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Technology Transfer as a Vehicle for Industrial Development Case of Basic Metals and Engineering Industries

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Abstract

Technology played a prominent role in satisfying social demand throughout the human history resulting in today's human development. It is one of the most important and powerful instrument that leads to improved standards of living by reducing poverty. Furthermore, the importance of technology to domestic economic development has been widely recognized and become the main strategy for competition between nations. Technology has made a huge impact on many nation's economies and societies through technology transfer, which is regarded as an essential step for technology advancements.

The objective of the research is to show direction of how industrial development can bring through coordinated and integrated transfer of technology, which leads to sustainable social and economic development in Ethiopian industries. To conduct this research, various related literatures have been reviewed both published and unpublished. It has also been reviewed the practice of China, Korea, Malaysia, Singapore, Brazil and South Africa and practice of technology transfer in Ethiopia since 1400 G.C. Furthermore, surveys on basic metals and engineering industries, international technical assistant agencies, government enterprises and institutions have been made. Moreover, ratio of imported to total raw material cost, percentage distribution of value added, and employment contribution of BMEIs have been analyzed by considering the past 14 successive years.

Review of socioeconomic development paths of the NICs of East Asian countries revealed that their initial conditions in early 1960s as being similar to many of the African countries. However, their rapid and successful transformation into industrialized economies through "free riding" technology transfer system based on the scientific, and technological knowledge base developed by the industrialized countries have contributed for their rapid technological development.

Ethiopia has a remarkable record of achievement of a two digit economic growth for the last five consecutive years. However, the contribution from the industrial sector remains minimal. To ensure the sustainable economic and social development of the country in today's competitive world, building technological capability of the industry is critical. This could be achieved through well organized and coordinated technology transfer system based on the need of the industry and society.

Most of the imported technologies to the country in the past had failed to be adopted, improved, re-engineered, and disseminated to other similar industries at the desired level, especially in BMEIs.

Ethiopian Basic Metals and Engineering Industries (BMEIs) are facing various challenges. Most of all, the challenges related to technology seriously affect the product development, profile versatility and quality of the product in terms of geometrical fitness and required properties. Moreover, the product profile and technological process are being stagnant. The country BMEIs have been engaged in low value addition activities. Therefore, there is no opportunity to develop new technology that enhance the capital income of the industries in particular and the nation as a whole.

As the research shows, besides the above mentioned challenges the industries are also suffering due to: low productivity caused by old technologies and inadequate attention given to their improvement and development; inadequate support and facilities for research and development activities ; lack of fully assimilating or internalizing the technologies and hence not using them to full extent; limited diffusion of knowledge within the country; lack of coordination, implementation, evaluation and controlling mechanism across the stakeholders.

Therefore, the researcher proposed various solutions that would enable technology transfer to BMEIs in particular and to the country at large. The proposed solutions mainly focus on technology policy, technical development of higher institutes, practical oriented Science and Technology Education, coordinate participation of the stakeholders, applied R&D, University-Industry linkage, establishment of Basic Metals and Engineering Industries Technology Transfer and Innovation Centre (BMETTIC) and Technology Incubation Centre.

Key words:- Technology, Technology Transfer, Technological Capability, Basic Metals and Engineering Industries.

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List of Acronyms

AAU	Addis Ababa University
ADLI	Agricultural Development-Led Industrialization
ATTIC	Agricultural Technology Transfer and Innovation Center
BME	Basic Metal and Engineering
BMEI	Basic Metal and Engineering Industries
BMEIA	Basic Metals and Engineering Industry Agency
ECBP	Engineering Capacity Building Program
ECSA	Ethiopian Central Statistical Agency
EDTC	Engineering Design and Tools Center
EIA	Ethiopian Investment Agency
EIAR	Ethiopian Institute of Agriculture Research
EIPO	Ethiopian Intellectual Property Office
EPRDF	Ethiopian People's Revolutionary Democratic Front
ESTA	Ethiopian Science and Technology Agency
FDI	Foreign Direct Investment
FDRE	Federal Democratic Republic of Ethiopia
GDP	Gross Domestic Product
GiZ	Gesellschaft für Internationale Zusammenarbeit
GNP	Gross National Product
GTP	Growth and Transformation Plan
HRD	Human Resource Development
ICTSD	International Centre for Trade and Sustainable Development
IDZ	Industrial Development Zones
IOE	Investment Office of Ethiopia
IPR	Intellectual Property Right
ITK	Indigenous Technology and Knowledge
JICA	Japan International Cooperation Agency
JV	Joint Venture
LIDI	Leather Industry Developments Institute
METEC	Metal Engineering Corporation
METTIC	Metal and Engineering Technology Transfer and Innovation Center
MIBIC	Mekelle Information Communication Technology Business Incubation Center

MIDI	Metal Industry Development Institute
MNC	Multi National Corporation
MoFED	Ministry of Finance and Economic Development
MoST	Ministry of Science and Technology
NBE	National Bank of Ethiopia
NIC	Newly Industrialized countries
Niko	National Indigenous Knowledge System Office
NPRP	National Priority Research Programs
NSTB	National Science and Technology Board
NTB	National Technology Board
PASDEP	Plan for Accelerated and Sustained Development to End Poverty
PRIC	Public Research Institutes and Centers
R&D	Research and Development
SDI	Spatial Development Initiatives
SME	Small and Medium Enterprises
STI	Science, Technology and Innovation
TBI	Technology Business Incubation
TFILU	Technology Faculty – Industry Linkage Unit
TIC	Technology Incubation Center
TIDI	Textile Industry Development Institute
TTO	Technology Transfer Office
TVET	Technical and Vocational Education and Training
UICP	University-Industry Cooperation Program
UIL	University-Industry Linkages
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Program
UNIDO	United Nations Industrial Development Organization
UTT	University Technology Transfer

Chapter One

Problems and their Approach

1.1. Introduction

Technology played a prominent role in satisfying social demand throughout the human history resulting in the today's human development. It is one of the most important and powerful instrument that leads to improved standards of living by reducing poverty from the society. Furthermore, the importance of technology to domestic economic development has been widely recognized and become the main strategy for competition across nations [1]. With the rise in knowledge-based economies and the fast pace of technological development worldwide, there is a growing trend to develop advanced technologies. Accompanied by economic globalization, the rising trend of globalization in technology enables the rational allocation, and flow of the elements of technology without restrictions. This also allows the sharing of technological activities and the space flow of technology more frequently. Hence, in the last two decades, technology gained more recognition than it had before. The recognition was accompanied by realizing that technology is a significant factor in the industrialization and maintenance of international competitive advantage of a country [2].

People's understanding of technology is diverse, and the definitions of technology are varied too. Diderot, a distinguished scholar, enlightened thinker, materialist philosopher, and education theorist, in France in the eighteenth century, gave a concise definition of technology in the *Encyclopedia*: "technology is varieties of tools and rules system that is collaborated for a common purpose." Some scholars also define technology on the basis of its purposes, components and functions. It has been pointed out that technology can be described in different ways: first, technology is the realization of resources into products or services; second, technology includes knowledge and resources, which can help to reach established goals; and third, technology is an entity of science and engineering, which can be used in production processes and product designs, and also in the exploration to gain new knowledge. Li Ping considered technology as an effective means used by people to engage in various economic activities in spite of scarce resources, and the extension of technology includes products, processes, human resource, and organizations [3]. Huang Jingbo holds that technology is a combination of knowledge, methods, skills, and special know-how that is used by humans in understanding and utilizing nature [4].

However, for the purpose of this research, the researcher uses the definition of technology as a system of all equipments of solid tools, skills, knowledge, expertise, means, methods and procedures used to produce, utilize and manage goods and services that satisfy social demand. Basically, technology is a kind of systematic expertise associated with production processes of goods and services, and is a combination of the means, methods and skills created and developed by humans to realize the needs of society.

There is a misconception of identifying technology as machinery or equipment. However, it is the means, capability and knowledge of how to do things to accomplish human goals. Therefore, it is a combination of equipment and knowledge. Equipment encompasses all kinds of tools, vehicles, machinery, buildings etc. Technological knowledge covers all kinds of skills such as process and product know-how, institutional and organizational know-how and information, and knowledge about equipment. Given a certain configuration of equipment and knowledge, it is knowledge that leads to the creation of new equipment and the acquisition of further knowledge. Of the two components, knowledge is therefore the most decisive factor. Since knowledge is embodied in human beings, development of technological capacity means, increasing the number of people with technological knowledge and improving their level of knowledge [5,6].

The basic characteristics of technology include purpose, sociality, and pluralism. Any new technology arises for a purpose, and the purpose of that technology runs through the entire process of technical activities. Hence, modern technology has strong utility and commercial features. The sociality of technology is highly related to its collaboration for a community, and power for transforming the society to the desired level. Regardless of its contribution, technology is subjected to variety of social factors. These social factors directly affect the success of technology and the development process. The pluralism of technology ensures that it can be expressed not only as tools for tangible equipment, machinery, entity material, and other hardware; but also as processes, methods, rules, and other knowledge, as well as information and design drawings that are not material entities with themselves, but material carriers of other manifestations [2].

Technology has made a huge impact on economies and societies through technology transfer, which is regarded as an essential step for technology to have a social and an economic value. Technology transfer has been given considerable importance in Newly Industrialized Countries (NICs), as it is the key for improving core competence, fundamental for the implementation and transfer of technological innovations to production. Technology transfer has been the weak link in establishing a national innovation system and a great handicap for improving the self-innovation abilities of businesses because of the lack of proper mechanisms, regulations, and policies. To promote knowledge flow and technology transfer, and to explore and improve the effective mechanism of technology transfer, it is important to fully utilize governments, colleges and scientific institutions.

It is important to be aware of technology transfer as it is far more complex than simply moving technology from one place to another. Different researchers and academicians give different meaning for technology transfer. The traditional definition of technology transfer is entirely associated to the transfer of hardware objects and this is a misconceived idea. However, technology transfer could often involve knowledge transfer that may be completely devoid of any hardware aspect of a technology. For example, the Work Regulations of the United Nations defined technology transfer as the transfer of a systematic knowledge for manufacturing of a product or for a provision of a service [8]. Technology transfer could also be defined as the transfer of skills and technical know-how, as well as the transfer of machinery and other capital equipment [9].

Hence, the concept of technology transfer is the purposive movement of established technology in one context when implemented in a different cultural, economical, and technological context. A technology is said to be transferred, when the recipient understands and knows the technology deep enough to use, adapt, modify or adjust it, until it begins to spread within the recipient economy [10]. The movement of technology often affected by the unplanned initiation process which is referred as diffusion of technology rather than transfer of technology.

Therefore, technology transfer doesn't mean merely transporting a machine from one place to another place, but the useful transfer must be accompanied by sensible and rational selection, assimilation and absorption on the part of recipients. Further, the processes should be extended to the creation of indigenous technologies. That means, technology transfer is not quite useful unless it helps the recipient to promote the technology for next generation.

From the above analysis and considerations, the researcher defined technology transfer for this research as the movement of physical hardware, skills, knowledge, experience and technology embodied or disembodied with the hardware from where it has been developed (Developed countries and domestic Research and Development (R&D) institutions) to the receiver enterprises, institutions, industries, and it will only complete when the receiver enterprises/institutions succeed in innovative activities (i.e., creation, adoption and adaption of those technologies). Therefore, technology transfer process includes innovation and commercialization that make it complete.

In recent years, technology transfer has got great attention and has often been spoken loud as a means of knowledge transfer. The flow of technical know-how from the developed world to developing countries, with limited research and development activities could to take out from the long existing technological gap persisting in them. The experiences of some successful East-Asian newly industrialized countries also ascertain that the acquisition of a significant amount of foreign technology plays a major role, in the move to catch up the developed world. Hence, technology transfer could be helpful in promoting the managerial and technical expertise skills, besides its importance in improving the productivity level through the adoption of a set of appropriate policies, strategies, processes and technologies, especially for developing countries like Ethiopia.

In general, there is widespread consensus that technological development is the solution to many of the industrial problems. It is the main way through which developing countries could comes out of poverty and backwardness. Industry is believed to create the best conditions for the efficient functioning of an economy, thereby maximizing national income and speeding up economic growth through enhanced capacity for domestic savings.

The aim of industrial development is to raise peoples' standard of living by increasing the domestic production of consumer, intermediate and capital goods, thereby raising income, markets, technology and employment. Therefore, technology transfer is one of the catalysts that help to bring industrialization in Ethiopia.

1.2. Technology Transfer in Ethiopia

The idea of modern science and technology in most African countries was introduced in the beginning of the 20th century. In the case of Ethiopia, it is believed that the first half of the 20th century was considered as the beginning of application of modern science and technology, along with the establishment of higher learning institution although its role to bring sustainable socioeconomic development of the country has not been to the desirable level [11].

In this sense, Ethiopia has attempted the transfer of various modern and noticeable technologies, since the era of Emperor Menilik II (1886-1930). Some of the major technologies have been acquired in the form of turn key projects, international technology co-operation, and recently through Foreign Direct Investment (FDI), Joint Ventures (JV), and via the local businessmen. However, technology transfer is not far from a one step shopping of technological hardware. Hence, most of the technologies imported to Ethiopia with limited resources have failed to be adopted, improved, re-engineered, and disseminated to other similar industries at the desired level, which should be considered as the ultimate goals of technology transfer. This result in, the lack of self capability to undertake major infrastructure development activities like, road construction, bridges, hydro power dams, sugar industries, cement industries etc. by the citizens of the country. This clearly indicates weakness in absorbing foreign technology from similar projects and industries which took place several decades ago.

Ethiopian government adopted and implemented the Agricultural Development-Led Industrialization (ADLI), as the leading national development plan that primarily aspired to increase agricultural productivity and then through the income effect. It is expected to augment demand for manufactured goods, thereby motivating industrialists to expand their production capacity utilization and also to increase investment in industry. However, the contribution of the manufacturing sector among others to the growth of the GDP of the country is still minimal, and the efforts being made to add value through manufacturing of the agricultural products are very little. This shows that the manufacturing sector's development is at its grass root level.

One of the reasons why ADLI failed to solve the root causes of low development of the industrial sectors is, it lacks national technology transfer coordination and implementation strategy to build the capacity of the industrial sectors through technology transfer from both foreign and domestic sources.

However, the Ethiopian governemt has develped the Growth and Transformation Plan (GTP) which is a medium term strategic framework for the five-year period (2010/11-2014/15). The plan could be considered as a major milestone towards building a modern and productive agricultural sector with enhanced technology and an industrial sector that plays a leading role in the economic development.

1.3. Basic Metals and Engineering Industries

All over the world, basic metal and engineering industry is regarded as the engine for industrial development. The progress of this industry is the key to social and economic progress. It is catalytic in achieving import substitution, export enhancement, high degree of value addition, optimal use of agriculture, mineral and other resources.

The Basic Metal and Engineering (BME) is a sub-sector within manufacturing sector. Basic metals industries are concerned with the refining and production of raw metal products from mineral ores. While engineering industries are industries which use these metal products as an input and fabricate them into various engineering products.

BMEI is backward linked to mining sector and forward to all sub-sectors of manufacturing. It can help; agricultural, construction, transports and electric power sectors, by manufacturing agricultural implements, construction machinery and structural bars and sections, vehicles, electrical equipment, respectively. Hence, the development of engineering industry is essential to the rapid growth of all other industries.

Technical knowledge and its application have changed greatly in the last few years, and there is no doubt that they will continue to change with even greater rapidity.

This is because, some old methods have nearly vanished, and others have altered almost beyond recognition because of new knowledge. Moreover, new materials and the demand for greater precision, increased output and higher efficiency are also at work. The development of basic metals engineering and technology has led many developed and developing countries towards tremendous economical growth.

Metal processing industrial sub sectors in Ethiopia, are still in their infancy over the years even if expansion of these industries are making a very substantial increment, and the sectors are not likely to make a very potential contribution to the National Economy. However, it is evident that metal processing industries can play an important role in serving other industries by providing experienced technical manpower at large, and by incubating small-scale industries.

Most industries in Ethiopia are facing challenges which may be categorized in different forms. However, the challenges related to technology seriously affect the product development, profile versatility, quality of the product both in terms of geometrical fitness and required properties, which in turn has negative effects on the service condition of the part produced. Moreover, the product profile and technological process are stagnant. Therefore, there is no opportunity to develop new technology that enhance the capital income of the industries in particular and the nation as a whole.

The rapid and massive economic growth of developing countries, like Ethiopia can only be achieved if appropriate technologies are transferred to produce competitive products, and services that are geared to satisfy global consumption. The best uses of technology enables enterprise in reduce cost of production, maintain consistency in quality, improve productivity and finally develop the competitiveness of the enterprise.

As a result, this dissertation has investigated the different technology transfer attempts made in our country, and their overall efficiency to buildup the local technological capacity and indicate possible means of alleviating the technology transfer problems.

1.4. Statements of the Problem

In the past, the Ethiopia government has given priority to subsectors that use local raw material (mainly agricultural products) and export their products. These sub-sectors are sugar industries, food industries, textile and apparel industries, leather and meat industries. On the other hand, BMEIs that have direct impact to the growth of these sectors, are not in a position to give support to these prioritized sub sectors.

The main reason is the Ethiopian government paradoxically gives lesser or no emphasis for this important sector. Furthermore, the metal and engineering firms, such as the Akaki Spare Parts and Hand Tools Factory, Truck and Bus Assembly, Kotebe Hand Tools Factory, Kaliti Steel Works, and Ethiopian Iron and Steel Industries, etc. have low capacities for adapting, developing, and producing the technologies required by the sector. Hence, industrial activities and competitiveness of targeted sectors: sugar, textiles, leather, and flour and oil mills industries are very weak.

Though, the new GTP has given attention to the BME sector and it has also succed to establish MIDI and METEC. However, still it is inshort of considering the current limtted technological capability of the sector and their major constraints towards upgrading their technological capability.

Even if, the number of BMEIs in Ethiopia is growing relatively better over five years, the country still has created little benefit and turned out to be net drains on government resources. In most of the Ethiopia industries, particularly BMEIs are facing different challenges. The challenges may be categorized in different forms. Among these challenges, practice shows that the technological challenges mainly affect their progress seriously. In most cases, the qualities of products are not competent, new technology transfer system is very limited and innovation trends are very low. Most metallic products produced in the Ethiopian metal industries are mostly consumed by construction sectors. Moreover, there are no indications to build large scale industries; like heavy machineries, engines and other similar parts that can reduce the consumption of hard currency. Besides, most metallic products are imported, but they are and can be produced locally. Limited types of products are produced repeatedly in a particular industry, which indicates that there is a stagnant technology. It means that there is a very large vacancy in increasing the profiles. To identify these technological problems of BMEs in Ethiopia, with reference to technology transfer and the problems associated with the transfer process are addressed through the following research questions.

- What are the efforts made and their short coming to transfer technology in Ethiopia?
- What are channels and barriers of technology transfer in Ethiopia?
- What are the key players (stakeholders) in the technology transfer of Ethiopia?
- What are the possible mechanisms to be employed for sustainable and accelerated technology transfer for BMEIs?
- What are the possible means to transform technology transfer to technology innovation?

1.5. Research Objectives

General objective

The general objective of the research is to show direction of how industrial development can be brought through coordinated and integrated transfer of technology which leads to sustainable social and economic development in Ethiopian industries.

Specific objectives

In order to achieve the general objective of the research, the following specific objectives have been identified and addressed.

- Identified channels, barriers and stakeholder of technology transfer in Ethiopian BMEIs
- Comment on the technology transfer policy of Ethiopia;
- Showed directions of possible ways of technology transfer for BMEs;
- Devised means through which integrated and coordinated technology transfer can be achieved in BMEIs.
- Developed model of technology transfer for Ethiopian BMEs;

1.6. Research Methodology

To achieve the general objective and specific objectives of the research, the following research methodologies have been used. Therefore, the overall research design of the dissertation includes: literature review, fact gathering, discussion, analysis, interpretation of data, ways forward, conclusion and recommendation. For further understanding, a conceptual model has been developed, as can be seen in figure 1.1. Both primary and secondary data collections have been carried out. The primary data gathering have been carried out through interviews, visits and distributing questionnaire. And the secondary data have been gathered from books, journals, articles, news papers, magazines, conference papers, reports, broachers, electronic databases, and genuine internet sources.

i. Literature Review

The research started with exhaustive literature review to understand the subject matter in one hand and to answer some of the research questions on the other hand. Basically the literature review is classified in to three parts based on its focus and purpose. These are technology transfer body of knowledge, benchmarking of technology transfer practice of NICs, South Africa and Brazil, practice of technology transfer from Ethiopian context in general. A detail explanation of each part is presented below:

- **Technology Transfer as the Body of Knowledge**

Technology transfer as the body of knowledge includes: a theoretical framework related to basics concepts of technology transfer, mechanisms of technology transfer, barriers of technology transfer, technology transfer models, process and appropriate technology transfer. Furthermore, impact of technology transfer in the industrialization process of a country is investigated. Exceptional emphasis is given to the experience of newly industrialized countries such as Korea, China, Singapore, Malaysia, Brazil and South Africa. Furthermore, the experience of South Africa and Brazil has been included. Also the lessons learned from these benchmarked countries have been drawn and included in the dissertation.

- **Practice of Technology Transfer in Ethiopian**

Technology transfer experience of Ethiopia has been reviewed, including the five years growth and transformation plan of the country. Detail assessment is conducted on the technological developments, and the strong attempts of the country in the Emperor Lbne Dengel (1508-1540), Emperor Sertse Dengel (1563-1595), Emperor Sussnyos's time (1605-1632), Emperor Theodros (1854-1867), Emperor Menelik, Emperor Haile Selassie, the Derg and EPRDF regimes. Moreover, transfer mechanisms and indigenous technology of Ethiopia have been discussed. Furthermore, the main case study of the research is on *BMEIs* of Ethiopia. Therefore, the researcher has given more emphasis on the practice of BMEIs on technology transfer, and reviewed a number of literature related to BMEIs since the Axumite period (14th century) practice in Ethiopia.

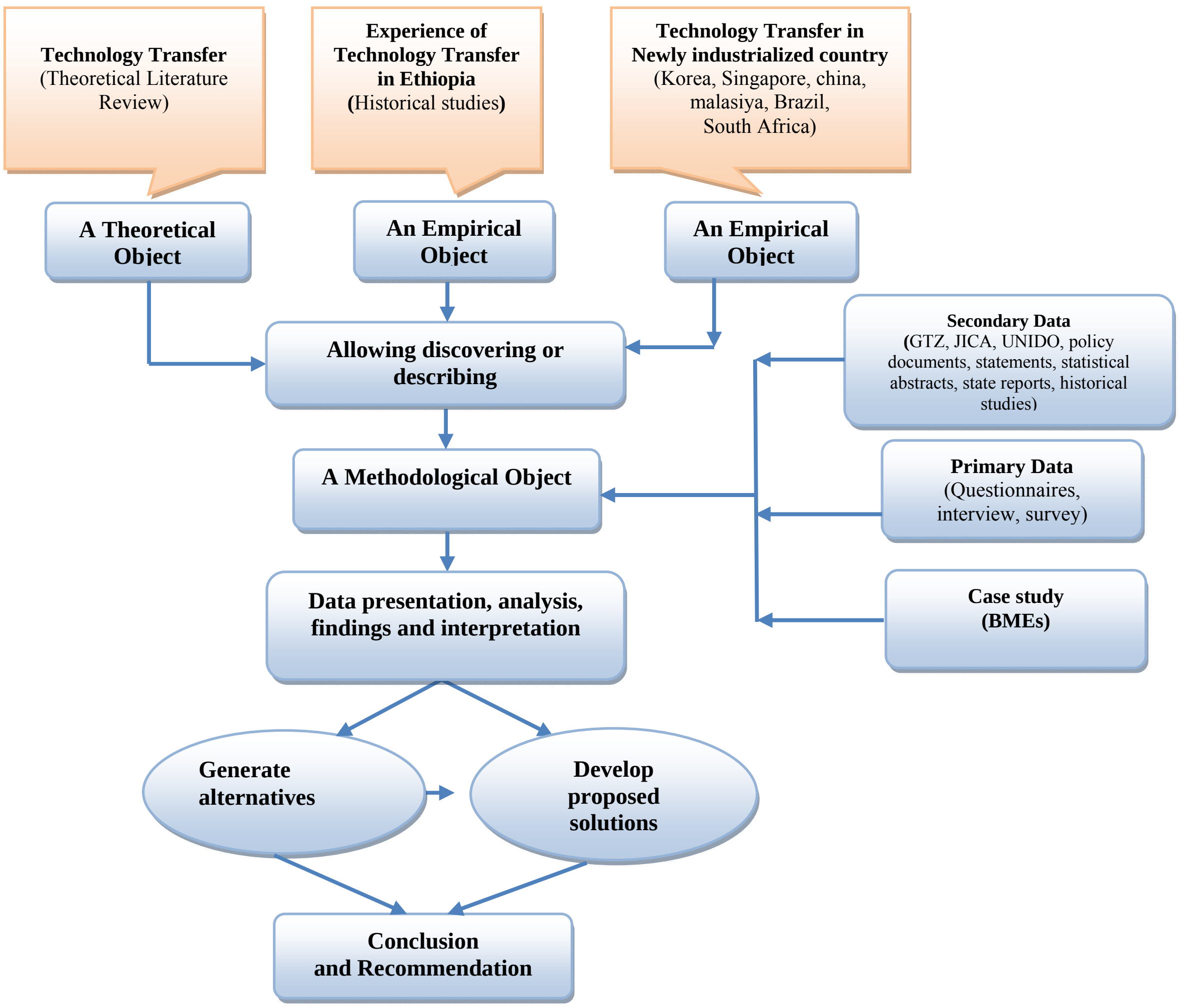

Figure 1.1 Conceptual model of the study

ii. Data Collections

Combinations of both qualitative and quantitative methods have been used to achieve the research output of this dissertation. Furthermore, the empirical material of the dissertation is worked out, and compiled based on primary and secondary data. The secondary data has been collected from different sources. To mention few of them; from policy documents, online data bases, brochures, books, journal articles, newspapers & magazines, conference papers, statistical abstracts, state reports, historical studies, reports of GiZ, JICA, UNIDO, ECSA, World Bank report , and unpublished graduate research papers from different university archives.

In the same manner, the primary source of information has been generated from a number of sources. Among these primary data sources, face to face interviews based on a thorough understanding of the literature, a semi-structure questionnaire based survey with the respondents to discuss and provide unique insights into the phenomenon of technology transfer in the targeted metals and engineering industries in Ethiopia, and industrial visits are the vital methodologies used to gather the necessary information. Furthermore, the primary data has largely focused on assessing the trend of technology acquisition, and the level of technological capability in Ethiopian BMEIs.

Before the final distribution of the questionnaire, a pilot survey has been conducted to avoid confusion, and make a language questionnaire a bit simple and straight forward to the respondent. The survey questionnaire was distributed using a 'drop and collect' method at respective human resource offices and in some specific cases at research and development offices within an allocated four weeks time. However, the information gathering through interview was conducted by taking an appointment from organizations. The researcher has also incorporated students data who are working their M.Sc. study in the area of technology transfer, when the researcher working as co-advisor.

Depending on the type of data available and the projected data analysis techniques to be used, different sampling strategies with different logics of approach could be used. In this regard, a stratified sampling technique has been used for purpose of this specific dissertation so as to obtain a representative sample, since the population from which a sample is to be drawn does not constitute a homogeneous group. Therefore, a sample size of 50% of the population has been considered to be representative of the population.

iii. Data Analysis and Interpretation

Based on the collected data, the data analysis, discussion and interpretation have been made. The analysis of the research has been largely qualitative, however quantitative analysis has been used to highlight patterns and make the analysis more robust.

Quantitative analysis is more likely to be secondary and exploratory or descriptive in nature, summarizing data in the form of charts, tables, percentages and averages. In the event that a survey is carried out, the data obtained can be mostly categorical. Hence, it is likely to be ranked across a scale. Finally, by combining findings of the research with the theoretical framework, ways forward have been proposed.

iv. Proposed Solution

Proposed solution have been forwarded based on the gathered facts, data analysis, discussion and interpretation, which clearly shows how the technology transfer process should be used to bring technological capability in coordinated, and integrated ways and helps as a framework for technology transfer in Ethiopia.

v. Conclusion, Recommendation and Future Research Areas

Based on the findings, conclusions and recommendations have been drawn so as to device fast industrialization of Ethiopia through technology transfer. Future research areas have been clearly articulated to make pave the way for others researchers.

1.7. Scope of the Study

The scope of the research has been limited to the problems related to technology transfer of basic metals and engineering industries in Ethiopia. Thus, the research has been delimited to treat the problems related to technology transfer of basic metal and engineering industries in Ethiopia.

1.8. Outcome of the Research

The main outcomes of the research are:-

- Channels of technology transfer of the BMEs have been identified.
- The barriers of technology transfer in Ethiopian BMEs have been investigated.
- Devised means of appropriate selection, importation, absorption and adaptation of foreign technology in coordinated and integrated manner have been proposed.
- Model of technology transfer for BMEs has been developed.
- The technology policies of Ethiopia have been devised (commented).

1.9. Significance of the Study

In addition to the significant results, that the sector under study can able to transfer technology from different stakeholders, the research work results:

- Would enrich the knowledge on the technology transfer;
- Would enable potential technology transferee to evaluate their technology transfer before they decide to implement the technology transfer;
- Would enable the concerned body (managers) to be aware of what is expected of them in managing the technology transfer in coordinated and integrated efforts;
- Give way for other researchers who want to make further investigations in the area;
- Provide the basis for technology transfer and serves other sectors as a supplement to their knowledge;
- May add to the existing literature so that it serves as an additional source of reference;
- Would understand the current and potential policy makers how the technology transfers of BMEs affect the industrial development;
- Could be used as a general frame work for technology transfer in the different Ethiopian engineering industries;
- Have clearly outlined the responsibility of higher institutions for the development of the sector.

- Could provide valuable information, be used as a reference and guide line for policy makers and those who wish to study in this discipline.

Furthermore, the beneficiaries of this research are the BMEs and other sectors, researchers, the government and society at large.

1.10. Organization of the Study

This research report is composed of six chapters. The first chapter deals with the problem and its approaches. Background and justification, statement of the problems, objectives of the study, outcomes and significance of the study have been clearly discussed. In the second chapter, related literature review in the area of technology transfer has been clearly discussed. The third chapter deals with other countries' experience (benchmarking) with related to technology transfer, especially from that of the newly industrialized countries. In the forth chapter, the practice of technology transfer in Ethiopia is thoroughly discussed from 1500 to 2011 G.C. Data collection, analysis, discussion and interpretation have been discussed in the fifth chapter. In the sixth chapter, the researcher proposes ways forward. Finally, conclusion, recommendation and future works have been discussed in the seventh chapter.

Chapter Two

Related Literature Review

2.1. Introduction

Technological progress and innovation play an important role in economic growth [13]. Over the past century, the wealthiest nations are those that had developed cutting edge technological capabilities that allow them to become global technological leaders. Countries, such as the United States, Germany, Japan, United Kingdom, Finland, Denmark, and Israel, are commonly regarded as leaders at the global technological frontier. In industrialized economies, many studies have shown that more than 50 percent of long-term economic growth stems from technological changes that improve productivity and lead to new products; processes or industries [1]. Their growth experiences offer important lessons for other countries attempting to emulate their economic successes.

In East Asia, newly industrialized economies, such as South Korea, China, Singapore and Malaysia have transformed their economies, since the 1970s by improving the technological sophistication of their industries with well organized technology transfer policies. In these countries, productivity growth, the best proxy for technology progress, accounted for as much as 30 percent of GDP growth. With their deepened technological capabilities, they now compete globally with advanced industrialized countries in a number of sectors [14].

Due to this, in the last four decades, technology has gained more recognition, it deserved, than it had before. The recognition was accompanied by the realization that technology is a significant factor in the industrialization, and for maintaining international comparative advantage of a country. In general, in the development of a community, state, or nation, the advancement of technology is vital for survival. Hence, the need for technology transfer arises and becomes a critical landmark.

2.2. Technology

Before 1940, little thought was given to the importance of technology. However, the value of technological advances to a strong military defense was recognized during World War II.

The emerging needs of the U.S. military resulted in a large increase in government-sponsored research. Government facilities could not accommodate all the R&D projects needed to fulfill U.S. military needs. The government began to contract with qualified companies, universities, and nonprofit organizations, but with no overall plan for handling the intellectual property that would be developed. In the last three decades, technology has gained more recognition, it deserved, than it had before. The recognition was accompanied by the realization that technology is a significant factor in the industrialization, and the maintenance of international comparative advantage of a country.

Technology could also be classified as production technology and process innovation technology [15]. The former is essential for producing goods, and the latter is comprises of devices that improve productivity, quality and/or reduce cost, which can be found on the shop floors and accumulated on the former. The technology, whether production or process innovation, used for manufacturing is different from product to product and it changes over time. Moreover, it is not always easy to distinguish between the two types of technologies as they often exist together.

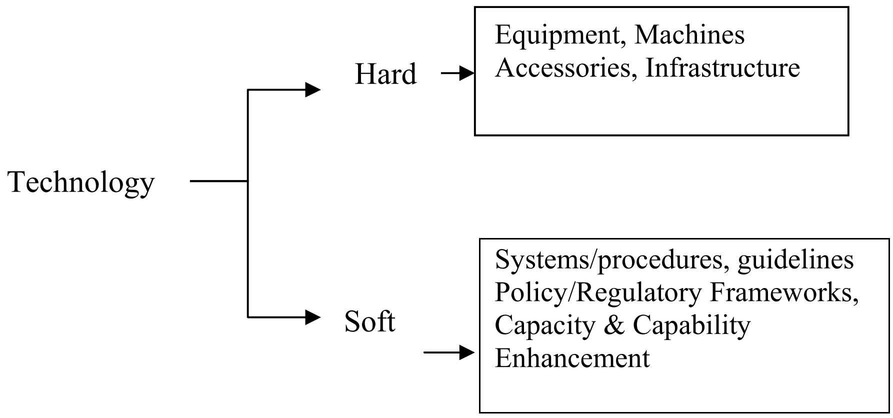

Figure 2.1 typology of technology

Given a certain configuration of equipment and knowledge, it is knowledge that leads to the creation of new equipment and the acquisition of further knowledge. Among the two components, knowledge is the most decisive factor. Since knowledge is embodied in human beings, development of technological capacity means increasing the number of people with technological knowledge and improving the level of knowledge of these skilled people. The broader way of defining technology gives us a liberty for a variety of technologies such as: industrial, agricultural, military and medical. For example industrial technology is considered to be scientific, engineering and managerial knowledge which makes the conception, design, development, production, and distribution of goods and services possible [16]. Furthermore, there were a number of various key technological developments over the past two and a half centuries, and the sectors defined the technological frontier in each phase and these can be shown in Table2.1.

Table 2.1 The global technological frontier - 1770s to 2003

Period	Key technology development	Key sectors
1770s to 1840s	Mechanization	Textiles, canals, turn pike roads
1830s to 1890s	Steam power and railway	Steam engine, railway, world shipping
1880s to 1940	Electrical and heavy engineering	Electrical engineering, chemical process industries, steel ships, heavy armaments
1930s to1980s	Mass production	Automobiles, aircraft, consumer durables, synthetic materials
1970s to 1990s	Information and communication	Computers, software, telecommunications, digital technologies
1990s to 2003	Biotechnology	Gene therapies, new pharmaceutical products

In the present world, competition among countries is defined mainly in terms of technology; and in the future, an industry's competitiveness would increasingly depend on its capacity to develop its technological potentials. Due to this, the developing countries have directed their social, political, and especially their economical tendency towards technological power [17].

2.3. Technology Transfer

Technology transfer is not a new thing. Researchers have traced technology transfer process back to the prehistory of the human species: where technology transfer largely involved tacit knowledge, which is evolutionary prior to explicit knowledge. As there were no written languages until 3000 BC, technology transfer had mainly occurred through language; which were supplemented by equations and diagrams which constituted as the major means of explicit transfer of technological knowledge. The spoken language and gestures have explicitly transferred technological knowledge in friendly encounters [18].

Despite the presence of dozens of research papers in the area of technology transfer, only a handful of them mentioned the historical perspective of technology transfer. However, some literatures mentioned the process of technology transfer to the Neolithic times, in which the Arabs played a major role in transferring technologies from East to West [19]. Until the sixteenth century, the Middle East Muslim nations were leaders in technological innovation and advancement. The ancient civilization of Egypt and Mesopotamia had transferred to the Romans in building construction and ship building. The so called "Greco-Roman heritage" was also built on the great civilizations of the Easterners. Furthermore, the major achievements in science and technology, those called Hellenistic and Roman were mainly near Eastern achievements due to the scholars and artisans of Egypt, Syria, and Mesopotamia [20].

The transfer of English textile expertise to the American textile industry, in the 18th and 19th Centuries, which could be considered as a pivotal point in the history of technology transfer due to the immense change it brought to the American people . In the 18th Century, despite the English law which prevents knowledge migration, France had successfully managed to obtain 'specialized steel making know-how' by defecting English workers which was seen largely as industrial espionage [19].

However, it is believed that the word "technology transfer" originated at the White House in 1945, from a report established for President Franklin D. Roosevelt by his advisor Vannevar Bush[21]. The document basically emphasized the importance of basic research and development activity for a strong economy. As the Government facilities failed to accommodate the huge R&D projects needed to fulfill U.S. military needs during and in the aftermath of World War II, they established the mechanism to participate the private sector in R& D. At the same time they defined a "technology transfer " guide line from the private sector to the military, which also sets rules and regulations in relation to patent rights and other issues, and eventually this work had defined the current technology transfer framework [21].

There are many potential stakeholders in technology transfer including innovators, developers, owners, suppliers, buyers, recipients, users, consumers, financiers, donors, governments (including policy makers and regulators), insurers, international institutions, and non-governmental and community-based organizations.

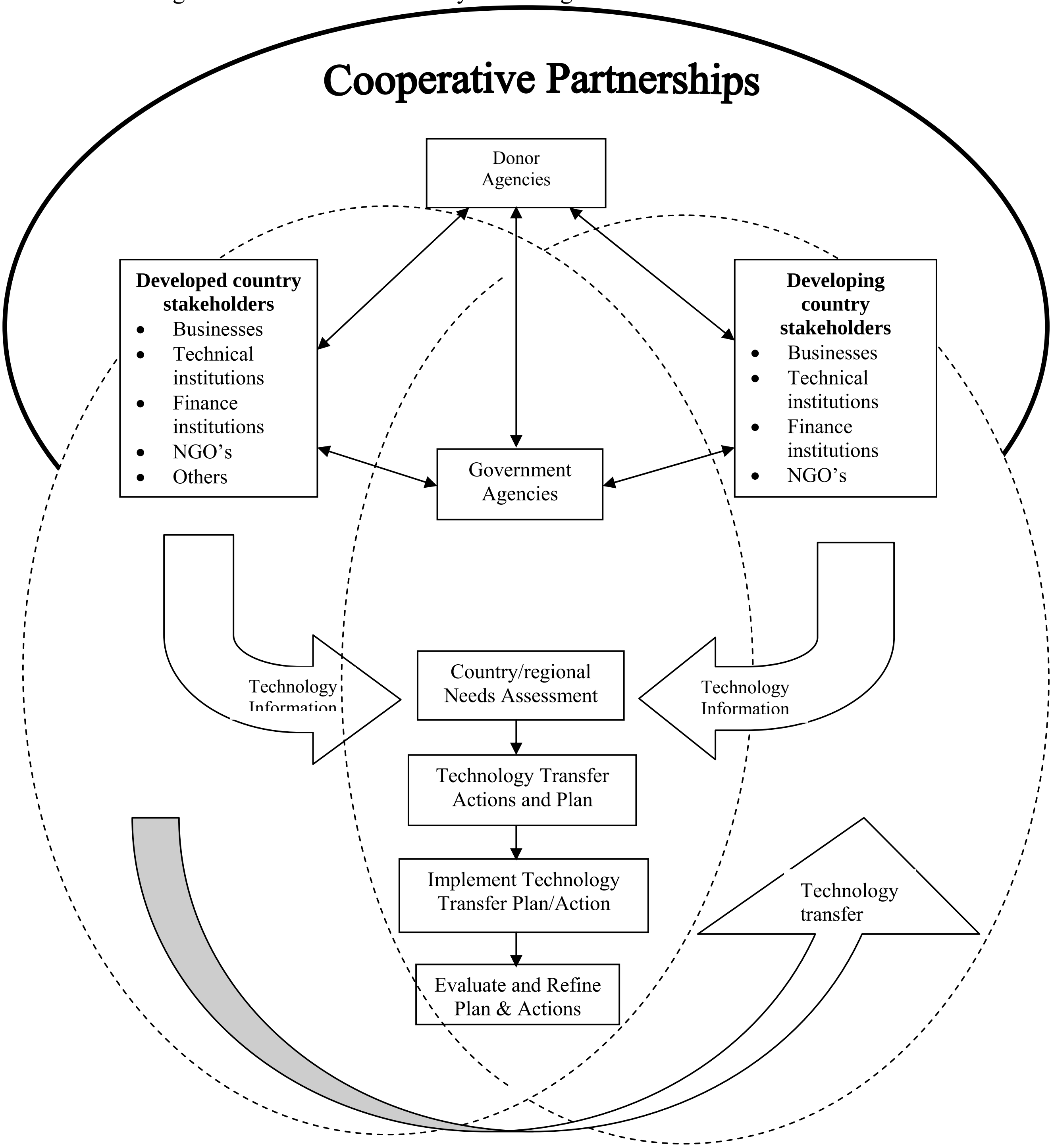

Figure 2.2 Possible key elements of an approach to technology transfer

The stakeholders involved in any specific transaction will depend on the type and status of the technology and the associated nature of the transfer pathway. Transfers of technology from developed countries to the developing nations have multifold benefits to both parties. Some of the reasons that can be cited by the developed countries are:

- The continuation of export;
- The development of defense of local markets;
- The lack of space for development in the home country;
- The increase of pollution in the developed countries;
- The assurance of supply of raw materials; and
- The search for low cost production site.

On the other hand, the imported technologies directly affect the recipient countries through:

- The increase of production resources like technical services, imported machinery and equipment, foreign raw materials, components, and parts not available in the host country;
- The extent of exploiting existing resources by generating new job opportunities, using local resources by widening indigenous entrepreneurship and/or technical capabilities;
- The substantial growth in the productivity of utilization of labor, capital and natural resources including land.

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

It is true that knowledge could be divided into tacit and explicit knowledge, and the explicit knowledge could be easily transferred than tacit knowledge (Figure 2.3). Tacit knowledge is the brain behind knowledge and technology transfer. Tacit knowledge is a key element that delivers the most sustainable advantages, when looking at knowledge transfer between parties. Tacit knowledge is blocked between transferor and transferee in terms of knowledge transfer [16]. Because tacit knowledge is personal and context-specific, it's hard to formalize and communicate.

But if tacit knowledge are properly enhanced and codified from people or group of people who have this tacit knowledge, it could then be easily transferred. Understanding is a key point to tacit knowledge transfer. If transferee and transferor both understand themselves, taking location, values, and belief into consideration, then tacit knowledge could be transferred. For knowledge to be transferred, both tacit and explicit knowledge have to be comprehended by transferee and transferor.

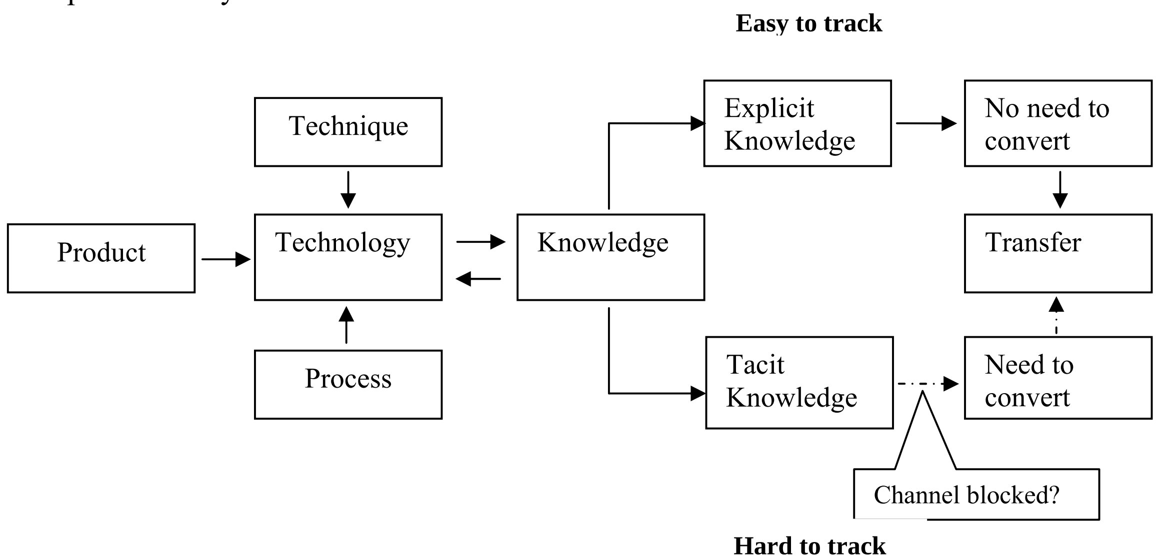

Figure 2.3 Knowledge transfer model [22]

Tacit knowledge is unlocked when experience on the job is totally transferred to the transferee. This could only be done through the following ways;

- **Direct key transfer:** Experience is transferable on the job training. This method of transfer is very effective. The trainer/transferor will train the trainees/transferees on the job; by teaching them what needs to be known at the same time providing practical work for them while showing on how to make corrections.
- **Tea-break:** Tea-break is an informal way of transferring experience. This method provides a forum where transferors and transferee can discuss over tea or at break

period in a common room. This method develops social relationship between transferor and transferee thereby building trust.

