.1.1 and4.1.2 below represent the profile of the research participant from NMIE and from selected industries getting services from NMIE respectively in terms of sex, age, educational qualification and years of experience in their current working positions in their respective organization as well as their total work experiences. Moreover, ten participants from NMIE and ten participants from industries were contacted for interview, i.e from each selected institutions two interviewees were selected.

Table 4.1.1: The Profile of Demographic Characteristics of NMIE Respondents

S/No	Item		NMIE	
			Fr.	%
1	Sex	Male	56	86.2
		Female	9	13.8
2	Age	18-25	1	1.5
		26-35	46	70.8
		36-45	17	26.2
		46-55	1	1.5
		above 55	-	-
3	Education	Diploma	1	1.5
		first Degree	54	83.1
		Second Degree and above	10	15.4
4	Work Experience	0-5	30	46.2
		6-10	26	40.0
		11-15	8	12.3
		above 15	1	1.5

Source: Data collected by the researcher through Questionnaire, 2021

From Table 4.1.1 above, it could be seen that 56 (86.2%) of the respondents from NMIE were male and 9 (13.8%) were females. From this finding, it could be deduced that female participation in NMIE seems below expected.

Concerning the age distributions of the participants from NMIE, only 1 (1.5%) were aged from 18-25; 46 (70.8%) were having their ages from 26-35; 17 (26.2%) were aged from 36-45 while the rest 1 (1.5%) were aged from 46-55. From this one can understand that most of the respondents are at their energetic ages to carry out their responsibilities in the institute.

From the same Table, it could also be seen that 54 (83.1%) of the research participants from NMIE have qualification of first degree, 10 (15.4%) have second degree and abovewhile the rest 1 (1.5%) were qualified at diploma level. This shows that there is adequate number of intellectuals in the institute where it could have high contribution to promote the service provision of the NMIE if their commitment is added. With regard to work experience of the participants from NMIE 30 (46.2%) have served from one to five years, 26 (40%) have experience from six to ten years, 10 (12.3%) were having a services years from eleven to fifteen years and 1(1.5%) have served above 15 years. From this, it could be seen that the staffs of the institute have adequate experiences to implement what they have been assigned to do.

In general the demographic data shows that the educational capacity, work experience and a composition of young experts and management in the NMIE are expected to transform the institutional activities in a better way to a higher level of achievements.

Table 4.1.2: The Profile of Demographic Characteristics of Industry Respondents

S/No	Item		Industry	
			Fr.	%
1	Sex	Male	226	82.5
		Female	48	17.5
2	Age	18-25	12	4.4
		26-35	178	65.0
		36-45	53	19.3
		46-55	23	8.4
		above 55	8	2.9
3	Education Level	Diploma	27	9.9
		first Degree	191	69.7
		Second Degree and above	56	20.4
4	Work Experience	0-5	126	46.0
		6-10	94	34.3
		11-15	35	12.8
		above 15	19	6.9

Source: Data collected by the researcher through Questionnaire, 2021

In Table 4.1.2 above, it could be seen that 226 (82.5%) of the respondents from the industry were male and 48(17.5%) were females. This shows that the sex composition of the respondents from the male group is greater than fourfold of females and the participation of the female is below the expected level.

The age distributions of the industry participants showed that 12 (4.4%) were aged from 18-25; 178(65%) were having their ages from 26 to 35; 53 (19.3%) from 36-45 while the rest 31(11.3%) were above 45 years old. From this one can understand that most of the respondents were at their active ages to carry out their responsibilities in their respective industries.
From the same Table, it could also be seen that 247(90.1%) of the research participants from the industry have qualifications equal to and above first degree while few numbers 27 (9.9%) were qualified at diploma level. This shows that there is enough number of intellectuals who are working in the industry, which can have its own contribution to promote the quality in industry if they exert their effort to their maximum.

With regard to work experience of the participants from the selected industries 126 (46%) have served from one to five years, 94 (34.3%) have experiences from six to ten years, 35 (12.8%) were having a services years from eleven to fifteen years and 19 (6.9%) have served above 15 years in their respected organization. From this it could be inferred that the staff of the selected industries have adequate experiences to implement the quality objectives of their respective industries.

The educational capacity, work experience and a composition of young experts and management in the industries are expected to enhance the provision of adequate services from the industries. The respondents' age, educational capacity and work experience of both categories of participants that is those from NMIE and from industries show that most of the employees are qualified, energetic, quite representative and competent in filing the questionnaire, assuming that they are working in relevant field of practice in relation to their educational qualifications in their respective organizations. Generally the experience and educational background of the respondents were reliable and it makes the study easier and able to get informative data for analysis. (UNESCO, 1985)

4.2. The Extent of Contribution of Calibration Services provided by NMIE to Firms Performance

The questionnaire was designed by using Likert Scale and the statements were measured on a five point. Likert Scale with 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree. Moreover, the calculated means are interpreted as; above 4.50 = Strongly Agree, from 3.50 to 4.50 = Agree, from 2.50 to 3.50= Neutral, from 1.50 to 2.50 = Disagree and below 1.50 is interpreted as strongly disagree.

The information obtained from the questionnaires are summarized and discussed in the following manner.

Table 4.2.1: Evaluation of NMIE's Contribution to the overall Performance of the Firms in the Selected Sectors by the Respondents

S/No	Item		NMIE							Industry							Grand Average	
			1	2	3	4	5	M	Std. D	1	2	3	4	5	M	Std. D	M	Std. D
1	Reduce waste	F	3	6	12	28	16	3.74	1.08	9	1	44	131	89	4.06	.89	3.9	0.99
		%	4.6	9.2	18.5	43.1	24.6			3.3	.4	16.1	47.8	32.5				
2	Improve Quality of Product and/or services	F	1		11	25	28	4.22	.84	4	4	34	100	132	4.28	.85	4.25	0.84
		%	1.5		16.9	38.5	43.1			1.5	1.5	12.4	36.5	48.2				
3	Improve Productivity	F	1	2	9	30	23	4.11	.87	2	6	45	116	105	4.15	.82	4.13	0.85
		%	1.5	3.1	13.8	46.2	35.4			.7	2.2	16.4	42.3	38.3				
4	Increase profit to the firm	F	2	3	10	29	21	3.98	.98	6	16	47	122	83	3.95	.95	3.97	0.97
		%	3.1	4.6	15.4	44.6	32.3			2.2	5.8	17.2	44.5	30.3				
5	Enhance effectiveness of the firm	F	1	2	14	24	24	4.05	.93	5	3	35	135	96	4.15	.81	4.1	0.87
		%	1.5	3.1	21.5	36.9	36.9			1.8	1.1	12.8	49.3	35.0				
6	Increase Acceptance	F	1	2	9	24	29	4.20	.91	6	3	23	100	142	4.35	.85	4.3	0.88
		%	1.5	3.1	13.8	36.9	44.6			2.2	1.1	8.4	36.5	51.8				
7	Increase Market Share	F	3	4	14	25	19	3.82	1.07	2	15	51	115	91	4.01	.90	3.92	0.98
		%	4.6	6.2	21.5	38.5	29.2			.7	5.5	18.6	42.0	33.2				
8	Increase Customer Satisfaction	F	2	4	11	26	22	3.95	1.02	6	9	23	108	128	4.25	.91	4.1	.96
		%	3.1	6.2	16.9	40.0	33.8			2.2	3.3	8.4	39.4	46.7				
9	Enhance confidence of the firm	F	1	3	7	31	23	4.11	.89	4	4	19	123	124	4.31	.786	4.21	0.84
		%	1.5	4.6	10.8	47.7	35.4			1.5	1.5	6.9	44.9	45.3				
Overall Mean								**4.02**							**4.17**			

Where;1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

Source: Data collected by the researcher through Questionnaire, 2021

The result of the analysis of item 1 in Table 4.2.1 shows that nine (13.8%) of the respondents of NMIE strongly disagreed or disagreed on the NMIE's contribution to reducing waste; 12 (18.5%) of the respondents preferred to be neutral and 44 (67.7%) responded agreed or strongly agreed. While 10 (3.7%) of the industry respondents rated strongly disagree or disagree on the NMIE's contribution to reducing waste; 44 (16.1%) rated neutrally and 220 (80.3%) responded agree or strongly agree. Since the grand average mean of the two groups of respondents is 3.9, it could be concluded that the services provided by NMIE give a strong contribution to reducing waste in industries.

The result of the analysis of item 2 in Table 4.2.1 shows that one (1.5%) of the respondents of NMIE rated strongly disagree on the NMIE's contribution to Improve Quality of Product and/or services and no one has disagreed; 11 (16.1%) rated neutrally and 53 (81.6%) responded agree and strongly agree. While 8 (3.0%) of the Industry respondents rated, strongly disagree, and disagree with the NMIE's contribution to Improve Quality of Product and/or services; 34 (12.4%) rated neutrally and 232 (84.7%) responded agree and strongly agree. The grand average mean of the two groups of respondents is 4.25 it could be concluded that the services provided by NMIE plays an important role to Improving the Quality of Products and/or services.

The result of the analysis of item 3 in Table 4.2.1 shows that three (4.6%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE's contribution to Improve Productivity; Nine (13.5%) rated neutral and 53 (81.6%) responded agree and strongly agree. While eight (2.9%) of the Industry respondents rated, strongly disagree, and disagree with the NMIE's contribution to Improve Productivity; 45 (16.4%) rated neutrally and 221 (80.6%) responded agree and strongly agree. Moreover, the grand average mean 4.13 of the evaluation showed that NMIE's makes a major contribution to Improve Productivity.