- **Discussion forum:** This is a formal way of transferring knowledge. Formal discussion forum should be created where both transferees and transferor discus relevant issues about the jobs and their problems at the job. This type of forum provides room where question will be asked directly to the transferor. This could also be termed as questions and answers forum. [65]

2.4. Technology Transfer Channels

There are several methods of classifying technology transfer but in essence there are two basic types, namely domestic and international transfer [23, 24, 25].

Domestic transfer: It is also known as vertical transfer or adaptation process, basically, it involves the flow of technology from one stage of research and development process to another. When the new context or stage in which the technology is to be applied is significantly different from the original one, it is required to adapt the technology. In essence it is the movement of technology along the continuum from basic research to the innovative product whereby an adaptation process refines the technology with each transfer stage.

International transfer: It is also denoted by horizontal transfer or adoption process, is the movement of technology from one culture of systems and methods that were developed for application into a different culture and location. In fact the transferred technology is adopted rather than adapted to the recipient condition. Little adjustment is made to exploit the advantages of differences in the quality, quantity of materials and labor. The technology is virtually the same in the new location, as it was in the original location.

Any means of conveying the elements of technology may not be available in the recipient countries for the purpose of meeting social objectives of the people is a channel of technology transfer. Technology could be transferred in different ways; however, most researchers broadly categorized them in two main streams. These are formally market-mediated channels and the informal or non market-mediated channels.

i. Market-mediated channels [26, 27]

The market mediated technology transfer channels involve the formal arms-length transactions between buyers and sellers, and it includes:

- ***Turn Key:*** the technology supplier may construct a fully functional facility where the recipient needs merely turn a key to get a facility functioning.
- ***Technical Enclave:*** Multi-National Corporations establish fully functional modern facility in developing countries, where the local population is employed as laborer, and the products of the facility would not find their way into the local economy, but would be exported abroad.
- ***Licensing:*** an agreement that allows a technology recipient to employ the transferred technology as per the conditions that are spelled out by both parties.
- ***Joint Venture:*** when two or more business entities set-up a third entity that will enable them to produce a good or service jointly, by sharing the enormous expenses of technical, marketing, production and managerial skills.
- ***Patent Right:*** a legal right to possess monopolistic control over an invention for a stipulated term can be bought and sold. A firm may buy this right for a technology that will help it to round out an existing product line, or in order to get into a new line of business or in order to avoid a legal suit.
- ***Direct Purchase of Naked Technology:*** the purchase of a product is based on complex technological device from a firm. This process can save considerable research and development, and production costs to the recipient.
- ***Purchase of Embodied Technology:*** the supplier may prefer to sell a key technology embodied in a product (for example, a special semiconductor device may be the key element of an instrument that measures high temperature) over the sale of the same naked technology.
- ***Purchase of Technological Services:*** enormous amount of technology can be transferred through hiring of technological services that the recipient's own people cannot handle through a suitable educational system.
- ***Education Abroad:*** the education of people overseas is a very important transfer mechanism, and has a significant impact in the development of scientific and technological capabilities of a country.

- ***Site Visits and On-the-Job Training to Abroad:*** technology can be transferred by sending people abroad for field visits and a short term on the job training.
- ***Journals and Seminars:*** the dissemination of research findings, the principal norm of science is done through scientific journals, meetings, seminars and colloquia. This is an excellent and relatively cheap source of information for scientists.

ii. Non-market channels [27, 28]

It is the second category, the so called the informal channels for foreign technology transfer, is conducted without mediation of the two parties, and basically the technology transfer take place without formal agreements and there is no any direct payments done to the technology owner. The specific technology transfer channels in this category are:

- ***Imitation:*** Among the different important non-market channels of technology transfer, the most significant one is the process of imitation in which a rival firm learns the technological or design secrets of another firm's formula or products. Imitation may be achieved through product inspection, reverse engineering, de-compilation of software, and even in simple trial and error.
- ***Departure of Employees:*** Another form of non-market channel for technology transfer is when technical and managerial personnel's leave the firm, and join or start a rival firm based on the knowledge they acquire over the years from the technology owner. Such competition can be a significant form of information diffusion in industries.
- ***Data in Patent Applications and Test Data:*** Registered patent applications are available in public databases for a legal right on the subject matter. However rival firms in principle can read such applications, learn the underlying technologies, develop competing processes, and products that do not violate the claims of the original applicants.
- ***Temporary Migration:*** Much technology could also be transferred through temporary migration of students, scientists, managerial and technical personnel to universities, laboratories, and conferences located mainly in the developed economies. The challenge for developing countries in this context is their failure to encourage

expatriate students and professionals to return home and undertake scientific, educational, and business development activities.

2.5. Process of Technology Transfer

The process of technology transfer begins with assessing the need for it. This may be due to the changes in policies governing social, economic, environmental and political issues. There are various stages in the process of the technology transfer at the transferee perspective [32, 33] as shown in figure 2.4.These are:-

i. Needs Assessment or problem identification: This is the first and crucial step in the technology transfer process. At the very beginning the needs of the country, the society in general, and the intended users have to be identified. These needs then lead to identifying technological options to satisfy them.

ii. Analyze how to satisfy the needs or options identification: The needs identified require options to meet them. These options of how to satisfy the needs may not necessarily be technology related.

iii. Analyze the national strategy and the policy plans for fulfilling the needs and for the options to satisfy that needs: In general, developing nations have set their priorities by strategic or development plans. These plans might determine the resources that governments are willing to commit to the options.

iv. Make or Transfer decision: Even though most of the technologies of developing countries are transferred from overseas, there are technologies that can be developed and used locally. The "make option" is attractive if the resources and skills needed are locally available, and the technology is of great economic or strategic interest to the country, but investing in the "make option" only for strategic interest can lead to disaster.

v. Assess the technology considering social, cultural, economic and environmental factors: The aim of technology assessment is to inform decision makers, to provide an early warning signal for unintended consequences, to prepare stakeholders for possible technological changes, or to facilitate the participation of stakeholders in decision making. Hence, technology assessment is done to assure technical validity, economic viability, political feasibility, and environmental and social acceptability of a technology transfer.

vi. Decision on a technology: After assessing the possible alternative technologies, the most appropriate technology is selected. If no satisfactory technology is available, the strategic plans and policies should be reconsidered.

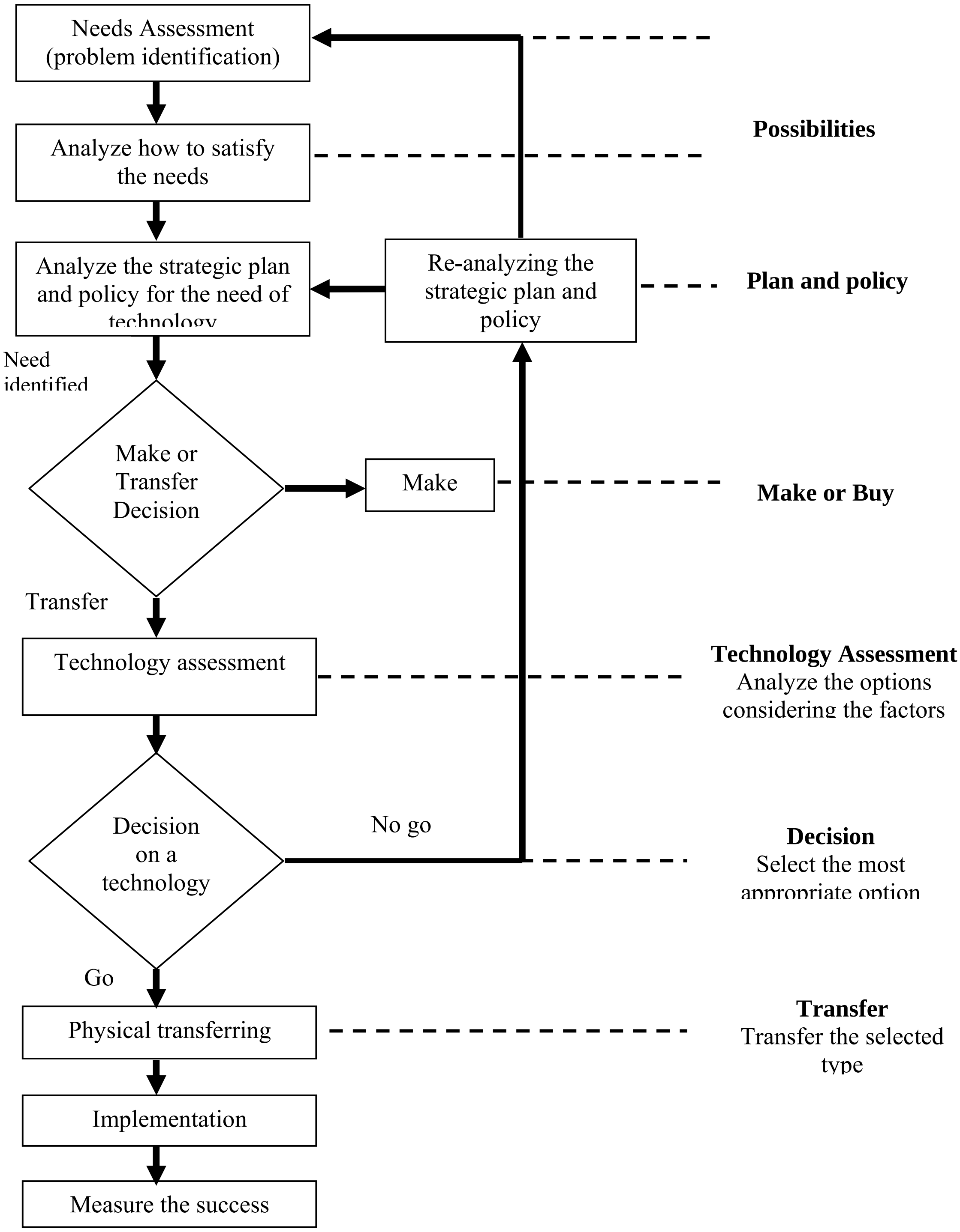

Figure 2.4 Technology transfer process model

vii. Physical transferring process: This is the actual and material transferring process of the selected technology. It includes all the procurement and transportation processes of the technology. But it must be remembered that technology transfer does not necessarily mean physical technology transfer, as services can also be included.

viii. Implementation: The final process of the technology transfer is implementing the technology. During implementation, absorption and further modification of the technology should be taken into account. Proper consideration should be given to personnel training and maintenance.

ix. Measuring the success: Once the whole transfer process is done, measuring the success or failure of the transfer process helps to learn from mistakes, and leads to improving the next transfer processes.

2.6. Influencing Factors of Technology Transfer

i. Law and Policy Factors

Technology is a kind of knowledge product; it needs to be protected by the legal system, particularly in the field of intellectual property rights. The degree of protection for intellectual property rights varies in different countries in the cross-border business environment. In some countries, a large number of counterfeit products infringe the international technology transfer and reduce the profit of export. Many companies in these countries can rarely get rid of the infringement problem, but the protection of intellectual property rights of technology transfer in the host country or region is an important factor.

The policy system plays a decisive role in the effectiveness of technology transfer. It is difficult for technology transfer to succeed in a country or region, where there are frequent government interventions, and many restrictions on foreign-funded enterprises. Policies of technology-importing countries or regions will have a direct impact on technology transfer in scientific technical and quality contents [1].

ii. Market Factors

Market factors are the fundamental factors of technology transfer. The effect of market competition and market size on technology transfer is particularly obvious. If the opening level of the home country or region is low, only a small number of transnational companies operating a monopoly in an industry will be able to maintain the technical advantage of their monopoly status to gain more profits. So the industry slows down the speed of technical progress and hampers the technical development.

The size of the market determines the scale of production. If the market capacity is large, economy grows steadily, residents' purchasing power is strong in a country or a region, and the growing space of technology-importing countries or regions will be great. Accordingly, these areas' attraction of investment and technology transfer will be stronger [1].

iii. Technology Basis

A nation or region's technology basis is important for technology transfer. The availability of human resources, the knowledge level, the development of productive forces, and the technology level will have a real impact on the transfer. The countries and regions with a great technology base and high skill levels will be capable of exporting technology. The conditions of technology-importing countries or regions restrict their ability to accept new technologies. If other conditions remain constant, the country with high-performance technology, and good technical basis is more likely to promote the country's technology transfer [1].

iv. Infrastructure Status

Infrastructure includes transportation, canals, ports, bridges, telecommunications, electricity, water and urban water supply and drainage, gas, electricity, and other facilities. These are substantial engineering facilities to provide public service for production and the residents. It is the common material base for production, management, work and life, and guarantees that the main facilities in a city operate normally. Moreover, it is not only an important condition for material production, but also an important condition for reproduction of labor. As the exporter or recipient of technology, the infrastructure construction must be taken into consideration in implementation of technology transfer [1].

2.7. Barriers of Technology Transfer

Anything that retards impedes, blocks the smooth flow of technology is considered as a barrier of technology transfer. National policies and contractual agreement clauses of the host governments and the suppliers respectively, can be major sources of barriers [26, 27]. The weak infrastructure, cultural differences, attitudinal diversities and communication gaps are some of the factors that hamper the smooth transfer of technology.

- ***Legal constraint:*** restrictive clauses that technology suppliers often require in the contractual agreements are the basis for legal constraints to technology transfer. By these clauses the recipients' free use of the technology is limited; consequently the governments of the recipient countries feel that they are paying very high a price for the technology with all the restrictions. This has given rise to the establishment of national legislation limiting the payment for technology, and the use of restrictive clauses in the contract. The rights and responsibilities of suppliers and recipients is not clearly defined, as a result conflict of interest and misunderstanding may develop and jeopardize the transfer. However, these can be generally negotiated to an acceptable level.
- ***Infrastructure barrier:*** is the most fundamental barrier that can block technology transfer. Technological infrastructure, the educational capability of the recipient country to absorb and utilize the transferred technology, is the basic requirement for a successful technology transfer. The capability should not be limited to engineers or high skilled personnel, rather operators must have the ability to operate and maintain production equipment; foremen should have basic supervisory skills; technicians, draftsmen, and production planners must have the capability to adapt the technology to local environment, while managers must be able to assess and negotiate business opportunities. The existence of this barrier may in part cause some of the other barriers.
- ***Cultural barrier:*** each society has a set of norms that govern the behavior of its population. There are times when neither the supplier nor the recipient understands, and gives due considerations to the others' cultural values. There are five basic factors in which the cultural barriers are apparent. Firstly, differing value systems may cause misunderstandings due to differing conceptions of right, wrong, proper, etc. Secondly, the economic system may give rise to different attitudes towards competition, labor and capital efficiency, and acceptable standards of living. Thirdly, in many societies job securities may be more important than the potential for advancement. Fourthly, social and family customs may affect interpersonal relationship, and the individual attitude towards group activities. At the fifth place, the personal relationship may affect the organizational patterns that are possible in the recipient firm.

- ***Attitudinal barriers:*** are closely related to the cultural barriers. The greatest of these is the resistance to change, which may be caused by the introduction of a new technology that will cause a radical change in attitudes, organizations, and current processes. Scientists and engineers may resist new technologies, due to the fact that they might consider new ideas as potential threats to their professional reputations.

  The resistance to change may also be as a result of lack of proper educational background to deal with the technology (intellectual resistance), the new technology may seem to be too expensive (economic resistance), the new technology may threaten peoples' ordered existence (psychological resistance), and the new technology may cause a change in organizational structure (sociological resistance).
- ***Communication barrier:*** affects a smooth people-to-people contact for an efficient flow of technology. Communication or language barrier, if not resolved, may break the bridge of transfer of technology.

In general, the technology and knowledge transfer have been a great challenge in developing countries, because of lack of infrastructure and educational development of the people. For developing countries, to achieve technology transfer certain factors has to be in place, such as good investment policy, basic infrastructures, attitude of people, good communication networks, etc. Over the years, developing nations have tried to encourage foreign investment participation in their countries, but these have been very difficult, especially because of the political un-settlement in these countries [41].

Another serious constraint is the loss of skilled personnel who have received training in developed countries, and hence resulting to the brain drain. In Africa, where working opportunities exist, employment terms are often unattractive due to low salaries and working conditions. [42]

2.8. Force of Technology Transfer System

According to the theory of technology transfer, because a new technology can improve efficiency, create more value, save labor costs, and improve the system thus creating new markets; there is "potential difference" between the innovator and the surrounding space. As a result of the existence of the "potential difference," a "field," called the field of technology transfer develops. According to the theory of field, a power balance will promote the diffusion of innovative technology or encourage surrounding areas to study, and imitate the technology to eliminate differences, in which case the transfer will take place objectively. In the field of technology transfer, when the sink exists, the field will have an effect on it to promote the introduction of new technologies. Theoretically, the action of transfer has the following two reasons, firstly, the transfer is driven by internal and external pressure, and secondly, the sink of transfer is attracted to accept the transferred technology.

2.8.1. Attraction of Transfer of Technology

The direction of the transfer option depends on the gravitation field of the transfer sink. The following factors influence the direction of transfer:

1. Labor force: including the price, technical level, technical ability, etc. of labor;
2. Resources: regions with abundant resources have greater attraction to technologies;
3. Location: regions geographically close to the source of transfer are more likely to receive the technology;
4. Marketing factors: a developed market is an important factor to generate high profits. Therefore expanding markets of commodity and technology provide the right conditions for the development and further innovation of the technology;
5. Financial situation: the diffusion process is often accompanied by investment behavior; especially the diffusion of high-tech processes. Well-developed capital markets have an important impact on the source's adoption of the technical achievement;
6. Institutional factors: including the policy of the source, the legal environment, protection of intellectual property rights, and environmental risks;
7. Attraction of technology: this attraction has a great impact on technology transfer, especially when technologies have increasingly become the dominant factor of productivity. Technology attracting technology is a more advanced method of technology transfer.

To sum up, these factors, namely labor, resources, location, market, capital, technology, etc. have a direct influence on the transfer. Therefore, the following model can be used to represent the attraction of the transfer sink to the technical innovation:

$$V = (X1, X2, X3, X4, X5, X6, X7)$$

Where:

V= Attractions of the transfer sink to the technology

$X1$=State of the labor force,

$X2$= State resources,

$X3$= Location factors,

$X4$= Market factors,

$X5$= Financial situation of the factors,

$X6$= Institutional factors,

$X7$= Attractive technical factors

2.8.2. Impetus for Technology Transfer of the Sink

The impetus of the technology transfer is affected by the following factors:

1. The cooperation intention based on the development strategy of the transfer source;
2. Market factors, that is, the prospect of the transfer product in the market of transfer sink;
3. The technical ability of the transfer source;
4. System factors, including the estimation and judgment of the source on the transfer sink in terms of the society, politics, economic environment, containing the policy and legal environment of the transfer source, national security policy, environment risks, etc;
5. The source's choice of transfer time and type of technology;
6. Excellent geographical location near the transfer sink can send out more radiation to the sink;
7. Options in the transfer mode of the transfer source (joint-venture, cooperation, sole proprietorship, etc.).

From the definition of the sink's attraction to the technology, the impetus of technology transfer from the source is defined as follows:

$$P = P(y1, y2, y3, y4, y5, y6, y7)$$

Where:

P= Impetus of technology transfer of the transfer source

$y1$= Cooperation intention based on the development strategy of the transfer source,

$y2$= Market factors,

$y3$= Technical ability of the transfer source,

$y4$= System factors,

$y5$= Transfer time and type of technology,

$y6$= Location factor

$y7$= Transfer mode of the transfer source (joint-venture, cooperation, sole proprietorship, etc.)

2.8.3. Resistance of Technical Transfer Field

Technology transfer is impeded by the following environment factors:

1. Barriers of information delivery;
2. Uncertainty of the benefits of innovative technology;
3. Incompatibility;
4. Adopted price;
5. The space constraints and so on.

We define the block degree of the technical transfer field as follows:

$$R = R(Z1, Z2, Z3, Z4, Z5)$$

Where:

R= Block degree of technical transfer field

$Z1$= Block of information delivery,

$Z2$= Uncertainty of the benefits of innovative technology,

$Z3$= Incompatibility,

$Z4$= Adopted price,

$Z5$= Constraint of space, etc.

2.9. Absorptive Capacity Framework

Technological capability is acquired through the process of technological learning. And effective technological learning requires absorptive capacity, which has two important elements: the existing knowledge base and the intensity of effort [37].

The existing knowledge base refers to existing individual units of knowledge available within the organization. It includes the basic skills, and general knowledge that is necessary to learn and assimilate the transferred technologies. The existing knowledge of the individuals or organizations is an essential factor in technological learning, because today's knowledge enables to create increased knowledge tomorrow by influencing learning processes. Thus accumulated existing knowledge increases the ability to make sense of assimilate and use new knowledge.

The intensity of effort refers to the amount of energy relinquished by the organizational members to solve problems. It is insufficient merely to expose firms to the relevant external knowledge, without exerting effort to internalize it [38].

The amount of effort that the organizational members or individuals exerted to learn and adapt their environment enables them to deal with many problems. Learning how to solve those problems is usually built up over many practice and trials on related problems associated with the relevant external knowledge. Thus, it requires considerable time and effort for solving problems early on, before moving on to solving the more complex problems. The effort intensifies interaction among the organizational members that in turn facilitates technological learning at the organizational level and hence to the country level.

Thus, the more the knowledge the organization and individuals have on the external knowledge, the more effort they make on learning continuously builds the absorptive capacity of the organization. Once the absorptive capacity is made the technological capability of the firm will be established. Figure 2.5 shows how the knowledge base and the level of the intensity of effort bring the absorptive capacity of the firm [39, 40].

In general, absorptive capacity of a firm is primarily a function of the recipient firm's level of prior related knowledge. Prior related knowledge is closely related to the individuals units of knowledge available within the organizations. This knowledge includes basic/minimal skills, a shared language, positive attitude towards learning, relevant prior experience and up-to-date information on knowledge domain, and it is critical for an organization to assimilate and exploit new knowledge. Based on this notion, an organization's absorptive capacity does not simply depend on the organization's direct interface with the external environment, but on the transfer of technology (i.e., knowledge, skills and tools) across and within sub-organizations.

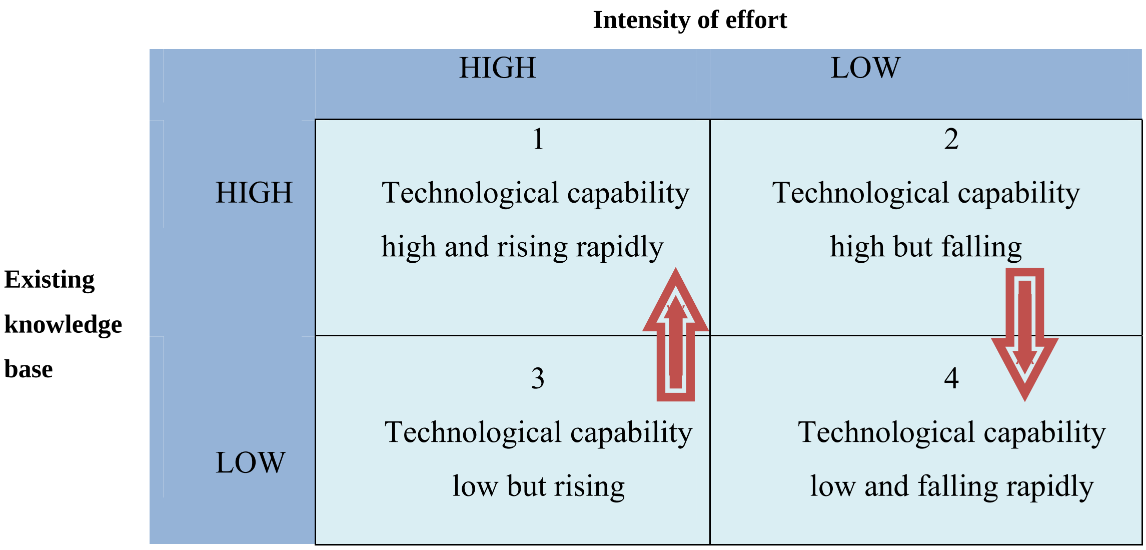

Figure 2.5 Absorptive capacity framework

These two variables: the existing knowledge base and the intensity of effort in the organization constitute, as presented in Figure 2.5, indicate the dynamics of technological capability. When both existing knowledge and the intensity of effort are high (1), technological capability is high and rapidly rising. On the contrary, when both elements are low (4), technological capability is low and falling. Organizations with high existing knowledge and low intensity of effort (2) may have high capability now, but will gradually lose it, as existing knowledge will become obsolete as technology moves along its trajectory. Those organizations will gradually move down to 4 because they are not aggressive learners. In contrast, organizations with low existing knowledge but with high intensity of effort (3) may have low technological capability now, but will acquire it rapidly. Both continuous and discontinuous learning can take place through significant investment in learning and move progressively to 1. These firms expeditiously accumulating their existing knowledge on the basis of strong intensity of effort. Therefore, it can be said that the intensity of effort or commitment is a more crucial element than the existing knowledge, for long-term learning and competitiveness of the firm.

2.10. Major Actors in Technology Transfer

Various terms have been used considered as major actors of technology transfer, such as technology parks, science parks, techno poles and research parks. They generally provide a place for technology transfer with high-skill people, and have strong relationship with the university and research institute. Moreover, parks offer high quality of working, living and learning environment, and they are equipped with advanced technological facilities to support research and development (R&D) activities. They offer opportunities for synergy between business incubators, technology enterprises and research institutes particularly in the early development and stimulation of business.

i. Science Parks

A science park is an initiative that is located in geographic proximity of high education institutes or advanced research centers, displays operational links with these organizations, and committed to encourage creation and growth of enterprises based on new technology. It is generally located in a university and essentially specializes in activities like development and project design, invention, experimentation and development of new products up to the production phase of prototypes. In such a structure, only the production and marketing phases appear rarely.

It often includes a real estate development, considering proximity to a university or a research center, or simply of its pleasant setting, is attracts to new or existing activities with a technological resource base, or to R&D departments of large corporations and actively promotes the transfer of technology from academic and research institutions to the enterprises located in the park. The R&D work implemented in the park is often limited to elaborating prototypes, while production is carried out elsewhere. In a few cases, however, some advanced technology components are produced within the park.

ii. Technology Parks

A technology park comprises firms engaged in commercial application of advanced technology, with activities including R&D, production, sales and assistance. The production activity is thus primarily important, while the presence of the university is not essential. The academic link is generally less important than for science and research parks. Admission to the park may be conditional to developing production and/or high technology activities. The park satisfies specific infrastructural needs of high technology enterprises with respect to productive activities.

iii. Techno Poles

Techno poles are relatively new entities that extend over a well defined geographical area, where scientific and industrial activities are co-located, and exchanges of expertise, are greatly facilitated owing to the proximity of various institutions and their willingness to collaborate. For existing new and evolving areas of applied science, techno poles offer and attractive environment, and ready access to research facilities. Techno poles usually involve urban development, and may extend over a region that includes several cities. They comprise research laboratories for large firms, universities, research institutes and high-technology enterprises, as well as services for technology transfer. Shortly they are integration of research, incubator and Science Park on one site.

iv. Incubation Centres

Special emphasis should be laid on term "business incubation", which is an interactive developing process which aims to encourage people to start their own business, and supports start-up companies engaging in the development of innovative products in general. Incubation also means of developing a supportive and stimulating environment for entrepreneurship and start-up companies.

Business Incubation Center is a center which concentrates within a limited space and period of time of new enterprises. It offers them material such as physical space, common facilities, 'network resources, and immaterial infrastructure such as technical services, marketing support, management advise, financial counseling. Its objective is to increase development possibilities and survival rates of new enterprises, by supplying them facilities and real services. Its main goal is to favor local development and job creation.

The following figure shows a typical business incubation process.

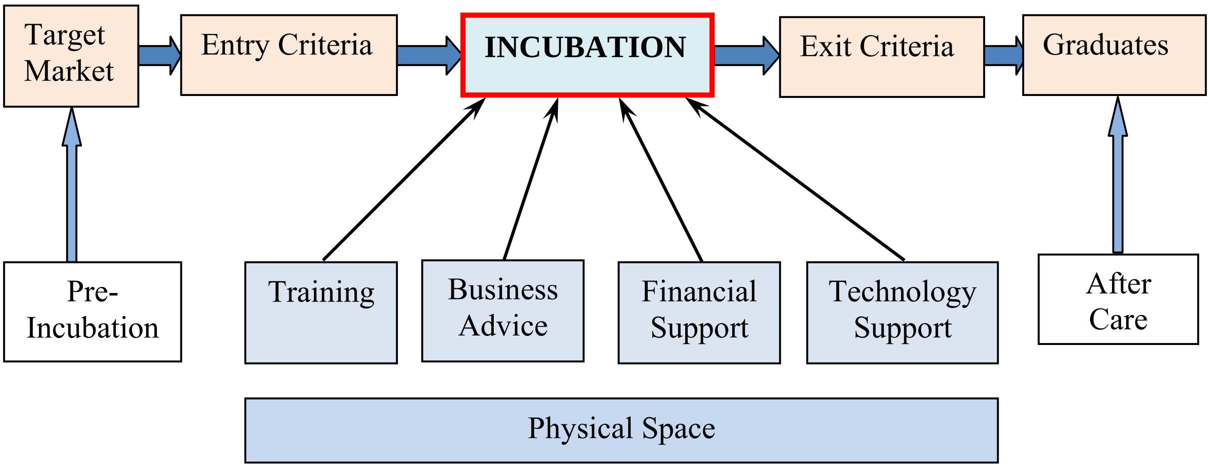

Figure 2.6 Business incubation processes [43]

From the above diagram, it is clear that business incubation is a targeted approach providing a range of focused services on a relatively small number of businesses. After business incubation has bee explained, technical business incubation is explained as follows:

v. Technology Business Incubation (TBI)

Technology business incubation refers to the type of incubation where the focus group consists of innovative service sectors, mostly technology-oriented, or knowledge-intensive, and interacts with the academic sphere giving a substantive element of the incubation process [44, 45]. The technology business incubator is an environment with a small management staff that provides the physical space, shared facilities, counseling, training and information specific to selected technology ventures, with access to university research, finance, and technical support services in one integrated and affordable package. TBI is usually linked to a technical university, research laboratory or technology park. It is service oriented and depends on the use of equipment, libraries and facilities from the university, as well as professional services from an informal network of community supporters [46]. In the same manner, the united nation for industrial development organization describes technology business incubators as a special type of business incubator specializing in new technology-based companies. The primary mission of a TBI is not to create jobs or to develop a region, but to facilitate the commercialization of research results, the acquisition and use of state-of the- art technologies that would promote domestic resource exploitation, and improve the international competitiveness of national industry [47].

The distinguishing features of the technology park as compared with TBI is that, technology park is an enhanced property based development that has high quality physical environment in park-like setting, located adjacent or at reasonable distance from a research or technical university, and emphasizes on activities promoting the growth of research, technology commercialization and knowledge-based enterprises. Depending on the context and focus, it could be called as research park, Science Park or science based industrial park. It may vary in size from covering a few hectares, to a city in itself-technopolis clustering technology related activities.

2.11. Technology Transfer Model

A review of the literature reveals that technology transfer researchers have attempted to develop new technology transfer model distinguishing from the traditional models developed during pre 1990, which mainly focused on technology transfer processes. Models developed during post 1990s have emphasized on the important element of communication between the technology developer, and the receiver and between different organizations [18]

2.11.1. Traditional Models of Technology Transfer Pre 1990

- **Appropriability Model**

This model was developed in 1945-1950s, and suggested that good or quality technologies sell themselves. The model emphasized on the importance of quality research, competitive market pressure in achieving technology transfer, and promoting the use of research findings. The underlying presumption of the appropriability approach was "viewing technology transfer as the result of an automatic process that began with scientific research and then moved to development, financing, manufacturing and marketing. One need not necessarily be concerned with linkages in the technology commercialization process.

- **Dissemination Model**

This model was developed in the 1960-1970s. This approach suggested the importance of technology, and innovation to be diffused or disseminated to the potential users by the experts. This model assumed that an expert will transfer specialized knowledge to the willing user. The presumption underlying this model was that once the linkages are established, the new technology will move from the expert to the non-expert. However, this model suffers from one-way communication or unilateral and characteristize no involvement from the users.

- **Communication Model**

This model was developed in late 1980s, and had a significant influence on technology transfer literature. The model perceived technology transfer as "a communication and information flow and the exchange and sharing of communication were understood fully. The model suggested technology as "an on-going process involving a two-way interactive process or non-linear by continuously and simultaneously exchanging ideas among the individuals involved.

2.11.2. Technology Transfer Models during Post 1990s

Several models developed after 1990s have emphasized on: (1) the important element of communication between the technology developer and the receiver, and between different organizations, (2) the levels of technology transfer, (3) the factors influencing technology transfer and (4) the technology transfer processes.

- **Gibson and Slimor's Model**

This model proposed that technology transfer consists of three levels of involvement: Level I-Technology Development, Level II-Technology Acceptance, and Level III-Technology Application. The model explained the levels of technology transfer involvements and integrated the activities involved in the traditional models.

- **Sung and Gibson's Model**

This model was developed to have similar objectives as Gibson and Slimor's (1991) model to address limitations in the traditional technology transfer models. As an expansion and improvement to the three levels involvement model of technology transfer , this model provided plausible explanations to the levels and factors affecting knowledge and technology transfer, by describing knowledge and technology transfer in four levels of involvements: Level I-Knowledge and Technology Creation, Level II-Sharing, Level III-Implementation, and Level IV-Commercialization.

- **Rebentisch and Ferretti's Model**

According to this model, technology transfer areas required further investigation and integration particularly on (1) the effect of the interdependencies between the technology characteristics and its organizational context, and (2) the interface between the core competencies of the firm and its ability to adopt new technology. The technology transfer process in this model consists of four categories that include: transfer scope, transfer method, knowledge architecture, and organizational adaptive ability.

- **Predictive Technology Transfer Model**

The linking mechanism necessary to achieve effective technology transfer is described by identifying the factors that contribute to the movement of technology from the source of knowledge or supplier to the users of knowledge and this is shown in the figure 2.7. These are method of information documentation, The distribution system, capacity of the receiver, informal linkers in the receiving organization, organization, credibility, reward and willingness [51].

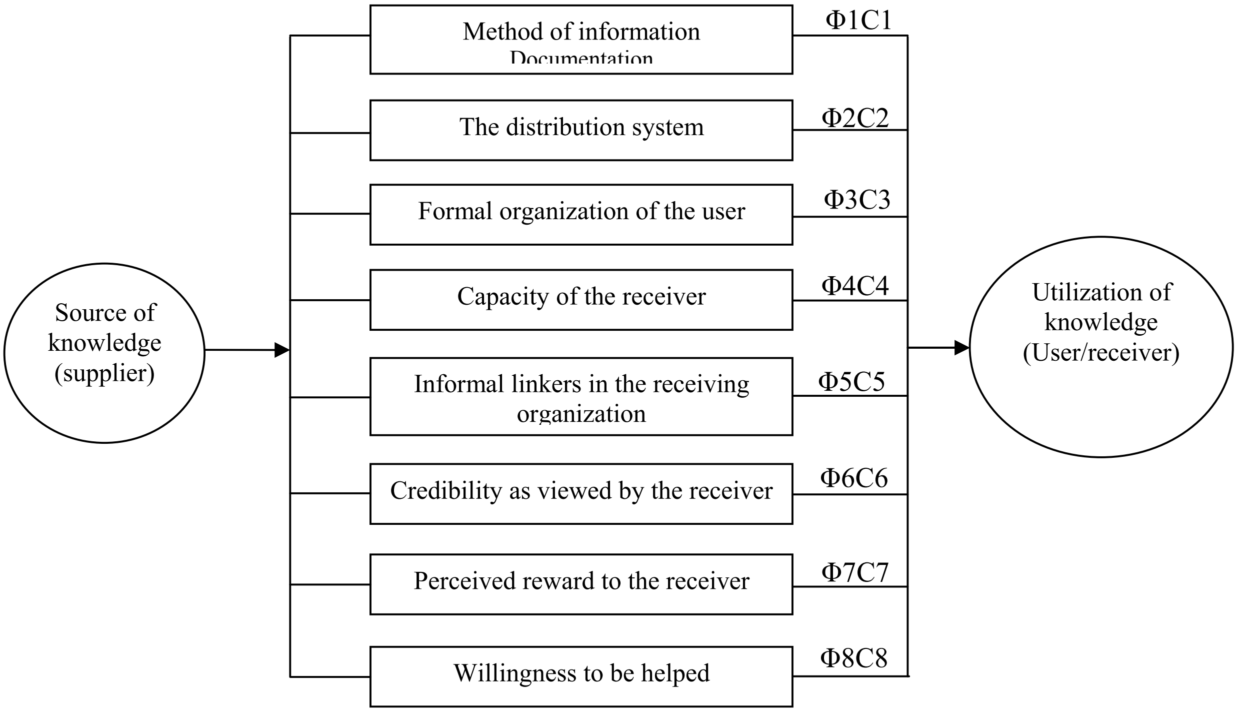

Figure 2.7 Predictive model of technology transfer

The model may be expressed in equation form as follows:

$$L_i = \sum (\Phi_1 C_1 + \Phi_2 C_2 + \cdots + \Phi_j C_k)$$

Where:

Φ_j = a measure of factor utilization ranges from 0 to 1. If 0, no utilization of that factor and if 1, the factor is utilized fully. This coefficient is a measure of the utilization of the factor which is applied for each organization or individual.

C_k = a measure of the factor contribution of each factor to the total transfer process. The sum of all C_k factors equals 1. C_k may be vary according to the population sector being studied.

L_i = linker index for an organization. By multiplying the Φ and C coefficients for each factor and summing for each organization, a numerical value is determined and helps to predicting the effectiveness of an organization's ability to achieve technology transfer. If the value of L_i approach to 1, it shows the company has higher technological capability to transfer the technology.

2.12. Role of Technology Transfer in the Development Process

Economic theory traditionally singles out three factors of production or groups of resources, for example; labor, capital, natural resources and land. Their ultimate contribution to economic development is the derivative of many factors, among which technology plays the prominent role. As the figure 2.8 shows, imported technology may directly affect the economic development of the recipient country, in terms of gross national product (GNP), through the following three, partly interrelated channels [52]:

1. Technology transfer may constitutes a source of increase in the physical stock of productive factors or resources available, for example; imported machinery and equipment, foreign raw materials, components and parts not available in the host country and accompanying technology transfer contracts.

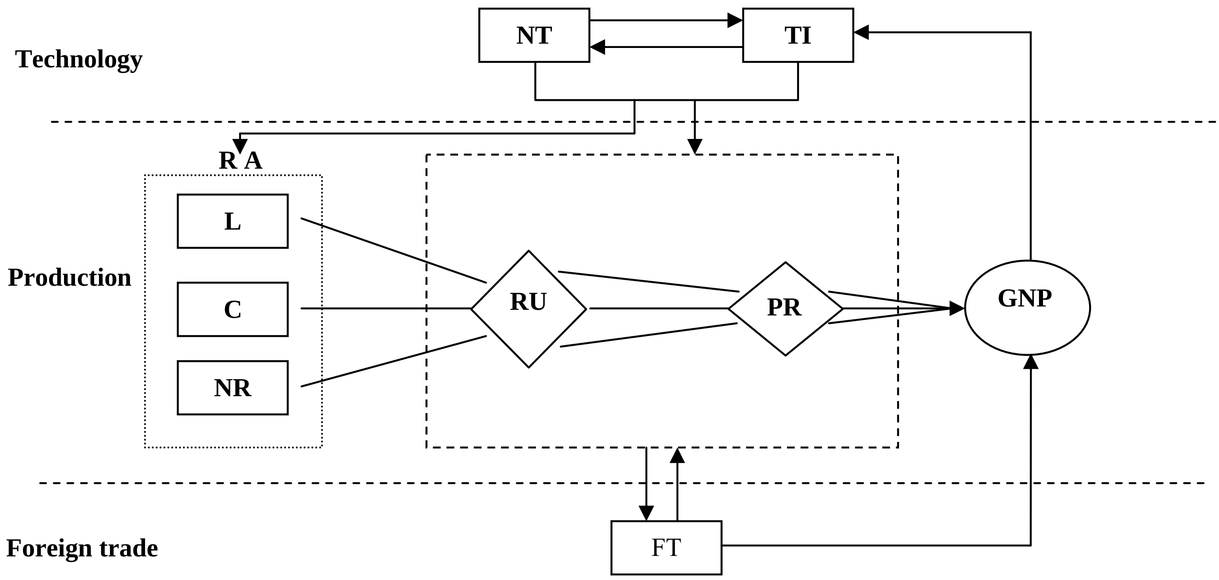

Figure 2.8 impact of technology on production

Key:

NT = national technology	**NR** = natural resources
TI = technology imports	**RU** = utilization of resources
RA = resources available	**PR** = productivity of resources
L = labor	**FT** = foreign trade
C = capital	**GNP** = gross national product

2. Foreign technology may contribute to the increase, and extent of exploiting existing resources for example, generation of new job opportunities for previously unemployed labor, decrease of idle capacity in some sectors of the economy, and extension of arable land for new cultures.

3. Transfer of foreign technology may result in substantial growth in the productivity of utilization of existing factors such as: labor, capital and natural resources including land.

2.13. Contribution of Technology Transfer

2.13.1. Economies of Scale Effects

Technologies imported to developing countries from the advanced economies predominantly involve mass-scale production. Therefore, technology transfer to developing countries entails a substantial increase in production capacity and, most typically, enables the achievement of economies of scale as shown in figure 2.9.

The economies of scale may be defined as a decrease of unit or marginal production costs as a result of the expanded production capacity or increase in the scale of output.

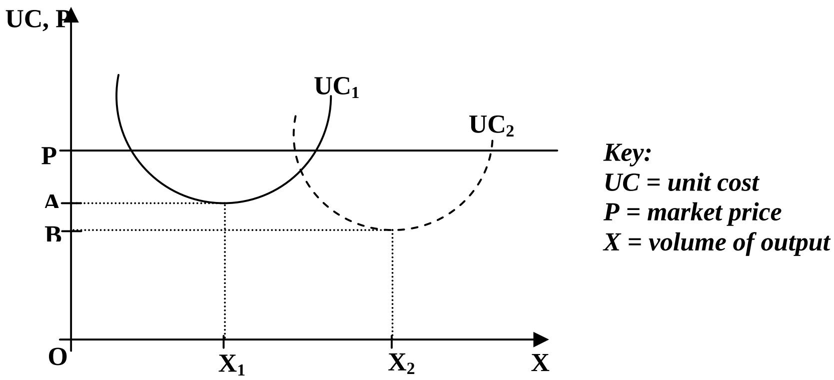

Figure 2.9 Economies of scale effects

2.13.2. Foreign Trade

Technology transfer to developing countries may produce three basic types of consequences i.e. import-substitution, import-creation and export-creation effects.

- **Import substitution effects**

Transfer of technology frequently brings about the substitution of hitherto imports with domestically manufactured goods and/or services. This effect may be due to two reasons. Firstly, imported technology consists of process innovations such as machinery, patented techniques, know-how, which enable a reduction of unit production costs of previously manufactured goods, and make them more competitive vis-à-vis their foreign equivalents. Secondly, technology transfer encompasses product innovations that allow in the foreign manufacturing commodities. Under conditions prevailing in the developing countries, the latter type of import substitution has been much stronger and more frequent.

- **Import-creation effects**

The complexity of modern technological processes requires appropriate productive inputs that are not mostly available in the developing countries. Therefore, technology transfer in such cases imposes the necessity of initiating accompanying imports of missing components of the production process, that is, high-quality raw materials, parts, machinery and equipment.

In the extreme case, the implementation of imported technical knowledge in a developing country leads to a substitution of previous imports of final goods only, and accompanying imports of productive inputs for new technology.

Apart from accompanying commodity imports directly connected with projects that involve foreign technology, transfer of technology may simultaneously induce additional merchandise imports in other sectors of the economy. The main roots of the induced imports result in technical disharmony of the recipient economy described earlier, and its adjustment reaction aimed at restoring the technical equilibrium.

- **Export creation effects**

Implementation of imported technical progress may result in the establishment of export sectors in the recipient country, and the undertaking of export expansion with new or modernized products. Foreign technology provides higher quality of domestically produced goods, and makes them more competitive in international markets. Better access of developing countries' products to foreign markets can be achieved by the right to use the supplier's trade mark, and to service export outlets through its sales network.

In the longer run, imported technical knowledge may also contribute to the technology exports creation effect, due to improvements in foreign technology introduced by the recipient and induced own innovative activity of new or modified product and process. Therefore, there must be continuous follow-up effort of the local R&D sphere and its full integration with the production sphere.