The result of the analysis of item 4 in Table 4.2.1 shows that five (7.7%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE's contribution to Increase profit to industries; 10 (15.4%) rated neutrally and 50 (76.9%) responded agree and strongly agree. While 22 (8%) of the Industry respondents rated, strongly disagree and disagree with the NMIE's contribution to Increase profit to industries; 47 (17.2%) rated neutrally and 205 (74.8%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.97, it could be concluded that the services provided by NMIE are major contributors to Increase profit to industries.

The result of the analysis of item 5 in Table 4.2.1 shows that three (4.6%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE's contribution to Enhance the effectiveness of industries; 14 (21.5%) rated neutrally and 48 (73.8%) responded agree and strongly agree. While eight (2.9%) of the Industry respondents rated, strongly disagree, and disagree with the NMIE's contribution to Enhancing the effectiveness of industries; 35 (12.8%) rated neutrally and 231 (84.3%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 4.1, it could be concluded that the services provided by NMIE highly contribute to enhancing the effectiveness of industries.

The result of the analysis of item 6 in Table 4.2.1 shows that three (4.6%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE's contribution to increasing acceptance of industries; nine (13.6%) rated neutrally and 53 (81.5%) responded agree and strongly agree. While nine (3.3%) of the industry respondents rated strongly disagree and disagree on the NMIE's contribution to increasing acceptance of industries; 23 (8.4%) rated neutrally and 242 (88.3%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 4.3, it could be concluded that the services provided by NMIE make an important contribution to increasing the acceptance of industries.

The result of the analysis of item 7 in Table 4.2.1 shows that seven (10.8%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE's contribution to the increasing market share of industries; 14 (21.5%) rated neutrally and 44 (67.7%) responded agree and strongly agree. While 17 (6.2%) of the Industry respondents rated, strongly disagree, and disagree with the NMIE's contribution to the increasing market share of industries; 51 (18.6%) rated neutrally and 206 (75.2%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.92, it could be concluded that the services provided by NMIE contribute to the increasing market share of industries.

The result of the analysis of item 8 in Table 4.2.1 shows that six (9.3%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE's contribution to increasing customer satisfaction of industries; 11 (16.9%) rated neutrally and 48 (73.8%) responded agree and strongly agree. While 15 (5.5%) of the industry respondents rated strongly disagree and disagree on the NMIE's contribution to increasing customer satisfaction of industries; 23 (8.4%) rated neutrally and 236 (86.1%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 4.1, I It could be concluded that the services provided by NMIE play

a major role to customer satisfaction for industries.t could be concluded that the services provided by NMIE play a major role to customer satisfaction for industries.

Finally, the result of the analysis of item 9 in Table 4.2.1shows that four (6.1%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE's contribution to enhancing the confidence of industries; seven (10.8%) rated neutrally and 54 (83.1%) responded agree and strongly agree. While eight (3%) of the industry respondents rated strongly disagree and disagree on the NMIE's contribution to enhance the confidence of industries; 19 (6.9%) rated neutrally and 247 (90.2%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 4.21, it could be concluded that the services provided by NMIE contribute to enhancing the confidence of industries.

Moreover, the majority of both respondents (NMIE & Industries) interviewees replied that NMIE's contribution to the overall performance of the firms is highly substantial in supporting the firms in reducing waste, in the improvement of product & service quality, and for improving productivity.

In general, from the foregoing analyses from Table 4.2.1, it could be seen that the responses from both NMIE and industry respondents, NMIE makes a Significant Contribution to the overall performance of the firms..

Table 4.2.2: Two Tailed t- Test for the Analysis of comparing idea of the two groups, the NMIE vs. Industry in response to the Extent of Calibration Services

Independent Samples Test											
			Levene's Test for Equality of Variances		t-test for Equality of Means						
			F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
										Lower	Upper
I.	Reduce waste	Equal variances assumed	6.842	.009	-2.493	337	.013	-.320	.128	-.572	-.067
		Equal variances not assumed			-2.217	85.876	.029	-.320	.144	-.607	-.033
II.	Improve Quality of Product and/or services	Equal variances assumed	.038	.845	-.594	337	.553	-.069	.117	-.299	.160
		Equal variances not assumed			-.598	97.395	.551	-.069	.116	-.299	.161
III.	Improve Productivity	Equal variances assumed	.058	.809	-.397	337	.692	-.046	.115	-.272	.180
		Equal variances not assumed			-.384	93.306	.702	-.046	.119	-.281	.190
IV.	Increase profit to the firm	Equal variances assumed	.018	.893	.271	337	.787	.036	.132	-.224	.295
		Equal variances not assumed			.266	94.987	.790	.036	.134	-.230	.302
V.	Enhance effectiveness of the firm	Equal variances assumed	1.863	.173	-.863	337	.389	-.100	.116	-.327	.128
		Equal variances not assumed			-.799	89.106	.427	-.100	.125	-.348	.149
VI.	Increase Acceptance	Equal variances assumed	.260	.610	-1.234	337	.218	-.147	.119	-.381	.087
		Equal variances not assumed			-1.188	92.774	.238	-.147	.123	-.392	.098
VII.	Increase Market Share	Equal variances assumed	4.378	.037	-1.547	337	.123	-.199	.129	-.453	.054
		Equal variances not assumed			-1.385	86.421	.169	-.199	.144	-.485	.087
VIII.	Increase Customer Satisfaction	Equal variances assumed	.312	.577	-2.326	337	.021	-.298	.128	-.550	-.046
		Equal variances not assumed			-2.158	89.298	.034	-.298	.138	-.572	-.024
IX.	Enhance confidence of the firm	Equal variances assumed	.381	.537	-2.018	337	.044	-.239	.118	-.472	-.006
		Equal variances not assumed			-1.970	94.076	.052	-.239	.121	-.480	.002

Source: SPSS Independent Samples Test, 2021.

The result of the analysis of Table 4.2.2 Two Tailed t- Test for the Analysis of Comparing idea of the two groups, the NMIE vs. Industry in response to the extent of NMIE's contribution of calibration services to the overall performance of the firms above for an item I, Reduce waste, the Levene's test for equality of variances has shown that the p-value of 0.009 is smaller than 5%. Thus, we do reject the equal variances assumed, and consequently, we refer to the result in the 'Equal variances not assumed' row. The p-value is 0.029, which is less than 5% and we do reject the hypothesis of equality of means of the two groups. Thus, there is significant difference in the idea of the two groups in regard to reducing waste.

On the contrary, for Item II, III, IV, V, VI, VIII, and IX the p-value is .845, 0.537, 0.893, 0.173, 0.610, 0.577, and 0.809 respectively which is greater than 5% and we do not reject the hypothesis of equality of means of the two groups for these items. Thus, there is no significant difference in the idea of the two groups in regard to improving the quality of products and/or services, improving productivity, increasing profit to the firm, enhancing the effectiveness of the firm, and increasing acceptance, increasing customer satisfaction and enhance the confidence of the firm. Moreover, for item VII, Increase market share, the Levene's test for equality of variances has shown that the p-value of 0.037 is smaller than 5% and we do reject the equal variances assumed, and consequently, we refer to the result in the 'equal variances not assumed' row. The p-value is 0.169, which is greater than 5% and we do not reject the hypothesis of equality of means of the two groups. Thus, there is no significant difference in the idea of the two groups in regard to reducing waste.

4.3. The Extent of Availability of the necessary Resources (Manpower, Finance & Material) in NMIE

The questionnaire was designed by using the Likert Scale, and the statements were measured on a five-point. Likert Scale with 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree. Moreover, the calculated means are interpreted as; above 4.50 = Strongly Agree, from 3.50 to 4.50 = Agree, from 2.50 to 3.50 = Neutra, from 1.50 to 2.50 = Disagree and below 1.50 is interpreted as strongly disagree. The information obtained from the questionnaires is summarized and discussed in the following manner.

Table 4.3.1: Analysis of the Extent of Availability of the necessary Resources that could promote the Provision of Calibration Service in NMIE by Respondents

S/No	Item		NMIE							Industry							Grand Average	
			1	2	3	4	5	M	SD	1	2	3	4	5	M	SD	M	SD
1	NMIE experts are competent to handle all calibration works	F	1	6	21	32	5	3.52	.83	4	12	62	153	43	3.80	.81	3.66	.82
		%	1.5	9.2	32.3	49.2	7.7			1.5	4.4	22.6	55.8	15.7				
2	NMIE personnel's are keeping professional ethics	F	3	5	29	23	5	3.34	.91	8	12	70	110	74	3.84	.97	3.59	.94
		%	4.6	7.7	44.6	35.4	7.7			2.9	4.4	25.5	40.1	27.0				
3	Equipment to be calibrated is properly Handled by NMIE personnel	F		1	19	33	12	3.86	.73		14	45	132	83	4.04	.82	3.95	.78
		%		1.5	29.2	50.8	18.5				5.1	16.4	48.2	30.3				
4	NMIE covers all calibration demands	F	12	19	21	12	1	2.55	1.05	16	62	92	76	28	3.14	1.06	2.85	1.06
		%	18.5	29.2	32.3	18.5	1.5			5.8	22.6	33.6	27.7	10.2				
5	NMIE services coincide to the time set by the standard	F	2	17	24	17	5	3.09	.98	10	30	100	99	35	3.43	.97	3.26	.98
		%	3.1	26.2	36.9	26.2	7.7			3.6	10.9	36.5	36.1	12.8				
6	NMIE has latest Standards and supporting utilities	F	1	10	25	25	4	3.32	.87	5	14	98	116	41	3.64	.86	3.48	.87
		%	1.5	15.4	38.5	38.5	6.2			1.8	5.1	35.8	42.3	15.0				

7	NMIE assist organizations from loss due to wrong measurement	F	2	5	16	32	10	3.66	.94	2	18	51	136	67	3.91	.87	3.79	.91
		%	3.1	7.7	24.6	49.2	15.4			.7	6.6	18.6	49.6	24.5				
8	NMIE calibration service is accessible to all customers	F	4	11	23	22	5	3.20	1.02	8	25	83	98	60	3.65	1.01	3.43	1.02
		%	6.2	16.9	35.4	33.8	7.7			2.9	9.1	30.3	35.8	21.9				
9	The existing calibration standards of NMIE are meet customer requirements	F	4	12	20	24	5	3.22	1.04	5	13	70	126	60	3.81	.89	3.52	.97
		%	6.2	18.5	30.8	36.9	7.7			1.8	4.7	25.5	46.0	21.9				
10	NMIE calibration cost are fair to all services	F	2	6	17	25	15	3.69	1.03	17	17	66	105	69	3.70	1.10	3.70	1.07
		%	3.1	9.2	26.2	38.5	23.1			6.2	6.2	24.1	38.3	25.2				
Overall Mean								**3.35**							**3.70**			

Where; 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

Source: Data collected by the researcher through Questionnaire, 2021

The result of the analysis of item 1 in Table 4.3.1 shows that seven (10.7%) of the respondents of NMIE rated strongly disagree and disagree on NMIE experts are competent to handle all calibration works; 21 (32.3%) rated neutrally and 37 (56.9%) responded agree and strongly agree. While 16 (5.9%) of the industry respondents rated strongly disagree and disagree on the NMIE's experts are competent to handle all calibration works; 62 (22.6%) rated neutrally and 196 (71.5%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.66, it could be concluded that NMIE experts are sufficiently competent to handle all calibration works to industries.

The result of the analysis of item 2 in Table 4.3.1 shows that eight (12.3%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE personnel are keeping professional ethics; 29 (44.6%) rated neutrally and 28 (43.1%) responded agree and strongly agree. While 20 (7.3%) of the industry respondents rated strongly disagree and disagree on NMIE personnel are keeping professional ethics; 70 (25.5%) rated neutrally and 184 (67.1%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.59, it could be concluded that more or less NMIE personnel are keeping professional ethics is in a fairly good position.

The result of the analysis of item 3 in Table 4.3.1 shows that one(1.5%) of the respondents of NMIE rated disagree on the equipment to be calibrated is properly handled by NMIE personnel and no one rated on strongly disagrees; 19 (29.2%) rated neutrally and 45 (69.3%) responded agree and strongly agree. While 14 (5.1%) of the industry respondents rated disagree on the equipment to be calibrated is properly handled by NMIE personnel and no one rated on strongly disagrees; 45 (16.4%) rated neutrally and 215 (78.5%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.95, it could be concluded that the Equipment to be calibrated is properly handled by NMIE experts is in a satisfactory position.

The result of the analysis of item 4 in Table 4.3.1 shows that 31 (47.7%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE covers all calibration demands of the firm; 21 (32.3%) rated neutrally and 13 (20%) responded agree and strongly agree. While 78 (28.4%) of the industry respondents rated strongly disagree and disagree on the NMIE covers all calibration demands of the firm; 92 (33.6%) rated neutrally and 104 (37.9%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 2.85, it could be concluded that the NMIE covers all calibration demands of the firm is on the more or less intermediate level.

The result of the analysis of item 5 in Table 4.3.1 shows that 19 (29.3%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE's services coincide to the time set by the standard; 24 (36.9%) rated average and 22 (33.9%) responded agree and strongly agree. While 40 (14.5%) of the industry respondents rated strongly disagree and disagree on the NMIE's services coincide to the time set by the standard; 100 (36.5%) rated average and 134 (48.9%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.26, it could be concluded that the NMIE's services coincide with the time set by the standard is in a satisfactory position.

The result of the analysis of item 6 in Table 4.3.1 shows that 11 (16.9%) of the respondents of NMIE rated Strongly Disagree and Disagree on the NMIE's has latest Standards and supporting utilities; 25 (38.5%) rated average and 29 (44.7%) responded Agree and Strongly Agree. While 19 (6.9%) of the Industry respondents rated Strongly Disagree and Disagree on the NMIE has latest Standards and supporting utilities; 98 (35.8%) rated average and 157 (57.3%) responded Agree and Strongly Agree. And since the grand average mean of the two groups of respondents is 3.48, it could be concluded that the NMIE has the latest Standards and supporting utilities are in a fairly good position.

The result of the analysis of item 7 in Table 4.3.1 above shows that 7 (10.8%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE's assist organizations from loss due to the wrong measurement; 16 (24.6%) rated average and 42 (64.6%) responded Agree and Strongly Agree. While 20 (7.3%) of the industry respondents rated strongly disagree and disagree on the NMIE's assist organizations from loss due to the wrong measurement; 51 (18.6%) rated average and 203 (74.1%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.79, it could be concluded that NMIE's assist organizations from loss due to the wrong measurement is in an adequate position.

The result of the analysis of item 8 in Table 4.3.1 shows that 15 (23.1%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE's calibration service is accessible to all customers; 23 (35.4%) rated average and 27 (41.5%) responded agree and strongly agree. While 33 (12%) of the industry respondents rated strongly disagree and disagree on the NMIE's calibration service is accessible to all customers; 83 (30.3%) rated average and 158 (57.7%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.43, it could be concluded that the NMIE's calibration service is accessible to all customers is in a satisfactory position.

The result of the analysis of item 9 in Table 4.3.1 shows that 16 (24.7%) of the respondents of NMIE rated strongly disagree and disagree on the existing calibration standards of NMIE are meeting customer requirements; 20 (30.8%) rated average and 29 (44.6%) responded agree and strongly agree. While 18 (6.5%) of the industry respondents rated strongly disagree and disagree on the existing calibration standards of NMIE are, meet customer requirements; 70 (25.5%) rated average and 186 (67.9%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.52, it could be concluded that the existing calibration standards of NMIE are meeting customer requirements is in a satisfactory position.

Finally, the result of the analysis of item 10 in Table 4.3.1 above shows that eight (12.3%) of the respondents of NMIE rated strongly disagree and disagree on the NMIE's calibration cost are fair to all services; 17 (26.2%) rated average and 40 (61.6%) responded agree and strongly agree. While 34 (12.4%) of the industry respondents rated strongly disagree and disagree on the NMIE's calibration cost are fair to all services; 66 (24.1%) rated average and 174 (63.5%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.70, it could be concluded that NMIE's calibration costs are fair to all services is in an acceptable position.

Furthermore, the majority of the respondents of the NMIE interviewees have positively replied to the entire variable that could affect the resource availability to promote NMIE's calibration services. In contrast, many of the industry interviewees said that there is an inconsistency of results, loss of items, and time-consuming during the measurement of calibration items. This may indicate that the extent of availability of the necessary resources that could promote the provision of calibration service in NMIE needs adjustment. Thus from the analysis of both the quantitative and qualitative data, it could be said that the provision of quality services by NMIE is not sufficient. From this, one can infer that the educational qualifications and the experience of the staff have to be checked and additional training must be considered to enhance the calibration service provision of the NMIE. In general, from the foregoing analyses from Table 4.3.1, it could be seen that the responses from both NMIE and industry respondents showed that the extent of availability of the necessary resources that could promote the provision of calibration service in NMIE needs continuous and serious follow up to address the need of the customer in terms of timely service provision and accessibility of the service.

Table 4.3.2: Two Tailed t- Test for the Analysis of Comparing idea of the two groups, the NMIE vs Industry in response to Availability of Resources

Independent Samples Test											
			Levene's Test for Equality of Variances		t-test for Equality of Means						
			F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
										Lower	Upper
I.	NMIE experts are competent to handle all calibration works	Equal variances assumed	1.772	.184	-2.466	337	.014	-.276	.112	-.497	-.056
		Equal variances not assumed			-2.422	94.745	.017	-.276	.114	-.503	-.050
II.	NMIE personnel are keeping professional ethics	Equal variances assumed	.153	.696	-3.789	337	.000	-.501	.132	-.761	-.241
		Equal variances not assumed			-3.952	101.770	.000	-.501	.127	-.752	-.250
III.	Equipment to be calibrated is properly Handled by NMIE personnel	Equal variances assumed	.089	.766	-1.579	337	.115	-.175	.111	-.393	.043
		Equal variances not assumed			-1.702	106.305	.092	-.175	.103	-.379	.029
IV.	NMIE covers all calibration demands	Equal variances assumed	.219	.640	-3.998	337	.000	-.585	.146	-.873	-.297
		Equal variances not assumed			-4.039	97.834	.000	-.585	.145	-.872	-.297
V.	NMIE services coincide to the time set by the standard	Equal variances assumed	.287	.592	-2.549	337	.011	-.342	.134	-.606	-.078
		Equal variances not assumed			-2.534	96.060	.013	-.342	.135	-.610	-.074
VI.	NMIE has latest Standards and supporting utilities	Equal variances assumed	.021	.884	-2.616	337	.009	-.312	.119	-.547	-.077
		Equal variances not assumed			-2.608	96.327	.011	-.312	.120	-.549	-.075
VII.	NMIE assist organizations from loss due to wrong measurement	Equal variances assumed	2.010	.157	-2.002	337	.046	-.244	.122	-.483	-.004
		Equal variances not assumed			-1.905	91.608	.060	-.244	.128	-.497	.010
VIII.	NMIE calibration service is accessible to all customers	Equal variances assumed	.127	.721	-3.185	337	.002	-.446	.140	-.721	-.171
		Equal variances not assumed			-3.176	96.377	.002	-.446	.140	-.725	-.167
IX.	The existing calibration standards of NMIE are meet customer requirements	Equal variances assumed	4.356	.038	-4.705	337	.000	-.598	.127	-.849	-.348
		Equal variances not assumed			-4.287	87.780	.000	-.598	.140	-.876	-.321
X.	NMIE calibration cost are fair to all services	Equal variances assumed	.240	.624	-.056	337	.955	-.008	.150	-.304	.287
		Equal variances not assumed			-.058	101.741	.953	-.008	.144	-.294	.277

Source: SPSS Independent Samples Test, 2021.