2.13.3. Domestic Technical Progress

According to widely-accepted definitions, technical progress means those technical changes in production equipment, production methods or techniques, and/or final products which generate positive economic effects.

The influence of imported technology on the domestic technical progress in the host country can take various forms. In the most general terms, two groups of effects may be distinguished, that is, direct and indirect effects.

- **Direct effects**

Assuming the existence of the technological gap between the recipient and the supplier, technology transfer fills the gap to a certain extent by directly enhancing the technological capability of the importing company and the country. Transfer of foreign technology may provide the recipient, either with product or process innovations, or both. In the case of product innovations, the country is able to manufacture new products, or improve the quality of the existing ones, thus upgrading its overall technological level and eventually establishing new export-oriented industries capable of competing successfully in the international markets and thereby generating hard currency revenues.

- **Indirect effects**

Transfer of technology influences the domestic technical progress in the developing countries not only in implementing imported innovation in the recipient country directly, but also indirectly. The latter effect is often referred to as a technological multiplier. It covers the broad range of technical improvements induced by a given project, with a foreign technology component in other segments of the national economy. In particular, induced domestic technical progress may take place in downstream industries, such as suppliers of raw materials, components and parts, machinery and equipment, as well as sub-contractors of the company implementing imported technology. Simultaneously, it may also occur in upstream industries, that is, recipients/users of goods and services produced on the basis of foreign technology. In both cases of backward and forward linkages, the main premise for further technological developments in the importing country stems from the necessity to catch up with higher technical standards imposed by foreign technology, and make the whole domestic technological chain compatible with imported technical innovation.

- **Skills-creation effect**

Transfer of technology, by means of transplanting foreign expertise and know-how, contributes for a skills-creation effect, both at the project level and in the whole national economy in the longer run. The effect in question may consist either in the generation of entirely new skills due to the transmission of foreign technology, or in the upgrading of existing ones. New or higher skills may be acquired via different channels, such as the training of the technology recipient's personnel prior to the start-up of the project, on the premises of the technology supplier or in-plant; employment of expatriate personnel during the implementation phase; by providing technical assistance to the supplier, etc., and these will provide the learning-by-doing effect of the local labor and managerial staff.

2.13.4. Local R&D Activities

The most direct, short-run impact of technology transfer on the domestic R&D activity takes place via the participation of the research and development sphere in starting up investment projects that involve foreign technology. In the most cases, imported technical knowledge requires a certain adaptation to local conditions, particularly in the developing countries. It should also be properly absorbed by the recipient during the running-in period at full capacity, and subsequently diffused to other segments of the national economy. Technology transfer may strengthen the domestic R&D capability, speed up its rate of growth, provides the science and technology spheres take to an active part in the project implementation process, and supports imported technology adaptation, absorption and diffusion.

Similarly, the inflow of foreign technology may indirectly contribute to the strengthening of a developing country's research and development capability. In particular, this sort of positive impact may be channeled by demonstrating to other segments of the R&D sphere, that is not linked to technology transfer, that attempt to imitate foreign innovations, and further develop their own new generations of innovative products or processes.

2.13.5. Structural Changes in the Economy

Transfer of technology has usually been associated either with the launching of new investment projects or the expansion or modernization of existing ones. In the simplest term, emerging new industries may be translated as the building of new segments to the hitherto structures of the economy. Similarly, the technical superiority of new projects generates an accelerated rate of growth of new industries and consequently of the whole economy. Assuming the existence of forward and backward linkages of new modern sectors with the rest of the economy, transfer of technology implemented in new projects may also induce structural adjustments in other sectors.

All these adjustment may, in the longer run, produce the following outcomes:

- Accelerate the rate of growth of downstream and upstream industries and hence, of the country's GNP;
- Increase in the efficiency of exploitation of production factors in the recipient country;
- Establishment of self sufficient structure of the national economy.

Likewise, in the case of modernization or expansion of projects, imported technology may be used to small scale, which usually increase the capacity of the existing product mix, and simultaneously upgrade its technical standards.

2.13.6. Institutional Adjustments

Technology transfer to developing countries affects not only the economy of the recipient country, but simultaneously influences its institutional environment in the broad sense, that is, organizational set-up, social habits and attitudes, values and behavior, economic system, etc.

As can be seen transfer of technology from the micro-economic angle, if the spillover effect takes place on a large scale, it may catalyze subsequent adjustments in the whole economic system of the recipient country. The establishment of new government agencies, restructuring of the existing institutional set-up, reshaping of the economic policy and development strategy, better selection of personnel for government and other positions, all these and other adjustments may result in the overall effectiveness of the economic system and accelerated economic development.

2.13.7. Distribution of Incomes

As a rule, economic ventures involving transfer of technology produce, changes in the distribution of incomes on different levels. Firstly, they can affect individual wages and salaries within and indirectly outside projects, based on imported technology, and this increases the relative shares of certain professional groups in national income distribution. If differences in earnings of labor and staff employed in new industries or projects, and those in other sectors of the economy are too high and this may result in social tensions and unrest.

Secondly, newly established projects and industries may change sectoral and regional distribution of incomes in favor of these modern sectors. Similarly, they may result in the increased outflow of foreign exchange or transfer of dividends for foreign partners, royalty payments, etc., imposing a burden for the country's balance of payment, and worsening the existing income distribution pattern between the host country and abroad.

Thirdly, as a long-term result of technology transfer, increased share of certain social or professional groups in income distribution may lead to the growth of the aggregate propensity saving. This in turn, may increase the amount of savings available for capital formation, and contribute to better development prospects of a developing country. However, it should be noted that the opposite changes can also happen, thus diminishing the economy's potential to invest.

2.13.8. Build Technological Capability

Technological capability is the technical, managerial and institutional skills necessary for industry to utilize capital equipment and technical information efficiently. As virtually all advanced technologies are imported from industrially developed countries, technological capability can also be defined as the ability to make effective use of imported technologies. At a more advanced stage of industrial and technological development, technological capability should enable firms to create new technologies, products and processes in response to a changing economic environment.

To acquire this technological capability, a technological effort is required. This effort usually takes the form of purposeful investments by a firm in training employees such as; managers, engineers, technicians and plant workers, searching for new technical and other relevant knowledge, and developing the organizational knowledge to create, communicate, and diffuse knowledge, internally within the firm. At a more advanced level of industrial development, absorption and mastery of new technologies also requires investment in R&D.

2.14. Technology Commercialization

Technology commercialization is the process of transforming innovative technologies developed by universities, companies and inventors into commercially viable products and services based on market demand. It is the series of activities enabling the acquisition of technology commercialization ideas, maturing them, developing technology to realize through research, making prototypes using accumulated developed, develop new process or make improvements to the existing process to enable mass production of products, through releasing the newly produced products to the market, make sales, construct new infrastructure, if necessary, to enable easy consumption in the market, and maintain the superior position of the new product in the market place.

Technology commercialization model provides a "road map" to commercialize technologies. Using such model helps to break the process down into a sequence of major phases, stages, and critical steps and activities that should assist with, and increase the likelihood of success as shown in figure 2.10.

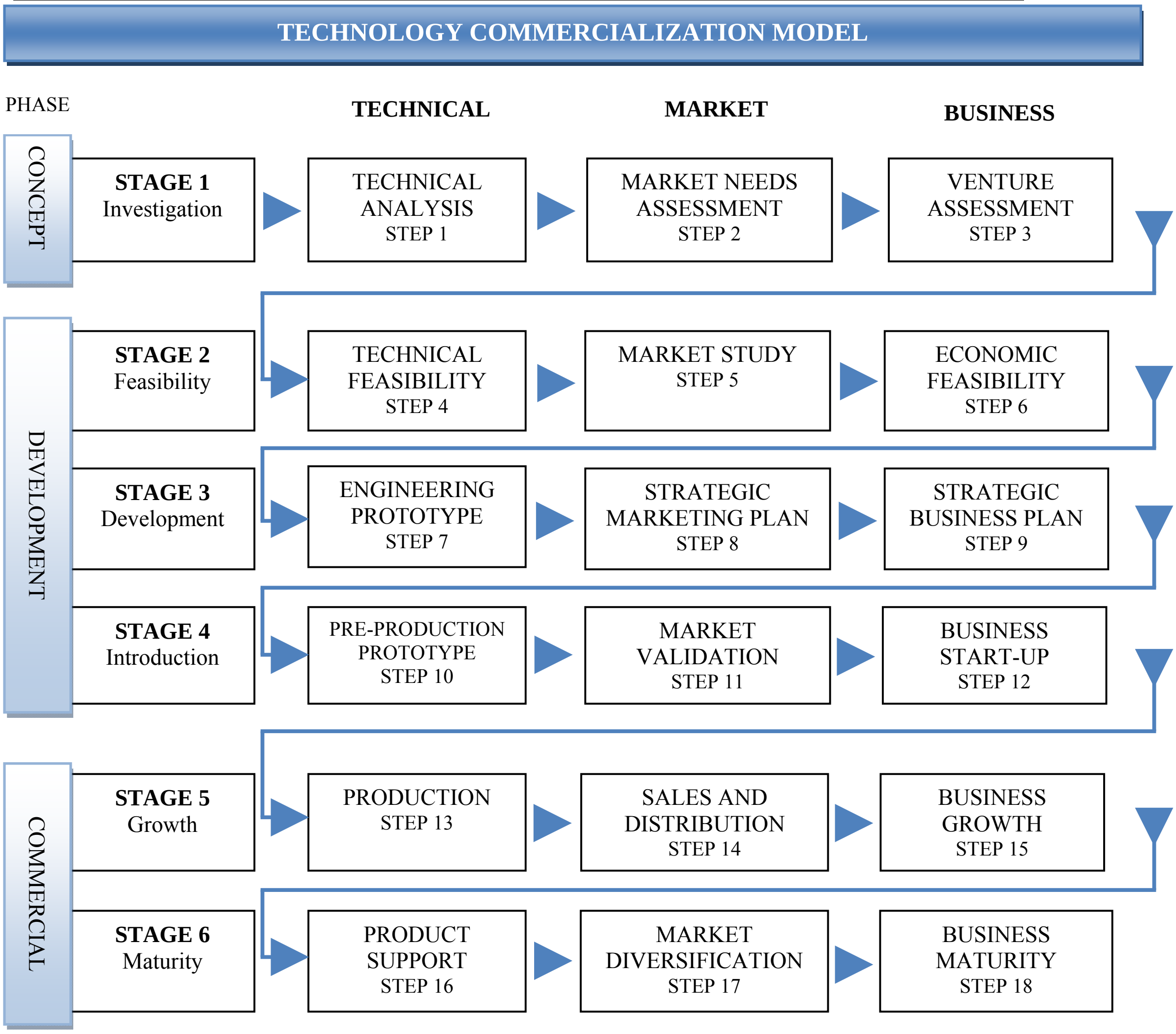

Figure 2.10 Technology Commercialization Model

Each phase has specific technical, marketing and business activities that must be considered as the planning moves through each step of the process. A product development and technology commercialization model also serves as a framework to develop progress measures, to identify information and technical assistance needs, to estimate development costs, and to forecast financing requirements. Such model has been attached in annex I.

Chapter Three
The Role of Technology Transfer in Development of the Newly Industrialized Countries

3.1. Introduction

Review of the socioeconomic development paths of the newly industrialized East Asian countries reveal that their initial conditions in early 1960s were not better than that of many of the African countries. Their economic structure was dominated by agriculture, and country like South Korea was in fact very poor in terms of agricultural and other natural resources. However, their rapid and successful transformation into industrialized economies was amazing.

A striking feature of the early development of the Asian NICs was that they largely sought to benefit from available technological knowledge from abroad. In this sense they were "free riding" on the scientific and technological knowledge base, developed by the industrialized countries. However, in order to absorb the technological and scientific knowledge; education, especially technical education, had to be of a high level [14]. The policy focus was on improving education and training to develop the capacity to absorb and use the imported technology efficiently as shown in figure3.1. What is important is how effectively a firm combines foreign technology elements with its own experience and knowledge, in order to strengthen its internal capabilities. Latecomer countries can catch up the frontrunners after a certain time lag and enter to technologically advanced sectors in which the frontrunners originally specialized. Then frontrunners move up in the manufacture of more advanced products [61].

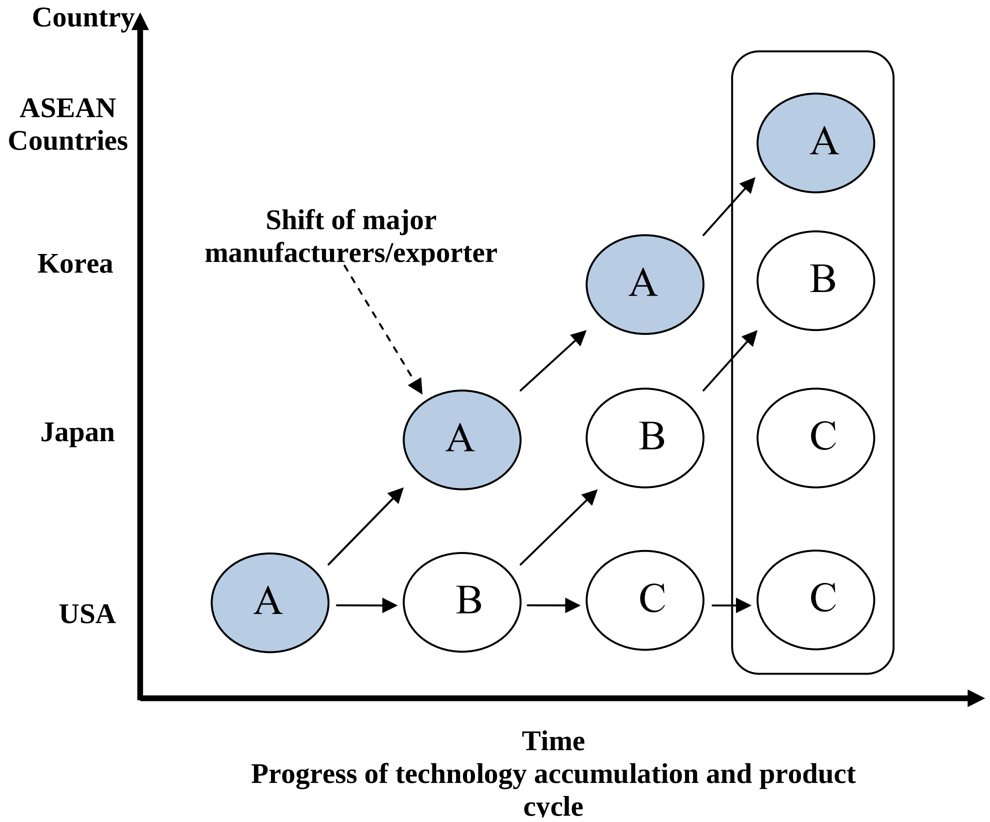

Figure 3.1 International Product Cycle and Technological Advancement

3.2. Korean Experience

Korea has developed diverse programs for technology commercialization, and some may provide insights to other developing countries. Economic growth of Korea depends on the policy related to technology and technological innovations inside Korea. In this regard, Korean government places great emphasis on stimulating technology business, and on promoting conducive climate to technology transfer [62, 63].

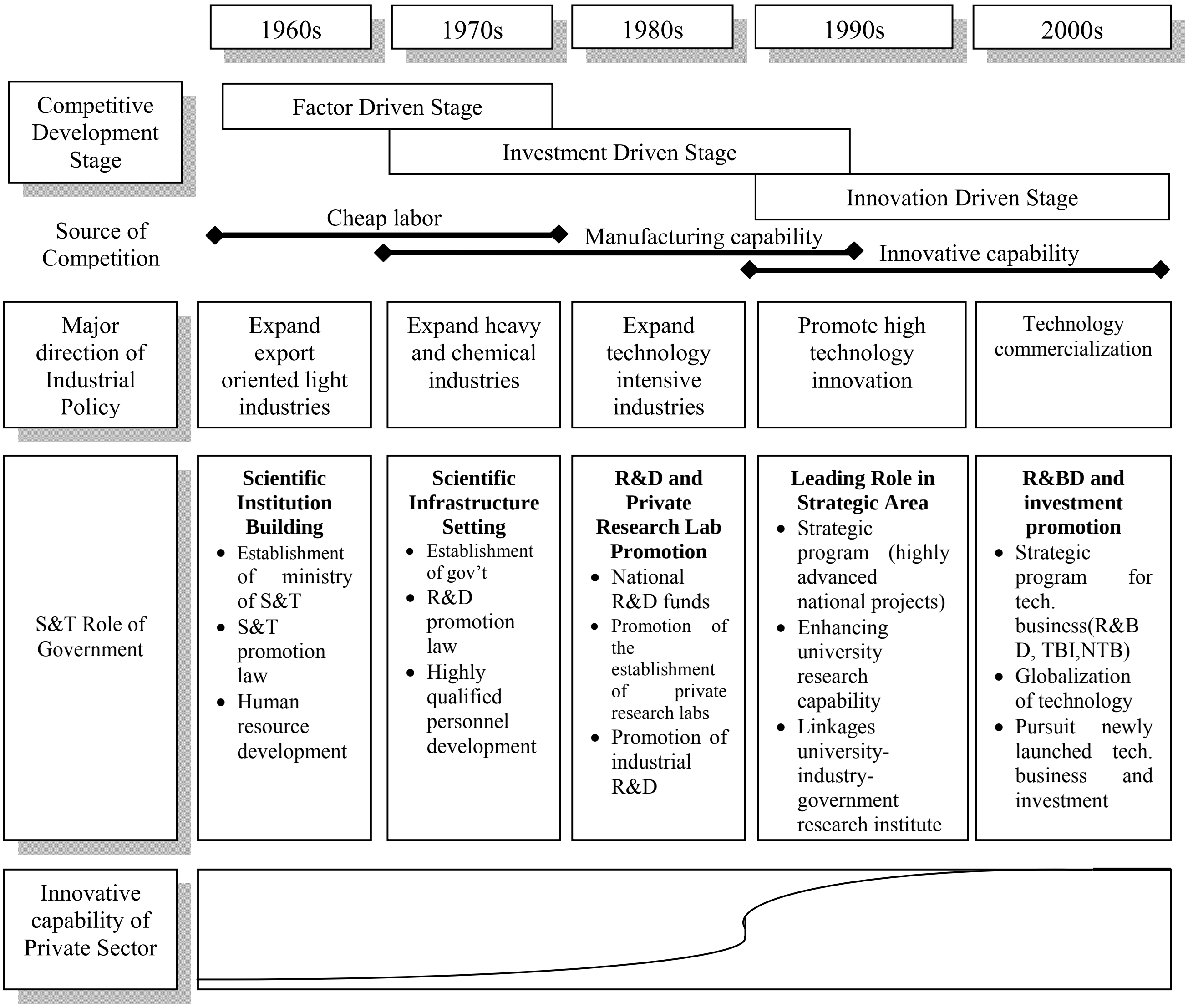

Figure 3.2 Science and Technology strategy Roadmap of Korea Government

One of Korea's unique industrialization strategies is the determination to develop advanced heavy industry independently. In order to enter heavy industry and acquire the technology, the country primarily relied on importing capital goods, technology licensing, and other technology transfer agreements. It imported large capital goods and encouraged firms to obtain the latest equipment and technology. It used reverse engineering, adaptation and own product development to develop its own technological capabilities. It invested heavily in local R&D to build up technological capabilities. To help resolve technical problems, Korea also encouraged the hiring of foreign experts, and the flow of engineers from Japan.

Korea is a forerunner in using imported technology successfully; to feed into its domestic technology and to develop an independent innovative base.

The Korean government heavily invested on technology infrastructure to promote and deepen local technological capabilities. The Korean Institute of Science and Technology, first established to conduct applied research aimed at solving simple problems of technology transfer and absorption, and it was later engaged in the study of a series of National R&D projects. A number of specialized research institutes focusing on specialized disciplines such as machinery, electronics, chemicals, shipbuilding, etc, were also established.

The central element in Korea's technology strategy, and which markedly differentiated it from other newly industrializing economies of the region, was its deliberate creation of large local private conglomerates, the so called, Chaebol. Such conglomerates were initially handpicked by the government from local successful exporters, and were given a range of subsidies and privileges for implementing the strategy of setting up capital-technology intensive activities geared to the export market.

A number of promotional measures were also taken to diffuse technology throughout the industrial sector, that, to enhance the technological advancement of smaller firms. An effective mechanism of technology diffusion was to promote subcontracting to SMEs. Generous financial and fiscal support was provided to support the operations of sub-contracting SMEs, and help them in process and product development. In addition, sub-contracting SMEs were exempted from stamp tax and granted tax deduction for a certain percentage of their investments in-laboratory and inspection equipment, and for the whole of their expenses for technical consultancy. Furthermore, to help resolve technical problems, Korea also encouraged the hiring of foreign experts and the flow of engineers from Japan. Korea is a forerunner in using imported technology successfully to feed into its domestic technology and to develop an independent innovative base [64, 65, 66].

Consistent with this central strategy of developing indigenous technological capability, FDI was given a secondary role. FDI was allowed only when it was the only alternative of obtaining closely-held technologies or gaining access to world-markets. In some cases foreign investors were even forced to sell out, after the technology has been absorbed locally. The government also intervened in technology imports and contracts to lower prices, strengthen domestic buyers, and maximize the participation of local consultants in engineering contracts to develop basic process capability. The government stipulated that foreign contractors transfer their design knowledge to local firms, in plant and process engineering. Therefore, Korea used FDI to further the acquisition of technology by local firms, but never became the engine for technological or industrial development.

3.3. Singaporean Experience

Singapore is a small state-city with a limited captive domestic market, therefore nurturing infant industries and companies with an active industrial policy was not a sensible strategy for economic development and growth. This meant that there were no opportunities for learning-by-doing by producing first for a protected domestic market first before becoming internationally competitive and subsequently exporting to external markets. Industrialization had to be necessarily export-oriented from the outset of a small state-city.

The country's policies for attracting Foreign Direct Investment (FDI) were based on liberal entry and ownership conditions, easy access to expatriate skills, and generous incentives for the activities that was seeking promotion. The new technologies that the Multi National Corporations (MNCs) had to bring into Singapore, were strongly influenced by the incentive system and the direction followed by the government, which provided the necessary skilled manpower in consultation with the MNCs. To upgrade the industrial base, government targeted activities for promotion and aggressively sought and guided MNCs to higher value-added activities using different incentives. Singapore relied heavily on foreign investors to bring 'ready made' technology and by specializing in small segments of the technology rather than seeking to establish integrated facilities.

Singapore also encouraged MNCs to establish their research center. The National Technology Board (NTB) of Singapore directed the expansion of a research and development infrastructure for new industries, such as agro-technology biotechnology, robotics and automation. To facilitate this, new incentives, such as the regional headquarters, international procurement, international logistics-center, and the approved traders' schemes were introduced.

Singapore chose a number of selective interventions to move from labor-intensive to capital-skill-technology-intensive activities. The country's technology acquisition policy was directed at consciously acquiring, and subsequently upgrading, the most modern technologies mainly based on direct foreign investment. In areas where foreign investment was not feasible or desirable, government directly set up a number of public enterprises to undertake activities considered to be of future interest to the country.

The government mounted strong effort to support small and medium enterprises (SMEs). Government agencies were established to provide support to SMEs with management and training, finance and grants, and coordinating assistance from other agencies. A substantial fund was also set up to facilitate product-development assistance, technical assistance to import foreign consultancy, venture capital to help technology start-ups, robot leasing, training, and technology tie-ups with foreign companies. Further assistance in various aspects, including disseminating technology, providing information on foreign technical requirements and how to meet them, management advice and consultancy, identifying technology requirements and purchase technologies, and technology up-grading strategies were provided to SMEs [67, 68].

Singapore also established several government-support research centers, including the Singapore Science Park, the Institute of Molecular and Cell Biology, the Institute of Systems Science, and the Information Technology Institute.

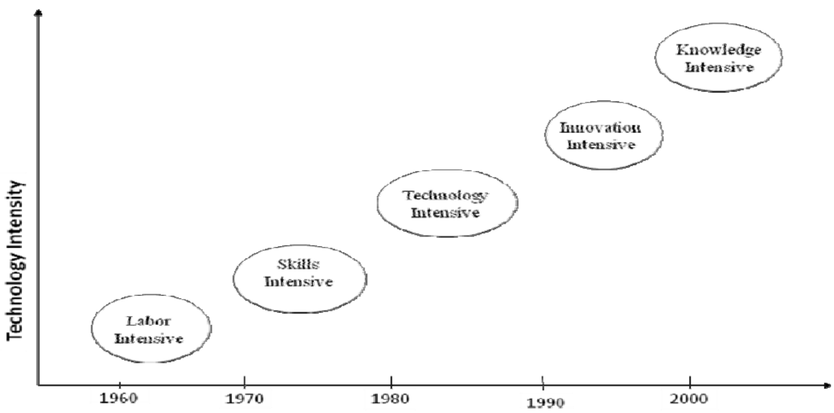

Figure 3.3 Singapore industrial developments

Each successive phase of technological transition was built upon the resources and technological capabilities accumulated in the earlier phases. In particular, there was a phased building up of MNCs, local manufacturing enterprises particularly in the electronics supporting industries, Public Research Institutes and Centers (PRICs) and university R&D, and, finally, local high-tech start-ups pioneering new products.

In terms of the development of technology capability, there was a sustained shift from learning to use with high reliance on internal transfer by MNCs to learning to adapt and improve via learning by doing within MNCs as well as learning by transacting in local firms acquiring external technology, learning to innovate; mainly applied R&D in product or process, and finally, learning to pioneer; creating indigenous technology and commercializing it in the marketplace through new ventures.

To accelerate the development and strengthening of capabilities in basic research, the National Science and Technology Board (NSTB) funded the establishment of 13 research institutes in industry specific areas. In the Second National Science and Technology Plan (1996–2000), Singapore's technology strategy was to build a world-class science and technology base in fields that match Singapore's competitive strengths, and that will spur the growth of new high value-added industries [69, 70].

Singapore's approach to deliver the skill needs of the industrial sector is said to be one of the best in the region. To provide the required skill, government selectiviely developed an efficient, industrial targeted, higher educational structure and a special worker training program. To this end the government established the vocational and industrial training board. Government also assisted employers to condct skills training courses at various levels matching their specific needs. Morover, the government collaborated with MNCs, and worked jointly with foreign governments to provide technical and training on the regional basis. Hence, availability of high skilled and specialized labour force and elaborate communication and transport infrastructure, accompanied by incentive system gave Singapore a competitive edge.

3.4. Malaysian Experience

Malaysia inherited, from its colonial past, a liberal economic system with a well functioning bureaucracy, stable macroeconomic policies, good infrastructure, trade oriented economy with foreign investment playing a large role in the productive sector, and a natural resource based sector that provided most of its export earnings However, before 1960, industries in Malaysia were meant to supply processed raw material; mainly tin, rubber, and palm oil, to industries in developed economies. After independence, Malaysia setted out to diversify and restructure its industry.

In the first phase of industrial policy (1960-1985), Malaysia employed both import substitution and export promotion policies, rather than free market trade policy. The export promotion policy of the country has attracted foreign investors to invest in processing industries for export. So, while import-substituting industries were given protection, generous incentives were devised in the area of export promotion.

However, despite the protection from import competition, locally owned light and primary processing industries were not able to develop their competitive status. They remained technologically backward, as they were not linked to technologically better advanced export industries. A further set back was the government's political agenda which linked the industrialization program with the improvement of the ethnic Malaysia’s economic status.

Failure to develop the indigenous industries prompted the government to establish state owned large firms, and this was highly in line with the Korean approach. However, such state owned giant industries suffered large losses in the early years of their operation. In addition, many of the other smaller state-owned enterprises also performed poorly [71, 72].

Malaysia was successful in its FDI program. A generous fiscal incentive, disciplined and literate labor force, good infrastructure, low wages, efficient administration, favorable regional location, and favorable investment climate helped Malaysia to attract MNCs and launch a successful high-tech export path.

Government moved into the second phase of industrial policy in the mid 1980s, with a fresh drive to attract MNCs, privatizing some public enterprises, and adopting a pragmatic strategy.

The new industrial policy in the second phase shifted to more selective strategy, that is, providing critical factors for industrial development such as skills and training, technical support, finance, quality improvement, and the like. The government moved to strengthening science and technology institutions, and stimulating private R&D enterprises. Industrial restructuring programs were devised to provide cheap finance for the textile and engineering industries. Infant industry protection continued but has been governed by dynamic notions of comparative advantage, and promoting the development of industrial sub-sectors that are intended to replace light manufacturing activity as the main exporters. The restructured public sectors retained a role in industries such as automotive, petrochemical, iron and steel, etc, where the required investments were large and long gestation periods involved.

Fresh and more generous incentives were designed to attract FDI. This time, the newly industrializing countries, Taiwan and Hong Kong, showed much interest in investing in Malaysia. Japanese MNCs continued to relocate their assembly operation in Malaysia, and induced many of their suppliers to invest along with them.

The government moved to more selective policies on export oriented MNCs. It started to use incentives to guide FDI into higher value-added activities and more technology-intensive processes; it was very much in the Singaporean mould. Malaysia introduced additional incentives to increase local content [73].
Malaysia launched programs to create specific skills, in electronics design, biotechnology, automobile design, etc. Government established an industry led training center – the penanag skill development center- in area where high technology MNCs engaged in exported activities are located. The center was allowed to bring in, without formal work permits, high level foreign trainers. The equipment needed for training was often obtained at no cost, from equipment manufactureres hopping to increase sales of their products. Some companies even moved their training equipment to the center, releasing space for their plants. The training center also provides pre employment training.

3.5. Chinese Experience

The policy on technology transfer has undergone a number of changes since the People's Republic of China was established. At first, turnkey project investments supplied by the former Soviet Union and Eastern European countries were the most important form of technology transfer. After the deterioration of relations with the USSR, followed by the 'Cultural Revolution', China turned inwards and tried to develop its own technological capability. During this period, there was limited technology transfer from Western countries and Japan. During the 1970s, the bulk of technology imports were still in the form of complete sets of equipment or turnkey plants [74, 75].

Investments during this time occurred mainly in the technologically backward sectors of petrochemicals, steel, electricity generation equipment and mining machinery industries, with the objective of developing technological capability in these sectors based on the more modern technology of the capitalist economies.

In 1986, the Chinese authorities announced “Provisions of the State Council of the People's Republic of China for the Encouragement of Foreign Investment" , to encourage the transfer of technology through foreign investment into what the government considered to be more 'productive' areas of the economy. Under these provisions, foreign joint ventures were granted a number of privileges including preferential taxation, simpler licensing procedures, and freedom to import inputs of materials and equipment, more autonomy from bureaucratic interference, interest free loans, and the right to retain and swap foreign exchange with each other. Foreign investment enterprises that employed advanced technology, and were export oriented also enjoyed additional tax benefits.

These improved incentives and a growing awareness of the potential of the Chinese economy stimulated a dramatic increase in foreign investment into China in the early 1990s. However, much of the foreign investment was in relatively low technology, labor-intensive operations that took advantage of China's low wage costs and policies to attract investment into the special economic zones.

As a consequence of this situation, there has been some tightening of regulations and concessions affecting foreign investments. In 1994, the State Council announced a number of policies to promote foreign investment in specified key sectors; including communications, energy and raw material sectors. There was also a tightening of procedures for the approval of contracts, and the registration of foreign enterprises. These included strict penalties if agreements were not fulfilled, new rules requiring foreign companies to invest capital within a prescribed period so as to reduce the gap between pledged and utilized investment, and new rules on the sharing of investment risks between Chinese and foreign investors to remove the need for investment guarantees.

In 1995, further guidelines were published detailing the foreign investments, the government now wished to encourage along with those that were to be restricted, prohibited or just permitted. These guidelines encouraged investment in high technology sectors such as chemical fibers, micro-electronics, precision machinery, civilian aircraft, biotechnology and energy development, as well as infrastructure and agricultural developments. Investment in the priority sectors would continue to benefit from tax preferences and foreign invested companies in these sectors would be permitted to sell up to 100% of their output in the domestic market. Elsewhere, tax preferences were mainly to be phased out, although the authorities subsequently relaxed their stance, when a number of high profile foreign companies made moves to reduce or withdraw their activities in China [76, 77].

In 1998, the State Planning Commission identified eighteen industries, mostly in high technology sectors, where China wished to promote further foreign investment. These sectors would be granted a restoration of duty free status on capital equipment imports. These newly promoted sectors were high-technology industries, new technologies, transport and telecommunications equipment, electric power generation, aviation, oil and petrochemicals, machinery, electronics, pharmaceuticals, medical equipment, textiles, metals and metallurgy, light industry, the service sector, and agriculture. At the same time, the State Planning Commission also reaffirmed broad limits to foreign ownership in businesses, in areas considered to be key sectors of the economy, such as nuclear power plants, satellites and aviation.

In 1998, the government also announced that the tax systems for foreign and domestic companies were to be merged by the year 2000, a change that would be more than double the tax burden on some foreign-invested enterprises. However, favorable treatment was retained for sectors and areas where China remains keen to attract foreign.

The removal of some tax incentives for foreign investors signaled a more discriminatory approach to foreign investment, and is part of the Chinese government's attempt to redirect growth from basic industries such as shoes and toys manufacturing industries, in favor of higher-technology sectors. In effect, the foreign investment regime is now more closely linked with domestic industrial policy priorities, and wider economic and social objectives [78].

3.6. South Africa Experience

From the early 1960s, South Africa adopted import-substitution policies. These policies were geared towards an attempt to build local industries behind protectionist walls to replace imports. Essentially, the Government sought to gradually replace imported manufactures by indigenous output. Tariffs were key to providing protective barriers so that local industries could grow and develop.

One of the main means of technology transfer is FDI. The South African government’s strategy for attracting FDI rests on three main pillars. The first is the maintenance of an attractive business and investment climate characterized by macroeconomic stability, investment-promoting regulatory and legal frameworks. The regulatory and legal frameworks are basically the same for domestic and foreign investors. There are no material restrictions on the repatriation of profits and the type (sectoral and otherwise) or extent of foreign investment [79, 80].

The second pillar consists of investment incentives, including tax holidays, depreciation allowances and relocation assistance to reduce investors’ input costs. Though seemingly underplayed, there are technology and human resource development incentives to raise the value of factors, the Department of Trade and Industry, for example, offers a skills support program. This is a cash grant for skills development with the objective of encouraging greater investment in training, and creating opportunities for the introduction of new advanced skills.

The third pillar of the investment-promotion strategy consists of spatial development initiatives (SDIs), and industrial development zones (IDZs) aimed at crowding in private investment through public sector financial support for infrastructure and anchor projects.

The South African government has been particularly keen to attract export-oriented FDI and in doing so, it has been hoped to stimulate innovation and exports in local firms through the technology and skills transfers and competitive pressures associated with FDI.

FDI has concentrated in a few sectors: energy and oil, motor and components, food and beverages, hotels, leisure and gaming, and, in recent times, banking. Especially, the automotive sector has grown rapidly in South Africa, constituting 5.5 percent of GDP in the early 1990s and 7.5 percent in 2008. The export share has risen even more dramatically from 4 percent in 1995 to 14 percent in 2007. FDI has often involved greater commitment by a parent company to the local company. This has led to associated positive spillovers such as technology transfer, human capital development, learning processes in organizational development and access to export markets. Furthermore, the acquisition of machinery and equipment is the most important source of technology transfer amongst both domestic and foreign owned firms in the sector. Licensing of technology on the part of automotive component firms is common in South Africa [81, 82].

In South Africa, capital goods sector is also undoubtedly the most technologically advanced sector, due to the strong research and technology base that was build during pre 1994. The local value added content is as high as 90 percent in this sector, reflective of the local competencies in the sector. At the product level, South Africa is a world leader in a number of mining equipment products. These include spirals for washing coal, pumping up water, hydropower, tracked mining, underground locomotives, ventilation, shaft sinking, turnkey new mine design and many others. Furthermore, South African expertise is particularly advanced, and at the global frontier in deep level mining and associated competencies. Outside of mining, there are a number of other areas where South Africa has leading global products such as transport, haulage and processing equipments. In many cases, the mining sector provided the initial source of demand, and successful domestic firms then branched out into other areas.

South Africa spent about 0.98 percent of its GDP on R&D in 2007. From 0.98 percent of GDP spent on R&D, 58 percent accounted for industry, suggesting a strong potential for meaningful UILs. The Higher Education Act of 1997 gave three missions to South African Universities: social and industry outreach mainly market-driven, entrepreneurial activities based on spinoffs of research results, research parks, and university-business joint research. The well-endowed universities emphasize research, while some of the less well- endowed such as the universities of technology, focus more on teaching and skilled development missions.

Indigenous technology and culture, appeared in the final revised National Curriculum Statements, implemented in 2006. This inclusion was seemingly unique to South Africa. There is no doubt that the inclusion of 'indigenous technology and culture' in the National Curriculum Statement promotes the visibility of indigenous knowledge [83].

The Department of Science and Technology established the National Indigenous Knowledge Systems Office (Niko), to increase public awareness, understanding, knowledge and appreciation of the IKS. Niko has created an appropriate platform through the Interdepartmental Committee on IKS to coordinate and promote the work of different departments. The National Recordal System, a large fingerprint initiative of the Department of Science and Technology, will document, record and store indigenous knowledge for the benefit of the communities of South Africa. It will be the first worldwide.

3.7. Brazil Experience

Brazil developed in the last 25 years the largest system of S&T in Latin America and one of the most significant among semi-industrialized countries. There are about 15 thousand active scientists and researchers in the country, and about one thousand graduate programs in most fields of knowledge.

Brazilian science and technology have achieved a significant position in the international arena in the last decades. The central agency for science and technology in Brazil is the

Ministry of Science and Technology; Brazilian science effectively began in the first decades of the 19th century.

Today's Brazil has a well-developed organization of science and technology. Basic research is largely carried out in public universities and research centers and institutes, and some in private institutions, particularly in non-profit non-governmental organizations [84, 85, 86].

Applied research, technology and engineering are also largely carried out in the university and research centers system, contrary-wise to more developed countries such as the United States, South Korea, Germany, Japan, etc. The reasons for these are many, but the main ones are:

- Few Brazilian private companies are competitive or rich enough to have their own R &D, they usually develop products by outsourcing from other companies, usually foreign ones;
- The high-technology private sector in Brazil is dominated by large multinational companies, which usually have their R&D centers overseas, and with a few exceptions, do not invest in their Brazilian branches.

However, there is a significant trend reversing this now. Companies such as Motorola, Samsung, Nokia and IBM have established large R&D centers in Brazil, starting with IBM, which had established an IBM Research Center in Brazil since the 1970s. One of the incentive factors for this, besides the relatively lower cost and high sophistication and skills of Brazilian technical manpower, has been the so-called Informatics Law, which exempts from certain taxes up to 5% of the gross revenue of high technology manufacturing companies in the fields of telecommunications, computers, digital electronics, etc. The Law has attracted annually more than 1.5 billion dollars of investment in Brazilian R&D. Multinational companies have also discovered that some products, and technologies designed and developed by Brazilians have a nice competitiveness, and are appreciated by other countries, such as automobiles, aircraft, software, fiber optics, electric appliances, and so on [87, 88, 89].

The larger part of the current S&T capability, however, was built during the 1968-1980 years, in a period of military rule. Three factors contributed to this rapid expansion. The concern of some military and civilian authorities with the need to build up the country's S&T competence, as part of a broader project of national growth and self-sufficiency; the support this policy received from the scientific community, in spite of earlier conflicts between scientists, academics and the government; and the economic expansion of the period, in which Brazil's economy grew at an annual rate of 7 to 10 percent. Another important element was the improvement of the government's ability to carry out policies in those years, through the establishment of small, independent agencies outside the federal bureaucracy, and an expanding fiscal basis.

With a long tradition as a host country for international direct investment, Brazil widely known as one of the most destination. Foreign companies have been in the country for decades and most big multinational corporations have been invested in Brazil. Today, Brazil is the most important source country for Foreign Direct Investment (FDI) in the Latin America. Over the last few decades, FDI have played a very important role in Brazilian industrialization, attracted by the large domestic power, government policies and directed preferentially toward capital and technology-intensive industrial sectors. Since the very start, foreign investments in the country were regulated by logic of market-seeking, the profitability of the investment being guaranteed by the protectionist trade policy.

Brazil was the main FDI destination in the region in 2007 and is considered to be among the most attractive destinations by foreign investors because of its large market, natural resources, and sophisticated and diversified industrial base. FDI in Brazil is quite an old story, the country’s flows and stocks have significantly increased over the past 15 years, making Brazil the largest host country for foreign investment in Latin America and second next to China among developing countries.

Important changes occurred in the sectoral composition of FDI inflows as well. Until 1995, the manufacturing sector accounted for almost 67% of all FDI stock in Brazil, whereas in the second half of the decade, the prevalence of the service sector was remarkable, with electricity, gas, water, postal services and telecommunications, financial services, and wholesale and retail trade attracting significant FDI flows. A large part of the investment in these sectors was associated with the privatization process. By 2000, the service sector's share in the FDI stock had increased to 64%, and that of the manufacturing sector had dropped to 33.7%, though manufacturing industries such as food and beverages, automotive, chemicals, metallurgy, and telecommunications equipment continued to receive significant volumes of investment [90].

3.8. Lessons Learned

These experiences provide ample lessons to Ethiopia, in striving for fast and sustainable socioeconomic development. Successful implementation of the current development policies and strategies of the country and sustainability of the results require scientific and technological capability that can deliver the support required by the development process.

First, though investors can provide access to the most modern technologies, they transfer only those technologies that the host country can absorb, with its skills, capabilities, supplier base and infrastructure. Therefore, a country with poor indigenous capabilities will only get simple technologies. While the investor should try to ensure that these are efficiently implemented, the further upgrading of industrial structure should depend upon the effort the country inputs into building up its skills, suppliers and so on. Ultimately, the foreign investor cannot do the capability development. There is no substitute for indigenous capability development effort, and technological transformation cannot be a passive process based on open doors to foreign investors.

Those that wanted to promote indigenous technological deepening had to intervene to restrict foreign entry and to guide their activities and maximize the spillovers. Those that choose to rely on MNCs and upgrade their global production structure had to intervene to target investors, guide their allocation and induce them to set up more complex functions. In general, two broad strategies of selective intervention were identified: the 'restrict and exploit' strategy of Korea and Taiwan and the 'target and guide' strategy of Singapore.

So there is no single optimal policy for developing countries on foreign investment. The entry of foreign investors should be encouraged, to boost technological capabilities and attract capital in capital-poor countries. Accordingly, over restrictive policies retard technological upgrading and capital deepening. On the other hand, simply opening doors to foreign investors without a broader strategic plan is not a solution to the problems on technological capability development. Perhaps to encourage domestic know-how with selective entry of foreign investors can yield significant dividends for industrial development at a certain stage of the process. And the optimal choice of the form of technology transfer should depend on the absorptive and innovative capacities of local firms, and the willingness of foreign investors to invest in deepening local capabilities

Table3.1 key lessons learned

Country	**Major practices**
Korea	• Emphasis on reverse engineering, • Intensive investment in the local R&D • Creation of large local private conglomerates(Chaebol)
Singapore	• Guided MNCs to higher value-added activities • Encouraged MNCs to establish their research center. • Government efforts towards calibrated manpower (industrial targeted special worker training program)
China	• Tightening of regulations based on the performance of technology transfer through FDI • Local content rules, backed by provisions that foreign firm transfer skills and technology to subcontractors and raise technological capability of local firms.
Malaysia	• Incentives to guide FDI into higher value-added activities and more technology-intensive processes • Government established an industry led training center
South Africa	• Providing protective barriers so that local industries could grow and develop. • Import-substitution policies • Department of S &T established the National Indigenous Knowledge Systems Office
Brazil	• Directed preference toward capital and technology-intensive FDI

Chapter Four

Practice of Technology Transfer in Ethiopia

4.1. Introduction

Every society has its own innovation potentials and history. Likewise, Ethiopia has its own innovations as one of the oldest countries and societies. The most prominent ones are the creation of its own alphabets through the church and church run school systems for nearly 1700 years which makes the country unique up to date [91]. In terms of construction and engineering, the pre-Christian era, Axum Obelisks, the Queen Sheba Palaces, the Lalibela rock Hewn Churches, the Dire Sheik Hussein Mosque, the Harar walls and other buildings, Queen of Sheba's Palace, Qusquam Palace, Mekele Castle, Entoto Palace, Menelik Palace and the Gonder Fasil Palaces are still exist and some of them are still giving service.

There were several closed classes of artisans such as blacksmiths, goldsmiths, silversmiths, tanners, weavers, tailors, woodworkers, potters, etc., which formed strictly endogamous castes. It is relevant to a study of technology in the Ethiopian context to note that the artisan castes were often credited with supernatural powers and much feared. The scar exists even today.

This chapter highlights the technological developments of the country by categorizing based on the technological development levels occurred at various eras, prior to pre-modernization period (1400-1840), Emperor Theodros (1840-1867, Minilik II , Hailesilase-I, the Derge and the EPRDF regime.