The result of the analysis of Table 4.3.2 Two Tailed t-Test for the analysis of comparing the idea of the two groups, the NMIE vs Industry in response to the availability of resources p-value is greater than 5% and we do not reject the hypothesis of equality of means of the two groups for these items. Thus, there is no significant difference in the idea of the two groups in regard to from I to VIII and for item X. But, on the contrary, for the item IX, Levene's test for equality of variances has shown that the p-value of 0.038 is less than 5%, Thus we do reject the equal variances assumed and consequently, we refer to the result in the 'Equal variances not assumed' row. The p-value is 0.000, which is less than 5% and we do reject the hypothesis of equality of means of the two groups. Thus, there is a significant difference in the idea of the two groups in regard to the existing calibration standards of NMIE are meeting customer requirements.

4.4. The Extent of Stakeholder's Engagement in the Activities being performed by NMIE

The questionnaire was designed by using Likert Scale and the statements were measured on a five-point. Likert Scale with 1 = Very Poor, 2 = Poor, 3 = Satisfactory, 4 = Good, and 5 = Very Good. Moreover, the calculated means are interpreted as; above 4.50 = Very Good, from 3.50 to 4.50 = Good, from 2.50 to 3.50 = Satisfactory, from 1.50 to 2.50 = Poor, and below 1.50 is interpreted as Very Poor. The information obtained from the questionnaires is summarized and discussed in the following manner.

Table 4.4.1: Analysis of the Extent of Stakeholder's Engagement in the Activities being Performed by NMIE according to respondents

S/No	Item		NMIE							Industry							Grand Average	
			1	2	3	4	5	M	Std. D	1	2	3	4	5	M	Std. D	M	Std. D
1	NMIE efforts in identifying relevant stakeholders	F	3	10	20	26	6	3.34	1.0	1	15	100	135	23	3.60	.74	3.47	.87
		%	4.6	15.4	30.8	40.0	9.2			.4	5.5	36.5	49.3	8.4				
2	NMIE efforts in assessing of stakeholders interest	F	4	10	26	20	5	3.18	1.0	1	26	92	121	34	3.59	.84	3.39	.92
		%	6.2	15.4	40.0	30.8	7.7			.4	9.5	33.6	44.2	12.4				
3	NMIE efforts in stakeholders consultation	F	4	8	28	20	5	3.22	.98	3	26	92	132	21	3.52	.81	3.37	.90
		%	6.2	12.3	43.1	30.8	7.7			1.1	9.5	33.6	48.2	7.7				
4	The extent of stakeholder trust on NMIE activities	F	1	10	21	27	6	3.42	.92	7	13	65	141	48	3.77	.88	3.60	.90
		%	1.5	15.4	32.3	41.5	9.2			2.6	4.7	23.7	51.5	17.5				
5	The extent of stakeholder participation on NMIE activities	F	5	12	25	19	4	3.08	1.02	5	15	80	141	33	3.55	.91	3.32	.97
		%	7.7	18.5	38.5	29.2	6.2			1.8	5.5	29.2	51.5	12.0				
6	Extent of coordination and collaboration in the implementation of technical regulations among the regulatory agencies and NMIE	F	1	9	29	20	6	3.32	.89	5	11	53	155	50	3.66	.83	3.49	.86
		%	1.5	13.8	44.6	30.8	9.2			1.8	4.0	19.3	56.6	18.2				

7	Transparency of NMIE activities to stakeholders	F	2	7	21	23	12	3.55	1.02	20	25	115	92	22	3.85	.83	3.70	.93
		%	3.1	10.8	32.3	35.4	18.5			7.3	9.1	42.0	33.6	8.0				
8	Stakeholders interest to assist for existence private calibration laboratory other than NMIE	F	6	10	28	16	5	3.06	1.04	2	12	106	105	49	3.26	.99	3.16	1.02
		%	9.2	15.4	43.1	24.6	7.7			.7	4.4	38.7	38.3	17.9				
9	There is a growing solidarity and mutual support	F	5	10	30	16	4	3.06	.98	5	28	83	122	36	3.68	.84	3.37	.91
		%	7.7	15.4	46.2	24.6	6.2			1.8	10.2	30.3	44.5	13.1				
10	NMIE prioritize stakeholders by interest	F	4	16	23	13	9	3.11	1.12	5	28	83	122	36	3.57	.91	3.34	1.02
		%	6.2	24.6	35.4	20.0	13.8			1.8	10.2	30.3	44.5	13.1				
11	NMIE prioritize stakeholders by influence	F	12	17	20	14	2	2.65	1.11	22	47	115	69	21	3.07	1.02	2.86	1.07
		%	18.5	26.2	30.8	21.5	3.1			8.0	17.2	42.0	25.2	7.7				
12	NMIE communicate its activity in a regular manner	F	1	13	20	24	7	3.35	.98	3	31	72	112	56	3.68	.96	3.52	.97
		%	1.5	20.0	30.8	36.9	10.8			1.1	11.3	26.3	40.9	20.4				
Overall Mean								**3.20**							**3.57**			

Where; Likert Scale 1 = Very Poor, 2 = Poor, 3 = Satisfactory, 4 = Good, and 5 = Very Good.

Source: Data collected by the researcher through Questionnaire, 2021

The result of the analysis of item 1 in Table 4.4.1 shows that 13 (20%) of the respondents of NMIE rated very poor or poor on NMIE efforts in identifying relevant stakeholders; 20 (30.8%) rated satisfactorily and 32 (49.2%) responded good or very good. While 16 (5.9%) of the industry respondents rated very poor or poor on the NMIE efforts in identifying relevant stakeholders; 100 (36.5%) rated satisfactorily and 158 (57.7%) responded good or very good. And since the grand average mean of the two groups of respondents is 3.47, it could be concluded that an NMIE effort in identifying relevant stakeholders is adequate.

The result of the analysis of item 2 in Table 4.4.1 shows that 14 (21.6%) of the respondents of NMIE rated very poor or poor on the NMIE efforts in assessing stakeholders' interest; 26 (40%) rated satisfactorily and 25 (38.5%) responded good or very good. While 27 (9.9%) of the industry respondents rated very poor or poor on NMIE efforts in assessing stakeholders' interest; 92 (33.6%) rated satisfactorily and 155 (56.6%) responded good or very good. And since the grand average mean of the two groups of respondents is 3.39, it could be concluded that an NMIE effort in assessing stakeholders' interest is satisfactory.

The result of the analysis of item 3 in Table 4.4.1 shows that 12 (18.5%) of the respondents of NMIE rated very poor or poor on NMIE efforts in stakeholders consultation; 28 (43.1%) rated satisfactorily and 25 (38.5%) responded good or very good. While 29 (10.6%) of the industry respondents rated very poor or poor on NMIE efforts in stakeholders consultation; 92 (33.6%) rated satisfactorily and 153 (55.9%) responded good or very good. And since the grand average mean of the two groups of respondents is 3.37, it could be concluded that NMIE efforts in stakeholders’ consultation are tolerable.

The result of the analysis of item 4 in Table 4.4.1 shows that 11 (16.9%) of the respondents of NMIE rated very poor or poor on the extent of stakeholder trust in NMIE activities; 21 (32.3%) rated satisfactorily and 33 (50.7%) responded good or very good. While 20 (7.3%) of the industry respondents rated very poor or poor on the extent of stakeholder trust on NMIE activities; 65 (23.7%) rated satisfactorily and 189 (69%) responded good or very good. And since the grand average mean of the two groups of respondents is 3.60, it could be concluded that the extent of stakeholder trust in NMIE activities is agreeable.

The result of the analysis of item 5 in Table 4.4.1 shows that 17 (26.2%) of the respondents of NMIE rated very poor or poor on the extent of stakeholder participation in NMIE activities; 25 (38.5%) rated satisfactorily and 23 (35.4%) responded good or very good. While 20 (7.3%) of the

industry respondents rated very poor or poor on the extent of stakeholder participation in NMIE activities; 80 (29.2%) rated satisfactorily and 174 (63.5%) responded good or very good. And since the grand average mean of the two groups of respondents is 3.32, it could be concluded that the extent of stakeholder participation in NMIE activities is satisfactory.