4.2. Pre Modernization Period (1400-1840)

During this period, ancient monasteries were innovators in Ethiopia. In addition, ancient hermit were researchers, engineers, agriculturalist and handicrafts, authors, doctors, smiths and weavers. We can mention Apostle Ezra for his innovation. Apostle Ezra had participated in church starting from his age 12. Even though he was a child, he had tried to create different things. At the beginning, he tried to create load lifting pulley which can transfer stone from lower areas to higher areas. Later he had been innovating various technologies. Such as stone mill operated by a donkey, a mill operated by water power, a mill operated by wind power, stone cutting material, oil squeezing machine, etc. He also showed his discoveries to King Emperor Naode [92].

In the 18th and 19th centuries, there was evidence that iron products were relatively cheap and were considered by travelers to be good quality [93]. Smiths produced a wide verity of articles until the end of the 19th century. These include plough-shares and iron parts of pick-axes, sickles and agricultural implements, knives and razors, spear-heads, daggers, swards, bullets and spare parts for rifles, tent-pegs, hammers, pincers, drills, nails, hatches, saws and files, steel for striking fire, pans to cook bread, bits and stirrups for horses and mules, chains and rings tweezers, scissors, and needles [94].

The technology of agriculture production has depended on the work of smiths for the production of tools for centuries. Digging sticks with iron tips, and two prolonged hoes have existed for long time in Southern Ethiopia, and ploughshares has been produced in Northern Ethiopia by local smiths, possibly since the first Millennium B.C. This constituted a revolution in technology, which provide substantial savings in labor time, higher yields and larger cultivated areas [93].

Since the re-establishment of contacts with Europe in the sixteenth century, Ethiopia had shown a desire to acquire European technology. Firearms were first introduced into Ethiopia during the reign of Emperor Lebna Dengel (1508–1540), a factor that played an important role in the outbreak of fighting in the sixteenth century. He was interested to get artisans from Europe [95].

As soon as firearms had been introduced into the country, the emperors at least had seen their importance. They all wanted better and more firearms, but this was expressed by different Emperors in different ways. Emperor Sertse Dengel (1564-1597) was intimidated by his own governor of the Red Sea area, Bahre Negasi Yishaq, who befriended the attacking Ottoman Turks. The Turks gave Yishaq some cannon, and he sent cannonballs as a gift to Sertse Dengel, implying that he had a new and much better armed master, the Pacha of Mitswa. Sertse Dengel was so affected by this that he kept one of the balls with the ark (Tabot) in the chapel of his court, and used to pray daily holding the ball [96]. Because of this, he sought allies in Europe and he saw that Spain was now the main

European power, and, instead of strengthening his existing Portuguese links, he wrote to the King of Spain requesting technicians who could make cannons, muskets, and gunpowder. Emperor Zedengel (1597-1607), who succeeded him, repeated this request and proposed that his son would marry a Spanish princess in order to make the two countries closer [97]. Even a number of the rulers in the Era of the Princess hoped to obtain technicians who would start an arms industry, as well as other industries, in the country, and train Ethiopians. These efforts invariably failed [98].

During Emperor Sussnyos's time (1607-1632), a number of new technologies were introduced into Ethiopia by European artisans, including a flour mill which required no human or animal power, and it was presumably a water mill, a new kind of bridge made with stone and lime, and a palace also constructed with stone and lime. However, it should be noted that the use of lime to make strong cemented walls to support vaulted buildings appeared new to Emperor Sussnyos's chroniclers, and presumably to the Emperor and his court, and churches, similar construction had already been reported in Tigray and Wello [95]. The supposedly new introductions of Emperor Sussnyos's time later gave rise to the grander castles of Gonder.

For a long time, the Biete Israel's were competitors to the Christian highlanders for hegemony, and wars were frequently waged between the two sides. After they had been repeatedly defeated, Emperor Yohannes I (1667-1682) had decreed that they should not live in the same villages as Christians. Quirin [99] traced the process which marginalized the Biete Israel, changing them from a mainstream farming nation to artisans and finally to an endogamous inferior caste. Their land was first taken away and given to Christians, unless they became Christians themselves. Then lack of land forced them to become artisans, especially blacksmiths, goldsmiths, potters, builders, weavers, and rug-makers.

The rise of the city of Gonder in their vicinity in the sixteenth century stimulated these crafts, especially that of masonry. The importance of the artisans to the city raised their status to tolerable levels, though they were still considered inferior to the Christians and Muslims. The decline of Gonder in the Era of the Princes denied artisans employment, except as blacksmiths making and maintaining the agricultural implements of the farming communities. This forced their dispersal into all of northern Ethiopia and induced an endogamy among blacksmiths scattered in the countryside, and within the small remnant communities of goldsmiths and silversmiths in the remains of former towns, mainly Gonder, Axum, and Adwa. The resulting total identification of the Biete Israel with blacksmiths and their endogamy, prepared the ground for their typecasting.

According to an informant in Tigray, well versed in his community lore, in the reign of "King Inenay" and "Ayte Baskimos" (these have not been found in the existing historical records), before the time of Ras Michael Shul (recorded as an important historical figure from 1744 to 1771), a short musket, called *quat,* was believed it had been made locally. Though the *quat* was probably imported rather than locally made, its maintenance, the manufacture of the necessary gunpowder and balls, as well as the means to fire it, were all done by local smiths [95].

The *quat* was equal to the length of an arm, essentially a tube with a handle and a kindling mechanism. A piece of cloth was pushed into the tube, followed by some gunpowder, followed by the bullet. More cloth was then packed into the tube. The kindling mechanism consisted of a hole on the lower part of the tube, through which access to the lowermost cloth layer was possible. The cloth was lightened through this hole, kindling the gunpowder and resulting in a shot being fired.

4.3. Emperor Tewodros Period (1840-1867)

A large part of the old empire was reunited by Emperor Tewodros (1840-1867), and he was Eager to introduce European technology into his country, especially he had tried to establish a firearms industry in Ethiopia. Professor Donald Karim expressed Emperor Tewodros as the first Ethiopia king who understood modern civilization thought. Tewodros had tried to change his modern civilization thought in to practice. In 1840, the emperor had been defeated by the Egyptian troops for the first and last time in his life history. He had identified that the basic reason for his unsuccessful war was luck of modern weapon. Tewodros purchased and surrendered many weapons from foreigners but his ambition was to manufacture modern weapons in our country.

1850s, Emperor Tewodros' awareness of the need for mechanical and other innovations in the military field had caused him to accept with enthusiasm an offer by the former European protestant missionary. He initiated a series of diplomatic contacts with Europe, especially with Queen Victoria of England. He exploited the history of the Ethiopian Church to appeal to European Christendom to send Protestant missionaries. Although his relationship with the Protestants was more amicable, his intensions were not entirely altruistic. He employed them in the manufacturing of armaments and restricted their proselytizing activities among the non-Christian Falashas [94].

Several technically-minded foreigners, who had come to Ethiopia independently to seek their fortune, were also settled at ‘Gafat’. He established large workshop at Gafat. At ‘Gafat’, these and other foreigners worked together fairly and harmoniously. They served, as smiths, carpenters, engineers, saddlers, carriage-builders, and even manufacturers of cannon. They were hard-working, and erected a long powerful water wheel to power different kinds of machinery [93]. The foundry at Gafat, had deserved an honorable place in the history of Ethiopian technology, and made use of three feet high furnaces, which were operated with the help of traditional skin bellows. The coal for the foundry came from ‘Chelga’ and the right bank of the Galila river where there were six seams while the lime was obtained from ‘Dabra Tabor’ and ‘Dalanta’ [95].

Tewodros made extensive use of missionary craftsmen as he had scarcity of skilled manpower. Emperor asked the artisans to devote their attention in making huge cannon. Brass was collected from all parts of the country to be melted down, together with 30 vases from ‘Maqdala’, after which the emperor manufactured cannon, which he called it Sebastopol. It had been said to have seven tons weight, and required as many as 500 people to pull it uphill [93,100].

The Emperor dream to make ‘Gafat’ as a city of civilization destroyed completely because Ethiopian’s who trained by European Protestants couldn’t transfer their knowledge to the society. Because the society believed that, handicrafts are work of lower class people and the weapons produced in ‘Gafat’ Weapon Factory didn’t show much benefit at the battle field for example the Canon or “Sebastopol” completely destroyed after one shot .

Gunpowder was locally manufactured and had been recorded by visitors to Ethiopia. Emperor Theodros's army made its own gunpowder and bullets. According to different historicians, these were inferior to imported ammunition. This is hardly surprising, since in order to bring improvements in bullets, a functioning and developing metallurgical tradition is necessary. Even the inferior quality that was produced was made possible because its production method was not tied to the blacksmith taboos.

The gunpowder was mined. Informants from Tigray had described the following procedure. The manufactured stone called *gunfal, found* around Adwa area specifically Segli, Bamba, and may Misham. A white powder was found stuck to the stone. The powder was scraped off with a sharp blade, and the powdery scrapings were boiled in water. On cooling, the gunpowder floated on top; this was lifted off and dried. The resulting powder was mixed with charred wood -either from the widely distributed trees *gnchb (Euphorbia tirucalli)* and *quiha (Salix subserrata)* or from the equally widespread shrub called *tch'ndog (Otostegia integrifolia)* - and sulphur, which came from the Dalol Depression in the east. The gunpowder was then ready for use. The balls for shooting were made either from lead, in the absence of lead or from a stone called *shashmme,* which can be easily scraped down to the desired dimensions. If the object was hunting wild fowl (e.g. guinea-fowl), sand was used instead of *shashmme[95].*

Furthermore, Tewodros actively recruited instructors, engineers, and artisans of all kinds from Europe to provide the technical assistance deemed necessary for his active domestic and foreign policies. These expatriates constructed roads, bridges, houses and even assisted in the local manufacture of some crude firearms and cannons [101].

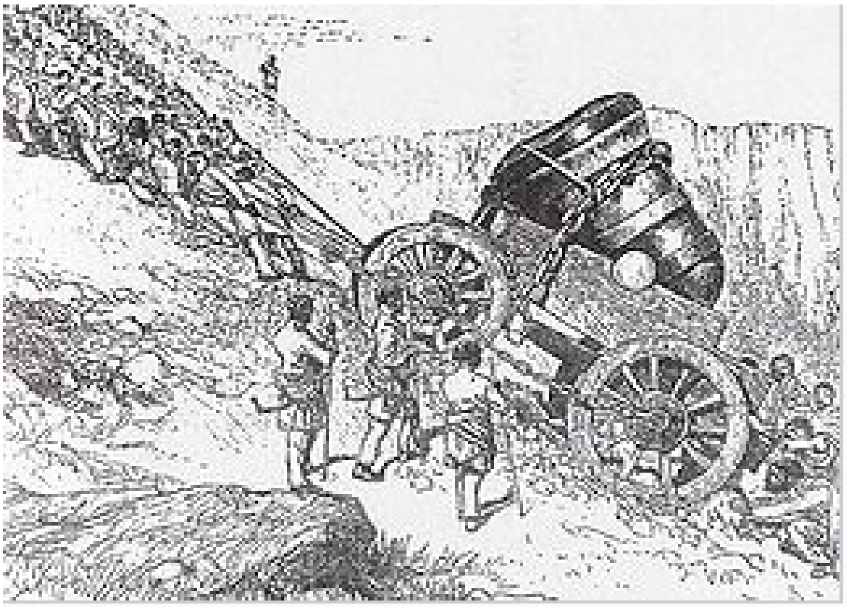

Figure 4.1 The Cannon Produced by Emperor Tewodros

The foreign artisans built a water-mill capable of cutting wood, grinding and sieving gunpowder, and building a fine house with glass doors and windows. The entire compound was protected by a strong wall guarded by four cannons. The remains of these buildings and the surrounding wall are still being seen. Furthermore, he tried to build a boat on Lake Tana that was propelled by a pedal system, and dreamed of establishing European modernism in the country.

Some of the missionaries did not endear themselves to the king, based on their cultural biases or insensitivity. Tewodros was unable to effectuate his modernizing impulses, with his political fortunes and popularity waning. The expressed his frustration by holding British missionaries and diplomats captive in Magdala which finally led to the death of Tewodross.

4.4. Menelik II period

Menelik II was fascinated by modernity, like his predecessor Tewodros II, and had a keen ambition to introduce Western technological and administrative advances into Ethiopia. He hungered to learn about the latest scientific discoveries, technological developments, artistic achievements, and an immense interest in modern medical care. He dreamed of bringing western advancements to Ethiopia, and bringing his people to a level of development that existed at that time in Europe [102].

The Russian support for Ethiopia led to the advent of a Russian Red Cross mission. The Russian mission was a military mission conceived as a medical support for the Ethiopian troops. It arrived in Addis Ababa some three months after Menilek's Adwa victory, and then the first hospital was built in Ethiopia. Following the Ethiopian victory at Adowa, rush by the major powers to establish diplomatic relations, more westerners began to travel to Ethiopia looking for trade, farming, hunting and mineral exploration concessions [91].

Menelik II founded the first modern bank in Ethiopia, the Bank of Abyssinia, introduced the first modern postal system, the first wireless radio, the first modern hotel which as built by his wife Empress Taitu, first modern school called the Menelik II School, and the first hospital, signed the agreement and initiated work to establish the Addis Ababa-Djibouti railway with the French, introduced electricity to Addis Ababa, as well as the telephone, telegraph, the motor car and modern plumbing. Furthermore, it was Emperor Menelik who brought, through foreign engineer, some of the technologies and instruments that we use today. Tap water (1894), electric power and telephone (1897), gramaphone (1897), mills (1901), bicycles (1901), automobile (1908), bullet factory (1911) were a few among others. Through the introduction of all these technologies, he faced many challenges internally starting from his wife, political leaders, religious leaders (the Ethiopian Orthodox Church) and the people at large [103].

Among the most conservative was Menelik's own wife. Although Taitu was amused by the knick-knacks and inventions that were brought before her, she was suspicious of the motives of the Europeans who brought them. When running water and electricity were installed in the palace and spread through Addis Ababa, she was displeased. She marveled at the phonograph recording of Queen Victoria that was brought to them in which the queen sent her warm greetings. Menelik and Taitu both recorded phonograph messages to be taken back to the Queen in return and were quite impressed.

In discussions with the Emperor's good friend and close advisor, Swiss born Alfred Ilg, the railway project was brought up and the Empress continued to voice strong opposition. She argued that it was unnecessary, that it would be too costly, that it would put many merchants out of work, and it could even bring an invader into the heart of the Empire. Menelk II replied cleverly, "Your Majesty, this train that you so strongly opposed might take you to Jerusalem and the Holy Places one day ". Suddenly subdued and taken aback the deeply religious Empress was said to have quietly stated "This I want more than all things." Regardless, Taitu remained a strong opponent of European intrusion into the Empire in the name of spreading progress.

The Emperor received the first telephone apparatus in Ethiopia and ordered that a line to be set up between his rooms and the house of his treasurer. Amazed in having a conversation with his treasurer while both were at their own homes, Menelik ran outside to make sure that someone wasn't hiding under his windosill and answering his questions[102,103].

However, the next day, the treasurer received an electric shock from his telephone, and his confessor along with other priests proclaimed the phone was the work of Satan and destroyed it. They went to the Palace together with more priests and burned the phone that they found there as well. The Emperor was livid when he heard what happened, but it was too late. A while later, when a movie projector was presented to the Emperor by a foreign visitor, he eagerly anticipated watching his first moving picture. However he was wary that the priests would definitely declare this as the work of the devil and destroy his projector too. However, the presenter of the gift had anticipated this, and the first film shown in Ethiopia was a film about the miracle of Christ walking on water. The priests could hardly protest this, so they remained silent. However, all these technological advances caught on and spreaded largely due to Emperor Menelik and his strong desire for modernization [102].

The main obstacle for these innovations was the resistance from the community which held that they were “the work of the Devil” – a resistance that stretched all the way from the common people to the priests around the Emperor who refused to drink tap water. The method that the Emperor used to curb such resistance was by testing the technologies first by himself, his family and his executives. For instance, he himself was the first driver (chauffer), the first to use the grinding mill, the first photographer and the first movie spectator. Then, the airplane and radio technologies were introduced in 1929 and 1936 respectively.

Craftsmen sought after by the society, were downgraded, and outcast with no or less social privileges; they were considered as possessors of evil eyes/ 'BUDDA', and as a result their belongings were confiscated and they were often persecuted. However, they were the source of different technical tools including agricultural tools, house furniture, clothing, decorations and armaments, weapons and construction materials. They have been in fact the sole source of satisfying the domestic needs for long period of time even up to now. Having a stagnated indigenous technology, we were then forced to import modern technologies from the industrialized world.

Though in 1908, Emperor Menelik II had passed a decree in which he warned his people to respect an artisan for his profession, the social attitude almost remained the same for long time. As a result of such wicked attitudes of the society, the technicians lacked freedom, and had to move from place to place, which in turn affected the improvement of their technical skills; certain craftsmen such as the gun smiths, jewelers and weaver to some extent were respected and had even a better protection from the royals [103].

During the Italian five years occupation (1935-1941), more technological hardware obviously came into the country with the Italians, but Ethiopian technological development was arrested, as the native Ethiopians were not allowed access to education beyond basic literacy in Italian. Nevertheless, owing to over 50 years of stay of the Italians in Eritrea, many people living there informally acquired knowledge of some European technologies, and they played an important role in the spread of European technologies to the rest of Ethiopia during the post-Italian period.

4.5. The Imperial Period (1950 - 1974)

Between l950 and l960, the imperial government had enacted legislation, and implemented a new policy to encourage foreign investments that had high capital costs, such as oil refineries and the paper and pulp, glass and bottle, tire, and cement industries This policy provided investors' benefits in the form of tax exemptions, remittances of foreign exchange, import and export duty relief, tax exemptions on dividends, and the provision of financing through the Ethiopian Investment Corporation and Development Bank of Ethiopia. In addition, the government guaranteed protection to industrial enterprises by instituting high tariffs and by banning the importation of commodities that might adversely affect production of domestic goods. Protected items for foreign investments in that era include sugar, textiles, furniture, and metal products [104].

In l963, with the Second Five-Year Plan was under way, the government enacted Proclamation No. 5l. The proclamation's objective was to consolidate other investment policies enacted up to that period, to extend benefits to Ethiopian investors since the previous legislation had limited the benefits to foreigners only, and to create an Investment Committee that would oversee investment programs.

The government's policy attracted considerable foreign investment to the industrial sector. For instance, in 1971/72 the share of foreign capital in manufacturing industries amounted to 4l percent of the total paid-up capital. Many foreign enterprises operated as private limited companies, usually as a branch or subsidiary of multinational corporations. The Dutch had a major investment, close to 80 percent, in the sugar industry. Italian and Japanese investors participated in textiles, and Greeks maintained an interest in shoes and beverages. Italian investors also worked in building, construction, and agricultural industries.

Furthermore, a number of technologies were introduced by Emperor Haile Selassie in and around Addis Ababa. Emperior Haile Selassie, built 14 colleges, 4 higher institutions (Universities), 136 factories as well as roads, the airline and TV transmissions. It is to be recalled that technological transfer was better, particularly during the last days of the Emperor [105].

With regard to technology transfer, the government used foreign direct investment which is the main channel of international technology transfer and turnkey packages in the government and domestic investment. Though they used the mechanisms of international technology transfer, the domestic absorptive capacity was the main limitation for effective technology transfer in Ethiopia. The regime was lacking human resource and institutional development in the science and technology fields that builds the national technological capability of the company. There was no technological university-industry, no center of excellence, science, technology, and innovation policies that promotes technology transfer in the country.

4.6. The Socialist Period (1974 – 1991)

When Derg came to power, the country's diplomatic ties were diverted to the Eastern bloc. And lots of technologies and communications were brought to the country from North Korea, East Germany and the USSR. As the policy discouraged private participation and innovation, and as the economy was under government control, the country was almost alien to new innovations.

During the Derge regime, all the policies, plans and programs was towards promoting socialism that prohibits private investment from both foreign and domestic sources. The l975 nationalization of major industries had changed the environment drastically, and private direct investment, according to the National Bank of Ethiopia report at that time had declined from 65 million birr in l974 to l2 million birr in l977. Even though it was the main channel of foreign technology transfer, the regime totally closed FDI. Though, there were movement of people from Ethiopia to socialist countries for education purposes, and there was no as such development program for domestic absorptive capacity during that regime. In fact there were some technology transfer activities in the military industries by establishing some few assembly plants and bullet manufacturing industries. The government also brought and introduced some heavy industries like cement, basic metals, textile, and other sectors in collaboration with the socialist countries. However, these didn't bring effective technology transfer in Ethiopia due to lack of national capability development program [106].

Issued in l983, Proclamation No. 235 (the Joint Venture Proclamation) signaled Ethiopia's renewed interest in attracting foreign capital. The proclamation offered incentives such as a five-year period of income tax relief for new projects, import and export duty relief, tariff protection, and repatriation of profits and capital. It limited foreign holdings to a maximum of 49 percent, and the duration of any joint venture to twenty-five years. Although the proclamation protected investors' interests from expropriation, the government reserved the right to purchase all shares in a joint venture "for reasons of national interest." The proclamation failed to attract foreign investment, largely because foreign businesses were hesitant to invest in a country whose government recently had nationalized foreign industries without a level of satisfactory compensation, and partly due to the ongoing civil war in that period

In l989 the government issued Special Decree No. ll, a revision of the l983 proclamation. The decree allowed majority foreign ownership in many sectors, except in those related to public utilities, banking and finance, trade, transportation, and communications, where joint ventures were not allowed. The decree also removed all restrictions on profit repatriation and attempted to provide more extensive legal protection of investors than had in the l983 proclamation [108]. However, the political instability and the prolonged civil war at the time further discouraged FDI. The political instability got worse and it consequently led to the overthrow of the regime in 1991.

4.7. The Market Based Economic Period (1991- to date)

After the end of the civil war in 1991 and took-over of power by the Ethiopia People's Democratic Front (EPRDF), the government enacted investment proclamation in line with the market oriented economic policy that was being pursued.

To facilitate investment administration, the Investment Office of Ethiopia (IOE) has been established as a 'one-step shop' to actively promote and co-ordinate all investment activity in the country. The IOE is supervised by the Ethiopia Board of Investment, which is accountable to the Council of Ministers [109, 110].

Although domestic investments constitute the main component of capital formation in Ethiopia, accounting for about 64 percent of total investment, FDI has started to play some role in the country following the 1992 liberalization program. The reforms as well as the government introduction of investment guarantee schemes, and incentives helped to raise the share of inward FDI in total investment form 0.04 percent in 1992 to 27 percent in 1997. Moreover, FDI flows to Ethiopia increased in absolute terms from an annual average of $131 million in 1995-2000 to $312 million in 2001-2006, with some fluctuations. The unstable political environment of the country may be one of the reasons of the fluctuations. As can be seen from Figure 4.2, during the Ethio-Eritrea war (1998-2000) the inflow of FDI had fallen to a large extent. Besides, during the country's election crisis time in 2005, the FDI flows declined to $221 million from $545 million compared with the preceding year of 2004 [113]. Morover, it also decline in 2008/09 due to global finanacial crisis.

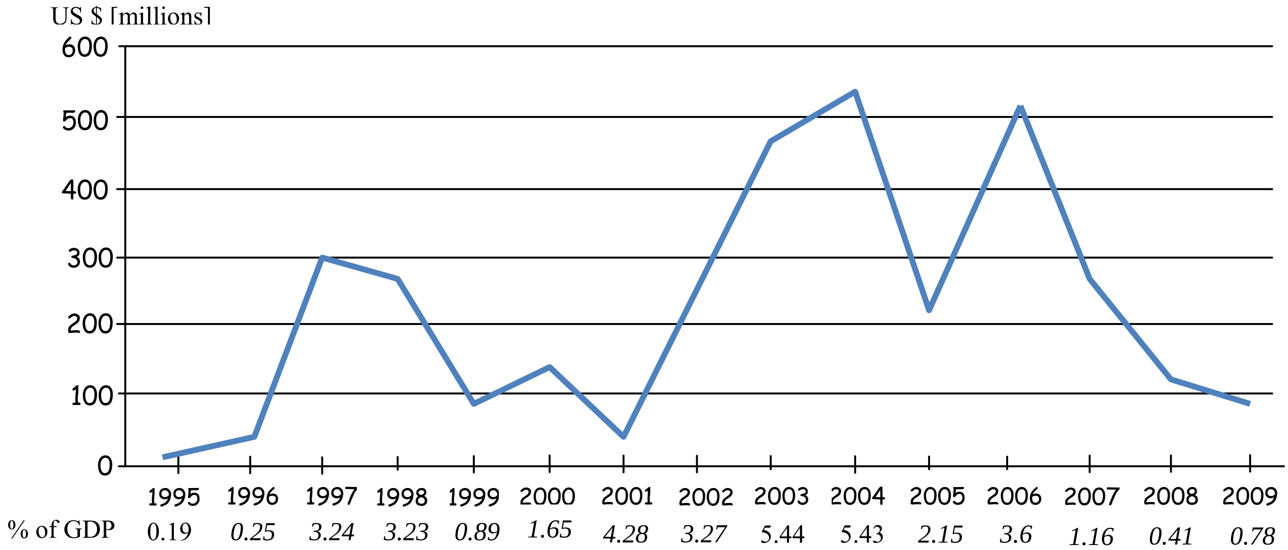

Figure 4.2 Trends in the FDI flow to Ethiopia
Source: world investment report 2001, 2003, 2006 and2007, UNCTAD

Foreign investors are encouraged to invest in all economic sectors, except those currently reserved for domestic private and state investments. The main business sectors which are open and in which the country is seeking foreign investment include:

- Manufacturing industries, including food, beverages, chemicals and pharmaceuticals, plastics, metallic and non-metallic products, paper products, leather and leather products, textiles and garments;
- Agriculture, including agribusiness and processing for exports;
- Real-estate development;
- Education and health services;
- Grade 1 construction contract;

- Mining and quarrying of gold, marble and granite; and
- Engineering and management consultancy.

The major investment incentives for FDI include: 100 percent exemption from payment of import duties and taxes levied on all capital equipments; exemption from payment of export taxes (except for coffee); income tax holidays varying from one to five years; tax deductible research and development expenditure; no taxes on the remittance of capital; the carrying forward of initial operating losses and investor choice of depreciation model of capital assets.

The Ethiopian investment codes also provide guarantees to create a reassuring business environment for potential foreign investors. Specific investment guarantees that have been issued for FDI include: full repatriation of capital and profits including dividends and interest payment on foreign loans; payments for technology transfer and management agreements; full repatriation of proceeds from sale or transfer of shares or liquidation of enterprises. Moreover, the investment proclamation No.37/1996 provides investment guarantees against measures of expropriation and nationalization, except in major cases of public interest when full market value will be paid promptly[113].

The government of Ethiopia has established the Ethiopian Investment Authority (EIA) to promote, coordinate and facilitate foreign investment in the country. The establishment of the Ethiopian Privatization Agency (EPA) is also another significant step in the promotion of FDI. The government is keen to encourage the participation of foreign investors in the privatization program, particularly in large state owned companies. Other government departments that are involved in the attraction of FDI to Ethiopia include: the Ministry of Trade and Industry; the ministries and agencies associated with specific sectors such as mining and tourism; the Ministry of Foreign Affairs and ministries dealing with taxation remits including customs. Moreover there are regional investment promotion agencies that encourage FDI into their region [114].

The first National Science and Technology Policy of Ethiopia was issued by the Transitional Government of Ethiopia in December 1993, although the efforts to coordinate and guide scientific and technological activities at national level in Ethiopia date back to the early 1970s. The major objectives of the policy include: building capability to generate, select, import, develop, disseminate and apply appropriate technologies, improving the knowledge, culture, scientific and technological awareness of the peoples of Ethiopia, and for the realization of the country's socio-economic development goals [115].

Implementation of the policies and strategies has resulted in positive outputs that contribute towards building an innovative economy in the country. The following are the major results:

- Rapid expansion of primary, secondary, technical and vocational and tertiary education both at undergraduate and graduate levels, through the Government capacity building national program;
- Strengthening of the national agricultural research system through human resource development, infrastructural capacity building of the Ethiopian Agricultural Research Institute and establishment of Regional Agricultural Research Institutes accompanied by deployment of three extension workers per *Kebele* to assist the farmers in using technologies to improve their productivity and life style;
- Technical, financial and administrative support to young graduates of Technical and Vocational Education and Training Colleges to develop and run their own micro and small business enterprises;
- Creation of conducive business environment and incentives that attracted a good number of foreign and local investors to establish and run business enterprises in agro-industry, manufacturing, construction and services;
- The aggressive and commendable efforts of expanding ICT use across the country (including the *Woreda Net* and School Net programs).

Although the regulations on FDI are much more relaxed than during the Derg period, some restrictions are still in place and foreign investors are excluded from large sections of the economy including banking, insurance, broadcasting, and printing. These exclusions, together with infrastructure weaknesses, could partly explain why Ethiopia receives less FDI than other developing countries.

During this regime a number of plans are developed. Agricultural led Industrialization is one of the plans that is considered as the fundamental building block of industrial development in Ethiopia. To implement this policy, the sectors development strategy focuses mainly on industries that are labor intensive, have broad linkage with the rest of the economy, use agricultural products as inputs, export oriented and import substituting, and contribution to rapid technology transfer.

Currently, GTP of the Ethiopian government gives especial attention for the following eight medium and large industries; Textile and Garment Industry, Leather and Leather Products Industry, Sugar and Sugar related Industries, Cement Industry, Metal and Engineering Industry, Chemical Industry, Pharmaceutical Industry and Agro-Processing Industry [117].

4.8. Historical Development of BMEIs in Ethiopia

The BMEI is crucial to the development of any modern economy, and it is also considered as the backbone of human civilization. BMEI is crucial to the development of any modern economy and is considered to be the backbone of human civilization and industrial development. This is due to, it is a product of a large and technologically complex industry having strong forward and backward linkages in terms of material flows and income generation.hence, it is evident that these industries can play an important role in serving other industries by providing experienced technical manpower at large and also a significant role by incubating small-scale industries. All major industrial economies are characterized by the existence of a strong steel industry and the growth of many of these economies has been largely shaped by the strength of their steel industries in their initial stages of development.

The Basic Metal and Engineering (BME) is a sub-sector within Manufacturing Sector. Basic Metals Industries are concerned with the refining and production of raw metal products from mineral ores. While Engineering Industries are industries which use these metal products as an input, and fabricate them into various engineering products. Products of basic metals industries fall under two categories ferrous are iron and steel, and non-ferrous are all other metals but most importantly, aluminum, copper, tin, bronze and brass.

Basic metal industries, as the name implies are normally upstream technologies that cater to the requirements of downstream technologies by providing the required raw material in sufficient quantity and acceptable quality. In connection with this all engineering industries, engaged in the manufacture of components, parts, capital goods, etc, depend on the output of the basic metal industries for their raw material requirement. The construction sector also depends on the basic metal industries, when it comes to concrete reinforcement and pre-engineered buildings. The agricultural sector is also a consumer of the output of these industries, for some of its requirements such as structures for green house, pipes for irrigation, etc.

All over the world, engineering industry is regarded as the engine for industrial development. The progress of this industry is the key to social and economic progress. It is catalytic in achieving import substitution, export enhancement, high degree of value addition, optimal use of agriculture, mineral and other resources, and forward and backward integration with other economic sectors.

During the Axumite period, agricultural ploughing was started and skilled craftsmen produced ploughs. Works in silver and bronze of crosses and coins also flourished during this period.

Iron ore was found in many parts of the country, but the process of transforming it into a usable metal was not an easy task at all. By the 1830 and 1840s iron ploughshares each weighing two to five kilogram were fairly general, and could be bought nearly at all markets [93].

Smelting was widely practiced by blacksmiths who operated one or more self-made sheep-skin bellows over a charcoal fire. When the ore was brought to smelting point, the iron was taken out of the fire with large awkward pincers or tongs and held by one man upon a flat stone, while two or three others, with large round or rather oval stones struck it in turn. The operation was repeated until it was free from all earthly matters, and fit for use.

The ambitious plan of Emperor Tewedros to manufacture fire-arms, led to the establishment a foundry at Gafat by Protestant Missionaries in the 1850s, which is relatively modern. However, it has still employed the traditional hand operated bellows skin. One of the workers records that three feet high furnaces were used which can produce a temperature of 700 degree centigrade. The coal for these furnaces came from chilga, on the right bank of the Galila River, where there were six seams of very good quality coal that are three miles long and ten inches to a foot deep. The lime came from Debretabor and Dalanta. By using large unskilled manpower, the missionaries succeeded in producing bars of iron.

Greek charcoal burners who began operation around 1912, producing a superior quality suitable for iron heating or smelting, which was sold for a dollar and a half per 50 kilos, while other local charcoal costed no more than half a dollar.

The iron produced in the previously maintained forms were hammered, carved and processed by handicraft's men into different shapes and sizes from simple household articles to complex agricultural implements using the traditional charcoal furnace. These include ploughshares, necessary iron parts for pickaxes, sickles, knives, razors, spearheads, swords and daggers, bullets and rifle spare parts, tent pegs, hammers, pincers, drills, nails, hatches, saws, files, flat pieces of iron on which to bake bread etc.

In the early 20th century, there were numerous blacksmiths in the Addis Ababa area, near Entoto, Gefersa, and as well as at the Palace. Considerable iron work was also reported in Jimma, Nekemte and Harar.

In Gondar, the casting process involved silversmiths making models of the required objects in wax. The wax model was then embedded with clay, which was easily destructible on completion of the process, and let thoroughly dry in the sun , it was heated so as to melt the wax contained inside, which flowed out through a hole left for the purpose. Molten metal was then poured into the space originally occupied by the wax, this was then left to solidify. The ready made object was then separated from the clay mould [94].

During imperial era (1950-1974), the Ethiopian Iron and Steel Foundry, and Kaliti Steel Industry were established to process corrugated sheet and reinforcement bars. Kotebe Metal Tools Factory and several sheet metal fabrication shops were also established towards the end of this period.

The industrial sector in Ethiopia was insignificant before 1974, and it was characterized by production for domestic market mainly to substitute imports, and large scale and medium sized manufacturing industries were owned by foreign nationals.

During Derg Era (1974-1991), the basic metal and engineering sub-sector was organized under National Metal Corporation. The corporation established the following new industries with objective of achieving self-sufficiency in industrial spare parts, tractors and pumps, and accelerating mechanization of agriculture. The industries include:

- Akaki Spare Parts and Hand Tools S.Co;
- Nazareth Tractor Factory;
- Pump Factory;
- Maru Metal P.L.C. (evolved from the private sector).

The National Metal Corporation in collaboration with foreign consultants conducted several studies among which are Basic Metal Sector Development Study, Kotebe Metal Tool Factory Improvement Study, Pre-feasibility of Steel Processing and others are to few to be mentioned. To support the sub-sector with product development, tool and die manufacturing, the Engineering Design and Tool Center (EDTC) was established with support of UNDP towards the end of the Derg era.

In the middles of 1990s, the Basic Metals and Engineering Industry Agency (BMEIA) was established to enable the sub-sector contribute to overall economic development in the country. The tasks of BMEIA include:

- Formulate, on the basis of the industrial policy of the country, policies for the development of the Basic Metals and Engineering Industry sub-sector, and follow up the implementation upon approval;
- Undertake market studies and promotional activities relating to the sub-sector;
- Provide services in the selection of technology and products, enhancing the development of the sub-sector;
- Restructure public enterprises engaged in the sub-sector, and direct and supervise their organization and management, other than their financial administration;
- Assess the production capacities and technological capabilities of enterprises engaged in the sub-sector with view of product identification, raw materials provision, capacity building and product development;
- Encourage the participation of private investors in sub-sector;
- Undertake studies regarding engineering and technical skills;
- Promote the expansion of modern engineering management and production techniques to raise the quality of products in the sub-sector;
- Render consultancy services in the identification and preparation of projects in the sub-sector;
- Undertake studies and research and dissemination in the sub-sector; and
- Manage scrap metal.

This measure helps to understand the government about BME sub-sector as the back bone for industrialization. BEMEIA has successfully carried supervision of public enterprise in the sub-sector, registration and certification of professionals, consultants and contractors in the sub-sector, offered support in industrial energy conservation and die manufacturing.

When the government prepared the industrial development strategy that encourages manufacture of goods for export market using agricultural products as raw materials, the BEME sub-sector was given less emphasis and during implementation BMEIA was reorganized as Metal Products Development Center with limited scope of activities. Nevertheless, the sub-sector’s growth is being propelled by increased construction activities in the country.

Important achievements in the BME sub-sector during this era are establishment of the following industries.

- Sheet metal cutting and corrugation plants;
- Several truck, bus and trailer bodies manufacturing plants were established;
- Several mechanical workshops for sheet metal and structural fabrication;
- Aluminum window and door manufacturing shops;
- Mechanical workshop for reconditioning of engines and part manufacture;
- Tube and hollow section plant;
- Aluminum profile plant;
- Reinforcement bar rolling mills; and
- Cold sheet metal rolling mill.

4.9. Actors of Technology Transfer in Ethiopia

For the realization of the technology transfer, the Ethiopian government has given considerable attention for the different actors of technology transfer. Some of the main actors are Ministry of Science and Technology (MoST), Ethiopian Intellectual Property Office (EIPO), Leather Industry Developments Institute (LIDI), Textile Industry Development Institute (TIDI), Metal Industry Development Institute (MIDI), Ethiopian Institute of Agriculture Research (EIAR), METEC etc. These are discussed in the following sections;

1. Ministry of Science and Technology (MoST)

Ministry of Science and Technology (MoST) is a governmental institution established for the first time in December 1975 by proclamation No.62/1975 as a commission. Following the change in government in 1991 and with the issuance of the new economic policy, the commission was re-established in March 1994 by Proclamation No.91/94. The commission went into its 3rd phase of re-institution on the 24th of August 1995 by Proclamation No.7/1995, following the establishment of Federal Democratic Republic of Ethiopia as an Agency. Later on, in 2008 the government upgraded the Agency as one of the cabinet ministries accountable to the prime minister and the council of ministers by the proclamation No. 604/2008 and re-established recently in October 2010.

Furthermore, the Ethiopian Intellectual Property Office (EIPO) is an autonomous unit of the Ministry of Science and Technology (MoST). It was established in 2003 to provide legal protection for intellectual property (IP) rights. It aims to be a development-oriented, national intellectual property office promoting the use of intellectual property as a means for social, economic and cultural development.

2. Higher Education Reform

Human resource development through education, training and competence development is considered to be the cornerstone of long-term S&T capacity building. Technological activity levels are closely linked to the skills level and need that are to be continuously upgraded. Traditional methods of education and training such as primary schooling, basic technical activities and ad hoc on the job training are not sufficient for today's technological advancement. Industrial development now requires high-level specialized training with close interaction between education institutes and industry, including cognitive skills relevant to information technology, tertiary enrolment in technical subjects such as science, mathematics, and engineering which affect the capability to absorb technology [31].

Hence, to foster the technology transfer in Ethiopia, the government launched two reforms; university and TVET reforms.

i. University reform

The objective of the reform is that engineering and vocational training faculties in Ethiopia should provide practice oriented and needs-driven training. Thus, ecbp (engineering capacity building programe) works to equip young Ethiopians with skills and knowledge in 8 universities throughout the country. With in these universities, technology institutes are assisting the revising of the curriculum for students as well as for teachers of the vocational training system, carrying out the universities, governance, management reform and human resource development, promoting linkages between universities and industries, and developing the infrastructure on the campuses. Thus, the major impacts of the University reform are:

- Revised curricula in all engineering faculties, moves Ethiopian universities closer to international standards and prepares students better for the needs of the labor market;
- All students graduating from Technology institutes will have practical experience built on top of their theoretical knowledge through a qualified internship system;
- Cooperation between universities and industry is being set up that allows for technology transfer and market oriented research;
- Cooperation agreements between Ethiopian and 4 European universities to raise the quality of teaching, research and international exchange.

ii. TVET system reform

The objective of TVET system reform is to make the technical and entrepreneur training services provided by the TVET system acquainted with the needs of the labor market. Ecbp is working with TVET institutions and the Ministry of Education to revise the systems and curricula of the schools in addition to developing human resources and increasing their institutional capacity. The TVET system also involves industry through in-company and cooperative trainings, as well as the placement of interns from TVET schools into companies. The major impacts of the TVET reform are:

- Since 2005 ecbp has been part of the overall modernization of the Ethiopian TVET system into a modern outcome based system;
- Technology Transfer has been integrated into TVET, leading to local production of machinery that previously imported;
- TVET students are being increasingly trained in practical skills, and thus respond to the demands of the industry;
- As a result of cooperative training with TVET institutes throughout the country, the Rural Electrification Project is able to bring electricity to more people quickly.

3. Research Institutes in Different Sectors

There are research centers established for the development and competitiveness of different sectors by providing support starting from the feasibility of study and an investment up to their application.

The major research institutes of the country are discussed below;

i. Leather Industry Developments Institute (LIDI);
ii. Textile Industry Development Institute (TIDI);
iii. Metal Industry Development Institute (MIDI);
iv. Ethiopian Institute of Agriculture Research (EIAR);

i. Leather Industry Developments Institute (LIDI)

The government of Ethiopia has established LIDI to get rid of the problems of the sector in skilled man power and technology, under the Ministry of Industry, with objective of the institute is to facilitate the development and transfer of leather and leather products industries technologies, and to enable industries to become competitive causing their rapid development. The institute provides full-fledged of services to the leather sectors in the investment, production and market phases.

ii. Textile Industry Development Institute (TIDI)

TIDI is also a young institute aimed at providing technical and managerial assistance to textile and garment sectors towards making the sectors competitive in the market. The objective of the institute is to facilitate the development and transfer of textile and apparel industries technologies, and to enable the industries become competitive and lead to rapid development. The institute is expected to create technical capability and enhance the sector competitiveness on global level by providing the required skillful human resource, undertaking applied research and providing practical consultancy.

iii. Metal Industry Development Institute (MIDI)

MIDI is established to provide sector specific and coordinated technology support by making use of capable professionals with a view to enhancing the capacity of metal and engineering manufacturing technology. The objective of the institute is to enhance the competitiveness of the metal and engineering industry through speeding up the transformation and development of the sector.

iv. Ethiopian Institute of Agricultural Research (EIAR)

The Ethiopian Institute of Agricultural Research (EARS) had evolved through several stages since its first initiation during the late 1940s, following the establishment of agricultural and technical school of Ambo and Jimma. Until the mid-1960s, it was called the Imperial College of Agricultural and Mechanical Arts, it is known as Haramaya University with its Agricultural Experiment Station at Debre Zeyit now, Debre Zeit Research Center was the major research entity. The establishment of the Institute of Agricultural Research (IAR) in 1966 revealed the first nationally coordinated agricultural research system in Ethiopia. The EIAR consists of Regional Agricultural Research Institutes (RARIs), and Higher Learning Institutions (HLIs). EIAR is responsible for the running of federal research centers, and RARIs are administered by the regional state governments. In addition to conducting research at its federal centers, EIAR is in charged of with the responsibility for providing the overall coordination of agricultural research countrywide, and advising government on agricultural research policy formulation.

Currently, the EIAR comprises of 55 research centers and it is located across various agro-ecological zones. The research centers vary in their experience, human, facility, and other resources capacities. Some of the research centers and sites have one or more sub-centers and testing sites [120].

4.10. Indigenous Technology in Ethiopia

Indigenous Technology (IT) can be broadly defined as the knowledge that an indigenous community accumulates over generations of living in a particular environment. This definition encompasses all forms of knowledge: technologies, know-how skills, practices and beliefs that enable the community to achieve stable livelihoods in their environment. A number of terms are used interchangeably to refer to the concept of IT, including Traditional Knowledge (TK), Indigenous Technical Knowledge (ITK), Local Knowledge (LK) and Indigenous Knowledge System (IKS). Indigenous Technical Knowledge (ITK) is the local knowledge that is unique to a given culture or society [121].

The special features of indigenous technical knowledge are; local, in that it is rooted in a particular community and situated within broader cultural traditions; tacit knowledge and, therefore, not easily codifiable; transmitted orally; experiential rather than theoretical knowledge; learned through repetition; and constantly changing [121, 122].

Indigenous technical knowledge are important because; it can provide problem solving strategies for local communities, especially for the poor; up to 2/3 of the world population depend on foods provided through ITK of species and farming systems; learning from ITK can improve understanding of local communities; understanding ITK can increase responsiveness to clients; building on local experiences, judgments and practices can increase the impact of a development program beyond cost effective delivery of stages; indigenous approach to development leads to sustainability creating sense of ownership; and it can provide a building block for the empowerment of the poor [123].

The integration of indigenous technology into the development process is essentially a process of exchange of information from one community to another. The process of exchange of ITK involves six steps and these are: recognition and identification, validation, recording, storage, transfer and dissemination [122, 124]. The basic component of any country's knowledge system is its indigenous knowledge, which encompasses the skills, experience and insights of people and applied to maintain or improve their livelihood. It is increasingly evident that past approach to development, which neglected local knowledge, systems and institution were unlikely to be productive in solving developing countries' problems [125,126]. Thus building on indigenous knowledge can be particularly effective in helping to reach the poor since indigenous technical knowledge often is the only asset they control and certainly one with which they are very familiar [126, 127].