The result of the analysis of item 6 in Table 4.4.1 shows that 10(15.3%) of the respondents of NMIE rated very poor and poor on the extent of coordination and collaboration in the implementation of technical regulations among the regulatory agencies and NMIE; 29 (44.6%) rated satisfactorily and 26 (40%) responded good or very good. While 16 (5.8%) of the Industry respondents rated very poor or poor; 53 (19.3%) rated satisfactory and 205 (74.8%) responded Good and Very Good. And since the grand average mean of the two groups of respondents is 3.49, it could be concluded that the extent of coordination and collaboration in the implementation of technical regulations among the regulatory agencies and NMIE is satisfactory.

The result of the analysis of item 7 in Table 4.4.1 shows that nine (13.9%) of the respondents of NMIE rated very poor or poor on the transparency of NMIE activities to stakeholders; 21 (32.3%) rated satisfactorily and 35 (53.9%) responded good or very good. While 45(16.4%) of the industry respondents rated very poor and poor; 115 (42%) rated satisfactorily and 114 (41.6%) responded good and very good. And since the grand average mean of the two groups of respondents is 3.70, it could be concluded that the transparency of NMIE activities to stakeholders is adequate.

The result of the analysis of item 8 in Table 4.4.1 shows that 16 (24.6%) of the respondents of NMIE rated very poor or poor on the stakeholders' interest to assist for the existence of private calibration laboratory other than NMIE; 28 (43.1%) rated satisfactorily and 21 (32.3%) responded good or very good. While 14(5.1%) of the Industry respondents rated very poor or poor on the stakeholders' interest to assist for the existence of private calibration laboratory other than NMIE; 106 (38.7%) rated satisfactorily and 154 (56.2%) responded good and very good. And since the grand average mean of the two groups of respondents is 3.16, it could be concluded that the Stakeholder's interest to assist in the existence of a private calibration laboratory other than NMIE is satisfactory.

The result of the analysis of item 9 in Table 4.4.1 shows that 15 (23.1%) of the respondents of NMIE rated very poor or poor on the existence of growing solidarity and mutual support; 30 (46.2%) rated satisfactorily and 20 (30.8%) responded good or very good. While 33 (12%) of the industry respondents rated very poor or poor on the existence of growing solidarity and mutual support; 83 (30.3%) rated satisfactorily and 158 (57.6%) responded good or very good. And since

the grand average mean of the two groups of respondents is 3.37, it could be concluded that the existence of growing solidarity and mutual support is satisfactory.

The result of the analysis of item 10 in Table 4.4.1 shows that 20 (30.8%) of the respondents of NMIE rated very poor or poor on the NMIE's prioritization of stakeholders by interest; 23 (35.4%) rated satisfactorily and 22 (33.8%) responded good or very good. While 33 (12%) of the Industry respondents rated very poor or poor on the NMIE's prioritization of stakeholders by interest; 83 (30.3%) rated satisfactorily and 158 (57.6%) responded good or very good. And since the grand average mean of the two groups of respondents is 3.34, it could be concluded that the NMIE's prioritization of stakeholders by interest is adequate.

The result of the analysis of item 11 in Table 4.4.1 shows that 29 (44.7%) of the respondents of NMIE rated very poor and poor on the NMIE's prioritization of stakeholders by influence; 20 (30.8%) rated satisfactorily and 16 (24.6%) responded good and very good. While 69 (25.2%) of the industry respondents rated very poor and poor on the NMIE's prioritization of stakeholders by influence; 115 (42%) rated satisfactorily and 90 (32.9%) responded good and very good. And since the grand average mean of the two groups of respondents is 3.86, it could be concluded that the NMIE's prioritization of stakeholders by influence is adequate.

Finally, the result of the analysis of item 12 in Table 4.4.1 shows that 14 (21.5%) of the respondents of NMIE rated very poor or poor on the NMIE's communication of its activity in a regular manner; 20 (30.8%) rated satisfactorily and 31 (47.7%) responded good or very good. While 34 (12.4%) of the industry respondents rated very poor or poor on the NMIE's communication of its activity in a regular manner; 72 (26.3%) rated satisfactorily and 168 (61.3%) responded good or very good. And since the grand average mean of the two groups of respondents is 3.52, it could be concluded that the NMIE's communication of its activity in a regular manner is adequate.

On the other hand, the majority of both respondents (NMIE and industries) interviewees replied that stakeholders' engagement in the activities being performed by NMIE is poor, not active, and lack proper knowledge about the role of metrology. In general, from the foregoing analyses from Table 4.4.1 it could be seen that the responses from both NMIE and industry respondents showed that the stakeholders' engagement in the activities being performed by NMIE needs great effort in identification, prioritization, and categorization of the stakeholders by their interest and influence.

Table 4.4.2: Two Tailed t- Test for the Analysis of Comparing idea of the two groups, the NMIE vs. Industry in response to Stakeholders Engagement

Independent Samples Test												
			Levene's Test for Equality of Variances		t-test for Equality of Means							
			F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
										Lower	Upper
I.	NMIE efforts in identifying relevant stakeholders	Equal variances assumed	12.860	.000	-2.375	337	.018	-.260	.110	-.476	-.045
		Equal variances not assumed			-1.966	81.033	.053	-.260	.132	-.523	.003
II.	NMIE efforts in assessing of stakeholders interest	Equal variances assumed	1.017	.314	-3.350	337	.001	-.403	.120	-.640	-.166
		Equal variances not assumed			-3.012	86.701	.003	-.403	.134	-.669	-.137
III.	NMIE efforts in stakeholders consultation	Equal variances assumed	1.057	.305	-2.594	337	.010	-.303	.117	-.533	-.073
		Equal variances not assumed			-2.318	86.244	.023	-.303	.131	-.563	-.043
IV.	The extent of stakeholder trust on NMIE activities	Equal variances assumed	1.908	.168	-2.859	337	.005	-.351	.123	-.593	-.110
		Equal variances not assumed			-2.795	94.232	.006	-.351	.126	-.600	-.102
V.	The extent of stakeholder participation on NMIE activities	Equal variances assumed	.026	.873	-3.673	337	.000	-.471	.128	-.722	-.219
		Equal variances not assumed			-3.413	89.428	.001	-.471	.138	-.744	-.197

VI.	Extent of coordination and collaboration in the implementation of technical regulations among the regulatory agencies and NMIE	Equal variances assumed	.756	.385	-2.947	337	.003	-.341	.116	-.569	-.113
		Equal variances not assumed			-2.826	92.343	.006	-.341	.121	-.581	-.101
VII.	Transparency of NMIE activities to stakeholders	Equal variances assumed	11.207	.001	-2.515	337	.012	-.300	.119	-.535	-.065
		Equal variances not assumed			-2.215	85.142	.029	-.300	.136	-.570	-.031
VIII.	Stakeholders interest to assist for existence private calibration laboratory other than NMIE	Equal variances assumed	.038	.846	-1.434	337	.153	-.198	.138	-.469	.074
		Equal variances not assumed			-1.386	93.113	.169	-.198	.143	-.481	.086
IX.	There is a growing solidarity and mutual support	Equal variances assumed	.042	.839	-5.173	337	.000	-.621	.120	-.857	-.385
		Equal variances not assumed			-4.703	87.609	.000	-.621	.132	-.883	-.359
X.	NMIE prioritize stakeholders by interest	Equal variances assumed	2.696	.102	-3.515	337	.001	-.462	.131	-.720	-.203
		Equal variances not assumed			-3.091	85.049	.003	-.462	.149	-.759	-.165
XI.	NMIE prioritize stakeholders by influence	Equal variances assumed	4.028	.046	-2.971	337	.003	-.427	.144	-.709	-.144
		Equal variances not assumed			-2.828	91.601	.006	-.427	.151	-.727	-.127
XII.	NMIE communicate its activity in a regular manner	Equal variances assumed	.215	.643	-2.475	337	.014	-.329	.133	-.590	-.067
		Equal variances not assumed			-2.450	95.596	.016	-.329	.134	-.595	-.062

Source: SPSS Independent Samples Test, 2021.

The result of the analysis of Table 4.4.2 Two Tailed t-Test for the Analysis of Comparing idea of the two groups, the NMIE vs. Industry in response to Stakeholders Engagement above, for all items except for Item I, VII and XI, the p-value is greater than 5% and we do not reject the hypothesis of equality of means of the two groups for these items. Thus, there is no significant difference in the idea of the two groups in regard to the following items, NMIE efforts in assessing stakeholders interest, NMIE efforts in stakeholders consultation, the extent of stakeholder trust in NMIE activities, The extent of stakeholder participation on NMIE activities, Extent of coordination and collaboration in the implementation of technical regulations among the regulatory agencies and NMIE, Stakeholders interest to assist for existence private calibration laboratory other than NMIE, There is growing solidarity and mutual support, NMIE prioritizes stakeholders by interest and NMIE communicate its activity in a regular manner. But, on the contrary, for items, I, VII, and XI, Levene's test for equality of variances has shown that their p-value is less than 5%. Thus, we do reject the equal variances assumed, and consequently, we refer to the result in the 'equal variances not assumed' row. The p-value is 0.018, 0.029, and 0.006 respectively, which are less than 5% and we do reject the hypothesis of equality of means of the two groups. Thus, there is a significant difference in the idea of the two groups in regard to NMIE efforts in identifying relevant stakeholders, transparency of NMIE activities to stakeholders and NMIE prioritize stakeholders by influence.

4.5. The Major Challenges that Affect the Provision of Calibration Services in NMIE

The questionnaire was designed by using the Likert Scale, and the statements were measured on a five-point. Likert Scale with 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree. Moreover, the calculated means are interpreted as; above 4.50 = Strongly Agree, from 3.50 to 4.50 = Agree, from 2.50 to 3.50= Neutral, from 1.50 to 2.50 = Disagree, and below 1.50 is interpreted as strongly disagree. The information obtained from the questionnaire is summarized and discussed in the following manner.

Table 4.5.1: Analysis of the Major Challenges that Affect the Provision of Calibration Service in NMIE by Respondents

S/No	Item		NMIE							Industry							Grand Average	
			1	2	3	4	5	M	SD	1	2	3	4	5	M	SD	M	SD
1	Inadequate understanding of the NMIE services by the firm	F	4	6	23	25	7	3.38	1.01	20	44	75	114	21	3.26	1.05	3.32	1.03
		%	6.2	9.2	35.4	38.5	10.8			7.3	16.1	27.4	41.6	7.7				
2	Inadequate equipment utilization	F	2	6	23	28	6	3.46	.90	12	54	88	93	27	3.25	1.02	3.36	.96
		%	3.1	9.2	35.4	43.1	9.2			4.4	19.7	32.1	33.9	9.9				
3	Frequent failure of equipment	F	2	18	24	19	2	3.02	.91	38	63	94	65	14	2.83	1.10	2.93	1.01
		%	3.1	27.7	36.9	29.2	3.1			13.9	23.0	34.3	23.7	5.1				
4	Inefficient maintenance activities of equipment	F	2	13	29	18	3	3.11	.89	27	48	95	82	22	3.09	1.09	3.10	.99
		%	3.1	20.0	44.6	27.7	4.6			9.9	17.5	34.7	29.9	8.0				
5	Lack of awareness on quality concepts across the society	F	4	10	16	23	12	3.45	1.15	24	49	77	73	51	3.28	1.21	3.37	1.18
		%	6.2	15.4	24.6	35.4	18.5			8.8	17.9	28.1	26.6	18.6				
6	Lack of motivating factors	F	4	11	15	25	10	3.40	1.13	20	39	77	95	43	3.37	1.13	3.39	1.13
		%	6.2	16.9	23.1	38.5	15.4			7.3	14.2	28.1	34.7	15.7				
7	Inadequate knowledge management	F	5	8	24	26	2	3.18	.97	16	58	87	79	34	3.21	1.09	3.20	1.03
		%	7.7	12.3	36.9	40.0	3.1			5.8	21.2	31.8	28.8	12.4				

8	Inadequate capacity of personnel of NMIE	F	4	11	26	22	2	3.11	.94	19	84	93	57	21	2.92	1.05	3.02	1.00
		%	6.2	16.9	40.0	33.8	3.1			6.9	30.7	33.9	20.8	7.7				
9	The scope of calibration covered by NMIE below expected	F	8	9	16	22	10	3.26	1.24	27	62	89	63	33	3.05	1.16	3.16	1.20
		%	12.3	13.8	24.6	33.8	15.4			9.9	22.6	32.5	23.0	12.0				
10	Lack of experienced personnel on calibration area out of NMIE	F	6	15	11	20	13	3.29	1.28	23	70	75	72	34	3.09	1.16	3.19	1.22
		%	9.2	23.1	16.9	30.8	20.0			8.4	25.5	27.4	26.3	12.4				
11	Lack of skilled personnel on field of metrology	F	7	13	17	20	8	3.14	1.20	21	67	106	45	35	3.02	1.11	3.08	1.16
		%	10.8	20.0	26.2	30.8	12.3			7.7	24.5	38.7	16.4	12.8				
Overall Mean								**3.25**							**3.12**			

Where; Likert Scale 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly

Source: Data collected by the researcher through Questionnaire, 2021

The result of the analysis of item 1 in Table 4.5.1 shows that 10 (15.4%) of the respondents of NMIE rated strongly disagree or disagree on inadequate understanding of the NMIE services by the firm; 23 (35.4%) rated neutrally and 32 (49.3%) responded agree or strongly agree. While 64 (23.4%) of the industry respondents rated strongly disagree or disagree on the inadequate understanding of the NMIE services by the firm; 75 (27.4%) rated neutrally and 135 (49.3%) responded agree or strongly agree. And since the grand average mean of the two groups of respondents is 3.32, it could be concluded that the services provided by NMIE are inadequate for the firms.

The result of the analysis of item 2 in Table 4.5.1 shows that eight (12.3%) of the respondents of NMIE rated strongly disagree or disagree on the inadequate equipment utilization; 23 (35.4%) rated neutrally and 34 (52.3%) responded agree or strongly agree. While 66 (24.1%) of the Industry respondents rated, strongly disagree, or disagree with inadequate equipment utilization; 88 (32.1%) rated neutrally and 120 (43.8%) responded agree or strongly agree. And since the grand average mean of the two groups of respondents is 3.36, it could be concluded that the equipment utilization is inadequate.

The result of the analysis of item 3 in Table 4.5.1 shows that 20 (30.8%) of the respondents of NMIE rated strongly disagree or disagree on the frequent failure of equipment; 24 (36.9%) rated neutrally and 21 (32.3%) responded agree or strongly agree. While 101 (36.9%) of the industry respondents rated strongly disagree or disagree on the frequent failure of equipment; 94 (34.3%) rated neutrally and 79 (28.8%) responded agree or strongly agree. And since the grand average mean of the two groups of respondents is 2.93, it could be concluded that there is the frequent failure of equipment.

The result of the analysis of item 4 in Table 4.5.1 shows that 15 (23.1%) of the respondents of NMIE rated strongly disagree or disagree on the Inefficient maintenance activities of equipment; 29 (44.6%) rated neutrally and 21 (32.3%) responded agree or strongly agree. While 75 (27.4%) of the industry respondents rated strongly disagree or disagree on the inefficient maintenance activities of equipment; 95 (34.7%) rated neutrally and 104 (37.9%) responded agree or strongly agree. And since the grand average mean of the two groups of respondents is 3.10, it could be concluded that the existence of inefficient maintenance activities of equipment.

The result of the analysis of item 5 in Table 4.5.1 shows that 14 (21.6%) of the respondents of NMIE rated strongly disagree or disagree on the lack of awareness on quality concepts across the society; 16 (24.6%) rated neutrally, and 35 (53.9%) responded to agree or strongly agree. While 73 (26.7%) of the industry respondents rated strongly disagree and disagree on the lack of awareness on quality concepts across the society; 77 (28.1%) rated neutrally and 124 (45.2%) responded agree or strongly agree. And since the grand average mean of the two groups of respondents is 3.37, it could be concluded that the existence of lack of awareness on quality concepts across the society.

The result of the analysis of item 6 in Table 4.5.1 shows that 15 (23.1%) of the respondents of NMIE rated strongly disagree or disagree on the lack of motivating factors; 15 (23.1%) rated neutrally, and 35 (53.9%) responded to agree and strongly agree. While 59 (21.5%) of the industry respondents rated strongly disagree and disagree on the lack of motivating factors; 77 (28.1%) rated neutrally and 138 (50.4%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.39, it could be concluded that the lack of motivating factors in NMIE.

The result of the analysis of item 7 in Table 4.5.1 shows that 13 (20%) of the respondents of NMIE rated strongly disagree and disagree on the inadequate knowledge management; 24 (36.9%) rated average and 28 (43.1%) responded agree and strongly agree. While 74 (27%) of the industry respondents rated strongly disagree and disagree on the inadequate knowledge management; 87 (31.8%) rated average and 113 (41.2%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.20, it could be concluded that NMIE's knowledge management is inadequate.

The result of the analysis of item 8 in Table 4.5.1 shows that 15 (23.1%) of the respondents of NMIE rated strongly disagree or disagree on the inadequate capacity of personnel of NMIE; 26 (40%) rated average and 24 (36.9%) responded agree or strongly agree. While 103 (37.6%) of the industry respondents rated strongly disagree or disagree on the inadequate capacity of personnel of NMIE; 93 (33.9%) rated average and 78 (28.5%) responded agree or strongly agree. And since the average mean of the two groups of respondents is 3.02, it could be concluded that the capacity of personnel of NMIE is inadequate.

The result of the analysis of item 9 in Table 4.5.1 shows that 17 (26.1%) of the respondents of NMIE rated strongly disagree or disagree on the scope of calibration covered by NMIE below expected; 16 (24.6%) rated average and 32 (49.2%) responded agree or strongly agree. While 89 (32.5%) of the industry respondents rated strongly disagree and disagree on the scope of calibration covered by NMIE below expected; 89 (32.5%) rated average and 96 (35%) responded agree or strongly agree. And since the average mean of the two groups of respondents is 3.16, it could be concluded that the scope of calibration covered by NMIE is below expected.

The result of the analysis of item 10 in Table 4.5.1 shows that 21 (32.3%) of the respondents of NMIE rated strongly disagree or disagree on the lack of experienced personnel on calibration area out of NMIE; 11 (16.9%) rated average and 33 (50.8%) responded agree and strongly agree. While 93 (33.9%) of the industry respondents rated strongly disagree and disagree on the lack of experienced personnel on calibration area out of NMIE; 75 (27.4%) rated average and 106 (38.7%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.19, it could be concluded that the existence of lack of experienced personnel on the calibration area out of NMIE.