Ethiopia is one of the world‘s cradle of ancient civilizations and gigantic resource area where indigenous technical knowledge could be retrieved for the overall human development. Although there is a very rich resource for indigenous knowledge, it is dispersed in various local entities. The exact periods of some technologies i.e. traditional technologies when they came into being, where originated and how they passed from generation to generation is not well documented. The continuity of most of these technologies must have been either by 'word-of mouth' or 'father-to-son' type of inherited transfer. The Aksumites were trading and minting coins during the 10th century and they had also developed an iron culture as they were smelting, tempering and shaping iron into different tools and weapons [128]. Some of the Ethiopians' different indigenous technologies are discussed as follow.

- **Agricultural Technologies:** The technologies in this area include tools used for land preparation and ploughing. Some metal is involved in turn implies, iron smelting, forging and grinding. Blacksmiths were responsible throughout the 19th century of the manufacture of a wide variety of articles of considerable economic and military importance. In addition to plough-shares, these included iron parts of pick axes, sickles and other agricultural implements, as well as knives, razors, spear-heads, daggers, swords and the like. What is embedded as technology is multi-faceted from iron ore mining and smelting to tool preparation. There is no documented evidence or formal educational system for the technologies. Seed preservation and storage are other aspects of technologies employed. Bee keeping, milk and milk products processing are just a few of the traditional agricultural technologies. For these to be replicated, there must have been some science of measurement.
- **Industrial Technology:** In this sector, one could talk about the processing technologies for food and beverages, textiles and garment making, wood works, leather and leather products processing, pottery, printing, construction, metal works, transport, and traditional medical technology.

  Traditional technologies in the area of food and beverages preparation involve some sort of 'biotechnology' such as fermentation. The biotechnology processes are in the preparation of local beer, 'tella', honey base wine, 'tej', and spirit called 'arake'. In the area of textiles and garments, clothes made of cotton (fiber-fabric of different designs and dresses), such as bana, buluko, netela, jano, shema of wool, such as blankets and an overcoat called 'bernos' etc. In the written documentation area, are specially prepared skin parchments called brana, and pen inks for brana. Modern printing press was introduced during the regime of Emperor Tewodros around 1863. In the technology of metal works, in addition to agricultural implements, and was fare items, there are precious metal base crosse and 'tsenastel' in religion mattes and monetary coins which go back as far as the days of the Axumite kingdom. With respect to construction and architectural technology, there are the Obelisks of Axum, the Lalibella churches and the Gondar palaces, the many stellae such as that of Tiya. Craftsmanship in the design and production of musical instruments such as begena, kirar, mesenko, embilta, kebero etc indicate the contribution of technology in the cultural development of the nation. With respect to traditional medical practices, including the use of medicinal plants, one can extrapolate the embedded technologies in the extraction and application of the medicaments.

Chapter Five

Data Collection, Discussion and Analysis

5.1 Economic Contribution of BMEIs

Ethiopia is still largely agrarian. 85% of the workforce is engaged in the rural economy, mostly in agriculture. Agriculture accounts for 43% of GDP. However, due to weak technological capability and lack of innovation there is very slow rate of growth of agricultural productivity. Therefore, there is a need to initiate a sustainable process of technological capability accumulation and transfer that could bring dramatic improvements in the performance of the sector.

Ethiopia has registered double-digit growth for the past five years. But there is still an effort by the Ethiopian government to sustain this growth with the understanding that national development would be ensured through integrated industrial development. Moreover, manufacturing industry lies at a very infant stage of development and for more than three decades it has been accounting for less than 13 percent of the GDP as shown in Table 5.1.

Table 5.1 Structure of the Economy (% contribution to GDP)

GDP per Sector	2004/05	2005/06	2006/07	2007/08	2008/09
Agriculture	47.4	47.0	46.3	44.0	42.4
Industry	13.6	13.0	13.3	13.0	12.9
Services	40.0	40.0	41.4	43.0	44.7
Total	**100**	**100**	**100**	**100**	**100**

Source: MoFED and NBE (PASDEP and related Reports)

Manufacturing industry is largely limited to simple agro-processing activities such as sugar production, grain milling, edible oil production, leather tanning, and production of basic consumer goods such as beer, footwear, textiles and garment. Industries are almost not exist, that might help accumulate technological capabilities and create dynamic inter-industry linkages such as chemical, electrical and electronics, metal-processing and other engineering industries. Hence, the level of technological capability in the country is insignificant.

Table 5.2 Share of Exports and Imports in GDP

Particulars	2005/06	2006/07	2007/2008
Exports	6.6	6.1	6.5
Imports	30.3	26.4	30.4
Trade balance	**-23.7**	**-20.3**	**-23.8**

Source: NBE

The main export products are agricultural. Coffee, oilseeds, chat, pulses, flowers, skins, meat and meat products account for about 80% of all exports. Manufacturing exports were as low as US$ 105 million in 2007, accounting for less than 10% of total exports. Basically all manufacturing exports are agriculture-based which are clothing, canned and frozen meat, semi-processed hides, footwear, beverages, and oilcakes. On the import side, Ethiopia imports most capital goods and manufactured consumer goods. In recent years, imports grew much faster than exports. Figure 5.2 depicts that average exports finance is less than 22% of imports. This shows that due to less technological capability of the industries, there is unsatisfied demand.

Although, Basic Metal and Engineering Industries (BMEIs) are the backbones to support all other downstream industries, the contribution of the sector in Ethiopia's economy is so limited. And according to the ECSA report, the number of industries in the sector including small scale metal product manufactures is only 7.04 % of the total manufacturing activities in 2007/2008. From the 7.04 % of basic metal and engineering industries, 5.45 % of them are largely engaged in the production of low tech metal products. Furthermore, according to the same survey, the employment opportunity created from BMEIs sector is around 10,000's and it is found to be less performing sub-sector compared to others sub-sectors.

Some African countries are benefiting from the BMEIs; the metal industry in Ethiopia could be viewed as undeveloped and its contribution to GDP is very low as shown Table 5.3. For example, in Kenya and North Africa countries, the metal sector constitutes about 19 % of the country's GDP. Hence, building a strong metal sector for Ethiopia has to be viewed as a main policy towards bringing economic development.

Table 5.3 Metal sector contribution to the gross domestic product in the different African countries (source. Report of metal and engineering sector in Africa)

Country	% GDP
South Africa	17.20
Egypt	19.40
Zambia	8.40
Kenya	19.00
Nigeria	4.70
Tunisia	19.40
Nambia	1.60
Mozambique	10.70
Tanzania	1.10
Ethiopia	0.91

The sector has also been found as the main cause for the drainage of the Ethiopia's limited foreign currency. According to the report of JICA, the country spent a total amount of Birr 2.76 Billion to import basic metal products and Birr 10.86 Billion for engineering products in the year 2005. The total import of basic metal and engineering products has reached Birr 13.62 billion. The highest expenditure was on metal and engineering products such as metal products, machinery and vehicles, which was 33.7 % of the total of import. Moreover, according to the Ethiopia association of Basic metals and engineering industries association report, the total import of metals and engineering products was 43% in the years of 2008 and 2009. This indicates that the needs of the country's in the area of basics metal and engineering products are increasing.

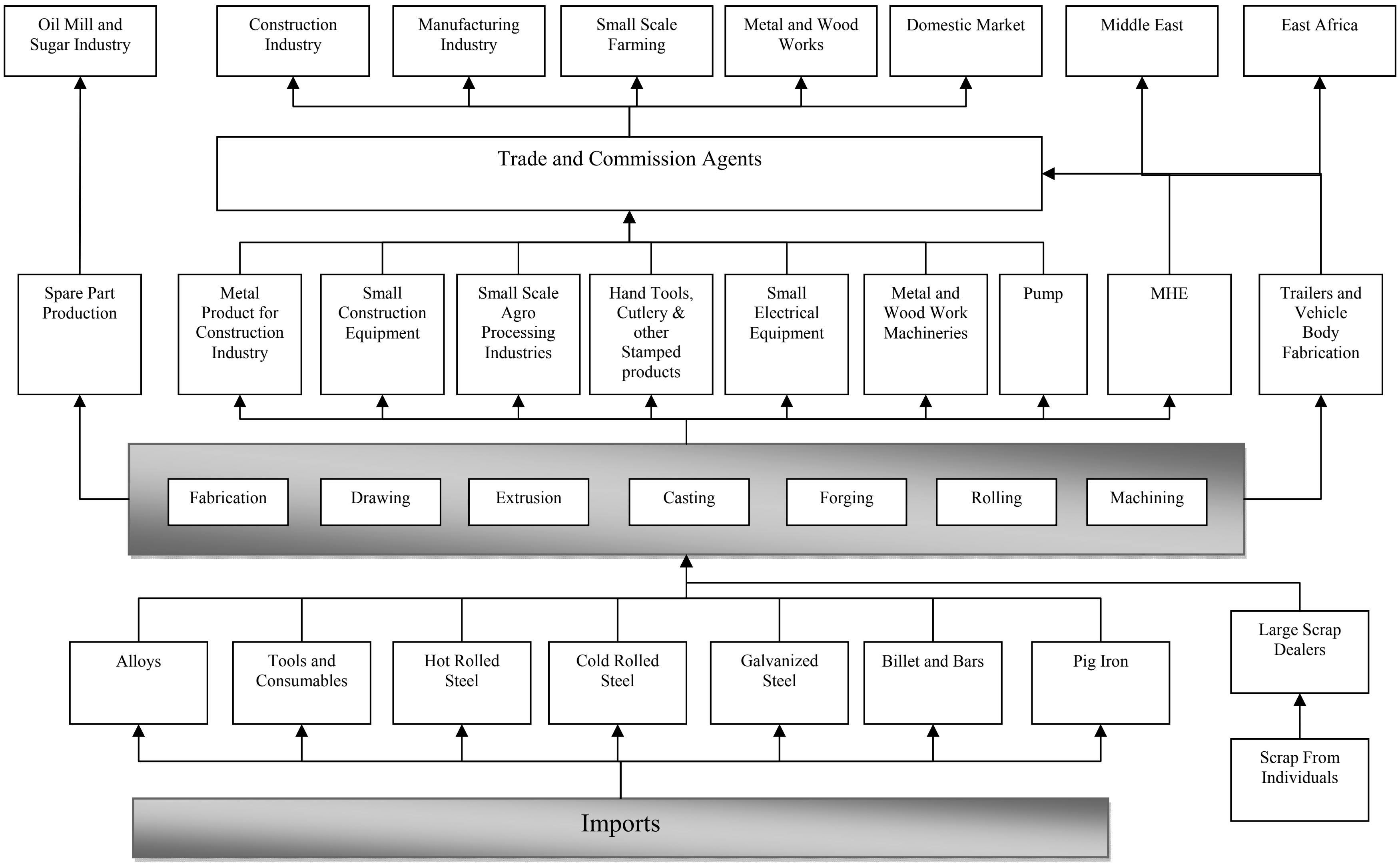

Figure 5.1 Value Chain of Basic Metal and Engineering Industries of Ethiopia

There are efforts made by national and international organizations to bring technological capability in Ethiopian industry, especially in BMEIs through technology transfer. The main efforts made are establishments of Ministry of Science and Technology, Metals Development Institutes, and Higher Education Institution reform focusing on science and technology in many universities are major strides from the government side. Moreover, formation of Basic Metal and Engineering Industries Association, establishment of new industries in different part of the country like Libo Sisay, Steel R.M.I. Plc, Yessu PLC, Abaye S.Co, Maru Metals P.L.C, Mesfin Industrial Engineering, etc; are the major private sectors initiatives and investments. GiZ, JICA, UNIDO and World Bank are also the main international organizations that are exerting effort in technology transfer. Hence, the effort made by the Ethiopian government, private sectors, international organizations and individuals is undoubtedly remarkable and has addressed the problem to a certain extent. However, these attempts lack integration and coordination among the actors.

5.2 Ethiopian Technology Policy

In order to have an efficient, robust and vibrant transfer of technology and to bring technological capabilities, it is important to have national policy frameworks that create a conducive environment. It is generally agreed that technology transfer is a critical component for economic development, which requires political action and will of Ethiopian government.

After 1991, basic principles of market oriented economy had begun to be introduced in Ethiopia. Following this a number of policies were enacted by the Ethiopian government and different institutions were established for the implementation of the policies. The Federal Democratic and Republic of Ethiopia (FDRE) has developed policies that support international technology transfer framework fully or partially. These policies are science and technology policy (S&T), education policy, trade and investment policy, export and import policy, industrialization policy, technology infrastructure development policies such as expansion of universities and its infrastructures, development institutes, research institutes, road infrastructure, urban development etc. However, the above mentioned policies are not structured, integrated and coordinated to promote technology transfer in Ethiopia.

However, implementation of the policies and strategies resulted in positive outputs that contributed towards building technological capability in the country. The following are the major results:

1. Rapid expansion of primary, secondary, technical and vocational and tertiary education (both at undergraduate and graduate levels) through the Government capacity building national program. Growth of the number of universities and colleges and their intake capacities is particularly impressive. The number of university is expected to hit a target of 33 within the coming two to three years. Participation of the private sector in education is also substantial. Furthermore, university and TVET have been reformed with the focus of trained and skilled manpower;
2. Strengthening of the national agricultural research system through human resource development, infrastructural capacity building of the Ethiopian Agricultural Research Institute and establishment of Regional Agricultural Research Institutes accompanied by deployment of three extension workers per *Kebele* to assist the farmers in using technologies to improve their productivity and life style ;
3. Establishment of a national intellectual property system with the necessary legal, organizational, and operational frameworks;
4. Creation of conducive business environment and incentives that attracted a potential number of foreign and local investors to establish and run business enterprises in agro-industry, manufacturing, construction and services;
5. The aggressive and commendable efforts of expanding ICT use across the country; including the *Woreda Net* and School Net programs;
6. Development of sectors centered institutes;
7. Upgraded (re-institutionalized) commission of science and technology to ministry level.

Moreover, issuance of the National Science and Technology Policy can be considered as a big stride towards coordinating STI activities in Ethiopia, although it has some weaknesses that may be due to the prevailing situation and the level of understanding prevailed during its adoption. First of all, the policy was too general in its content and it did not clarify the most important policy issues in detail. The policy placed too much emphasis on research and research result dissemination without due consideration to the fact that innovation can take place without having basic research capacity through copying and adaptation. Thus, the strategy and importance of technology commercialization and implementation were neglected.

However, in realizing the objectives and to accomplish the duties and responsibilities, the Ministry of science and technology gives grant for different researches that focus on agriculture, health, mine, water, energy and industry (Table 5.4).

Table 5.4 Granted Researches by Ministry of Science and Technology (MoST)

SN	Year	Number of Agriculture Researches	Number of Health Researches	Number of Mine, Water and Energy Researches	Number of Industry Researches	Total
1	1995	6	7	4	9	**27**
2	1996	8	8	0	5	**21**
3	1997	18	12	0	1	**31**
4	1998	16	12	0	4	**32**
5	1999	11	11	6	7	**35**
6	2000	8	6	7	9	**30**
7	2001	10	8	3	5	**26**
8	2002	13	6	2	6	**27**
9	2003	7	3	4	3	**17**
10	2004	7	2	5	2	**16**
11	2005	8	3	6	3	**20**
Total		**112**	**78**	**37**	**54**	**281**

***Source**: Proceedings of the workshop on local research grant by Ministry of Science and Technology*

From the above table, it can be concluded that during 1995-2005, 39.8% of the researches granted by ministry of science and technology were related to agriculture, 27.7% related to health, 19.2% related to industry and the remaining13.2% were related to mine, water and energy. And this shows that there was an increment in the number of researches except fluctuation for few years. Regarding the applicability of the granted researches by the Ministry, assessment is not done and nothing is stated about the commercialization of the researches.

Furthermore, the national science and technology policy strategies (1993) gave emphasis on strengthening and making the national intellectual property system efficient to promote and support local creativity, technology development and innovations on the one hand and enabling successful researchers and technologists to directly benefit from application of their research outputs. The first comprehensive law of the country in the field of intellectual property is the Proclamation concerning inventions, minor inventions and industrial designs which was issued in 1995. There are also legislations with regard to copyrights and trademarks which are designed to provide protection to intellectual creations in the literary and artistic field, and to create an environment which encourages fair competition between business entities respectively.

Moreover, IPRs can be considered as beneficial, when they foster the development of domestic technological capabilities through diffusion of knowledge, technology transfer, foreign direct investments and licensing. However, the intellectual property office of Ethiopia has played a minimal role in facilitating the transfer of foreign technology and the development of local innovative activities.

Ethiopian intellectual property office gives utility model to innovations at a small and medium level, and patent introduction grant for a new innovation fulfilling all the requirements set by the office. The granted innovations focus mainly on the application of engineering and technology.

Table 5.5 List of Granted Patents

Year	Invention			
	Number of Health Patents	**Number of Industry Patents**	**Number of Agriculture Patents**	**Total**
1997	1	2	0	3
1998	0	1	0	1
1999	1	4	0	5
2000	1	21	0	22
2001	1	28	6	35
2002	1	11	0	12
2003	0	29	6	35
2004	0	30	2	32
2005	0	14	2	16
2006	0	11	0	11
2007	0	2	1	3
2008	0	0	0	0
2009	0	26	2	28
Total	**5**	**179**	**19**	**203**
% out of total	**2.5%**	**88.2%**	**9.35%**	**100%**

Source: *Ethiopian Intellectual Property Office (EIPO)*

From the above table, it can be concluded that from 1997-2009, Ethiopian Intellectual property office granted 203 patents for individuals and companies. From these; 88.2% of the patents were given to industry related inventors and the remaining 11.8 were given to inventors in the area of agriculture and health. But there is no assessment by the office regarding the commercialization of the granted patents.

Moreover, the EIPO lacks systems which promote a clear understanding of legal relationships, and enabling environment to realization of benefits of potentially valuable disclosure (public domain) patent of intellectual property of the developed world to the creators, to the higher education institutes and the research organizations.

5.3 Technological Capability Assessment of BMEIs

From technology transfer point of view, a given foreign technology is believed to be effective under the following conditions. Firstly, the transferred technology should have to be successfully used or executed by the transferor. In doing that, the industry or organization involved in foreign technology acquisition should have the capacity to use both the hardware and the software components of the imported technology without any technological difficulty. Secondly, the organization or the firm which owns the technology should have the technical and managerial excellence to modify , re-built , re-codify and even to resell it either to other local companies or even abroad.

5.3.1 Product Profile

The Basic Metal and Engineering Industry could play a leading role in the realization of the Agricultural Development Led Industrialization strategy of the country. This is because of its scientific and technological contribution in supplying inputs such as raw materials, machinery, hand tools, spare parts, components, construction materials, expanding infrastructure, providing material and technical services for agriculture, and other economic sectors. These and other similar inputs of BMEI can undoubtedly enhance and expedite the productivity and volume of production of the agriculture sector.

Most of the basic metal products currently produced in Ethiopia are downstream products and manufactured using simple technology with less value addition. A general process flow is shown in Figure 5.2, and local production coverage are marked with circles.

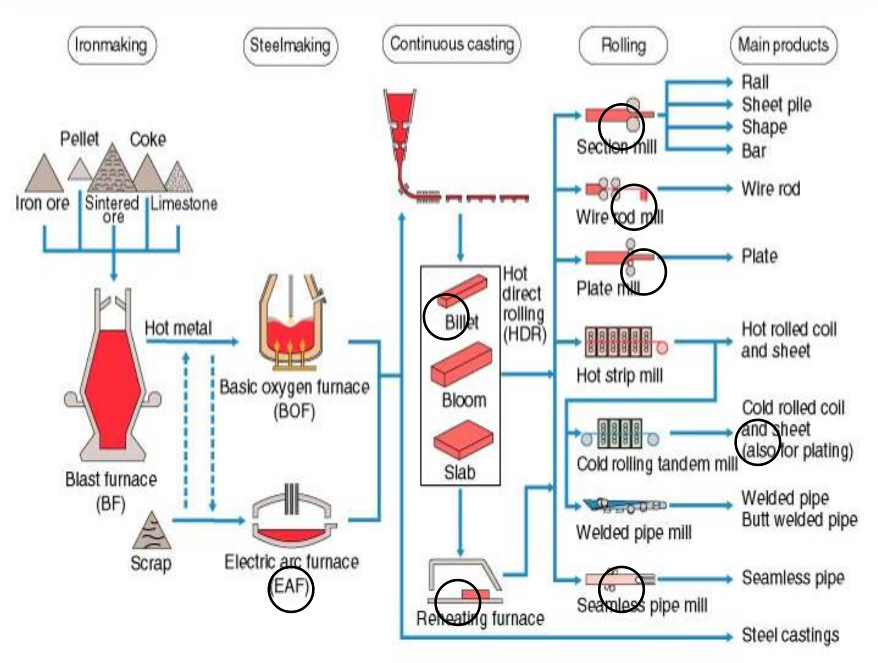

Figure 5.2 Manufacturing process for iron and steel (Ethiopia's coverage is marked with circles)

The manufacturing capability of BMEIs in Ethiopian is only limited to hot rolled ribbed, plain reinforcement bars, wire rod, angles, cold rolled tubes of various profiles, cold rolled sheets, limited galvanized sheets and tubes as shown in figure 5.2. Furthermore, limited types of products are produced repeatedly in a particular industry. Thus, there is very large unsatisfied demand in regards to other product varieties. This indicates that the industry use simple technology, and there is also a stagnant technology transfer across the Ethiopia BMEIs.

In general, the technological challenges in metal industries of Ethiopia affect their progress. For example, in most cases the qualities of products are not competent, technologies transfer is very limited, and innovation trends are very low. Hence, there are no indications to build large scale industries like heavy machineries, engines and other similar parts that reduce the consumption of hard currency of the country.

5.3.2 Awareness of Technology Transfer

Technology transfer could only be effective if and only if there is a comprehensive understanding of the subject matter by all stakeholders. Specifically, industry personnel workers, academicians, government policy makers, national experts, and the community as a whole should be aware of technology transfer and the basic concepts associated with it.

In this regard, from the opinion of industry mangers, senior engineers, technicians, and experts at different government enterprises and also the view of international organizations to the awareness level rating of Ethiopians towards technology transfer have been examined.

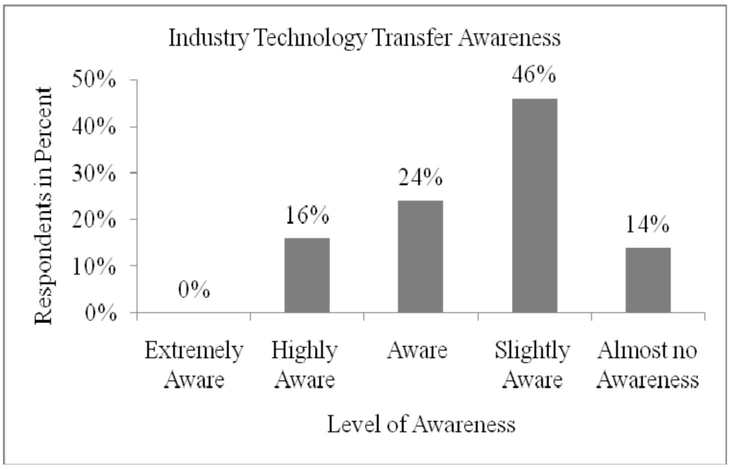

Figure 5.3 Industrial Awareness towards technology transfer

However, the opinion polls collected from the leading industries and international technology institutes as Figure 5.3 depicts that, over half of the respondent (60 %) of senior engineers and managers working as key staff members in their respective industry have expressed their awareness is less than the average. Similarly, the different experts working at MoST, JICA, and ECBP have all rated the overall awareness of the industry as “slightly aware”. This is due to lack of technology transfer awareness creating mechanisms such as seminar, workshops, demonstrative projects, case studies, basic trainings and technology transfer guide, and these problems are reflected both at the national and industrial levels.

5.3.3 Technology level

As per the survey conducted for the research purpose, the majority of industries (78%) have been found stack with outdated, reconditioned and / or aged capital equipments and production processes, with a clearly visible technological gap as shown in figure 5.4. This indicates that competency levels and technological capability to assimilate new foreign technology of the sector is low. Hence, the locals could find it difficult to make a quantum jump towards new and sophisticated technology.

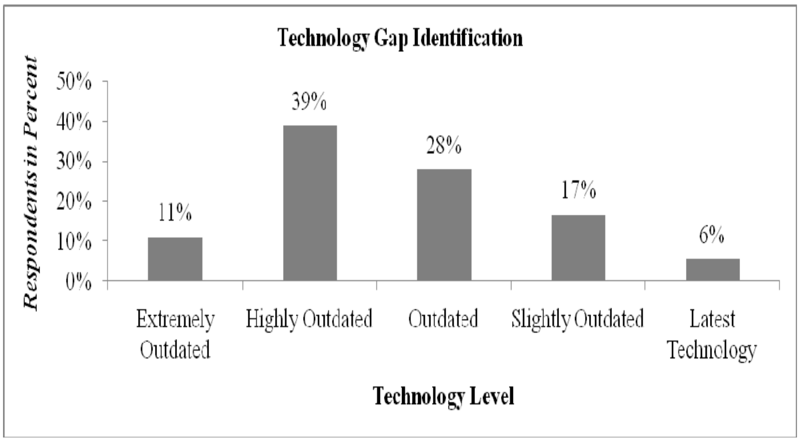

Figure 5.4 Technological possessions of Ethiopian Metal Industries

Most of respondents agreed that lack of finance and management commitment is prominent problems for the currently seen outdated technology in Ethiopian industries. However some of them have expressed different reasons for the lagging technology seen at their respective industry as shown in figure 5.5.

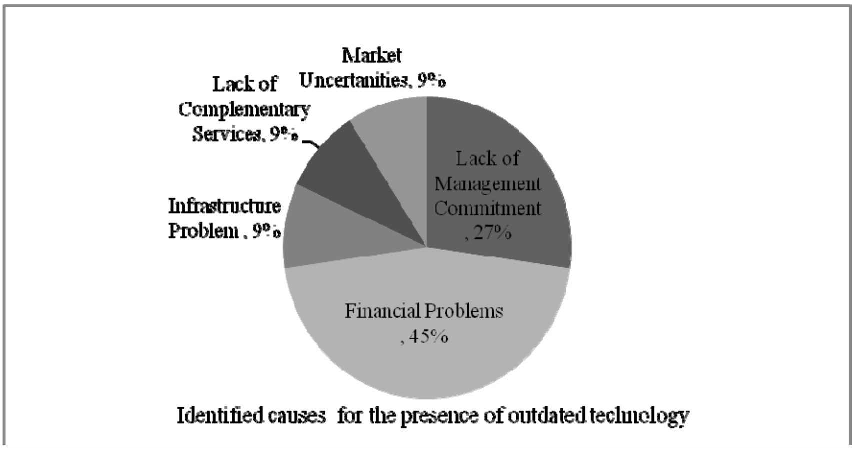

Figure 5.5 Identified problems for the sector to update its technology

However, 45% of the respondents have mentioned financial constraints are prominent problems of the industry to achieve latest technological hardware's and software's, while 27% of them express management commitment is a cause for the problem. Others have mentioned infrastructure problems, and lacks of complementary services are problems to upgrade their current technological level.

Thus, it is believed that, nothing could be properly handled without the participation and the commitment of the top management as it is the ultimate stake holder of the issue at hand.

To assess the commitment of these groups, the survey has been investigated to get the view of senior engineers, technicians and experts working at the international technical institutes. In doing that, the researcher tried to appraise whether Ethiopian mangers strive to get new technologies, despite a number of constraints or do they prefer to go ahead with the existing condition. Most of the respondents (65%) agree there is less effort of management, especially in the area of acquiring latest technology, toward reverse engineering, budget of R&D activity and supporting young technologist.

Furthermore, most industry managers have been found keen to import a given technological hardware rather than thinking reverse engineering as a means to upgrade less sophisticated technological equipments, even at time where there is acute shortage of spare part supplies with the possibility of having idled of capital equipments that will be bottlenecks for the manufacturing process of the industries. Therefore, Ethiopian industry managers, institute directors, science and technology minister, etc, all should be convinced that they could bring a noticeable change to the country, and need to be committed by strengthening and supporting technology transfer.

5.3.4 Human Resource Development

To bring industrial development at higher pace, it needs skilled man powers with engineering and technology background that closely interact with industrial production. Thus, the need of skilled man powers in science and technology at higher level of quality that meet the production requirements is the necessary criteria for capability of technology transfer.

The acquisition, diffusion and upgrading of technologies in technologically advanced countries require locally available scientists, engineers and technicians that can use, maintain, upgrade and modify imported technologies. However, the different sectors of the Ethiopian economy face serious shortage of trained man powers that can actively be involved in the imitation of foreign technologies and subsequent innovative activities.

Human resources are crucial for the development and application of technology. Certainly, some inventions have been made by individuals with little education, but now a day, the majority of inventions are made by those with substantial education in science or technology.

The long-standing problems associated with Ethiopian education system are complex. The system did not have the capacity to produce practically oriented qualified professionals. The old education system did not emphasize basic sciences and application of modern technology and hence it was almost impossible to train professionals capable of solving practical problems of the country. Besides, the curriculum was not designed base on actual country conditions in mind, and was predominantly based on theoretical. Many of those professionals engaged in teaching had no practical exposure with the industry as well. Consequently, the institutions were not capable of training technical and skilled personnel in sufficient numbers and quality to meet the country's skilled manpower needs. Furthermore, the capability of engineering academicians in Ethiopian universities to come up with laudable researches and renovations are very rare.

The contribution of technicians and engineers for the BMEI technology transfer have been analyzed and seen in figure 5.6.

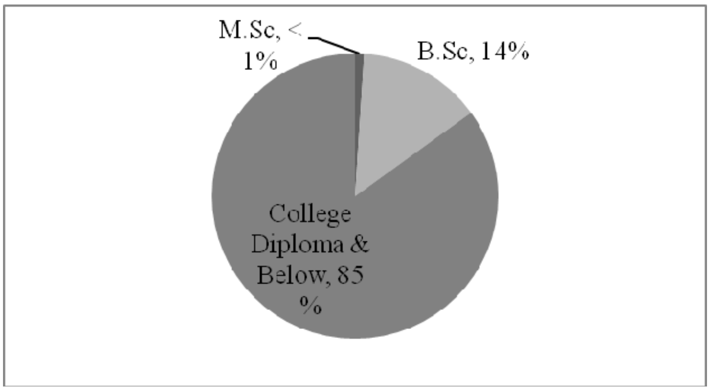

Figure 5.6 Profile of workers at Ethiopian metal industries

Most of the respondents agreed that the contribution of engineers and technicians with respect to technological absorbing capacity, participating in reverse engineering and contributions towards Technology transfer is very low as shown in figure 5.7. And, this is due to traditional education system which is more focused on theory rather than practice, especially in the science and technology. Most of high level industry managers have recommended an intensive apparent ship program, and also more practical and technology focused educational program at the university, as a solution to improve the currently seen problem of young engineers and technicians.

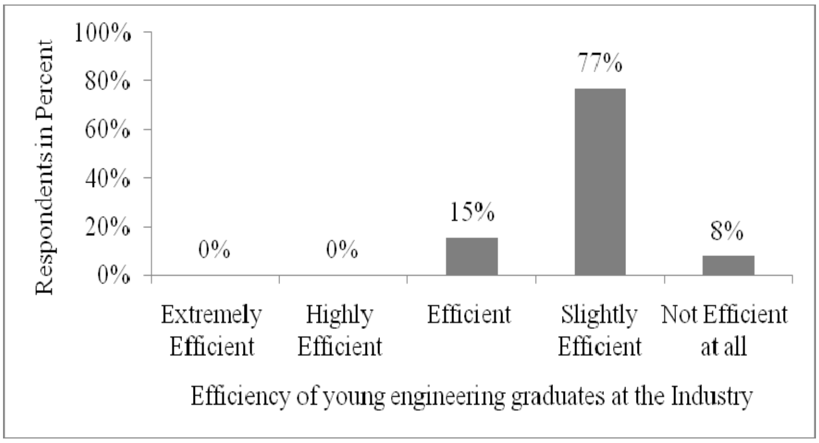

Figure 5.7 Industry view towards the efficiency of young engineering graduates

On the other hand, the Government has been expanding Technical and Vocational Education and Training (TVET) significantly since 2000/01, with the major objective of meeting the middle level human resource demand of the industry, service, commercial and agriculture sectors. TVET has also become a breeding ground for producing technicians equipped with practical knowledge, who would be job creators rather than job seekers.

Ethiopia TVET system is comprehensive and 70% is based on practical training.. They are centers for supporting SMEs, consultants, and centers for skill assurance mechanism.

The government has also came up with the university program that restructures the institute of technology's towards the science and technology education program of 70:30 ratio . This is the first Ethiopian education and training program of its kind in Ethiopia that promotes technology transfer. The justification of this reform is that the lack of well qualified scientists, engineers and technologists is one of the major problems of Ethiopia to respond to the national demands for food security, import substitution, export promotion and also to global competitiveness. The experiences of NICs demonstrated that they gave due attention to train scientists, engineers and technologists to be a fast follower through technological imitation to support the growth of the economy.

In this regard, Ethiopian government has tried to emphasize on human resource development that will generate large and competent pool of technical manpower, as one of the key pillars towards building an effective technology transfer. However, there are still malpractices in most of the higher institutions resulting in quality of education.

Therefore, Ethiopia needs to educate its citizens to a higher level of quality and standard. Universities have to train high caliber, innovative and practical graduates with a practical education that encourages flexibility and innovation with the economic and social structures of the fast-changing world. Besides, the institutions have to realign themselves with the socioeconomic policies and strategies of the country so that they can produce capable graduates who can select, and adopt technologies developed elsewhere.

5.3.5 Preference of Private and Governmental Industries

The presence of technological capability in Ethiopia could have been spotted, if there were an active participation in reverse engineering to substitute the imported technology and spare parts and also the presence of soft technology acquisition. In general, most of the respondents viewed that technology transfer is just only as the import of hardware technologies and the knowhow to operate it. Though most of the firms already acquire their technology as turn key projects and via foreign technical assistance, the majority of the respondents agreed that, going through a joint venture is the best technique to unlock tacit knowledge from foreign firms as shown in figure 5.8.

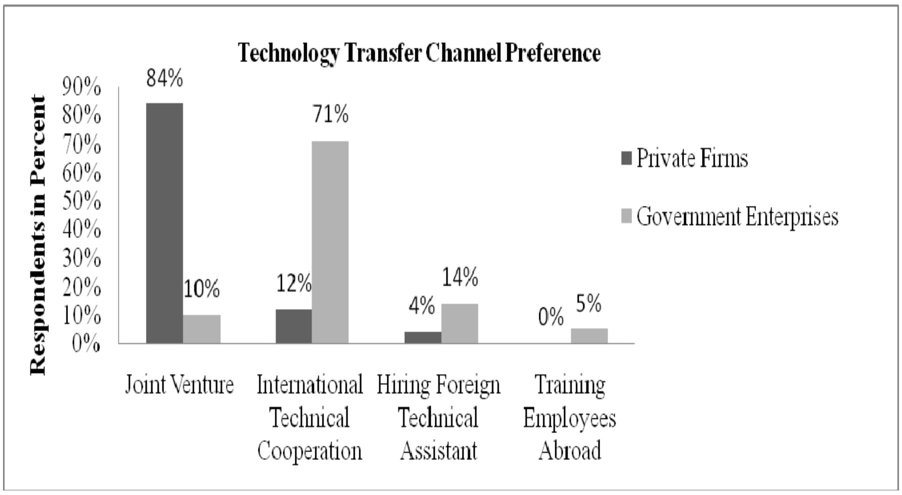

Figure 5.8 Technology transfer preference of Ethiopian metal Industries

However, the respondents have two different opinions; on one hand, government development enterprises expressed international technical cooperation as the best technology transfer channels, on the other hand, the private sector has limited technical cooperation's through international institutes. Joint ventures as the best technology transfer channel have been preferred as shown in figure 5.8.

This is generally true as most of the technical cooperation usually work with government based enterprises and institutions, without any noticeable cost at least at their respective enterprise or institution level. However, the experience of these international institutions to work with domestic private sector is so far limited and as a result the private sector couldn't view it as a reliable source of technology.

In the contrary, the domestic private sector seems happy to work with foreign investors as a joint venture which could be viewed from two different angles. First and most, foreign firms possess a more or less better technological and managerial capability in comparison with their local counterparts. As a result, the locals have the chance to benefit from this business relation at a relatively limited expense or for free. Besides this, the joint venture system allows the locals to share some of the incentives available only for foreign based companies. As a result, the favorite technology transfer channel between the two business enterprises seems reasonable and explanatory.

5.4 Mode of Technology Transfer in Ethiopia

The transfer of foreign technology plays a major role in the current endeavor in Ethiopia to bring rapid and sustainable economic development. Different channels of technology transfer have been used to transfer foreign technologies in Ethiopia. However, the major channels which are discussed in this research are foreign direct investment, trade in goods, turnkey packages, joint ventures, technical collaboration, trade in goods and international technical assistance programs are major ones and discussed in the next section.

5.4.1 Foreign Direct Investment

The foreign technologies which are being used by the various sectors come to the country through various channels. One major channel is foreign direct investment (FDI). The existing institutional and policy arrangements for investment are designed to facilitate the flow of investment from abroad. The country's investment law gives equal treatment for both foreign and domestic investors with some limited exceptions. The present Investment Proclamation No. 280/2002 and its amendment (Proclamation No. 375/2003) aim at the creation of various opportunities for foreign capital acquisition. There are also various tax and other incentives which obviously have a positive impact on facilitating the transfer of technology to Ethiopia via FDI.

The government of Ethiopia has recognized the importance of FDI for the country and opens many economic sectors for foreign investors. Despite the numerous attempts by the government to encourage foreign investors, the flows of FDI are quite low. The average annual FDI flows to Ethiopia from 2003 to 2006 were only $399 million, which is only 1.56% of FDI that flows into Africa. Therefore, Ethiopia accounted for only 1% of Africa's inward FDI stock, while representing close to 9% of the population of the continent. Ethiopia's per capita inflows were $5 in 2006, compared with $ 39 for African countries as a whole. FDI as a percentage of GDP of Ethiopia was 0.81% in 2006, compared with 1.6% for African countries as a whole. The investment incentives offered to FDIs of Ethiopia are primarily designed to be effective through the reduction of corporate taxes and import duties, including the carry forward of initial operating losses to offset against subsequent profits [113, 114]. However, in Ethiopia, there is no strategy that mainly focuses on strengthening technology transfer of domestic companies.

Table 5.7 Foreign Direct Investment inward flows to Ethiopia (Millions of dollars and percentages)

Inward FDI Stocks(% of GDP)				
1990	1995	2000	2006	2007
124 (1.1%)	165 (1.5%)	941 (12%)	3366 (25.3%)	3620 (18.6%)

Source: African statistical year book, 2010.

5.4.2 Trade in Goods

The second channel of technology transfer is the import of capital goods. Quite a large number of machineries, equipments and plants have been imported in Ethiopia from different developed countries for government and private enterprises and projects uses. This import of foreign machineries, equipments and plants represent important sources of technology for the country. For example, a report by the Ethiopian Revenues and Customs Authority shows that in 2007/08 the total value of imports of capital goods was 1.8 billion USD which is around 17 percent of the GDP. The share of imported equipments was 36.7% in 2007, 17.3% in 2008 and 21.8% in 2009. These show that Ethiopia has been importing considerable number of plants, machineries and equipments that demands a huge amount of foreign exchange. Thus, if Ethiopia devised a mechanism to transfer technologies by adapting and adopting of these technologies embodied within the equipments, it will lay a ground to the technological development of the country. There is also a dissatisfying level of imitative activities which are based on imported capital goods. There is no coordinated program of actions in the use of technologies embodied within equipments and machineries that are imported through trade in goods that help transferring to the local firms [113, 115, 116].

Table 5.8 Share of imported items from different countries to Ethiopia (2007-2009)

Imported Items in %	2007	2008	2009
Raw materials	4.6	2.6	2.6
Semi finished goods	16.5	12.3	14.3
Fuel	13.3	20.3	11.2
Equipment	36.7	17.3	21.8
Consumer goods	24.7	16.7	19.5
Miscellaneous	4	30.7	30.6

Source: Central statistical authority of Ethiopia, 2009.

5.4.3 Turnkey Contract/Package

The government of Ethiopia is engaged in many infrastructure projects including hydropower, road, irrigation, telecommunication, etc. Moreover, the private domestic investors are investing in food, garment, textile industries, etc, on these bases. However, due to the lack of knowhow, policies and strategies, both sectors are implementing the projects by the suppliers or the foreign technology contractors without enforcing them to transfer technologies and expertise to domestic professionals and engineers. This made the country to lose the benefits of technology transfer associated with this package.

5.4.4 Joint Ventures

In Ethiopia, a foreign investor may team up with a domestic investor or company for a joint investment, usually in the form of a partnership, private limited company or share company. Under the Investment Proclamation No.280/2002, a minimum capital of USD 60,000, except in consultancy services and publishing, is required from a foreign investor who intends to enter into a joint venture partnership with a domestic investor. There is no restriction about share ownership in a joint venture. Due to these privileges, there are a number of companies in JVs with Ethiopian company in areas of pharmaceuticals, garment, energy, furniture, etc… however there is no means and mechanisms of technology spillover to the other local industries.

5.4.5 Technical Cooperation

The presence of international technological cooperation's with like the GIZ, UNIDO, JICA, ECBP, and others have contributed for technology transfer. Introduction of clustering by UNIDO, kizen by JICA and reorganizing of technology institutes by GIZ and through ecbp are some of the effort made by different international technical cooperation. But the Ethiopia government has to take the responsibility to assure the effective utilization of these institutions and their integration with the industries.

5.4.6 Licensing

Although the transfer of technology to Ethiopian enterprises through licensing is mentioned, the basis on which the license agreements are concluded is not clear. The word license in a technology transfer context means permission granted by the owner of an intellectual property right to another to use it on agreed terms and conditions, for a defined purpose, in a defined territory and for an agreed period of time. There are limited patents granted by the Ethiopian Intellectual Property Office and there are no records of license agreements concluded between foreign technology owners and Ethiopians on the basis of these proprietary rights. Thus, it is difficult to speak about technology transfers made to Ethiopia using licensing as a channel.

5.4.7 Reverse Engineering

The experiences of countries which have built their technological capability in a relatively short period of time show that technology copying is an important vehicle for technological capability building. The rapid catching-up of the East Asians with the developed countries is achieved, to a great extent, by transferred technology. Korea exploited the late comer advantage by importing and utilizing foreign technologies and building up its technological capabilities through learning by doing. Korea emphasized the promotion of absorptive capacity as well as the indigenization of foreign technology through reverse engineering, while restricting both FDI, and foreign licensing.

Through the relationships that have been established with the World Intellectual Property Organization, the European Patent Office and the national patent offices of the technologically advanced countries have built a big collection of technical information contained in patent documents on departmental basis. There were also some attempts to prepare patent monographs in specific areas of technology. However, the performance of the department in promoting the use of this important non- market channel of technology transfer remained to be very low. Even after the establishment of the Intellectual Property Office no encouraging results were recorded with respect to the promotion of the use of patent information for technology transfer.

As figure 5.9 depicts that the channels of technology transfer that BMEIs built their technological knowhow in their respective industry. According to the survey, 38 % of them have mentioned that turn key projects as a main source of technical know how or commissioning of machineries as a means to acquire the hardware necessary for their respective manufacturing activities. 29 % of the respondents have also mentioned foreign based technical assistant as their main source of technological knowhow.

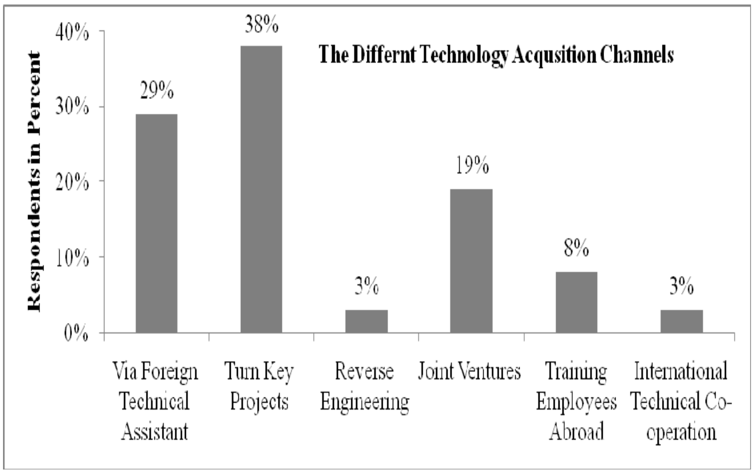

Figure 5.9 Technology transfer channels of BMEs

Though it is possible to find a number of technologies transferred through foreign technical assistance, joint ventures, turn key projects, licensing, and other channels, the survey has revealed that most of the technologies are simply imported and commissioned by the foreign suppliers which basically lowers the adoption tendency of Ethiopia.

Furthermore, Ethiopia's capacity towards reverse-engineering is rated low by both national and international institutes, and also in the scale of other developing countries. Even though, the level of Reverse Engineering (RE) in Ethiopia is still at its infant stage, but it is believed that strengthening reverse engineering help as a tool to satisfy the countries hardware and software needs in the future.

5.5 Collaboration of BMEIs in Ethiopia

5.5.1 University – Industry linkage

A previous university-industry cooperation program (UICP) organized in 1986 between Addis Ababa University and the Ministry of Industry declined and became ineffective after government change in 1991. In 2000 a revival started through the newly formed Technology Faculty – Industry Linkage Unit (TFILU) that began its operation after getting a grant from the Ethiopian Science and Technology Commission. In general, the linkage between universities and industry has been very weak for several reasons; firstly, even if the universities encourage the best graduates to remain in academia, the universities are mainly engaged in education and training of manpower practices. Secondly, most of academic staffs and researchers have strong interest and linkage with international scientific community and are interested in publishing the academic journals than creating industry linkage. Moreover, they do not attempt to copy or develop any kind of technology or address problems of the local industry. And hence the linkage between the universities and the industrial establishments has therefore been limited mostly to educational visits of university students and teachers to some industries, and apprenticeship training of students in some of the factories.

Among the total respondents from the industries, 45% of them have indicated as they don't have any noticeable linkage with the university with the objective either to share what they have or to get assistant from the university. At the same time, those industries which expressed the presence of collaboration with the university (55%), have rated their level of collaboration as limited.

Furthermore, those respondents who answered no or, 45% of them have been asked to mention why they failed to reach the university, and the majority expressed the following prominent reasons; some have blamed the university for shielding itself from the industry, others have expressed a long starting routine works at the industry which neither requires assistance nor having valuable input to be transferred and few of them have clearly underestimated the universities potential as futile to assist the industry.

Moreover, the collaboration may provide firms with access to scarce resources, external expertise on new technologies, and allow for the exchange of knowledge between partners that stimulate learning**.** Therefore, such efforts may lead to the creation of technologies with a high novelty, value and yielding potential future revenue.

5.5.2 Inter Industry Linkage

Whether between individuals, work groups or organizations, it is widely accepted that collaboration plays an important role in the process of technology transfer. As the operating environment becomes more discontinuous, the more impossible it is to do everything in-house. This is particularly the case where there is a regime of rapid technological development with broadly distributed research breakthroughs. Furthermore, many studies have observed that close interfirm collaborations have positive effects on a firm's technological capability.

Most of the industries responded that there is very weak inter-industry linkage. Hence, it becomes a major cause for the technological spillover to be weak as shown in figure 5.10.

Figure 5.10 Level of Industry-Industry collaboration

One of the main reason is there is no institutions that bridge the gap of interfirm linkages. Moreover, weak inter firm linkages are due to taste difference, lack of trust, uniqueness of certain materials, weak association and also due to independence and individualism.

5.6Level of R & D Activities

R&D activities are the main tools to achieve state of the art technology for the industry. In a sense, having an intensive R&D activity will enable the industry to participate in reverse engineering activities with the objective to assimilate and adopt foreign technology besides the innovations that could be done to solve industry specific problems.

Looking at the Ethiopia R&D activities, agricultural research system is better organized than the other sectors. But, there is still, major weakness of the R&D activities in the agricultural research centers. These are inadequate attention to copying and adapting technologies that can be used by the farming community and the local industry.

Furthermore, the fast growth of domestic technological capability in particular, the development of a capacity to adapt foreign technologies and introduction of incremental innovations requires systematically organized research activity and by scarifying a certain amount of resources for research to achieve the desired results. The current ratio of R&D expenditure to gross domestic product in Ethiopia, which stands at 0.2% is also one of the lowest in the world.

Table 5.9 R&D expenditures

Country	**Expenditures on R&D (billions of US$, PPP)**	**R&D as % GDP (2007)**	**Year**
Ethiopia	0.1	0.17	2007
South Africa	3.7	0.93	2007
South Korea	44.8	3.21	2007
India	36.1	0.8	2007
China	153.7	1.44	2007
Japan	144.1	3.44	2007
Turkey	6.9	0.72	2007
Germany	69.5	2.54	2007
UK	38.4	1.82	2007
USA	405.3	2.72	2007

(Source: The World Bank)

In general, R&D activities for most scientific fields are at infant stage. And it is also depends mainly on donor funding. This means that R&D priorities are largely set haphazardly by the whims of individual donors. Lack of National Priority Research Programs (NPRP) will lead to chaotic research projects and cannot contribute to the national effort of technology acquirement. The experiences of effective and successful countries in R&D activities showed us that they developed priority programs in the areas where they wanted to bring breakthroughs.

From the survey conducted, 64 % of the respondents have genuinely replied as they don't have R&D activities in their respective industry. Similarly, 36 % of the respondents, who expressed the existence of R& D activity, have rated the successfulness of their respective R& D activities as very low or not functional. At the same time, the industry has failed to support R&D activities conducted by higher institutes. Therefore, the Ethiopian, R&D institutes are only depends on the fund allocated by governments. Thus, due to government limited funds, the institutions R&D activities are highly affected.

Furthermore, the tradition of conducting research within the universities are very feeble and even the few research activities being done by the university personnel as mentioned earlier are merely for academic purposes. They do not attempt to copy or develop any kind of technology or address the problems of the local industry. Most of the university research activities are therefore aimed at publishing at local or foreign journals with no specific problem solving applications in mind. In addition, in most of the industries, there is no R&D department. Hence, this will hinder the industry capacity to use research results from Universities, R&D institutes and within the industries' R&D departments.

5.7 Evaluation Mechanisms

Technology transfer is an extremely complex process with some common features and a number of uncertainties. As a result the process could slip in different directions and most often negatively. In this respect, the presence of technical mechanisms to assess the progress of a given technology transfer process or finished project will enable the transferors to scrutinize what is going right and wrong. The presence of such mechanisms will enable companies and organization to be best fit in the procedure of the future technology transfer processes.

In general, understanding the success or failure of previous attempts of technology transfer could have a valuable lesson for the future similar technology transfer project. As the objective of any technology transfer process is to gain access to modern technology and an improved mode of production and service, the ultimate goal of technology transfer evaluation will be focused in knowing the significance of the transferred technology. Ethiopia lacks evaluation mechanisms and responsible organization that evaluate the extent of technology transfer from the given project and take lesson for the next. Hence, Ethiopian actors of technology transfer should have evaluation mechanisms that would help to evaluate the extent of technology transfer and its effectiveness.

Chapter Six

Way Forward

6.1. Introduction

Ethiopia has a remarkable record of achievement of a two digit economic growth for the last five consecutive years. However, the contribution of the industrial sector remains minimal as the country pursues agricultural development lead industrialization. To ensure sustainable economic and social development for the country in today's competitive world, building technological capability to the industry is critically important, especially BMEIs.

Recently, Ethiopia has released the five years medium term development plan called the Growth and Transformation Plan (GTP). According to this plan, it is identified that maintaining agriculture as a major source of economic growth while creating favorable conditions for the industry to play key role in the country's economy. After the completion of the five years GTP, industry is believed to take the led as a major drive for the economy. This implies that industrial development has been given a greater emphasis in the future development plan of the country. The plan also promotes import substitutions and export oriented industrialization.

Even if the governments of Ethiopia laid out various policies, strategies, programs and setup different technology transfer offices in the public institutions, but integrated and coordinated technology transfer system is hardly incorporated in the plan of action. The national science, technology and innovation policies take the lead; and the education, industry, capacity building policies, strategies and programs follow for the action and implementation. Though, some of the policies and programs support technology transfer activities in the country, they lack coordination and organized implementation system to bring technological capability in Ethiopia. Thus in this chapter the proposed solutions and the actions are presented that should be taken to achieve promising technology transfer in Ethiopia that lead to the development of industrialization with the emphasis of BMEIs.

6.2. Formulating Technology Transfer Policy

Technology policy is a set of government actions that affect the generation, acquisition, adaptation, diffusion and use of technological knowledge in a way that the government deems useful for the society. From both developed and the recently emerging giant world economies experience, the technology policy plays the major role in the development of a country as discussed in previous chapter. In this regard, creating favorable technology policy for all stakeholders in general and for BMEI in particular is by far expected from the government. Therefore, the government should ascertain all stakeholders to fulfill their roles and responsibilities in creating a conducive environment for the development of the metal sector which is then be a catalyst for the other sectors. In general terms, Ethiopia government should focus on technology transfer policy with the focus of technology transfer main pillars so that the industry could benefit from technology transfer.

6.2.1. Identifying Channels of Foreign Technology Transfer

Ethiopia can also learn from the experience of the newly emerged industrialized countries as they adopted different means of foreign technology transfer as their national priority. For instance, China adopted FDI as a first priority and Korea's policy used import of capital goods and turnkey packages as a first priority. Thus, national priority has been proposed on the national policy for transferring foreign technology to the country, based on the socio economic situation of Ethiopia.

As a first priority, Ethiopia should use FDI as the main channel to transfer foreign technology. This is because, domestic investor of BMEIs lack the crucially needed financial and technological capabilities to undertake major industrialization. As a result, the participation of foreign firms on technology and capital intensive activities becomes undisputable means of industrialization. The effects of FDI could be primarily viewed in expanding domestic outputs, capital accumulations, creating job opportunities, expanding export activities, etc. However, the most appreciable importance of FDI is its indirect benefits through technology transfer, technology diffusion, skill upgrading and development of local auxiliary industries by creating backward linkages. Therefore, the following facts should be focused so that the country can get benefits from FDI.

- **Priority for Technology Intensive FD Investments** – FDI could serve as a technology transfer channel on condition that, the type of investments are technology intensive in comparison with those found in the local market. In this regard, the government should therefore focus on BMEIs rather than less technological intensive sectors, for example, agriculture, textile, and the food processing industries. Hence, the government could place great incentives schemes to attract foreign investors in the area of BMEIs, as the technology spillover is usually much higher in comparison with the direct benefits the other industries could bring in.
- **Local Partners Participation Requirement** – In this case, the government should place a time frame for foreign firms to go to sub-contracting arrangement or local supplier development activity with the objective to diffuse their technological knowhow to the BMEIs. From the experience of the Chinese and the Indian auto motive industries, the placement of such agreements will enable FDI's to manufacture some components within the local industries; otherwise they will be imposed on heavy taxes. For example, it is common to see automotive assemblers in Ethiopia which are making profit only from available cheap labor, while their technology spill over contribution is insignificant.
- **Participation of local personnel's** – Besides the presence of local content requirement for foreign firms, there should also be an agreements placed in order to assure the presence and the participation of local employees at key posts of foreign firms. In doing that, it will be possible to speed up the spillover of technical knowledge from the foreign firm into the BMEIs. The local participation must not be limited only to FDI, but the government should also assure the local participation during the implementation of foreign large scale project.

The second priority is to pursue turnkey package as means of foreign technology transfer channel in Ethiopia. The reason why Ethiopia should use this channel to transfer technologies in both public and private sectors is; government invests mainly in the infrastructure development using this channel and most of the private industries are established based on turnkey packages. Hence, putting a policy on turnkey packages as a second priority benefits the country in the transfer of foreign technologies.

6.2.2. Infant Industry Promotion

From the experience of China, regulating import activities is the main weapon to protect weak local industry from the devastating impact of foreign products. In doing this, the government should identify what could be and couldn't be produced locally. The nation's limited foreign currency should also be distributed based on this fact. Foreign multinational companies should be encouraged and regulated from dumping foreign good to the country in a life time basis. Instead they should have a provision to enter and manufacture in a step by step manner.

The development of technological capabilities at the firm level is critically dependent on the amount of production experience of the firms. Most firms in the developed countries are more productive and technologically capable. However, the developing countries firms face problems when they try to build up new technological capabilities in new areas. This implies that some kind of infant industry protection is necessary for the firms in Ethiopia to have breathing space to accumulate experience in new areas. Infant industries can be protected through tariffs and other trade restrictions, explicit and implicit subsidies, appropriate restrictions on FDI activities, and preferential treatment of domestic firms in government procurement. Furthermore, by imposing restriction on imports, or by levying high import tariffs on those who are importing products, it will be possible to force infant industries to collaborate with their principals and then finally entered to the field of manufacturing.

6.2.3. Support from Financial Institutes

Finance causes a problem to technology in two different levels: firstly, research projects have to be funded and their results have to be properly developed to ensure effectiveness and applicability; secondly, these results have to be transferred from universities and research centers to firms in order to foster innovation and growth. For all these stages, adequate financing instruments, therefore, hold a prima facie claim as it is an important element for technology transfer.

The Ethiopia government has been working hard to secure finance for the agricultural, textile and leather industries for the past ten years. At present, banks and other lending institutions are somewhat hesitant to finance the BMEI sector, due to its long return on investment period. The capital intensiveness of the BMEs calls for the establishment of a solution road map towards financing the sector. Hence, both government and private financiers should identify and tailor financial policy for the sector. Moreover, the government should re-consider its financial policy and establish a means to setup development banks that can finance the sector.

6.3. Strengthen Technical Development of Higher Institutes

Universities can play an important role in the rehabilitation of the country's economy when a modest atmosphere is established by all the stakeholders. Therefore, investing on higher institutions and regulating their output will pay off a golden price at the end. Hence, the presence of higher institutes that are capable of delivering expected result to the industry should be viewed as a main priority in the country's development plan. Moreover, the higher institutes programs should be tailored in such a way that it can foster industrial growth, and reinforcing and establishing R&D centers, should be a significant priority. As a summary, the government should intervene in the education sector to alleviate the problem in the following areas.

6.3.1. Focus on practical oriented Science and Technology Education

Human resources are crucial both to the development and application of a given technology. An important prerequisite for building technology capability is a skilled human resource that can select, install, maintain, assimilate, design, manufacture and even create the technology. Therefore, the extent of technology spillover will also depend on the absorptive capacity of the local skilled man powers.

Singapore's experience in skill development is one of the best policies that Ethiopia can learn. The skill development or knowledge policy of Singapore was directed by consciously acquiring, and subsequently upgrading, the most recent technologies in highly internalized manners. To attract foreign investment and induce technological upgrading, Singapore invested heavily in education, training and physical infrastructure. This helped

Singapore in developing an efficient, industrially oriented, higher education structure and become the best in developing specialized worker training system in the world.

In general, the current human resource development activities are inadequate to move Ethiopia's economy towards a knowledge based economy in the future. Key obstacles that are responsible for this include; poor science and technology education development, low level of R&D in science and technology, and insufficient technical manpower with desirable quality of skills.

Therefore, skilled workers in engineering and scientific competences are required either to make significant adaptations of existing technologies or to create new ones. Otherwise, firms cannot perform "reverse engineering" or even low tech products, if there is no an adequate supply of skilled manpower. Therefore, the content and quality of the Ethiopian education in technological institutions should be structured well and emphasized on the high level practical oriented science and technology education and training are compulsory. In addition, the government should arrange adequate incentives and recognition system to attract and retain Ethiopian local & Diaspora scientists to share their enriched research capability, scientific and technological knowhow within the education and industry as South Korea did.

6.3.2. Emphasis on applied Research and Development

The technology institutes are not only a place where students are trained to be engineers but also it is a place where industrial problems are to be solved, applied research is conducted and new ideas are also to be changed in to industrial products and processes. They are supposed to do entrepreneur activities through licensing of their innovation, spinoff companies establishment, consultancy, applied and experimental R&D and other technological services. However, Ethiopian higher institutes are mainly engaged in teaching and learning activities.

Therefore, the technology institutes should understand the technological level of the industry and research programs should be conducted from industry point of view. Moreover, to build technological capability from Ethiopian point of view, higher education

R&D activities should firstly be focused on the utilization of the already available and matured foreign technologies being adopted by using reverse engineering.

6.3.3. Establish Metallurgy and Material Engineering Department

The government has tried to establish a number of new universities in the past besides upgrading the already existing ones. Similarly, the establishment of hundreds of vocational colleges in the country, and the 70-30 school enrollment schemes could be viewed as major strength of the government towards building technological capability.

In the technology institutes, the department of mechanical engineering could provide some of the basic concepts to metallurgy and material engineering by giving few introductory courses, but it will not enable young graduates who are tailored for the BMEIs. Therefore, the establishment of the Metallurgy and Material Engineering education, either at institute level or at least at department level in the technology institutes should be given a significant priority for BMEIs as the establishment of Ethiopian Leather and Leather Products Institute for leather sectors and Bahir Dar Textile Institute for textile sectors.

6.3.4. Strengthen Industry –University Linkage

Technology transfer from universities and research institutes to firms is important to utilize domestic technological capability for industrial development of the country. In such technology transfer activities, universities and research institutes also benefit from collaboration with the industry.

The current linkage between the university and the industry in Ethiopia is mainly through apparent ship practices. The link between the university and the industry is weak. Hence, establishing a strong university –industry linkage, with defined goals and accountability will be the most effective mechanism where both parties act as complementary organizations to share their mutual resources to achieve the common goals.

The link will enable the university to get the fund needed to conduct applied R&D, and the academicians will also gain practical knowledge in doing the applied research. This will helps university to deliver practical oriented teaching learning activities. Furthermore, the industry would get support to alleviate their industrial problems.

Therefore, the strategies that should be followed in promoting university-industry technology transfer are:

- Establish university industry linkage office at vice president level within the university;
- Prioritize key and strategic areas of research and development that could benefits the industries;
- Encourage the development of a strong research infrastructure in the universities;
- Provisions of special tax exemptions for expanding industrial support of Research and Development (R&D);
- Supporting universities towards collaboration with foreign R&D supporting institutions;
- Encouraging researchers with incentives, higher payments, rewards, promotion, etc.

Furthermore, to encourage collaboration of industries with universities or R&D supporting institutes, there should be supportive mechanisms; such as collaborative research grants should be set up. The ministry of education, ministry of industry and ministry of science and technology should also provide research grants to university industry collaborative R&D projects.

6.4. Strengthen Technical Co-operations

International technical and development assistance organizations could play a vital role on technology transfer. Technology transfer via these organizations is either free or nearly free compared to the technology acquisition made in open foreign market. Among the different mechanisms which these organizations could help the local, engineering education and research is one of the effective means in the process of human resource, and institutional capacity building activity to make less developed countries internationally competitive.

In this sense, international technical organizations could be effectively utilized in the process of foreign technology mediation, technological need identification and technology appropriateness evaluation. Similarly, they could also be used as consultants at time of major policy and infrastructure development activities. In this case, the activities of GIZ, ECBP, and JICA could be mentioned at the forefront. However, a close government careful attention and follow up are required to effectively utilize the resources allocated to and applied for the intended use. The government should also list down priority areas for these technical institutes, and a policy frame work should also be formulated to assure the participation of locals along with these institutes.

6.5. Establish Industry Level R&D Center

There is evidence that R&D is positively correlated with productivity and has a crucial determinant ability to absorb technology. Since most Ethiopian firms do not conduct R&D, they are located well below the global technological frontier. Yet, technology adoption requires skills and research and development (R&D), which encourages the identification, selection, acquisition and effective adaptation of existent technologies that are new to the firm. Therefore, if firms invest in R&D, it would help increasing competitiveness and generating sustainable growth and productivity of the firm. R&D also enhances the ability of firms that are below technology, in speeding up the technology absorption. Therefore, Ethiopia needs industry level R&D activities to effectively absorb and adapt imported technologies.

6.6. Coordinated Participation of the Stakeholders

BMEIs have played a major role for economic success of developed world. For example, the technological success of the US could be associated with the success story of its giant industries like Boeing, GMC, GE, Ford, Chrysler, etc. Similarly, in Japan successful companies like, Toyota, Sony, Nissan, and others can be mentioned. South Korea has Hyundai, Samsung, Daewoo and other noticeable companies.

Having this in mind, building a strong BMEI in the country could lead to country wide economical and technological achievements. Therefore, all the stakeholders of the BMEIs should be coordinated and convinced towards the development of the sector. The following lists some of the stakeholders that need coordinations:

- **Ministry of Industry:** The ministry should recognize BMEI as backbones for other industries and attention should be given for the sector.
- **Ethiopian Investment Agency:** The EIA could play a major role in developing the sector more than anyone else. As the sector is extremely capital and technology intensive, it couldn't reach at its boom level, given the limited financial and technological capability of the locals. Therefore, having the significant benefit of a strong BMEI industry, the agency should select the sector as one of a priority area as it did for leather, textile, and flower industries. In doing that, FDI and JV projects should be incentivized so that they could get the courage and assurance to invest in the sector.

- **Higher Education Institutes:** In the developed world, the university and the industry are the two faces of a coin based on mutual benefits. The university is source of new technological ideas, and the industry is the place where these new ideas are converted in to business via the creation of new technologies and products. In turn, the industry is the source of finance for university to undertake capital intensive research and development activities.

  Therefore, Ethiopian higher institutes could assist the industry in many ways. Firstly, the university should consider major undertakings to develop a skilled manpower based on the industry's need. Secondly, university professors and young engineers should be engaged in training, consulting, research, and other activities which are aimed and tailored to assist the BMEI. Hence, government, university and the industry should take a coordinating effort in establishing coordinated and accountable offices to promote university-industry linkage.

- **Ministry of Science and Technology:** The ministry is specifically established to assist the country's science and technology development activities. Hence, the ministry should work in identifying the country's technological needs in a prioritized order, encouraging young innovators and strengthening the country's intellectual property right, especially to work on disclosure intellectual property of developed countries. The ministry should also be engage in preparing a sound science and technology implementation strategy in collaboration with other stakeholders at all levels.

- **Ministry of Mines:** Except the recently published work of JICA experts, the availability of Iron ore in the country doesn't seem well studied and identified. Therefore, the ministry should take the lead in identifying the potential in iron ore processing in the country and to engage in the production of iron ore at a commercial level. Furthermore, studies in identifying other metallic ores that are being imported could also be undertaken. Besides this, the ministry should give a clear statistical data on the presence of coal and lime stone in the country, which all are the necessary raw materials to produce iron and steel within the country.
- **Ethiopian Metal and Engineering Corporation (METEC):** This is a recently established corporation under the merger of national development enterprises with the military section. Since the corporation is at a better position when comes to political and resource support from the government, it could be helpful to move the sector many laps ahead. The corporation's mission and vision to arrange job contracts with private sector, the training activities it thought to offer, and the standards it is going to set both the private sector and on those enterprises under its command could be major boasts to the struggling private sector. Morover, the corporations move towards assembling the buses for the public transport sector, manufacturing machinery and component to the sugar and cement factory, and the proposed plan to largely engage in the development of the country's rail road could be seen as the few of the sound initiatives which the corporation is trying to handle. Therfore, the corporation is capable of revolutionizing the country's metal sector on condition it gets the right management practice and resources.
- **Ethiopian Professional Associations:** professionals associations in the developed world are capable of contributing the government policy making for a specific sector. Like wise, the Ethiopian, professional associations such as Ethiopian Society of Mechanical Engineers, Ethiopian Society of Civil Engineers, Ethiopian Society of industrial engineers, Ethiopian Society of Geologists, etc should actively participate in providing BMEI sector oriented trainings, technology need identification and others supports with the objective of building the country's capacity in the metal sector.
- **International Technical Cooperation Institutes:** The presence of international technological cooperation's like the GIZ, UNIDO, JICA, ECBP, and others has to be

seen positively and used wisely. Introducing clustering by UNIDO, kizen by JICA and restructuring of technology institutes by GIZ are some of the effort made by different international technical institutions. But the Ethiopia government has to take the responsibility to assure the effective utilization of these institutions and their integration with the industry. Especially, the participation of JICA in the metal sector has to be strengthened and the possible ways to participate with others have to be devised.

- **Association of Ethiopian Basic Metal and Engineering Industry:** The establishment of Ethiopian Basic Metal and Engineering industry association could be viewed as major breakthrough to address the problems of BMEIs. However, a lot is expected from the association in addressing the need for government intervention and in assuring the participation of other stakeholders for the country wide awareness on the importance of the sector. At the same time, the association has to be at the forefront in identifying the development paths of the sector.
- **Ethiopian Financial Institutes:** At last, the need to have a sustainable and adequate finance is a crucial factor for the development of the sector. In this sense, the country's financial institutions have to come up with a short and longer term plan to finance the country's BMEIs as they did for the textile, leather, and horticulture industries. Hence, a major financial overhaul is also expected from government owned banks as well as private banks. Moreover, they should understand that the BMEI sector is highly profitable but need considerable time to do so.

6.7. Shift to more Technically Feasible and Value Added Products

According to the International Metalworkers' Federation report, the production and first handling of metals (iron, steel and non-ferrous metals) accounted 12% of the overall added value. However, 88% of added value was produced in the metal processing or engineering works which includes the production of metal goods, transport machinery, non-electrical machinery, electrical machinery, and fine machinery. This implies that, the primary production of basic metals and their initial processing are less important for the overall production value of the metal industry compared with high tech manufacturing activities. As a result, more emphasis should be given to the metal manufacturing rather than the primary production of iron and steel, which is largely dependent on the presence of raw materials such as iron ore or scrap in the local market.

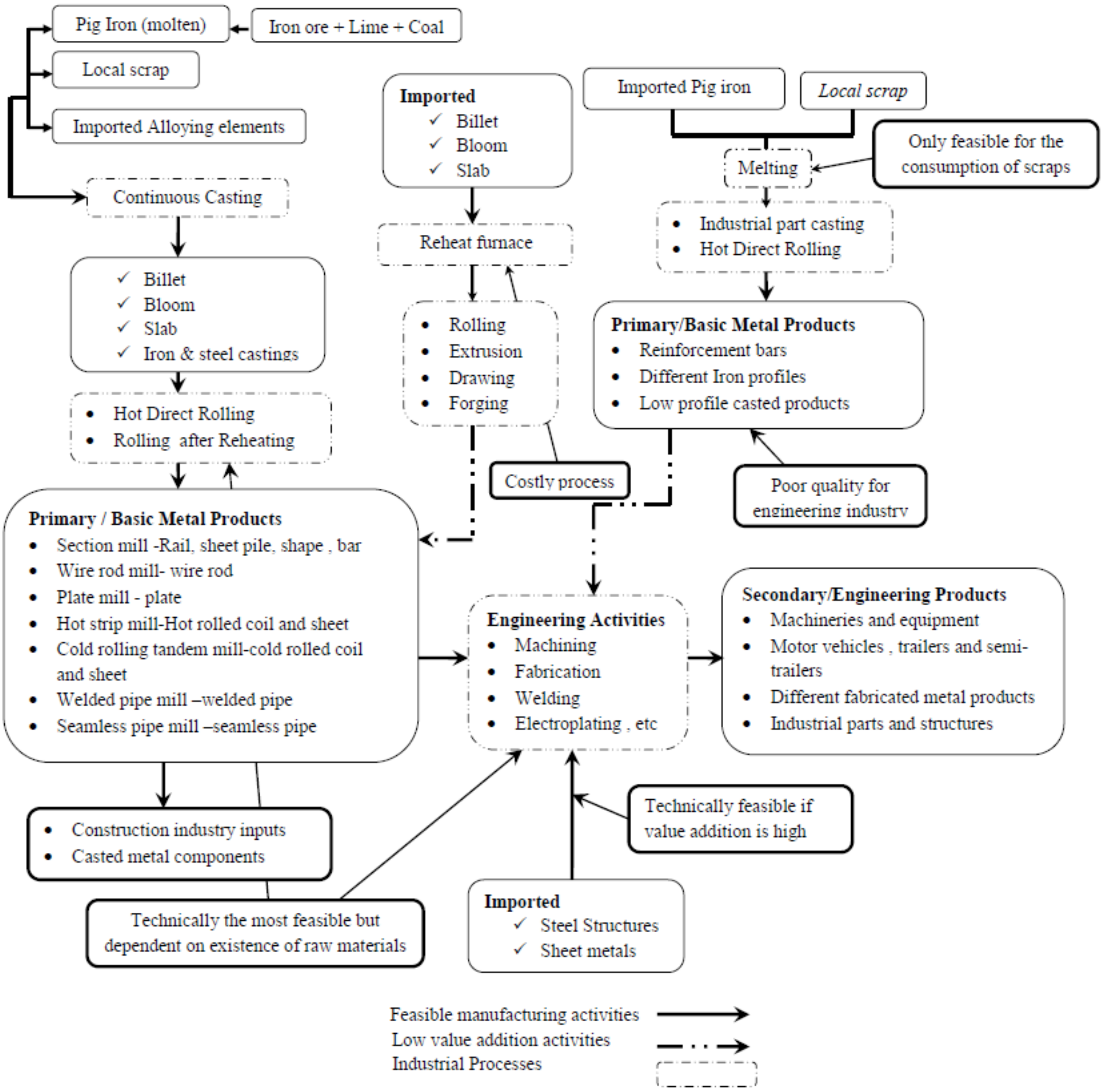

Figure 6.1 Manufacturing activities of the BMEI

The major problem in Ethiopian metal industries is that, they are neither the primary producer of iron and steel nor manufacturers of intensive engineering products. Most of the products of the basic metal industry are unconventional products which is caused by iron and steel manufacturing process. The problem lies on reheating and melting of pig iron, iron ingots and billets. Similarly, the products of Ethiopian basic metal industry are not suitable for all engineering industries' uses. For example, the basic metals industry has limited contributions to Ethiopian trailers and semi-trailers manufacturers.

The primary market target of most basic metal industries is the construction sector. Furthermore, Ethiopian products are expensive in comparison with foreign imported products, due to reheating energy, manufacturing and material handling related costs. Therefore, it is recommended to shifts from the current low value added activities to the upper stream and its immediate downstream activities as shown on figure 6.1.This implies, the basic metal industry should focus on a long term plan towards building pig iron production from iron ore. Therefore, further investigation should be conducted in addition to JICA iron ore study. Having said that, the basic metal industry will have different varieties of products from its immediate downstream and it could supply the engineering stream with the necessary metal products and structures. In addition, the BMEI should strengthen its technological capability, and shift to a more technically feasible and value added technology intensive products.

6.8. Establish Basic Metal and Engineering Technology Transfer and Innovation Center (BMETTIC)

There have been many attempts by government, national and international organizations to resolve the problem of technological underdevelopment. Some of the efforts made are establishments of industrial plants, design centers, scientific and technological institutions, in addition to conducting seminars, workshops, trainings abroad and advisory services at different levels. The Ethiopia government has formulated S&T policy. It can be clearly seen that most important issue in the Ethiopian S&T development is not lack of a policy guideline, but it is lack of systematic efforts to coordinate and implement the government policy. The Ethiopian government has also been implementing new methodologies to industries for the last 15 years. The effort made by government, donor organizations and international agencies is undoubtedly remarkable and has addressed the problem to a certain extent. However, the attempt lacks controlling and coordinating efforts and result in duplication of efforts and resource, under-utilized capacity of industries, weak regional co-operation and weak link between university, industry and government especially in BMEIs sectors. Therefore, to improve the existing technological problems of the sector, it is strongly recommended that establishment of Basic Metals and Engineering Technology Transfer and Innovation Center (BMETTIC).

The proposed Center, in this study, is not a duplicate of what the others are doing like various development institutes (LIDI, TIDI, and MIDI) in Ethiopia. These development institutes are sector oriented and give support for specified sector but they don't coordinate and work together with different technology transfer actors. But, it is an attempt to make a coordinated effort, in order to implement an efficient and effective technology transfer system. This will provide a linkage to integrate the resources available at higher education institutions, industries, research institutes, individuals, and contribute an immediate impact on the effort of bringing technological capability.

BMETTIC will facilitate the industrial use of technology developed and owned by individuals, research institutes and companies, thereby building an infrastructure for the effective transfer of technology. Especially, construction of commercialization infrastructure including industry support, venture start-up, small & medium scale business technology support, research results proliferation operations, business start-up support , technology evaluation, utilization of the local university technology development support, and building autonomous joint industry-university technology development systems are considered as the major area of interest for the center as shown in figure 6.3. Moreover, the regional technology institutes and joint area industry-university technology development consortia will be designed and supported actively.

Technologies covered by BMETTIC are wide-ranging, from metal processing to engineering development, from industry study and basic research to design and construction of equipment and machineries and then up to commercialization of the technology. Applied research and development work constitutes the major activities of the Center. BMETTIC can provide technical and information services for industries in collaboration with universities, with its in-house R&D capabilities and in collaboration with partners in various universities, R&D institutes and industry. BMETTIC can also provide technical and information services by its in house capability.

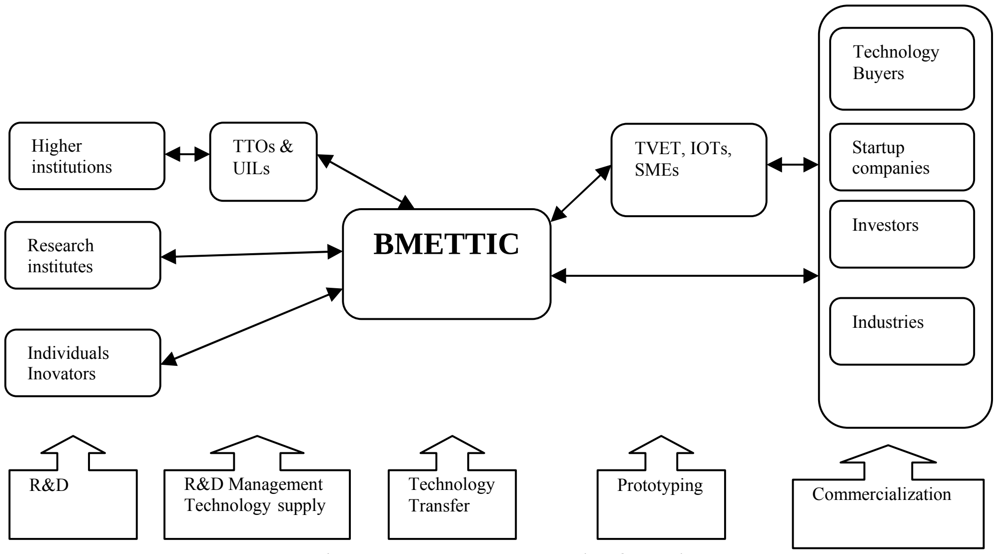

Figure 6.2 ETTIC main functions

In general, the main objective of the BMETTIC is to develop, transfer, adapt and apply technology; improve the terms of technology transfer, and identify and promote the development and transfer of technologies relevant to the different regions of the country, specifically in areas of BMEIs.

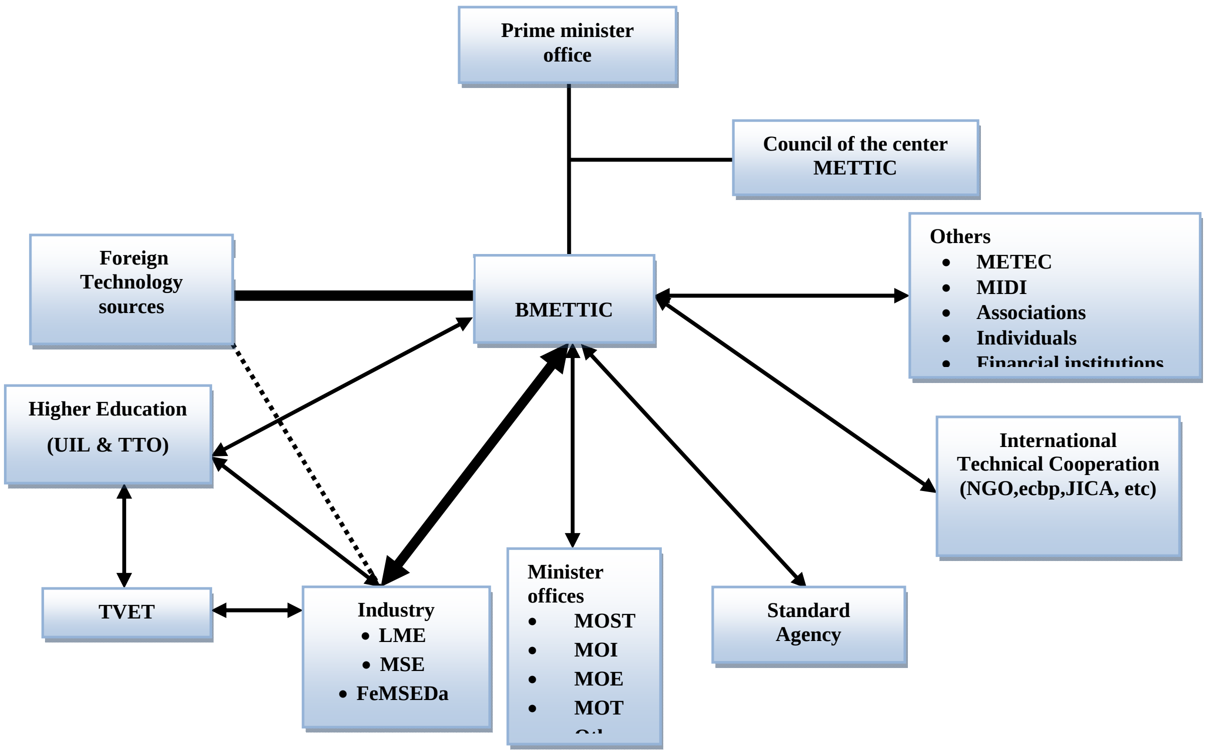

Figure 6.3 Frame work of BMETTIC

BMETTIC works with Government Agencies, Ministry of Trade, ministry of Industry, Ministry of Education, higher education academic and research institutions, Ethiopian professional Associations, Chambers of Commerce, Universities, and Industry Associations so as to develop technology roadmaps in priority areas as shown in figure 6.4. It also helps industries to avoid from buying outdated, inappropriate technologies, and to ensure non-obsolescence of technology while the technology transfer is in progress.

The primary goals and tasks of BMETTIC are:

- Identify and prioritize national technological demands, and focus on generation, imitation and adaptation of existing technologies;
- Facilitate transfer of technology developed from university, research institutions, and individuals to appropriate stakeholders;
- Helps in prototype development, building incubation units, and initiating Techno parks;
- Assist in the growth of companies, including from startups up to supporting in the technology transfer and commercialization leadership;
- Facilitate technology transfer activities through meetings, conferences and workshops;
- Provide advice and assistance to industry, university, research institutes and individuals on strategies for technology transfer including, but not limited to, advice and assist in the following areas:
    - Assessing the viability and value of developing technologies;
    - Defining and exploiting potential markets for such technologies;
    - Developing commercialization strategies;
    - Assessing intellectual property issues, including licensing strategies;
    - Helping in business development; and
    - Giving technical support during purchasing of technology and running of high technology machineries and equipment.
- Develop a list of technology suppliers in different areas of technology and helping industries to access the supplier's databases so that the problems of pricing and imperfect technology suppliers can be minimized; and

- Ensure the establishment of a national technology transfer network between university, research institutions and industry to exchange best practices and to disseminate new technologies.

Conducting R&D, consultancy, Training, coordinating University Technology Transfer (UTT), building technology databases and publishing reports on various technology commercialization topics are among the key roles that BMETTIC plays. Furthermore, BMETTIC also works with different ministries to frame policy directions and build infrastructure for technology commercialization.

BMETTIC requires a Board of Directors which is composed of government, higher education institutions and the industries that will be vested with responsibility for establishment of polices, strategy, and supervision activities. The Board shall be represented by the following (with additional members to be added as needed)

- Ministry of Education;
- Ministry of Industry;
- Ministry of Trade;
- Ministry of Science & Technology;
- Public Enterprises Supervising Agency;
- Public Higher Education Institutions;
- Private Higher Education Institutions;
- Ethiopian Chamber of Commerce;
- Addis Ababa Chamber of Commerce;
- Professional Association Joint Secretariat;
- Private Companies.

Under the guidance of the Board members, the Center's director serves as chief executive officer of the BMETTIC. He/She will be responsible for the planning, directing, supervising and controlling of all day-to-day activities of the centre.

To achieve the above primary goals, BMETTC comprised of five main units; and the role of each unit is explained.

- R& D Unit;
- University Technology Transfer (UTT) Unit;
- Technology Commercialization and Consultancy Unit;
- Information Technology Unit;
- Administration Unit.

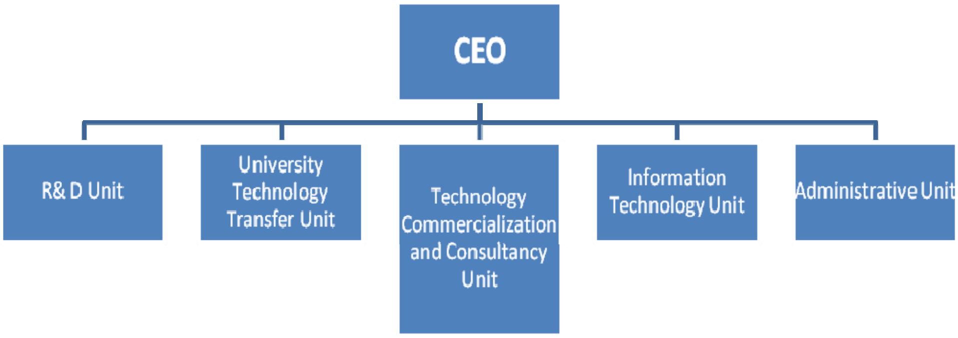

Figure 6.4 Organizational Structure of BMETTIC

i. R& D Unit

The main objective of the R&D unit would be to carry out research activities on need identification, reverse engineering, generation, imitation and adaptation of technologies as per identified and prioritized national technological demands that are relevant to the Ethiopian industries and societies.

R&D unit involves both in-house experts and outside specialists. Engineers from research institutes and industries, patent agents, venture capitalists, market analysts are the main outside specialists. It also participates with the research institute, university and individuals researchers, if further development and high commercial potential are needed.

ii. Technology Commercialization and Consultancy Unit

The successful technology development does not just mean successful completion of R&D, but also it is extended to the successful commercialization. This unit is responsible for commercialization of technology, conduct market feasibility studies on early-stage technologies, technical and economic analysis and business performance and technology evaluation.

It also reviews technology to sell, estimates the commercial viability of the market and indentifies trends and potential licensees or partners. Technology that passes the verification step is registered in a database, with detailed analysis information, such as the merits of the technology and its commercial validity, and thse will be attached to IT platform.

The unit also gives training, consulting service and also organizes relevant workshops and seminars on a regular basis and disseminates the outcomes using newspapers, newsletters, professional journals or any other appropriate means.

iii. University –Technology Transfer (UTT) Unit

Most technologies emerging from universities and research institutes are in need of further development or patent protection/modification, so as to be used in industries. Therefore, METTIC will encourage further commercialization of technological innovations of universities and R&D institutes.

Hence, UTT collects the research outcomes of universities, research institutes and makes them transferable into technical packages, ready for dissemination to the communities, industries and graduates as future entrepreneurs. It creates a system on how the developed technologies by IoTs are promoted and transferred to the interested and relevant stakeholders.

Moreover, the unit helps to ensure the establishment of a national technology transfer network between institutions to exchange best practices, disseminate new technologies and it also ensure the transfer of demand based technologies to industries and communities, focusing on adaptation and reverse engineering.

Technology Transfer Office (TTO) strengthens the regional technology transfer system. TTOs in universities and public research institutes are expected that they would function as a regional hub for technology transfer. BMETTIC then plays a central role in managing and connecting each regional centre to centralize the technology transfer activities in the nation.

iv. Information Technology (IT) Unit

The objective of this unit is to electronically network research conducted by METTIC, higher education institutions and industries. To this effect the established network by the center will disseminate information to the institutions and the public at large. This helps to reduce the duplication of efforts by different research entities, and all the stakeholders of the technology transfer will have timely and accurate information on research conducted and technology developed in Ethiopia. The web based information system institutionalizes a standard system on the collection and summarization of research output in a structured manner, and forwards it through TTOs to different regional technology institutes.

v. Administrative Unit

The objective of this unit is administration of human resource, financial and others common administrative task of BMETTIC.

Therefore, based on the above disscusions, the researcher has developed a technology transfer model which is specific to the basic metal and engineering industry. In general, the model shows the role and integration of higher institutes, government bodies, the industry, international technological institutes, and financial institutes and other stakeholders.