Finally, the result of the analysis of item 11 in Table 4.5.1 shows that 20 (30.8%) of the respondents of NMIE rated strongly disagree or disagree on the lack of skilled personnel in the field of metrology; 17 (26.2%) rated average and 28 (43.1%) responded agree and strongly agree. While 88 (32.2%) of the industry respondents rated strongly disagree and disagree on the lack of skilled personnel in the field of metrology; 106 (38.7%) rated average and 80 (29.2%) responded agree and strongly agree. And since the grand average mean of the two groups of respondents is 3.08, it could be concluded that the existence of lack of skilled personnel in the field of metrology.

On the other hand, the majority of the respondents of the industry interviewees replied the existence of problems related to the scope of calibration, accredited certificate, and timely response. This may indicate that some challenges that affect the provision of calibration services in NMIE have also affect the development of industries. In general, from the foregoing analyses from Table 4.5.1 it could be seen that the responses from both NMIE and industry respondents showed some challenges that affect the provision of calibration services in NMIE have also affect the development of industries needs continuous and serious follow up.

Table 4.5.2: Two Tailed t- Test for the Analysis of Comparing idea of the two groups, the NMIE vs. Industry in response to Major Challenges

Independent Samples Test												
			Levene's Test for Equality of Variances		t-test for Equality of Means							
			F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
										Lower	Upper
1	Inadequate understanding of the NMIE services by the firm	Equal variances assumed	.537	.464	.845	337	.399	.122	.144	-.162	.406
		Equal variances not assumed			.867	99.697	.388	.122	.141	-.157	.401
2	Inadequate equipment utilization	Equal variances assumed	1.889	.170	1.518	337	.130	.210	.138	-.062	.481
		Equal variances not assumed			1.640	106.604	.104	.210	.128	-.044	.463
3	Frequent failure of equipment	Equal variances assumed	4.994	.026	1.249	337	.213	.183	.147	-.105	.472
		Equal variances not assumed			1.400	112.570	.164	.183	.131	-.076	.443
4	Inefficient maintenance activities of equipment	Equal variances assumed	4.132	.043	.138	337	.890	.020	.145	-.266	.306
		Equal variances not assumed			.157	114.658	.876	.020	.128	-.234	.274
5	Lack of awareness on quality concepts across the society	Equal variances assumed	.374	.541	.977	337	.329	.161	.165	-.164	.487
		Equal variances not assumed			1.010	100.682	.315	.161	.160	-.156	.479
6	Lack of motivating factors	Equal variances assumed	.008	.927	.178	337	.859	.028	.156	-.279	.334
		Equal variances not assumed			.178	96.686	.859	.028	.156	-.281	.337
7	Inadequate knowledge management	Equal variances assumed	2.687	.102	-.159	337	.874	-.023	.147	-.313	.267
		Equal variances not assumed			-.171	106.290	.864	-.023	.137	-.295	.248
8	Inadequate capacity of personnel of NMIE	Equal variances assumed	1.511	.220	1.353	337	.177	.192	.142	-.087	.470
		Equal variances not assumed			1.448	105.288	.151	.192	.132	-.071	.454
9	The scope of calibration covered by NMIE below expected	Equal variances assumed	1.692	.194	1.324	337	.186	.214	.162	-.104	.532
		Equal variances not assumed			1.267	92.112	.208	.214	.169	-.122	.550
10	Lack of experienced personnel on calibration area out of NMIE	Equal variances assumed	3.358	.068	1.252	337	.211	.205	.164	-.117	.526
		Equal variances not assumed			1.177	90.448	.242	.205	.174	-.141	.550
11	Lack of skilled personnel on field of metrology	Equal variances assumed	2.619	.107	.750	337	.454	.117	.155	-.189	.422
		Equal variances not assumed			.715	91.818	.476	.117	.163	-.207	.440

Source: SPSS Independent Samples Test, 2021.

The result of the analysis of Table 4.5.2, Two Tailed t-Test for the analysis of comparing the idea of the two groups, the NMIE vs. industry in response to major challenges above the Levene's test for equality of variances for the item III and IV have shown that their p value Two-Tailed is less than 5%. Thus, we do reject the equal variances assumed, and consequently, we refer to the result in the 'equal variances not assumed' row. The p-value is 0.164 and 0.876 respectively, which are greater than 5% and we do not reject the hypothesis of equality of means of the two groups. Moreover, for other items in the same table, Levene's test for equality of variances showed that their p-value was greater than 5%. Therefore, we do not reject the hypothesis of equality of means of the two groups for these items. Thus, there is no significant difference in the idea of the two groups.

On the other hand many of the industry interviewees said that there is problem on accuracy of result during measurement of calibration items. Thus from the analysis of both the quantitative and qualitative data it could be said that there are challenges that affect the provision of calibration services in NMIE.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

This chapter presents the summary of the quantitative and qualitative data analysis and interpretation in the previous chapter, conclusions and recommendations are presented. It also discusses the extent to which this study has achieved its objectives and areas of further research.

5.1. Summary

The major findings of the study were to assess the existing practice and challenges of calibration service provision in the case of the National Metrology Institute of Ethiopia.

5.1.1. NMIE's Contribution to the overall Performance of the Firms

The study was aimed to show NMIE's contribution towards organizational performance. Based on the analysis, it can be concluded that the NMIE calibration services help the industries in their reduction of wastes, in improving the quality of products and/or services, and improving the productivity of the industries. Moreover, it can be seen that without NMIE calibration services it could be difficult for the industries to realize customer satisfaction, increase their market share, and for the overall effectiveness & efficiency of the company. In general NMIE's contribution has paramount importance in the overall industrial performance.

5.1.2. Availability of the necessary Resources that could promote the Provision of Calibration Services in NMIE

Regarding to the availability of resource, the analysis indicated that equipment handling by the NMIE personnel is inefficient and improper that could have its own negative effect on resource management. On top of that, the calibration services to satisfy the customer demand in terms of coverage, accessibility, and timely provision of the service are hugely lagging behind the standard plan. These findings are self-assertive to conclude that the availability and management of the resource are poor and found at a rudimentary level, which needs to be improved much.

5.1.3. Stakeholder's Engagement in the Activities being performed by NMIE

The result showed that there was a satisfactory effort paid by NMIE in the identification of relevant stakeholders. However, assessing their interest and effort in conducting their consultation is found at a low level as is explained by NMIE respondents.

The study showed that trust development by the stakeholders and their participation in NMIE activities are found on good ground as is explained by the industry respondents. In a similar way, they asserted that there were good collaboration and cooperation between the regulatory and NMIE.

It can be seen that the prioritization of stakeholders' interest by NMIE is adequately practiced as explained by the NMIE respondents.

The findings of the study showed that the contribution of stakeholders' engagement in the activities being performed by NMIE to the selected industries needs attention.

5.1.4. The Major Challenges that Affect the Provision of Calibration Services in NMIE

In the analysis of challenges on the calibration services, NMIE respondents claimed that equipment utilization at NMIE, societal awareness on quality issues, and motivation mechanisms are major challenges identified by the study. The failure of equipment maintenance activities, knowledge management, and the capacity of calibration personnel were not big challenges that could affect NMIE activities.

5.2. Conclusion

This section provides the conclusion that is inferred from the result of empirical exploration conducted to know the existing practice and challenges of calibration service in the case of the National Metrology Institute of Ethiopia.

NMIE needs to develop the right skill for managing the industry's needs. These can be done through developing work ethic, creating good communication, enhancing customer service strategy, and making ready to adapt to the ever-changing changing needs of the industry properly. The study shows that there exist limited services within the NMIE due to the limited scope of calibration services. To increase the service coverage, NMIE needs to study and analyse the existing and future demand of the customer to increase the coverage of the services in the field of metrology. NMIE also face a lack of qualified human resource on the technical activities, which can be associated with no local higher training centres that produce skilled manpower in the field of metrology. The majority of respondents were agreed that there are low-quality concepts across society. This shows that there is a need for the participatory approach and education to increase understanding of NMIE services by the firm and the society at large. The provision of NMIE supports to bring product quality and compatibility need to be improved in its scope and quality to address the demand both for the NMIE and for the industry. The global experience shows that

when there is development and growth in an industry, the demand for the provision of capable calibration services will increase, which in turn attracts private investments and therefore the government should facilitate and encourage the private sector to provide the calibration services.

5.3. Recommendation

On the existing practice and challenges of calibration service in the case of the National Metrology Institute of Ethiopia, the study effectively identifies and tries to address some of the major problems and is able to recommend improvement strategies. Based on the research findings, the following possible recommendations are forwarded to all the concerned bodies.