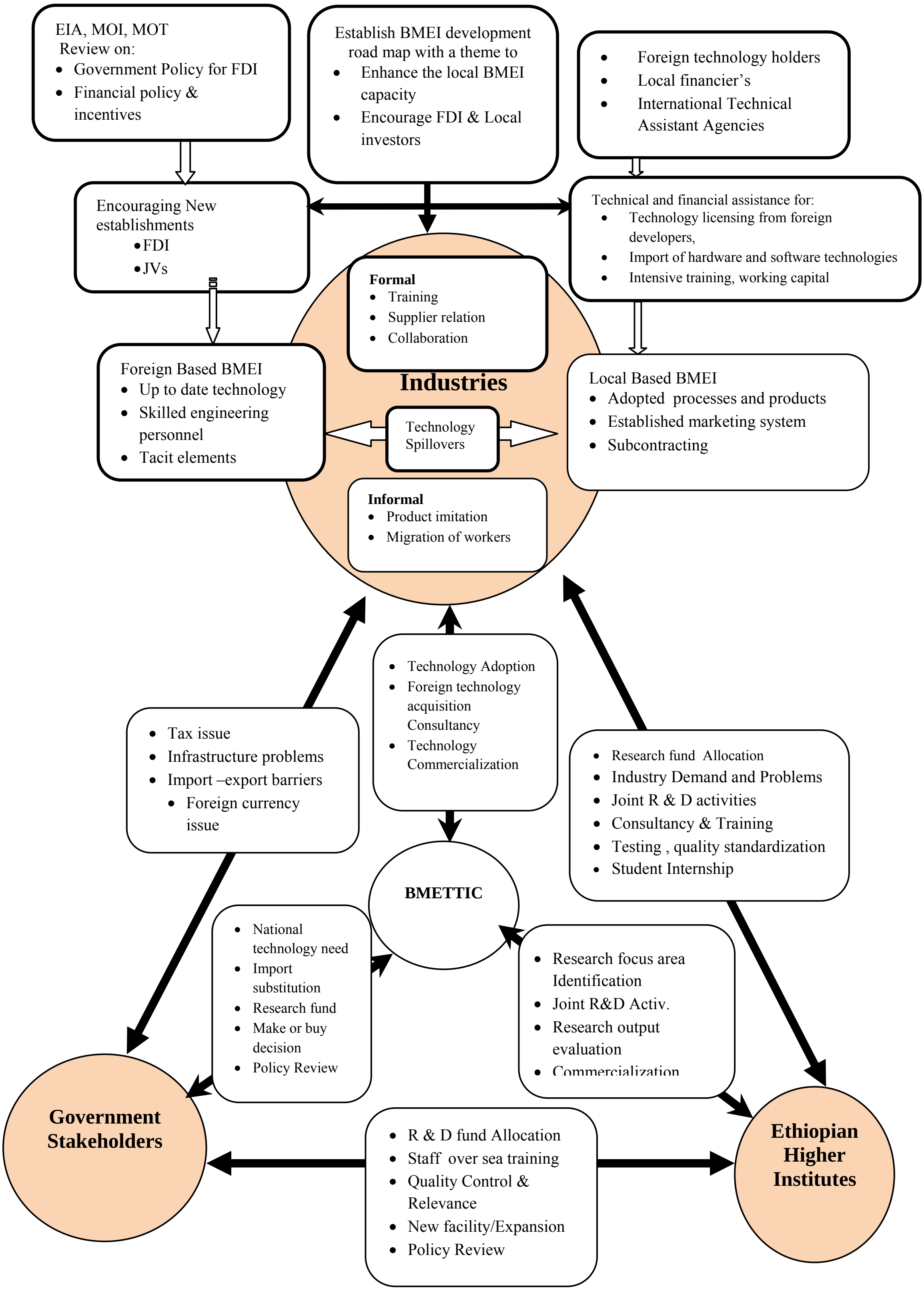

Figure 6.5 Model of BMEIs Technology Transfer in Ethiopia

Since, most of the technology supportive institutes of other sectors are not well coordinated and controlled in Ethiopia, there is a duplication of efforts and resources. Hence, the BMETTIC will develop further to country level technology transfer center to coordinate different technology supportive institutes to the others sectors. The main objective of establishing Ethiopia Technology Transfer and Innovation Center (ETTIC) is to develop, transfer, adapt and apply technology; improve technology transfer; and identify and promote the development and transfer of technologies relevant to different sectors. ETTIC works with Government Agencies, Ministries, higher education, research institutions, Ethiopian professional Associations, Chambers of Commerce, and Industry Associations to develop technology roadmaps in priority areas. It also helps industries to avoid from buying outdated, inappropriate technology, and ensure non-obsolescence of technology in technology transfer.

It is recommended that the inclusion of legal ownership under a common umbrella organization as shown in figure 6.6. This entity shall:

- Simplify the governing task of uncoordinated efforts of technology transfer within Ethiopia;
- Address cross sectional aspects and tasks such as website maintenance, legal and IPR service and others common administrative tasks, etc.

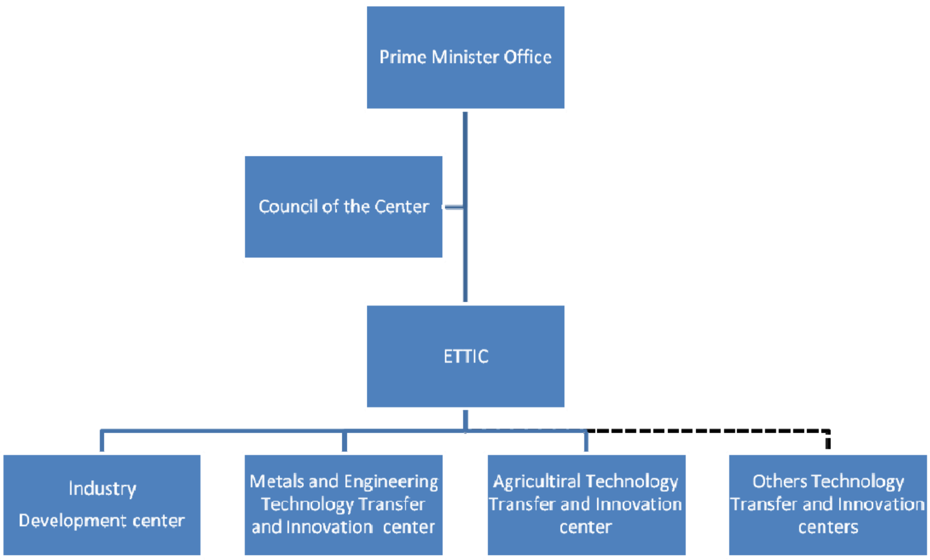

Figure 6.6 proposed frame of ETTIC

- **Industry Development Center**

In Ethiopia, there are many research centers, development institutes established for development and competitiveness of different sectors, by providing support from the feasibility study and investment set up and to its application. Some of the development institutes are: Leather Industry Developments Institute (LIDI), Textile Industry Development Institute (TIDI), Ethiopian Development and Research Institute (EDRI), Metal Industry Development Institute (MIDI), Pan-Africa competitive forum, quality and productivity movement, Kaizen institutes, etc. These different sectorial development institutes should be controlled, coordinated and organized under the umbrella of Industry Development Center.

- **Agricultural Technology Transfer and Innovation Center (ATTIC).**

The Agricultural Technology Transfer and Innovation Center should also be organized aim at transferring, developing and spreading the latest agricultural technologies to various regions of Ethiopia. It also evaluates, controls, coordinates, facilitates and organizes different agricultural technologies in collaboration with stakeholders of the agricultural sector like ministries, research institutes, higher educations, industries, associations, individuals, etc.

If there are others technology transfer and innovation centers that need to be established in Ethiopia, they will be organized under the umbrella of ETTIC.

6.9. Establish Technology Incubation Center

As part of globalization, new technologies are emerging from every corner of the world, and international competition is also hitting its peak period. As a result, countries are moving further into knowledge-based economic development, of which technological development is a key factor for international competitive advantage both in the metal and other sectors. In addition, building the local knowledge and technological capabilities are also becoming increasingly decisive in order to effectively respond to the existing and newly emerging challenges and opportunities. Hence, strengthening and promoting incubation centers, as a channel of technology transfer will accelerate technological innovation, economic growth, employment and social equity, and links R& D centers to the industry.

Incubation centers are essential element in the process of technology transfer from research facilities to the industries. However, except the Mekelle Information Communication Technology Business Incubation Center (MIBIC) and the ongoing effort to establish an ICT park in Addis Ababa, the trends of establishing technology incubation centers are not common practice in Ethiopia. Knowing the significant benefits of these technology accelerators, the establishment of such centers will not be a disputable act. Therefore, Addis Ababa University (AAU) has to be at the fore front towards establishing Technology Incubation Center (TIC). The design and drawing of Technology Business Incubation (TBI) center is attached at annex II and III.

Chapter Seven

Conclusions and Recommendations

7.1. Conclusions

Technology which is important to domestic economic development has been widely recognized, and has become the main strategy for competition across nations. It is essential for transformation and modernization of the country. Over the past century, the wealthiest nations were those that had developed cutting edge technological capabilities that allow them to become global technological leaders. Therefore, with the rise of knowledge-based economies and the fast pace of technological development worldwide, there is a growing trend to develop high-end technologies.

There are basically two schools of taught with regards to the technological gap between developing and developed countries. The first one claims that, the gap is very large and yet it is growing over the year. On the other hand, whatever large the gap may be, with recent technological advancements, the bases are being built up for narrowing it rapidly. Hence, it has been agreed with the second school of thought. Therefore, based on the research findings, the task of the Ethiopian government should be to building up national technological capacity through technology transfer. This will help to get the maximum advantage from all available technologies, and to embody them in the production machineries and equipment and in the labor force for an accelerated rise in productivity.

Moreover, to narrow the technological gaps of developing country like Ethiopia, focus needs to be placed on building technological infrastructure. A country's technological infrastructure encompasses the education system, network of research organizations, legal framework that protects intellectual property rights and providing incentive schemes to create and exchange technologies. In addition to the technological infrastructure development, a well-structured technology policy that can stimulate innovation and encourages entrepreneurship is critical component for growth strategy.

Technology transfer has been given considerable importance in Newly Industrialized Countries such as South Korea, China, Malaysia, Singapore, Brazil and South Africa. It has transformed their economies by improving the technological sophistication of their industries with well organized technology policies. Hence, their advanced technological capabilities enable them to compete globally with advanced industrialized countries in a number of sectors. Moreover, their governments had decisive roles in driving technological progress and shaping the process of technology transfer and assimilation. The NICs governments have also stepped up their efforts to build technological infrastructure in order to foster a conducive environment for innovation and technology transfer activities.

As the Ethiopian economy is largely dominated by agriculture, achieving and sustaining broad based economic growth requires improving the performance of the sector. However, due to weak technological capability and lack of innovation, there is very slow rate of growth in agricultural productivity. Therefore, there is a need to initiate a sustainable process of technological capability development and transfer that could bring dramatic improvements in the performance of different economic sectors.

In most Ethiopian industries mainly BMEIs, the challenges related technology seriously affect the product development, profile versatility, product quality both in terms of geometrical fitness and required properties, which in turn has negative effects on the service condition of the products. Moreover, industries have been engaged in low value adding activities and their technological processes are also stagnant. Hence, there is less opportunity to develop new products and technologies that would serve as capital income generators of the industries in particular and the nation as a whole.

As the research shows, besides the above mentioned challenges, the industries are also suffering due to: low productivity caused by old technologies and inadequate attention given to their improvement and development; inadequate support and facilities for research and development activities ; lack of fully assimilating or internalizing the technologies and hence unable to use them at best practice level of technical efficiency; limited diffusion of knowledge within the country; lack of coordination, implementation, evaluation and control mechanism of technology transfer across the stakeholders. Ingenral, BMEIs have found tied up with a series of problems ranging from government policy to industry inherted problems. As a result the country has largely missed both economical and technological advantage associated with the sector.

As a conclusion, technological capability could only be acquired through unlimited effort on R&D, human resource development, stakeholders' collaboration and forming technology initiative centers. If properly implemented, transfer of technology represents a leap-frog opportunity for Ethiopia, and would also promote a wider distribution of wealth and help redress the peace and stability of the nation. Above all, Ethiopia would serve as hub and technology bank for others Africa countries.

7.2. Recommendations

The efforts made by government organizations, development partners and international agencies towards technological capacity building are undoubtedly remarkable and have tried to address the problems to a certain extent. However, their attempts lack technology transfer focus, coordination, evaluation and controlling mechanisms resulting in not using the existing industries effectively and efficiently.

Therefore, the Ethiopia government should develop national technology transfer policies and implementation strategies that are consistent with national development needs and resources, by considering all the stakeholders. Ethiopian government should also introduce a policy which fosters FDI and joint ventures in the metal sectors. This would bring outmost solutions to bring technological capability. In doing that, the government should give due attention for BMEIs industrial growth, mainly for industries strong potential and for the country technological capability. This could be achieved by developing feasible industrial policy and financial incentives of BMEIs. Since BMEIs are capital intensive, the government has to establish high tech or capital intensive metal industries, as a joint venture or as a partner , like what has been done for development of sugar and cement industries.

As the effects of globalization are inevitable, the government need to develop policies and controlling mechanisms that protect the economy against harmful importation of products and encourage use of goods produced domestically to substitute imports.

Encouraging and facilitating linkages and cooperation schemes between firms and supporting institutions at regional and international levels are the main instrument to promote technology transfer in Ethiopia. Hence, there is a need to establish institutions that bridge the gap of linkage, integration, coordination and implementation of all technology transfer stakeholders of the country. Thus, the researcher strongly recommends the stakeholders of BMEIs have to work strongly towards establishing metal and engineering technology transfer center. This will help as coordinating and controlling units, reporting to the highest level of government authority.

Indigenous knowledge's are sources of technology. Therefore, Ethiopia government should facilitate schemes to identify and document available indigenous knowledge and technologies. For improvement of indigenous technologies, government should provide the facilities required for conducting further research and to commercialize the technologies. Hence it will support the national economy in the process of technology transfer.

Technology transfer is an extremely complex process and having a number of uncertainties. As a result, the process could slip in different directions and most often negatively, which could be viewed from different angles. Hence, the presence of technical mechanisms, to assess the progress of a technology transfer process, enables the transferors to scrutinize what is going right and wrong. In general, the presence of such mechanisms will enable companies and organization to fit themselves in future technology transfer processes. Therefore, evaluating and controlling mechanism are essential elements in determining the nature and extent of the technology to be transferred in Ethiopia. Hence, there has to be follow-up, evaluating and controlling mechanisms of stakeholders such as: research, technology, technical cooperative, development institutes etc, with respect to level and contribution towards creating technological capability.

In summary, the researcher strongly recommends for the address of the following issues.

- The government should place great incentive schemes to attract foreign investors in the area of BMEIs, as the technology spillover is usually much higher in comparison with the direct benefits the other industries could bring in.
- Industry protection should be inplace to give a breathing space for underdeveloped metal sectors in Ethiopia till they build technological capability to compete at international level.
- The content and quality of the Ethiopian education in technology institutions should be structured and emphasized on the high level practical oriented science and technology education and training.
- The BMEI should strengthen its technological capability via an effective technology transfer system so as to shift towards a more technically feasible and value added products.

- All the stakeholders should come up together and work harmonsily with objective to use BMEI as engine of industralization. Inaddtion, they are highly advised to establish technology initiative centers that coordinate and facilitate technology transfer.

Finally, the researcher strongly recommended the government should conduct and make available feasibility study in different manufacturing sector. In such way that, it is possible to use the foreign capitalist and domestic capitalists as the engine or his domestic counter part as the sole engine. After compliting feasibility study, identify and communicate those with some interest to invest in Ethiopia and discussing with them what their requirements would be to establish their enterprises, we have to fulfill their demand and convince them to invest. Parallel to this, it has to establish a working system where foreign investors would collaborate and assist domestic establishments in worldwide marketing networks, advanced technology and modern management, improving the quality and productivity of the industry.

7.3. Future Research Areas

The researcher recommended the following research areas:

- The degree of technology transfer through government funded projects
- Impact of government policy on technology transfer
- Evaluation and measurement mechanism for technology transfer

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ANNEXES

Annex I

Table A-1 Product development and technology commercialization framework

	TECHNICAL	MARKET	BUSINESS
CONCEPT PHASE			
Stage 1 Investigation	**TECHNICAL ANALYSIS** **STEP 1** **Activities** Define concept Confirm critical assumptions Survey state of the art Id critical barriers Evaluate applicability Determine technology **DELIVERABLES** Provisional patent, patent, copyright, patent scan, license agreement	**MARKET NEEDS ASSESSMENT** **STEP 2** **Activities** Conduct market overview Id pricing structure Id market barriers Id risks Id distribution channels Id trends and competitors ***DELIVERABLES*** Background research materials	**VENTURE ASSESSMENT** **STEP 3** **Activities** Estimate profit potential Conduct self, enterprise and commercialization assessments Id professional needs Id capital needs ***DELIVERABLES*** Preliminary cost and revenue estimate
DEVELOPMENT PHASE			
Stage 2 Feasibility	**TECHNICAL FEASIBILITY** **STEP 4** **Activities** Develop working model Test technical features Assess preliminary producibility Conduct manufacturing assessment Assess safety & environmental features Finalize designs **DELIVERABLES** *A working model of the product*	**MARKET STUDY** **STEP 5** **Activities** • Id and quantify: • Market size • Customers • Volume • Prices • Distribution • Competitors ***DELIVERABLES*** Primary market research	**ECONOMIC FEASIBILITY** **STEP 6** **Activities** • Formulate financial assumptions • Develop pro forma • Id seed capital • Form advisory team ***DELIVERABLES*** A financial model accurately representing the business opportunity

Stage 3 Development	**ENGINEERING PROTOTYPE** **STEP 7** **Activities** • Develop prototype • Id materials and processes • Conduct tests • Develop manufacturing methods **DELIVERABLES** An accurate prototype representing the materials and functionality of the end product	**STRATEGIC MARKET PLAN** **STEP 8** **Activities** • Id marketing team • Define target market • Select market channels • Field test ***DELIVERABLES*** The final marketing plan based upon discussions with suppliers, market representatives, and customers	**STRATEGIC BUSINESS PLAN** **STEP 9** **Activities** • Decide venture or license • Finalize intellectual property • Id management team • Select organization structure • Write business plan ***DELIVERABLES*** The business plan
Stage 4 Introduction	**PRE-PRODUCTION PROTOTYPE** **STEP 10** **Activities** • Develop production prototype • Determine production process • Select manufacturing equipment • Design field support system • Demo product features **DELIVERABLES** A limited production	**MARKET VALIDATION** **STEP 11** **Activities** • Establish market relationships • Conduct limited sales • Analyze sales • Survey customers • Refine marketing plan ***DELIVERABLES*** Sales	**BUSINESS START-UP** **STEP 12** **Activities** • Establish business function • Hire staff • Execute contracts • Secure first-stage financing ***DELIVERABLES*** An Enterprise
COMMERCIAL PHASE			
Stage 5 Growth	**PRODUCTION** **STEP 13** **Activities** • Prepare commercial design • Establish quality control • Construct facilities • Conduct full production • Finalize internal distribution system **DELIVERABLES** Production	**SALES AND DISTRIBUTION** **STEP 14** **Activities** • Expand distribution • Analyze competitor response • Assess customer satisfaction • Assess distributor satisfaction • Refine product features ***DELIVERABLES*** Growing sales	**BUSINESS GROWTH** **STEP 15** **Activities** • Monitor enterprise position • Hire and train personnel • Execute contracts • Arrange financing • Institute vision, mission and management policies ***DELIVERABLES*** Increasing revenues

Stage 6 Maturity	**PRODUCTION SUPPORT STEP 16** **Activities** • Maximize production • Establish after market support, repairs and spares • Warrantee service • Implement training program **DELIVERABLES** Maximum production	**MARKET DIVERSIFICATION STEP 17** **Activities** • Develop market retention • Establish market scan • Id new markets • Id new products ***DELIVERABLES*** New products	**BUSINESS MATURITY STEP 18** **Activities** • Establish SWOT process • Invest profits • Monitor product life cycle • Monitor business trends • Monitor mgmt. technologies • Implement innovations ***DELIVERABLES*** Profits

Note: Id=Identify

Annex II

Design of TBI for metal and engineering sector

2.1General Description of the Center

The primary mission of the proposed incubator is to contribute to the growth and success of emerging technology businesses in metal and engineering sector. In line with this, the center will bring a number of direct and indirect benefits to the sector, community and the country at large. The proposed incubator includes facility space, business development assistance, networking to financial and other resources. From the benchmarked countries the following general parameters are adopted for the proposed TBI establishment.

Table A-2 Adopted parameters for the proposed establishment

Parameters	Description	Reason
Objective	To assist the growth and success of technology or innovation based enterprises in metal and engineering sector	The sector has a considerable economic impact and should be assisted with enabler of technology transfer in order to bring technological development.
Nature	Not-for-profit	Incubation industries are new to Ethiopia, and the idea for profit is not analysed yet.
Governance	Board of directors who are representative of stakeholders governs the center	The participation of stakeholders in governance of the center brings sustainability.
Sponsor for establishment	Government and governmental institutions	Since the concept is new; the participation of private sector in the TBI establishment may not be practical
Duration of tenants	A maximum of three years	From the experience of bench marked countries of manufacturing focused incubators has taken 3 years.
Number of tenants	Twelve	By considering the initial development stage of TBI in Ethiopia and the experience of bench marked countries.
Services offered to tenants	Common workshop, individual offices, common facilities, business development services, networking services.	Considering the basic metal and engineering sector along with the experience of benchmarked countries
Selection criteria	Innovation based	Emanates from the objectives of the established center
Graduation criteria	Full fill the exit criterion of the center	Meeting the milestones
External client service	Business development services, consultancy, training,	To support the Ethiopian basic metal and engineering industries.

The above parameters serve as the general guidelines for the establishment of the TBI center; moreover, the detailed design parameters are elaborated in the subsequent sections.

2.2 Location Area for the Center

The general criteria for selecting location of the newly established TBI would be considered based on proposed use, location relative to the market served, costs of acquisition (rehabilitation), availability of space, lease flexibility, access to the stakeholders etc. In terms of location, there are a number of potential places/regions that satisfy the above criteria for the development of TBI. However, due to its location in the central part and availability of all required parameters (infrastructure); Addis Ababa is selected. Some of the reasons are 47.49, % of basic metal and engineering industries are concentrated in Addis Ababa, there are diversified economy like commerce, manufacturing, finance, real estate and insurance than others regions; The city has also numerous private colleges in addition to government's universities and institutions; all the roads interconnecting to regional governments are passing through it; it has Bole international airport and had had a railway connection with Djibouti city. Generally, Addis Ababa is considered to excel all potential towns in the country in terms of communication infrastructure, proximity of knowledge source, business and finance service, availability of entrepreneurs and environment that stimulate creativity.

Additionally, the selection of specific site for technology incubator rests on a number of parameters. Because of its nature and mission, the proposed TBI should be near to technical universities. From this perspective there are two basic site options for the proposed TBI in Addis Ababa sub cities. Either it should be near to Addis Ababa technology institute in Arada sub-city or Addis Ababa Science and Technology University in Akaki Kality sub-city. However the latter option is better for a number of reasons such as adequate land to accommodate an incubator facility of the recommended size, possibilities for future expansion, land cost, availability of a large number of industries in the region. Hence Akaki Kality sub-city is the proposed site and the land is in close proximity to Addis Ababa Science and Technology University.

2.3Services Offered in the Center

2.3.1 Physical Infrastructure

While considering design parameters of TBI, it is widely agreed that there is no standard or one size fits to all incubators. Therefore, the subsequent design parameters are adopted from the feasibility study conducted for incubators and manuals in the bench marked countries.

2.3.2 Foundry and Mechanical Workshops

Since every innovators/ entrepreneurs are coming to the TBI center with their own unique idea, the series of processes required for their innovative products could be quite different. Therefore, the proposed medium sized workshops are designed to include all facilities that are required for performing basic metal and engineering manufacturing processes. The manufacturing of basic metal and engineering passes through different processes such as; casting and foundry, forming and shaping, machining, joining, and finishing processes. Therefore, the proposed TBI includes basic machineries, equipments and tools are considered to perform the above processes.

- **Casting and Foundry Processes and Equipments:** Foundry operation consists of mainly melting, molding, sand preparation and conditioning, core making, pouring, cooling, surface cleaning, fettling, heat treatment, inspection and casting repair. Sand casting is selected for the process, because it is an inexpensive method for making a small, medium and large number of parts ranging from ferrous and nonferrous alloys. Considering the scale of the proposed TBI; sand casting equipments which are relevant with the objective of the center are proposed. The equipments and materials proposed for the center to perform the processes are melting furnaces, sand core shooting, sand mixer (muller), molding machine and hand tools such as hand riddle, shovel, draw spike, lifters, slicks, smoothers and etc.
- **Forming and Shaping Processes and Equipments:** A multitude of operations are classified as bulk forming processes, of which rolling, forging, and extrusion are the most important. On the other hand sheet-metal operations include shearing, bending, stretch forming, spinning, and explosive forming are included under this process.

Though there are a number of equipments available for this process, shearing and bending (rolling) machines are proposed.

- **Machining processes and Equipments:** Machining processes also called material removal processes use a sharp tool to remove material from the work piece in the form of chips. For the purpose of performing machining operations, saws, lathes, milling machine, drilling machines and grinding machines are included.
- **Joining Processes and Equipments:** Joining processes include mechanical fastening, adhesive bonding, and welding processes. For the purpose of such operation arc welding equipments and riveting machine are incorporated.
- **Finishing Processes and Equipments:** There are a number of finishes that can be applied to metal products. In most cases, the finishes will help protect the product from corrosion**.** Finishing processes include polishing, sand blasting, cladding and electroplating, and coating and painting. Compressor with spray gun is the machine proposed for the finishing process.
- **Metrology equipments**: These are equipments that are used for measurement tasks. Scales, vernier scales, micrometer scales, dial indicators, calipers and transfer gauges are included. Moreover metal layout equipments like scribers, dividers, trammel, hermaphrodite caliper, surface gauge and surface plate are considered.
- **Miscellaneous equipments**: Apart from the above equipments, simple material handling equipment (hand trucks or trolleys) , some safety materials such sh: welding aprons, gloves, face shields, respirators, fire extinguishers, comprehensive first aid equipment, and simple electrical testing equipments are included.

The aforementioned machines and tools are general purpose equipments; however, the tenant might need special equipment and testing apparatus that are not available in the incubation center. In this case the manger of the center can facilitate the access of such equipments and apparatus through networking with universities or other organizations.

The raw materials used in the center are mainly sheet metals and various sizes of metal rods. It is assumed that there is no need for larger storage area, as space allocated for tenants are adequate to accommodate their own raw materials. Therefore, a small common storage area is designed with in the workshop. By considering the number of machines and equipments included, the size of tenants and experience of benchmarked countries, the following area requirement is proposed for the design of foundry and mechanical workshop facilities.

Table A-3 Space requirement for common workshop area

Facility	Area requirement
Workshop area	$460m^2$
Storage	$50\ m^2$
Total area	**$510m^2$**

As traditional mechanical workshop facility design practices, a high ceiling clearance of 4.5 m and long clear span distances of 10 m with high bay lighting fixtures are considered. The machines are laid with a minimum aisle distance of 1.5m between two machines. Moreover, an office of size $9m^2$ for technical assistants is recommended. The facility is equipped with basic utilities such as electric power, water and fire emergency equipments.

2.3.3 Individual Tenant Rooms

Offices that are offered for tenants can vary depending on specific factors. The space requirements for tenants of manufacturing sectors are larger than any others sector specific incubation centers. Based on the stage of development, tenants are classified into early stage, mid level stage and near graduation stage. The resource capacities of near graduation tenant companies are higher than the new entrants. As a result near graduation stage companies require larger area than others; similarly the mid level stage tenants require larger area than early stage companies. Such allocation of space allows tenants to move within the building and provides flexibility to accommodate tenants as they grow. By taking the size, sector and stage of development of the tenant being targeted, the following office configuration is proposed.

Table A-4 Office area requirements and configurations for tenants

Type of Tenant	Number of Units	Size of Units	Total size
Early stage	6 (50%)	$50\ m^2$	$300\ m^2$
Mid level stage	4 (30%)	$90\ m^2$	$360\ m^2$
Near graduation stage	2 (20%)	$120\ m^2$	$240\ m^2$
Total Space			$900\ m^2$

Additionally, a separate toilet with an area of $6m^2$ and two shower rooms with an area of $10.5m^2$ are designed for tenants. The flexibility of each tenant's office sizes is possible by creating moveable office partitioning. Each individual office units is designed to have roll-up doors that are 2m wide. Moreover they have equipped with office furniture. However it is the right of tenant companies to change their interior office space based on their needs and requirements.

2.3.4 Offices and Common Facilities

Administrative and support functions included in the center are mainly adopted from the bench marked countries. However, based on the context of Ethiopia additional secretary rooms, security rooms and first aid room are included. The design parameters for facilities are based on the anticipated organization structure, administrative function, and expected number of persons. In addition to these factors the general practices of incubation centers' office configuration are incorporated. The following table shows the designed office and common facilities space requirements.

Table A-5 Area requirement for offices and common facilities

Offices and common facilities	Proposed Area	Description
Offices		
General manager office	$17m^2$	Adequately sized to accommodate private meeting with 7 people.
Executive secretary	$12m^2$	Can accommodate up to 4 guests
Administrative assistants office	$12m^2$	Can accommodate private meeting with 5 persons
Technology advisor office	$12m^2$	Can accommodate private meeting with 5 persons
Reception	$14m^2$	To provide information to guests
Common Secretary office	$9\ m^2$	
General service officer	$9\ m^2$	Private office with 2 guest seats
IT officer	$9\ m^2$	Private office with 2 guest seats
Common facilities		
Secretarial service room	$12\ m^2$	To provide clients with secretarial services
Conference hall	$80m^2$	Can handle 50 individuals
Training hall	$50m^2$	Can handle 20 individuals

Computer lab	24 m^2	Can handle 10 individuals at a time
First aid room	13 m^2	
Resource Center	40 m^2	Provides tenants with information and resources
Material store	11 m^2	To store materials such as stationery, sanitary
Cafeteria	60m^2	Provides seating for more than 25 customers
Janitorial	4m^2	
Toilets	10 m^2	For management staffs alone
Lobby area	15 m^2	
Total Area	**433m^2**	

Moreover, 1.8m networking spaces (corridor), in which people have to pass, is proposed. The totals built up area for the center are summarized in the following table.

Table A-6 The total built up area of the center

Facility	**Land allocation in m^2**
Offices and common facilities	590
Foundry and mechanical workshop	510
Tenant offices with common toilets and showers	920.8
Total built up area	2020.8

Additional Facilities

- **Car parking:** A parking area which accommodates 20 cars at a time is proposed. It is assumed that most vehicles that come to the facility are external clients' (guests) and tenants' cars. Therefore based on parking standards, 2.4m x 4.8m, parking space for each car is proposed. Though it might not be frequent, heavy trucks can come to the center to load and unload raw materials, products, machines and etc. For this purpose 3.06m x 6.12m parking area is considered.
- **Road:** Assuming the frequent types of cars coming into the center are small, a road of 5 m wide is designed.
- **Security room:** security or guard room is designed at the gate which has an area of 6m^2.
- **Green area:** an area of 100 m^2 is allocated for green area.
- **Expansion region:** an area 17 % of the total which is 660 m^2 for future expansion is anticipated.

- **Electrical system:** A 3-phase electrical supply is connected to the center. The foundry and mechanical workshop uses different electrical meters from the administrative and common office areas.
- **Telephone and Internet:** Each administrative office unit has a fixed line telephone and broadband internet connection. Moreover each office unit is networked with each other.

Generally the total land requirement for the proposed facility is 4565 m^2, of which 2020.8 m^2 is a built-up area. The remaining land is used for pass way, green area, parking and future expansion.

2.3.5 Business Development Services

Business development services (BDS) include the types of expertise required by businesses in order to be successful. BDS are offered to both the tenants and external customers. Through such services, the center is able to provide an integrated coaching and training program for small and micro enterprise at very affordable prices. Apart from this, BDS enable the facility to be financially independent by generating incomes. A number of business development services are provided based on the need and requirements of the clients. However the major services included in the center are:

- **Business planning and skills development**: In order to help both internal and external clients and overcome their common barriers to start-up, survival and growth, the center provide a range of business planning advice, support and basic business skills training. These include; Preparation of business plans, financial documentation, marketing research, feasibility studies for business development, management skills training and etc.
- **Consulting Services:** The center provides consultants to the established or yet to be established organizations on a fee basis.
- **Educational programs:** Based on recommendation from the general manager, an education program that is relevant with the client companies is provided on regular basis. Such services include: courses on production process, new manufacturing technology, quality, maintenance engineering and etc.

- **Seminars:** Seminars emphasizing topics of special interest to emerging technology businesses are provided on a regular basis. The general manager identifies topics based on an understanding of incubator client needs and invite guest speakers with expertise in the topic area.

- **Resource Library:** The center builds and maintains up to date information resources for technology startups including: resource directories, business form templates, and checklists.

2.3.6 Networking Services

Networking services are the major responsibility of the general manger and mainly delivered to the tenant companies. Since they are new and their business knowledge is low, entrepreneurs are unable to connect themselves to the financial and business network easily. Therefore, in order to overcome such barriers of startup companies, the TBI center provides the following services to its tenant companies.

- **Financial network:** The incubator establishes and maintains relationships with a network of banks, creditors, associations and investors to acquire seed and venture capital for tenant companies. The incubator provides introductions between incubator clients and appropriate investment resources. Such networking can be made with Commercial Bank of Ethiopia, Development Bank of Ethiopia, Construction and Business Bank of Ethiopia, Addis Ababa credit Associations, private and cooperative banks.
- **Professional network:** The incubator develops a high-quality professionals, technologists and business owners that have the technical and business skills needed to support client businesses. It screens such professionals and facilitates the interaction between them and the client. Addis Ababa is a home of many international and national organizations. Moreover a number of professionals and scholars are dwelling in the city. As a result it is possible to identify and network them with the center.
- **Educational institutions network:** Educational institutions provide a talented, affordable work pool to support incubator and incubator client projects. Moreover they provide library, technology and research resources for start up companies. Apart from Addis Ababa University and Addis Ababa Science and Technology University; many

private colleges, training institutions, technical and vocational institutions are available in the city.

- **Networks of suppliers, customers, investors:** the center facilitates interaction between its clients and key industry participants including raw material, accessory and machinery suppliers, potential users and buyers of technology products and investors who are willing to invest as business partner. Most of metal and engineering companies, technology product suppliers and big investors are in and around the city. Hence the task of networking the center with suppliers, customers and investors can be smooth.

The aforementioned networking services alone might not be adequate; governmental organizations, technology institutions, policy makers can also be contacted and networked with the center. Generally it's the responsibility of the general manger to identify individuals, organizations and institutions with which networking are important.

2.4 Facility (Layout) Design

While designing the layout of the proposed center, it is tried to use the space efficiently. The minimum distance between parking and building as well as between road and building is considered. The parking is designed in a way to accommodate large number of cars with available space. Each building side is accessible, except for workshop building which is aligned with the fence in order to save construction cost. Green area and future expansion region also placed based on their intended purposes. The cafeteria and product display facilities are easily accessible by external visitors. Generally the layout of all facilities is depicted in Annex IV.

2.5 Governance of the TBI Center

Apart from making policy document and monitoring the progress, in this model of TBI, the task of establishing and funding the center lays on the government and its institutions. The TBI center is sponsored by government and it serve as a non-profit entity. The non-profit establishment enables the tenants to acquire the supports at minimum charge. The following institutions are identified as the potential stakeholders of the center. The institutions, which are regarded as the owners, provide the required support during and after the establishment.

1. Addis Ababa Institute of Technology
2. Addis Ababa Science and Technology University
3. Ministry of Science and Technology
4. Addis Ababa city Government
5. Ministry of Education
6. Addis Ababa Credit and Saving Institution
7. Development Bank of Ethiopia
8. Ministry of industry
9. Ethiopian Association of Basic Metal and Engineering
10. Metal Industry Development Institute

The reasons behind the selection of the above institutions as stakeholders are mainly related to their importance and direct relation with TBI establishment. Addis Ababa Science and Technology University, Addis Ababa Technology Institute, Ministry of Education and Ministry of Science and Technology provide coaching, training, technology related materials, research and innovation documents to the center. Addis Ababa Credit and Saving Institution and Development Bank of Ethiopia serve as the financial sources, both for the center and its clients. Ministry of industry provides the required support for graduated companies in order to sustain them in business. The established TBI center is located in Addis Ababa; hence Addis Ababa city government plays an indispensable role by providing the necessary infrastructures such as land, water and electricity. The established TBI model is sector specific; as a result the involvement of MIDI, Ethiopian Association of Basic Metal and Engineering assist the incubated companies by creating links and integration with the big and already established metal and engineering firms.

Through their restless effort, the board of directors and the general manager can attract a number of stakeholders. Other institutions, private organizations, donors, NGOs and governments could be stakeholders. Increasing the number of stakeholders broaden the quality and the quantity of supports that the facility can receive.

Organizational Structure

The TBI center is run as an autonomous business entity and report to the board of directors. The following organizational structure is customized in order to administer the activity of the center. The structure enables to implement the incubator program with a minimum of administrative and bureaucratic effort.

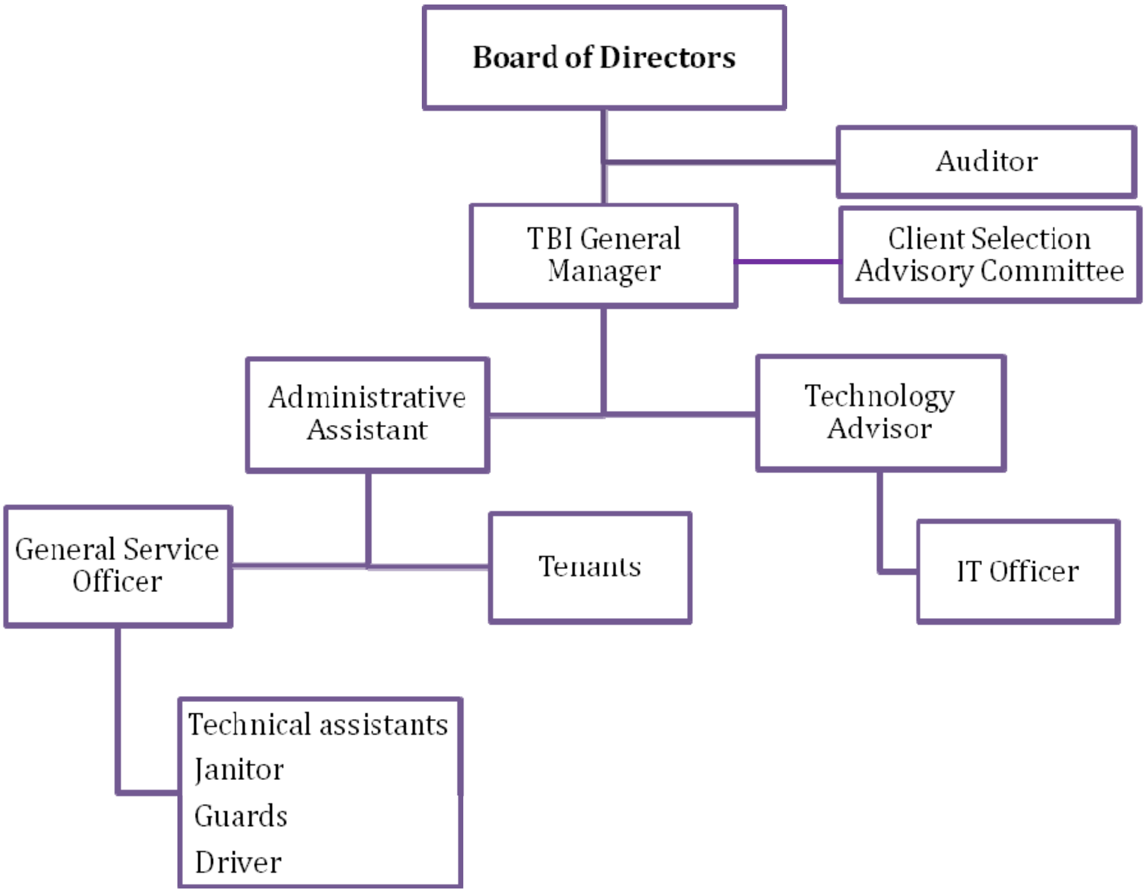


Figure A-1 The organizational structure of the TBI

The components of the TBI's organization structure

- **Board of directors:** The board of directors is comprised of 10 members. The members are the representative of the stakeholders (owners) of the TBI center. Board members are nominated by stakeholders. Planning and formulating policy (strategic planning), hiring the general manager position, managing external relations and promoting the incubator are some of their roles and responsibilities.

- **Client Selection Advisory Committee:** Client selection advisory committee members are chosen from their experience and understanding of business development issues, interest in technology development, and adequate academic knowledge. Their numbers are greater than five and serve the incubation center on temporary basis. They are drawn from the universities, professional association, metal industry and other agencies, to advise on the selection of tenant businesses, and their exit.
- **Auditor**: An independent, external auditor is nominated and hired by executive committee of the board. The Auditor audits the financial operations of the incubator on an annual basis and report to the board of directors.
- **General Manager:** The general manager is hired by the board of directors and reports to them. The general manager should have an entrepreneurial capacities and experience, excellent communication, sales, negotiating, decision-making and networking skills. Experience in technology start-ups and understanding of business management are crucial criteria. A person with master's degree in technology affiliated and business administration fields such as industrial engineering, business administration or operation management suit the position. Some of the major duties of the general manager are: managing the overall operations, identification of constraints to tenant success followed by corrective actions and establishing network of venture capitalists.
- **Administrative Assistant:** An administrative assistant is the first contact that people have with the incubator and tenants. Administrative assistant supports the manager on public relations, computer systems, administration, and maintain equipment and supplies.
- **Technology advisor:** Technology advisor is responsible to the manager for technology support, counseling and information programs focused on tech-venture creation. While not necessarily technologist or engineer, a technology orientation is essential for the position. A person with a strong interest and experience with issues of technology venture creation, and familiarity and contacts with the local

technology establishment are some of the qualification required for technology advisor.

- **Technical assistants:** Technical assistants are hired to support tenant companies on technical matters. Some innovative products may require complicated processes; hence technical assistants should have extensive work experience on the sector. Additionally, their educational level should be competent with the requirement of the facility. A diploma level education and an experience of machine maintenance are some of the criteria.
- **IT officer**: IT officer is an expert in IT field and has some experience in office equipment maintenances. He/ she assist the center in IT related tasks.
- **General Service Officer:** General Service officer oversee the overall facilities in the center and reports to the administrative assistants.
- **Other staffs:** Additionally, three secretaries, four guards, one driver and two janitors are proposed for the center.

Generally, at the initial stage, the incubation might not have adequate capital to hire the required number of staffs. Therefore the existing staffs are likely to perform multiple tasks. All managerial and technical staffs are employed by the TBI general manager. All decisions related to staff are made by the general manager, including selection, hiring and dismissal.

2.6 Financial Analysis

The financial analysis presented in this sub topic includes a facility development budget that considers a new construction of the TBI facility located within the Akaki-Kality sub city, an estimate of capital expenditures for start-up, and operating costs for the first year. The estimated costs are based on the data obtained from Ethiopian investment Agency, Addis Ababa city administration investment authority, and from the field survey of suppliers of furniture and office accessories.

- **Facility development budget:**

The facility development budget includes land and construction related costs for the TBI facility. Although the land required for the TBI facility can be acquired free of lease, the lease cost of the land is included in the estimation. The minimum lease price in Addis Ababa administration is varying based on the grade of land. The following table shows the minimum lease price of land in Addis Ababa.

Table A-7 Minimum lease price for expansion zone in Addis Ababa city administration

Land zone	Grade of lease land	Minimum price in birr/m^2
Expansion zone	1	273
	2	230
	3	167
	4	147

The lease holding of urban land is on auction or negotiation basis. Assuming the land in expansion zone of Akaki-Kality sub city and the city administration can provide it with birr 273 on negotiation.

Regarding with cost of building, it generally defers by type of the construction materials used, the type of foundation, wall height, and location. The data from Ethiopian investment agency shows the average cost of simple storage building is birr 1500-2500 per m^2.

Table A-8 Building cost in Addis Ababa

Building type	Price in birr per m^2
Simple storage building	1500-2500
Apartment building up to four stories	2500-3800
Tower building with elevator facilities	2800-4500
Residential G+1 building (normal)	2400-2800
Residential villa type building (bricks)	2500-3000
Residential villa type building (HCB)	2000-2600

However, for the proposed TBI, 3000 birr per m^2 is taken by considering the current increased construction material cost. The total budget for facility development is summarized in the following table.

Table A-9 Facility development budget estimation

Facility cost	Units	Unit cost	Total cost in Birr
Land lease cost	4565 m^2	273 birr per m^2	1,246,245
Construction cost	2020.8 m^2	3000 birr per m^2	6,062,400
Roads and parking area	800 m^2		130,000
External areas, fence, landscaping etc			220,000
Total facility development budget			7,658,645

- **Capital Expense Costs:**

Capital expenses are related with start-up costs such as furnishing for foundry and mechanical workshop, administrative offices, computer lab, training and conference rooms. Costs for furnishing the cafeteria are not included in this estimation, because it is desired to lease/rent the cafeteria from service providers.

The cost of machinery is obtained from the suppliers and from field survey of local markets. Though there are simple machineries and hand tools which are available in local markets, most machineries required for the center are to be imported from abroad. The valuation for locally available machines and tools are based on market survey. But the cost for other machineries is based on the value of machineries to be imported from China. The cost is assumed to cover the shipping of all the machineries to the port of Djibouti. After the port, a road freight transport mode is used. Dry bulk traffic from port Djibouti to Addis Ababa charges 75 birr per quintal and this rate is used in calculation. The weight and other specification of the machines are shown in Appendix D. Since the center is sponsored and established by the government, custom duty charges and clearance charges are neglected. The individual and total estimated costs for capital expenditure are presented in the following tables.