5.3.1. Recommendation to NMIE

- NMIE's Contribution to Metrological activities such as the provision of reliable and accurate measurement results need to be continually improved for achieving better performance of a firm. This could be realized through keeping sustainable Measurement traceability to the SI system, enhancing metrological infrastructure, and establishing a resident Metrological system in the country. Moreover, conducting continuous follows upon the integration of Firms and NMIE activities, as well as in falling a feedback mechanism could help to see opportunities and challenges on the achievement of their performance.
- It is suggested that NMIE needs to deal with higher educational institutions and training centres to include the field of metrology in their field of studies. This will help NMIE to get skilled personnel in the area of metrology which is subjected to frequent technological changes.
- The most important thing to Collaboration between the international and the national experts is an effective and sustainable way to achieve know-how transfer. International recognition in the field of laboratories and inspection to get accreditation through ILAC and recognition in the fields of management systems, products, services, and personnel assessment through IAF is needed to be sought by the NMIE.
- It is suggested that NMIE needs to upgrade the competence of technical personnel, to perform calibration works even high precision equipment, to properly handle equipment to be calibrated;
- NMIE need to Monitor and regulate the ethics of personnel in a regular manner;

- It's generally advisable to assess the scope and size of calibration especially on medical equipment and new technologies that enter the country, calibration demands, and services coincide to the time set by the standard, the accessibility of calibration service to all customers, the existing calibration standards of NMIE to meet customer requirements.
- Since calibration and most of the quality-related questions are presented on a voluntary basis it is advisable to create awareness to increase stakeholder participation.
- The NMIE need to build institutional capacity through support and recommend suitable governance, this can be achieved through involving outstanding industrialist at the strategic management level.
- It is recommended that NMIE needs work to promote employee satisfaction and to increase workers' commitment level through the provision of a positive working environment and implementing a system of reward and recognition.
- Since no experienced personnel in the metrology area are found in the local market, NMIE needs to work on developing the skills and knowledge of the workforce and conduct a continuous evaluation and measure of job satisfaction.
- NMIE needs to create a favourable environment in transferring knowledge and best practices of quality infrastructure systems through devising different training schemes both in the country and outside.
- NMIE needs to understand that the on-going changes in how quality institution systems work internationally require the constant upgrading of professional knowledge. In this regard good practice is to conduct and participate in a regular international conference to exchange best practices among experts in the field of quality infrastructure development is desirable.

5.3.2. Recommendation to Future Research

The result now provides evidence to show that there are some forms of challenge in the calibration service provision as is indicated in the analysis part. Therefore, for better understanding of the implication of the result of this study, future studies could address the challenge & opportunities of calibration services by comparing with other industrialized nation.

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APPENDICES

A. QUESTIONNAIRE

ST. MARY'S UNIVERSITY SCHOOL OF GRADUATE STUDIES

INSTITUTE OF QUALITY AND PRODUCTIVITY MANAGEMENT

DEPARTMENT OF QUALITY AND PRODUCTIVITY MANAGEMENT

This *questionnaire* is filled by both groups of selected respondents from NMIE and Industry

Dear Respondent:

This questionnaire is designed to collect information regarding to the factors that shows **the existing practice and challenges of calibration service in the case of National Metrology Institute of Ethiopia**. The study also will contribute towards the fulfillment of the researcher's Degree of Masters of Science Degree in Quality and Productivity Management (QPM).

I kindly ask you in all regard to fill the questionnaire carefully at your best knowledge.

The accuracy of information you provide determines the ultimate reliability of the study.

Note: Your answers will be strictly confidential and will only be used for academic purposes.

Contact Address: Feyissa Worku Tel: +251 911 676 557, +251 923 700 756

E-mail; feyissawm@gmail.com; Addis Ababa, Ethiopia.

Thank you in advance for your cooperation and timely response!

Part One: Demographic Information - Please put an 'X' in the box

1.1. Your Sex:

Male		Female	

1.2. Your Age Group:

18-25		26-35		36-45		46-55		>55	

1.3. Your Educational Status:

Grade 12 Complete		Diploma		First Degree		Second Degree and above	

If other, please specify

_____

1.4 Your organization:

1.5. Your service year in the organization you are working in?

0-5		6-10		11-15		>15	

Part Two:

Instruction:

Answering these questions helps to understand the extent of calibration service provided by NMIE contribute to overall performance of the firm in the selected sectors and able to assist them in product and service quality

Please indicate your answer by writing 'X' in the respective column using the following rating scale?

Where: 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

S/No	Statement	Rating				
		1	2	3	4	5
1	Reduce waste					
2	Improve quality of product and/or service					
3	Improve productivity					
4	Increase profit to the firm					
5	Enhance effectiveness of the firm					
6	Increase Acceptance					
7	Increased market share					
8	Increase customer satisfaction					
9	Enhance confidence of the firm					

Part Three:

Instruction:

Answering these questions can help the researcher to answer the question on the extent of availability of the necessary resources (manpower, finance & material) that could promote the provision of calibration services in NMIE.

Please show the extent of your agreement on the statements by writing 'X' in the respective column using the following rating scale?

Where: 1 = Strongly Disagree 2 = Disagree 3 = Neutral 4 = Agree 5 = Strongly Agree

S/No	Statement	**Rating**				
		1	2	3	4	5
1	NMIE experts are competent to handle all calibration works					
2	NMIE personnel's are keeping professional ethics					
3	Equipment to be calibrated is properly Handled by NMIE personnel.					
4	NMIE covers all calibration demands					
5	NMIE services coincide to the time set by the standard					
6	NMIE has latest standards and supporting utilities					
7	NMIE assist organizations from loss due to wrong measurement					
8	NMIE calibration service is accessible to all customers					
9	The existing calibration standards of NMIE are meet customer requirements					
10	NMIE calibration cost are fair to all services					

Part Four:

Instruction:

Answering these questions can help the researcher to answer the question on the extent of stakeholder's engagement in the activities being performed by NMIE.

Please indicate your answer by writing 'X' in the respective column using the following rating scale?

Where: 1 = Very Poor 2 = Poor 3 = Satisfactory 4 = Good 5 = Very Good

S/No	Statement	**Rating**				
		1	2	3	4	5
1	NMIE efforts in identifying relevant stakeholders					
2	NMIE efforts in assessing of Stakeholders' interest					
3	NMIE effort in stakeholder consultation					
4	The extent of stakeholder trust on NMIE activities					
5	The extent of stakeholder Participation on NMIE activities					
6	Extent of coordination and collaboration in the implementation of technical regulations among the regulatory agencies and NMIE.					
7	Transparency of NMIE activities to stakeholders					
8	Stakeholders interest to assist for existence private calibration laboratory other than NMIE					
9	There is a growing solidarity and mutual support					
10	NMIE prioritize Stakeholders by Interest.					
11	NMIE prioritize Stakeholders by Influence.					
12	NMIE communicate its activity in a regular manner.					

Part Five:

Instruction:

Answering these questions can help the researcher to answer the question on the major challenges that affect the provision of calibration services in NMIE.

Please indicate your answer by writing 'X' in the respective column using the following rating scale?

Where: 1= strongly dis agree, 2= disagree, 3= Neutral, 4= agree, 5= strongly agree

S/No	Statement	**Rating**				
		1	2	3	4	5
1	Inadequate understanding of the importance of the NMIE services by the firms					
2	Inadequate equipment utilization					
3	Frequent failure of equipment					
4	Inefficient maintenance activities of equipment					
5	Lack of awareness on quality concepts across the society					
6	Lack of motivating factors					
7	Inadequate knowledge management					
8	Inadequate capacity of personnel of NMIE					
9	The scope of calibration covered by NMIE is below expected					
10	Lack of experienced personnel on calibration area out of NMIE					
11	Lack of skilled personnel on field of metrology					

B. INTERVIEW GUIDES

This interview question is filled by senior experts and management group of both the respondents from NMIE and industries. The answer from the question helps the researcher to understand the overall performance of the NMIE, which is the basic question of this study.

1) What is the organizational performance that NMIE contribute to the firm?

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2) How do you evaluate the resource allocation of NMIE in the provision of calibration services? -

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3) How do you describe the stakeholder engagement in NMIE activities?

N.B: For non NMIE Respondents only;

4) Describe what your organization is doing and what is your interest from NMIE?

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5) Do all your needs of calibration service satisfied locally by NMIE? 1. Yes 2. No

6) If the answer to question No 5 above is "No" please mention the calibration service which NMIE couldn't provide ----------

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Thank you for giving your precious time! Stakeholder trust on NMIE activities

C. ANALYSIS OF INTERVIEW DATA

In order to enrich the data and gather further information, interview were conducted with twenty senior expert and management of both the industry and the NMIE respondents. Their response to the questions is tabulated as follow:

No.	Interview Questions	Response	
		NMIE	**Industry**
1	What is the organizational performance that NMIE contribute to the firm?	Adds Value, Limited scope	Calibration service,add value,acceptance,customer satisfaction, increase profit
2	How do you evaluate the resource allocation of NMIE in the provision of calibration services?	Inadquate,fair, shortage of standards	Late response,inadequate,good, no enough mobile laboratory,
3	How do you describe the stakeholder engagement in NMIE activities?	Not active, Poor, lack proper knowledge about the role of metrology	Good,poor, no close coopration, training, consultancy,
For Non NMIE Respondents only			
4	Describe what your organization is doing and what is your interest from NMIE?	Accridited Certificate, timely response,	
5	Do all your needs of calibration service satisfied locally by NMIE?	Partly no	

6	If the answer to question No 5 above is "No" please mention the calibration service which NMIE couldn't provide	▪ **Dimensional Lab;** Angle,Refractometer, Microscope ▪ **Electrical, Time and Frequiency Lab**; High voltage,power factor, spectrometer, speed,time,soldering machine,GSM Network signal testing machine patterngenerator device, photometry, Luminous flux ▪ **Mechanical Lab;** Accredited Certificate of Force, Abrasion tester, Pressure Gauge with 5000 psi,Turbidity metre, Alcolizer(OG,Ea,AOF,Er), CTPO-CO2, Schimidist Hammer ▪ **Temperature and Chemical Lab;**Temperature 1200-1800c, PH-meter,conductivity, Bomb calorimeter, chemistry machine, CBC, TDS, calorometer, IR 500-1100c ▪ **SSDL**;X-ray Flourecence, , Ultrasound