Table A-10 Estimation for capital expenses

a) Foundry equipments and costs

Foundry Equipments	Unit	Price in birr	Description
Foundry Electric Induction Furnace	1	103462.5	Imported
Sand Core Shooting Machine	1	86300	Imported
Foundry Sand Mixer	1	43675	Imported
Sand molding machine	1	95275	Imported
Hand Tools (hand riddle, shovel, draw spike, lifters, slicks, smoothers etc)		20,000	Local Market
Sub total		348712.5	
Contingency 5 %		17435.63	
Total		**366,150**	

b) Imported machineries cost for mechanical workshop

Imported machineries for mechanical workshop	Unit	Price in Birr
Heavy duty lathe machine	1	349850
Universal lathe machine	1	175007.5
Universal milling machine	1	139250
Power hacksaw machine	1	14270
Vertical drilling machine	1	17950
Metal cutting band sawing machine	1	45470
Mechanical eccentric press	1	116105
Hydraulic shearing machine	1	173725
Rolling machine	1	104925
Tool grinder	1	13289
Radial drilling machine	1	86825
Sub total		1236667
Contingency 5%		61833.33
Total Cost		**1,298,500**

c) Locally available machineries and tools cost for mechanical workshop

Locally available machineries and tools for mechanical workshop	Unit	Unit cost in birr	Total cost in birr
Hand drilling machine	2	2700	5400
Circular saw	2	5500	11000
Hand grinding	2	3500	7000
Bench grinder	2	1500	3000
Bench drilling	2	7500	15000
Riveting gun	3	1200	3600
Bench vice	4	3840	15360

Welding machine	2	17000	34000
Compressor with spray gun (270L)	1	22800	22800
Hand tools and accessories		30000	30000
Metrology Equipments		10000	10000
Miscellaneous equipments		45000	45000
Sub Total			202160
Contingency 5 %			10108
Total			**212,268**

d) Capital costs for office furniture and accessories

Capital Expense	Unit cost	Unit	Estimated costs
Administrative Office Equipments			
Desk top Computers (including all accessories and	9000	11	99000
Lap top computers	12500	2	25000
Printers	6500	3	19500
Photocopier	11000	3	33000
Scan print and copy machine	4000	2	8000
Fax with installation	8000	2	16000
Tables	different types	10	41546
Chairs	different types	10	23774
Guest chairs	different types	26	34390
File cabinets		13	24700
Shelving		4	10400
Fixed line telephone and internet supply			10000
Contingency			15000
Computer lab equipments			
Computers (including all accessories and install)	9000	10	90000
Computer tables	1010	10	10100
Chairs	1000	10	10000
Conference room			
Desks	2300	66	151800
Tables		1	3164
Audio visual equipments and white board			39000
Digital camera		1	4500
Training room			
Desks	1800	25	45000
Tables	different sizes	10	36200
Whiteboard and other accessories			10000
Resource Center			
Tables	1100	4	4400
Chairs	1000	4	4000
Shelves	2400	6	14400
Books, softwares	Estimated		15000

Furnishing Tenant offices			
Chairs	1840	12	22080
Tables	3103	12	37236
Cabinets	1900	12	22800
Pick up truck		1	300000
Miscellaneous			45000
Total costs in birr			**1,224,990**

From the above tables, the capital cost for machineries and office equipments is 366,150 +1,298,500+212,268+1,224,990 = **birr 3,101,908**.

The estimated cost of erection including consulting from mechanical engineers, preparing special foundations and physical erection of machineries is birr 75,000. Similarly the cost of electrical equipments such as electric motors, starters, switches, cables & other electrical items for mechanical workshop are assumed to be birr 150,000.

Therefore, total capital cost is 3,101,908 +75,000+150,000= **birr 3,326,908**

Operating Budget: The operating budget estimates expenses associated with the first year of incubator operation including salaries. But some expenses such as utility costs for foundry and mechanical workshop should be paid by tenants. The administration/management of the center will propose mode of payments for each tenant. The following table shows an annual salary of the employee based on the current minimum salaries of civil servants.

Table A-11 Estimated salaries for the employee of the TBI

No	Description	Required number	Salary (Birr)	
			Monthly	Annually
1	General Manager	1	6530	78360
2	Technology advisor	1	4500	54000
3	Administrative Assistant	1	3000	36000
4	General service officer	1	2500	30000
5	IT officer	1	3000	36000
6	Secretaries	3	3300	39600
7	Technical assistants	2	2000	24000
8	Janitor	2	970	11640
9	Driver	1	800	9600
10	Guard	4	2200	26400
11	Gardener	1	450	5400
	Total	18	29250	**351,000.00**

Likewise the remaining operating budget is estimated in the following table.

Table A-12 Estimated annual operational costs for the first year

Operational Expense	**Description**	**Annual Estimated Costs (in birr)**
Salaries		351000
Employee reimbursement	Travel, parking etc	36000
Meeting refreshment		6000
Employee training		8800
Professional services for TBI		90000
Utilities (for administrative)	Electric, water, internet etc.	41000
Simple Equipments		15000
General Supplies		50000
Maintenance(other than workshop)		20000
Miscellaneous expenses		30000
Contingency	2% of the total	12956
Total annual operational costs		**660,756**

Based on the above estimations the total budget for establishing and operating the technology incubation center for the first year is 7,658,645 + 3,326,908 + 660,756= **birr <u>11,646,309.</u>**

2.7 Incubate Selection Process

Applicants might learn about an incubation program (notice for application) through web site, telephone, mail, personal contact or an incubator visit. Therefore, if they are interested, all prospective candidates complete a brief application form. The brief application form includes description of the applicant's current business (personal) status and a very preliminary sense of the applicant's service and facility needs.

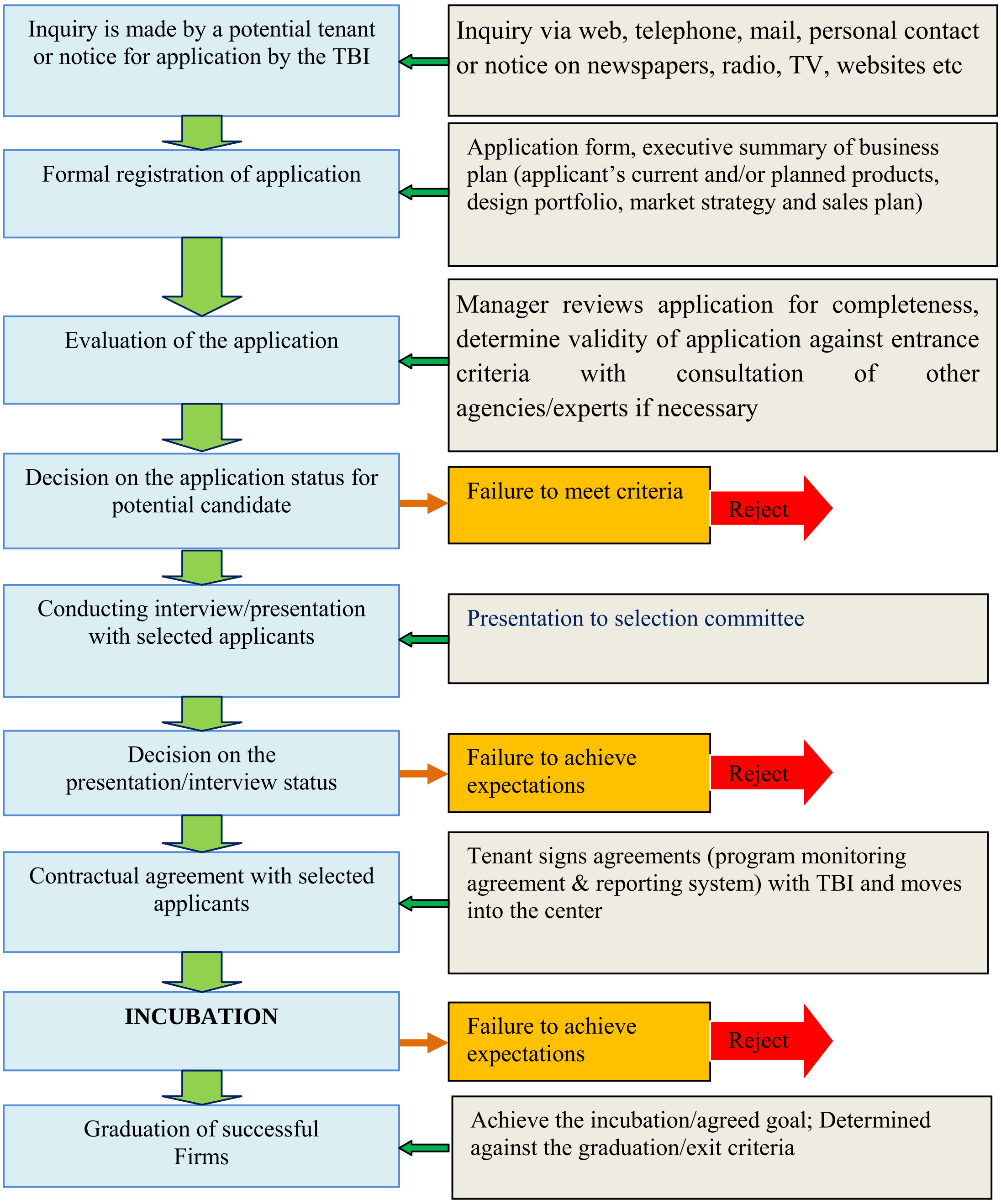


Figure A-2 The incubate selection process

Then the managers evaluate the completeness of the application against the predetermined criteria. If the business description or business plan adequately addresses screening criteria, the potential candidate is informed for further interview or presentation in the presence of selection panels. Meanwhile, applicants that fail to fulfill the criteria are informed by the manager.

Applicants who meet an incubator's basic qualifications (pre-screening) are invited for a formal interview or presentation with the manager and selection panels. Based on the panel's input, the executive director makes a decision regarding acceptance and inform the Board. Then after the decision of the board of directors, the selected clients sign contractual agreement with the center. The contractual agreement include, understanding of the TBI center objectives, graduation criteria and possible reasons for a client's termination from the program and the time they have to quit.

When the clients enter into the program, all the efforts of the incubator is toward offering services and programs which strengthen the company for its future entry to market. Moreover continuous monitoring of the client companies is carried out.

Finally, after going through all the process of incubator, the management evaluates the performance of the clients. If the clients satisfy the graduation criteria, clients leave the incubator, setting up an independent room and consolidating itself to the market of its choice. Meanwhile, the clients that fail to satisfy the objective of the incubator or fail to perform according to the agreement are forced to leave the program.

2.7.1 Selection Procedures

The selection committee which is a panel of six to eight people ,comprise of representative of stakeholders and experts in the field of technology and manufacturing backgrounds, and assist the general manager in understanding the business case and determining if the applicant should be approved for acceptance into the incubator.

2.7.2 Entry Criteria

In order to ensure clients benefit from the services provided and to achieve the goal of the incubator, all applicants are evaluated against a predetermined set of criteria. In this particular case, the following entrance criteria have been adopted for use at the TBI center.

Table A-13 Entry criteria for the proposed TBI

• Applicants should have a certain level of academic competence
Applicants have an innovative business idea with a technology related character. • It should be an idea of innovating new products related to basic metal and engineering. • It should introduce a new skills or technical knowledge to the country; • There should be the existence of a definable market for the potential product or technology and adequate funding • The product should be commercialized within shortest possible time. • With potential to replace currently imported products to the local economy
Applicants shows eagerness and sufficient evidence of interest to become techno entrepreneur • They should provide a written business plan including a market strategy • The applicant business must have the capacity to provide economic benefits including high employment potential and opportunities,
Applicants business must comply with local and state legislation.
Applicants are able and willing to pay a subsidized fee when it is proved to be necessary. • ability to pay incubator rents while they develop positive cash flow
Applicants should aim to start trading within one year.
Applicants should agree to work with the incubator management. • To identify their business development needs in order to deliver the required support/service • To ensure milestones for successful graduation from the program.
Applicants agree to participate in confidential/non confidential surveys while in the program and for certain years after graduation from the program. • They should provide baseline business data as requested by incubator management. • They should inform the center for changes related to business plan, financial status and internal operations

2.7.3 Exit Criteria

In order to leave the incubator program, set up their independent room and consolidate themselves on the market of their choice; the clients should graduate successfully. The graduation stages of the clients are determined against certain criteria of exit. In this particular case, the following graduation or exit criteria are adopted/designed.

- Clients who have progressed beyond the incubator’s ability to provide sufficient value:
    - When the business needs more space than the TBI can accommodate.
    - Firm no longer requires incubation (when the pre-agreed milestones are reached);

- Clients who developed the capability of being competitively marketed on local and international market;
- Clients who own the rights to intellectual property (IP) of a product that has been developed;
- Clients who failed to meet the terms of the contractual agreement, to comply with centers regulations, to accept professional mentoring and/or achieve upon agreed milestones, can result in early termination of the tenants;
- Clients who change their company emphasis from originally planned in the business plan.

Occupancy is determined by the incubator management. The manager reviews the performance of the client on each successive three months after the commencement of tenancy, but expected to last no more than three years. Extensions beyond three years are at the judgment of the board of directors.

After the client company is graduated and leaves the program, it should be in close contact with the center. The information obtained from the graduated companies enables to measure the effectiveness of the program.

2.8 Financial Strategy for the TBI

Financing is one of the crucial issues for the success and sustainability of any technology business incubation. TBI requires funding for three main purposes; these are capital cost, operating cost and seed money. The designed TBI model is for not-profit organization. Hence taking this into consideration, the following financial strategy is devised.

2.8.1 Financial Strategy for Capital Cost

The direct capital budget is come from governmental institutions in different forms. Addis Ababa city administration can provide land free of lease. Since TBI strengthens the technological capability of the nation and result in industrial development, the city administration is a strong partner in providing suitable land free of lease.

Addis Ababa University, Ministry of Education and Ministry of Science and Technology provide the required capital budget for the establishment of TBI. The proportion of contribution of each institution is decided after negotiating on the program. If the negotiation agreed on the primary stakeholder of the program, then it is the responsibility of that stakeholder to cover most of the capital cost. However, if all stakeholders agreed on equitable involvement, then the financial contribution is formulated as to reflect the situation. It is understood that the contributions might be in kind like furnishing the offices.

Since private investors can be interested in profit making businesses alone and they perceive the TBI as government projects, their support is less likely. However, they might contribute, if they are convinced about the indirect benefits they are going to achieve. The starting point is recognition of the kinds of assets and benefits that may attract private investors. Therefore, the incubator managers work to mobilize private sector involvement, in mutual interest. Moreover grants can be obtained from international donor agencies such as the United Nations industrial development organization (UNIDO), European Union, Non- governmental organizations, foreign governments with economic cooperation agencies (such as Japan, Germany, USA etc.). Generally, doing a research on the sources of grants and securing the required financial budget is the responsibility of the TBI project team and management.

2.8.2 Financial Strategy for Operating Cost

Income like rent for use of the incubator facility, service charge from internal and external clients, fees from special projects and community activities, can be generated from the TBI program. The revenues received from the tenants usually cover only a part of the total operation costs. Moreover, the remaining sources of income might not generate the required amount of money to fund the operational cost, at least until the activities and services of the program is well known in the public. So it is required to secure a constant fund from a definite source till the program become stable, and convinces others to operate independently.

The operating cost of the TBI is covered by government until the cash flow of the center demonstrates a positive trend. The boards of directors approve an annual budget that is contributed from the stakeholders. Each stakeholder contributes their share for the operational cost of the program. Apart from the stakeholders, other possible sources of operating cost can be assessed.

2.8.3 Financial Strategy for Seed Money

Access to finance is one of the services provided by TBI for clients. It might be difficult to find a precise source of seed capital for clients, as the knowledge of financial institution of the country, in this aspect, is uncertain. However, there are a number of option to acquire seed capital such as financing from own resources, contacts with investors/business, bank loans and etc.

Bank finance is a viable option for financing the business of tenants. To facilitate bank financing, the TBI develop a special financial advisory unit to assist tenant companies prepare loan applications and service bank debts. Therefore, clients are helped in preparation of their business plan before soliciting banks for seed capital financing.

In this regard the Addis Ababa credit and saving institution and the development bank of Ethiopia could be the main stakeholders of the program. Moreover royalty financing based on future returns from innovations is one way of helping the program to obtain seed capital. In this regard the private sector can also be involved in providing seed capital for the clients and can own a proportion of tenant business.

2.9 Strategy for Sustainability

The achievement of sustainability for the TBI center is one of the crucial responsibilities of each stakeholder. Rental and provision of space are not sufficient to cover all the costs of the incubator. Therefore mode of raising additional revenues should be devised. Providing consultation and advisory service, technology sources, training and renting conference hall for external clients, could be a viable source of income for the center. Sometimes it might happened that machines could be idle; in this case the foundry and mechanical shop can be used by external clients through negotiation or contract.

Moreover, the sustainability of the center is guaranteed when it tries to achieve the objective of establishment. The center should prove its impact on the sector and bring innovation or technological development. In other words, the efficiency of the center should be measured.

Operational cost and revenue structure

To verify the self sufficiency or financial independency of the proposed TBI, it is tried to plan the structure of cost and revenue. Revenues are expected to be generated from rent, tenant client service fees, external client service fees and cafeteria rent. Though it is difficult to estimate, grants and donations are also included in the revenue structure. As the service of the TBI center is expanding, more revenue sources can be added. While analyzing the operational costs, it is assumed that the expense will grow at a rate of 8 % for the consecutive 4 years and will remain the same for the following years.

It is found that rental rates for office space in Addis Ababa vary significantly from location to location or from building to building, depending on the quality of the building and distance from the center of the town. However the minimum bid prices set by the administration for rented houses are from birr 45.5 to 60 per m^2 [14]. Hence birr 55 per m^2 is taken as rental rate for tenant offices. By considering yearly occupancy rate and a 6 percent annual inflation, the following rental income is generated.

Table A-14 Estimation of occupancy rate and rental income

Rental Revenues						
Operational years	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
Percentage of space leased	10	30	50	75	80	80
Space leased in square meter	90	270	450	675	720	720
Rental rate in birr/m^2	55	58.3	61.8	65.5	69.4	73.6
Rental revenue in birr	59400	188892	333720	530550	599616	635904

Additionally, the service of cafeteria will be rented at 60 birr per m^2 for the first operational year and will grow at the rate of 6%. Likewise, the revenues generated from the service rendered to tenants assumed to grow by 6%, and revenues from outside customers are estimated to grow by 15 % annually. Generally, the following revenue and cost structure is developed.

Table A-15 Operational cost and revenue structure

Revenue						
	Year 1	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
From tenant rent	59,400	188,892	333,720	530,550	599,616	635904
From tenant services	50,000	53,000	56,180	59,551	63,124	66,912
From external services	70,000	80,500	92,575	106,462	122,431	140,795
From cafeteria	43,200	45,792	48,540	51,452	54,540	57,812
From grants & donations	-	-	-	-	-	-
Total Expected Revenue	222,600	368,184	531,015	748,015	839,711	901,423
Operational costs						
Annual Expenses	**660,756**	**713,617**	**770,706**	**832,363**	**898,952**	**898,952**
Operational Results						
	-438,156	-345,433	-239,691	-84,348	-59,241	2471

Looking into the cost and revenue structure, it is estimated that the center able to cover its operational costs at 6^{th} year after commencement of operation. Therefore, there is a need to constantly financing the center, and it is the responsibility of the government to provide funds until the center is self-sufficient. The board of directors warrants the availability of yearly operational costs on their budget plan.

After the first 6 years, the center is capable to generate adequate revenue to run its programs. At this junction, the center should look for an expansion or additional program. It can be transformed into hi-tech facility with introduction of advanced machines such as computer numerical control (CNC) and robotics. But the feasibility study should be conducted for the project prior to implementation.

2.10 Implementation Plan

The incubation program is developed in three phases.

Phase 1: Initiation: This first phase of TBI development plan is assumed to take one year. The first major action under initiation phase is to hire the incubator project manager. The detailed activities of project manager include;

- Work with the identified stakeholders;
- Create the legal structure;
- Identify supporters for the program;

- Review and file legal documents;
- Create incubator advisory committee;
- Create board of directors;
- Identify funding sources for incubator build-out; and
- Identify funding for first year operations and initiate fund raising program.

Phase 2: Implementation: The second phase of an incubation program takes the duration to establish the facility with the required support services and commence the incubation program. The detailed activities under this phase include;

- Hire an incubator general manager;
- Identify and lease commercial space;
- Accept resident client companies; and
- Continue working with affiliate companies and solidify the incubator program and services.

Phase 3: Expansion: After the incubation program is implemented and lays its foundation in the community, the next phase is to look for an expansion project. The major activities under this phase include;

- Conduct formal six-month review and explore feasibility of developing affiliate client program;
- Increase the program offerings to attract a greater number of incubator companies; and
- Secure stable and diverse revenue streams toward a long-term facilities solution.

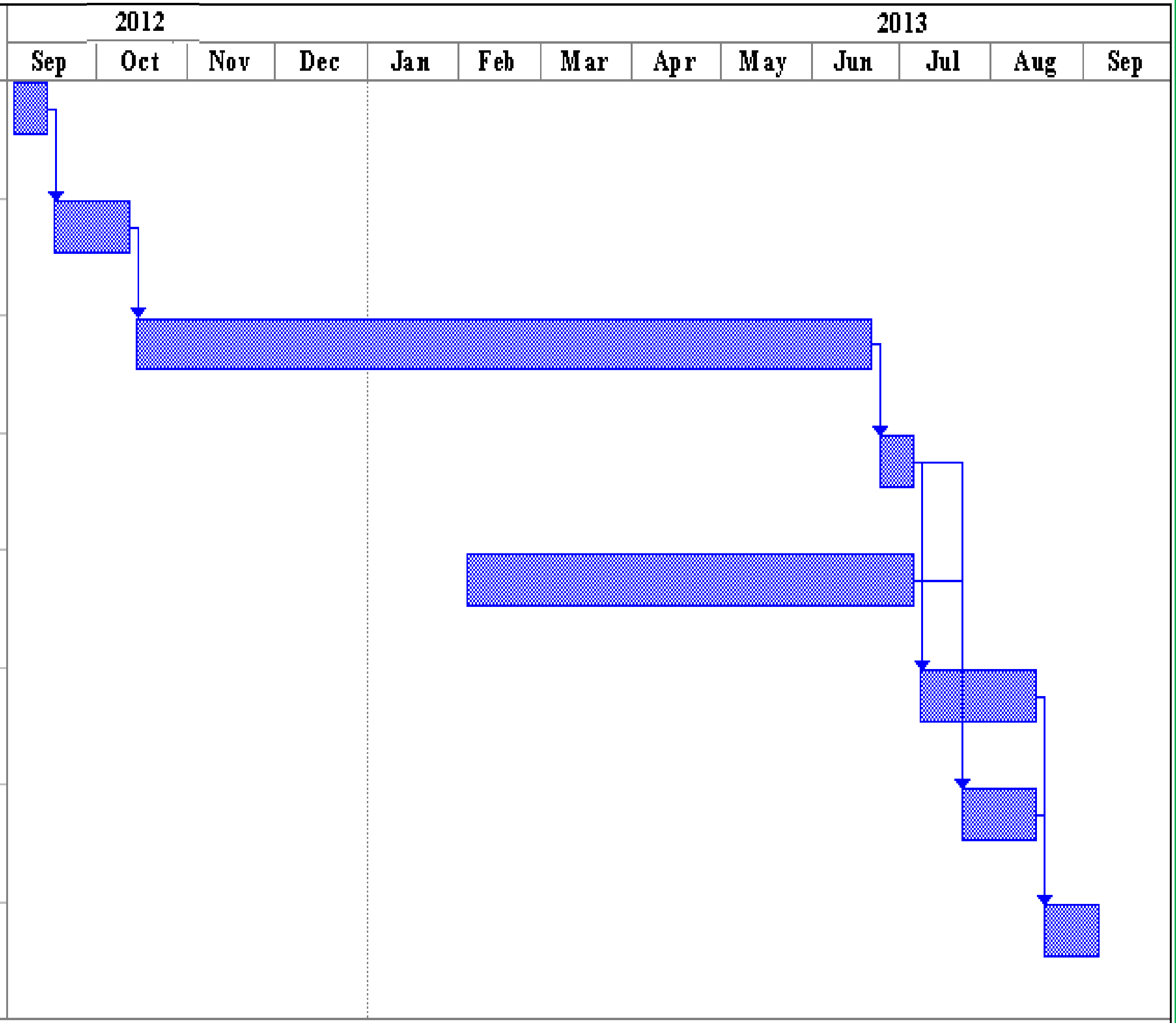
TBI Project Implementation Schedule: It is assumed that the first phase, initiation of the incubation program, takes one year. Therefore an implementation program for the facility development is assumed to begin on September 2012 after the first phase is accomplished. Based on the above assumptions the project schedule for the establishment of the facility is developed below.

Table A-16 Project schedule for the establishment of the facility

Activity Name (ID)	Description	Duration (days)	Precedence
1	Licensing and registration	10	-
2	Acquisition of land	20	1
3	Land development and Building	180	2
4	Electrification and Utility	10	3
5	Purchasing machines and equipments	110	2
6	Machine installation	30	4,5
7	Hiring Staff	20	4,5
8	Launch facility	15	6,7

The starting and finishing time for each task is scheduled and depicted in the following Gantt chart. From the graph, it is found that 255 working days are required to finish the project. Activity 1, 2, 3, 4, 7 and 8 are considered as a critical activities and need due considerations during project execution.

ID	Start	Finish
1	Mon 9/3/12	Fri 9/14/12
2	Mon 9/17/12	Fri 10/12/12
3	Mon 10/15/12	Fri 6/21/13
4	Mon 6/24/13	Fri 7/5/13
5	Mon 2/4/13	Fri 7/5/13
6	Mon 7/8/13	Fri 8/16/13
7	Mon 7/22/13	Fri 8/16/13
8	Mon 8/19/13	Fri 9/6/13



Annex III

Specification for foundry and mechanical workshop machines

Foundry Machines

Foundry Induction Furnace

Technical Specification

Item	Unit	Value
Rated capacity	KG	10-50
Rated power	KW	50
Input voltage	V	380
Transformer capacity	KVA	60
Out voltage	V	750
Output frequency	KHZ	2.5
Melting time	Min	20-60
Power consumption(steel)	Kw.h/T	900
Water cooling	T/h	3
Input Water Pressure	MPa	0.2
Volume	M^3	1.2
Weight	kg	350

Supplier: Qingdao Tongfeng Casting Machine Co. Ltd., China

Sand Core Shooting Machine

Technical Specification

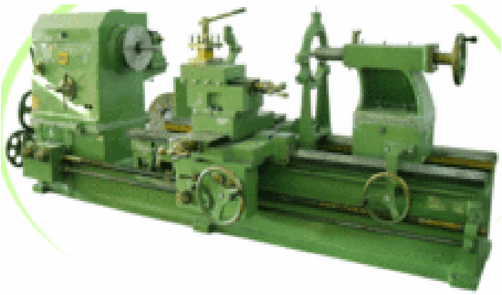
Item	Unit	Value
Core box of size	mm	450*400*300
Maximum weight of shoot sand	kg	15
Template's maximum size Max/min	mm	500/190
Core boxes to force	kg	1300
productivity	hour	60S
working pressure	Mpa	0.65
Shoot sand pressure	Mpa	0.4
power supply	AC	380V
heating method	electrical	electrical
heating power	KW	20
Sand-up way		Air slide

Supplier: Qingdao Tongfeng Casting Machine Co. Ltd., China

Foundry Sand Mixer	Technical Specification		
	Item	Unit	Value
	Disc diameter	mm	1000
	Feeding Capacity	Kg/s	110
	Productivity	t/h	1.5-2.5
	Power	Kw	4
	Spindle Speed	rpm	45
	Single-round pressure		0-1100
	Machine Weight	kg	900
	Supplier: Qingdao Tongfeng Casting Machine Co. Ltd., China		

Sand molding machine	Technical Specification		
	Item	Unit	Value
	Foundry flask maximum dimension	mm	500X450X200
	Worktable size	mm	600X550
	Jolting load	kgf	300
	Compressive stress	kgf	5000
	Molding process	mm	180
	Productivity	box/h	40-60
	Jolting cylinder diameter	mm	150
	Compress press		160
	Consumption of free air	M^3/box	0.4
	Overall dimension(LXWXH)	mm	1300X800X1700
	Supplier: Qingdao Tongfeng Casting Machine Co. Ltd., China		

Mechanical Workshop Machines

Lathe Machine (Heavy duty)	Technical Specification			
	Item		Unit	Value
	Max. swing over bed		mm	800
	Max. swing over carriage		mm	520
	Center distance		mm	1000
	Width of gap		mm	320
	Swing over gap		mm	1000
	Width of guide way		mm	550
	Spindle bore diameter		mm	105
	Rapid traverse speed		m/min	3.8
	Max. travel of cross slide		mm	493
	Travel of top slide		mm	200
	Main motor power		kW	11
	Rapid traverse motor power		kW	1.1
	Coolant pump motor power		kW	0.09
	Gross/Net weight	4000mm	kg	7800/6100
	Supplier: Tengzhou Xili Machine Tool Co. Ltd., China			

Lathe Machine (Universal)	Technical Specification			
	Item		Unit	Value
	Max. swing over bed		mm	400
	Max. swing over carriage		mm	230
	Max. swing over gap		mm	700
	Width of gap		mm	250
	Max. length of work piece		mm	1000
	Width of guide way		mm	394
	Spindle speed		rpm	26-2000
	Dia. of spindle bore		mm	82
	Taper of spindle bore			90/1:20
	Max. travel of cross slide		mm	348
	Travel of top slide		mm	150
	Travel of tailstock quill		mm	150
	Diameter of tailstock quill		mm	75
	Main motor power		Kw	7.5
	Gross/Net weight	2000mm	Kg	4010/3030
	Supplier: Tengzhou Xili Machine Tool Co. Ltd., China			

Universal Milling Machine

Technical Specification		
Item	Unit	Value
Table size	mm	360X1250
Longitudinal travel	mm	700/680
Max transverse travel	mm	255/240
Max vertical travel	mm	410/390
Table size	mm	1250×360
Distance from horizontal spindle to supporting	mm	175
Spindle speed range	rpm	60-1800
Vertical up-down(z axis) speed table	mm/min	590
Range of table travel	mm	18
Main motor power	Kw	4
Motor of lifted table	Kw	1.1
Overall size LxWxH)	mm	1880×1700×1700
N.W/G.W	kg	2000/2200
Supplier: Tengzhou Xili Machine Tool Co. Ltd., China		

Power Hacksaw Machine

Technical Specification		
Item	Unit	Value
Maximum sawing size for Round steel	mm	250
Maximum sawing size for shape bar	mm	250x250
Saw blade width	mm	450×35×2
Stroke of sawing bow reciprocation	time/ min	91
Length of saw blade strokes	mm	152
Motor	Kw	1.5
Net weight	Kg	680
Overall dimensions (LxWxH)	mm	1550×700×1000
Supplier: Qingdao Prosper Machinery Co. Ltd. , China		

Vertical drilling Machine	Technical Specification		
	Item	Unit	Value
	Max. Drilling capacity	mm	32
	Max. feed resistance	N	9000
	Max. Permissible spindle torque	N.m	160
	Throat distance	mm	280
	Spindle travel	mm	200
	Spindle box travel	mm	200
	Spindle speeds range	r/min	50-2000
	Feed rates	r/min	0.056-1.8
	Max. Travel of table	mm	310
	Working Surface of Worktable	mm	400×530
	power of main motor	Kw	2.2
	Flow of cooling pump	L/min	25
	Overall dimensions (LxWxH)	mm	962×847×2340
	Net weight of machine	kg	1000
	Supplier: Qingdao Prosper Machinery Co. Ltd. , China		

Bench Drill Press	Technical Specification		
	Item	Unit	Value
	Drilling capacity	mm	16
	Chuck size	mm	16
	Table travel	mm	190
	Table size	mm	200×190
	Spindle travel	mm	55
	Distance spindle axis to column	mm	125
	Column diameter	mm	60
	Spindle speeds range	r/min	300-3190
	Spindle speeds series		12
	Motor power	HP	1/2
	Overall height	mm	860
	Net weight./Gross weight	kg	40/43
	Packing case dimensions	mm	680×440×255

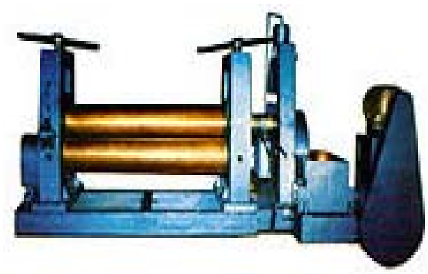
Metal Cutting Band Sawing Machine

Technical Specification		
Item	Unit	Value
Cutting capacity round	mm	280
Cutting capacity rectangle	mm	280x350
Oil pump Motor power	Kw	0.42
Main motor output	Kw	2.2
Voltage	V	380V
Frequency	Hz	50
Band saw dimensions	mm	0.9x27x3505
Process Speed	m/min	20/45/80
Overall size	mm	2095x1095x1445
Machine weight	kg	1000
Supplier: Qingdao Prosper Machinery Co. Ltd. , China		

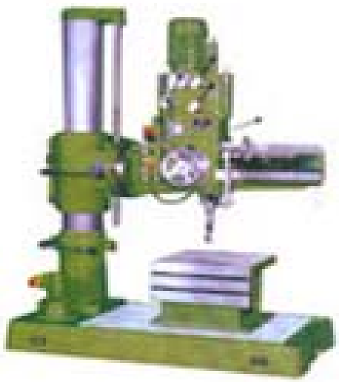
Mechanical Eccentric Press

Technical Specification		
Item	Unit	Value
Nominal capacity	KN	250
Nominal pressure stroke	mm	6
Stroke of slide	mm	80
Strokes per minute	mm^{-1}	100
Max. die height	mm	180
Die height adjustment	mm	45
Distance between slide center and frame	mm	500
Thickness of bolster	mm	50
Distance between columns	mm	250
Bench size	mm	400×600
Hole dimensions in bed	mm	ø160
Bottom size of slide	mm	180×200
Size of the handle hole	mm	(ø38)ø40×60
Main motor power	KW	3
Overall dimension	mm	1600×1100
Height above floor	mm	2180
Total weight	KG	2300
Supplier: Anhui Laifu NC Machine Tool Co., Ltd., China		

Hydraulic shearing machine	Technical Specification		
	Item	Unit	Value
	Max.shearing thickness	mm	4
	Max.shearing width	mm	2500
	Stroke times	Per min	18
	Back gauge range	mm	20-600
	Shearing angle	$(^0)$	0.5-1.5
	Throat depth	mm	100
	Motor power	Kw	4
	Overall dimensions(LxWxH)	mm	3000x2000x1850
	Supplier: Qingdao Prosper Machinery Co. Ltd. , China		

Rolling machine	Technical Specification		
	Item	Unit	Value
	Plate yield limit	Mpa	245
	Maximum Plate Thickness	mm	8
	Maximum Plate width	mm	2500
	Minimum diameter	mm	500
	Diameter of Upper Roller	mm	240
	Diameter of Lower Roller	mm	200
	Central Distance	mm	310
	Main Motor Power	Kw	11
	Overall dimension	mm	4550×1350×1610
	Supplier: Qingdao Prosper Machinery Co. Ltd. , China		

Tool grinder	Technical Specification		
	Item	Unit	Value
	Diameter of edge mill	mm	90-630
	Max. diameter (mill cutter thickness)	mm	φ200×150
	Max. length (straight cutter)	mm	250
	Carving cutter	mm	φ13
	Sand wheel specifications	mm	φ125×180
	Spindle speed	r/min	2860
	Motor power	W	370
	Water pump power	W	40
	Overall dimensions	mm	650×800×1580
	Supplier: Qingdao Prosper Machinery Co. Ltd. , China		

Radial drilling machine	Technical Specifications		
	Item	Unit	Value
	Drilling Depth	mm	140
	No. of Spindle: Speeds/Range	r/min	6(72-1000)
	No. of Spindle: Feeds/Range	mm/rev	2(0.1 a 0.2)
	Drill Power	KW	1.5
	Drilling Radius Max/Min	mm	750/350
	Drilling Head: Traverse	mm	400
	Distance Base Plate to Spindle Max / Min	mm	835/ 275
	Diameter of Column Sleeve	mm	190
	Working Surface of the Base Plate	mm	750x650
	Length x Width x Height	mm	1170x670x160
	Arm Elevator Motor	KW	0.75
	Standard Box Table (XxYxZ)	mm	400x350x350
	Weight of Machine	Kg	1100
	Supplier: Qingdao Prosper Machinery Co. Ltd. , China		

Arc welding machine	Technical Specifications		
	Item	Unit	Value
	Input power voltage	V	AC380 ±10%
	Frequency	HZ	50/60
	Rated welding current	A	400
	Welding current range	A	5~400
	Rated duty cycle		60%
	Rated input capacity	KVA	13
	Phase		3 phase
	Weight	KG	35

Annex IV

Findings from the Questionnaire

1. Findings from HEIs

The questions developed for Higher Education Institutions has four parts and a total of 68 questionnaires have been distributed. The data and analysis is presented as follows.

Part 1: The points listed in this part are used to get an insight from the employees working in HEIs about the economic contribution of their organizations:

In what areas do you see your higher education institute is making the greatest contribution to economic development?

Table A-17 Economic contribution of HEIs

S.N	Description	Appropriate	Percentage	Top three	Percentage
1	Access to education	66	97.1	59	86.8
2	Graduate retention in local region	22	32.4	12	17.6
3	Technology (knowledge)transfer	55	80.9	34	50.0
4	Supporting micro & small enterprises	32	47.1	5	7.4
5	Attracting inward investment to region	6	8.8	8	11.8
6	Research collaboration with industry	47	69.1	24	35.3
7	Strategic analysis of regional economy	10	14.7	8	11.8
8	Support for community development	43	63.2	9	13.2
9	Developing local partnerships	21	30.9	7	10.3
10	Management development	10	14.7	1	1.5
11	Meeting regional skills needs	52	76.5	16	23.5
12	Meeting national skills needs	60	88.2	31	45.6

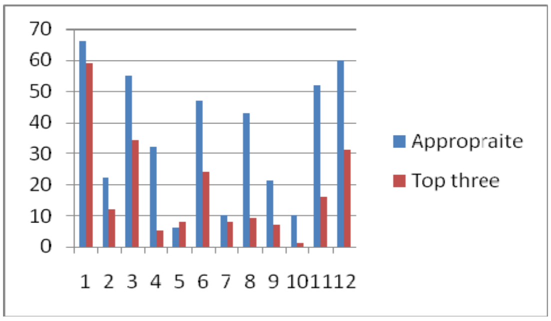


Figure A-3 Economic contributions of HEIs by employees

Interpretations

Base on the above percentage distributions obtained from the employees working in the Higher Education Institutions, the primary objective of the institutions is to provide access to education to the nations which indicate little attention has been given to other important objectives of the Higher Education Institutions like technology transfer and support for the community.

Part 2: In this part, a number of points that are related to working with technology transfer have been mentioned and respondents show their agreement by selecting from the available choices.

What do you think are the problems towards working with research activities as a means of technology transfer in your institutions?
SA (strongly Agree), A (Agree), NS (Not Sure), DA (Disagree) and SDA (Strongly Disagree)

Table A-18 percentage of respondents agreed to problems of TT in HEIs

S.N	Descriptions	(SA)	(A)	(NS)	(DA)	(SDA)
2.10	High intake of students	41.2%	36.8%	5.9%	8.8%	7.4%
2.20	Awareness of staffs about research and technology transfer	38.2%	39.7%	14.7%	5.9%	1.5%
2.30	Shortage of budgets or funds	42.6%	33.8%	16.2%	4.4%	2.9%
2.40	Paper work related to research fund acquisition and processing	20.6%	39.7%	27.9%	11.8%	0.0%
2.50	Capacity and capability of institutions in carrying out research activities	25.0%	48.5%	16.2%	10.3%	0.0%
2.60	Absence of technology transfer offices that facilitate research collaboration	30.9%	38.2%	20.6%	10.3%	0.0%
2.70	More emphasis is given for teaching activities	47.1%	41.2%	5.9%	5.9%	0.0%
2.80	Absence of clear policies and procedures related to innovation and intellectual property right in the institutions	33.8%	33.8%	25.0%	5.9%	1.5%
2.90	Student performance is highly rated based on written exams	38.2%	47.1%	11.8%	1.5%	1.5%
2.10	Previous research outcomes are not properly disseminated throughout the institution and to other organizations	33.8%	44.1%	19.1%	2.9%	0.0%

Part 3: The purpose of this section is to get an insight on how workshops, laboratories, machine shops etc are handled in higher education institutions. Staffs of different universities have been given a chance to indicate how the above resources are utilized.

Table A-18 Number and percentage of respondents for identifying practical session's handlers

SN	Description	No. and % of respondents	
1	By Technical assistant (Diploma holders)	67	98.5%
2	By Graduate assistant	8	11.8%
3	By Assistant lecturers	2	2.9%
4	By Lecturers and above	1	1.5%

The graphical distribution of the respondents has been depicted in the figure below (Figure A-4)

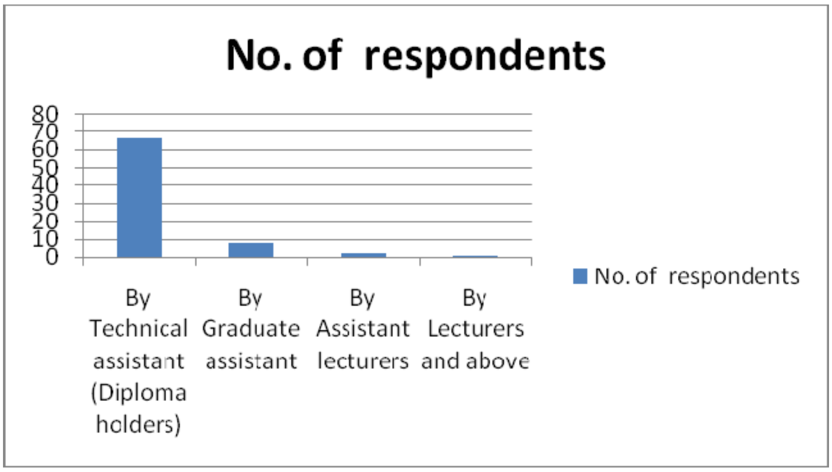


Figure A-4 Number of respondents for identifying practical session's handlers

From the above, it is clear to see that 98.5 % of the respondents have identified or agreed that the practical sessions in the laboratories, machines shops, workshops etc are usually handled by technical assistants. Lectures are usually delivered by senior staffs but it is uncommon to see senior staffs inside rooms where practical activities are carried out. This will definitely make hard for the students to easily familiarize themselves with what has been discussed in class and in turn affects the smooth technology (knowledge) transfer in higher education institutions.

Part 4: In this section an attempt has been made to obtain a self assessment about the performance of the Higher education Institutions by staffs working in HEIs. The data obtained is presented in the table below.

Table A-19 Percentage of respondents for self assessment in HEIs

Descriptions		Excellent	Very good	Good	Weak	No comment
4.1	Teaching and learning process	5.9%	48.5%	44.1%	1.5%	0.0%
4.2	Research and publication	4.4%	7.4%	23.5%	63.2%	1.5%
4.3	Public service	5.9%	5.9%	20.6%	57.4%	10.3%
4.4	Collaboration with industries	0.0%	5.9%	26.5%	63.2%	4.4%
4.5	Collaboration with micro & small scale industries	2.9%	2.9%	14.7%	72.1%	7.4%
4.6	Collaboration with other organizations (university, research institute etc)	1.5%	7.4%	38.2%	45.6%	7.4%
4.7	Information of students after graduation (their whereabouts)	1.5%	2.9%	2.9%	80.9%	11.8%
4.8	Establishing business as a result of research findings in your institutions (spin off)	1.5%	4.4%	1.5%	83.8%	8.8%
4.9	Utilization of resources in workshops, laboratories, etc	4.4%	7.4%	42.6%	41.2%	4.4%
4.10	Generating funds through institutional consultancy	2.9%	2.9%	23.5%	60.3%	10.3%

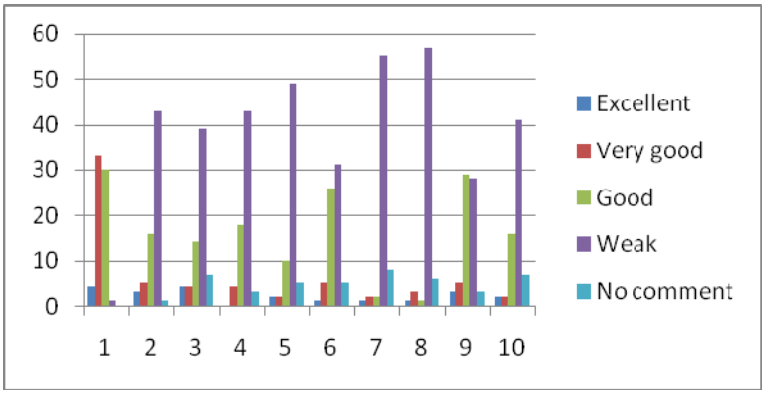


Figure A-5 Number of respondents agreed for self assessment in HEIs

Interpretation: the above figure revealed that there is weak interaction between Higher Education Institutions and Other organizations, weak research activities and fund raising system. In order to improve the capacity of the higher institutions in technology transferring using research activities, the following points should be considered.

- Make appropriate resources available for high intake of the students
- Consider research activities as the main part of the teaching learning process.
- Developing a system on which research outcomes will be disseminated and easily accessible to other organizations.
- Encouraging students to participate in different research areas and give credit for that
- Enhancing awareness of staffs about research and technology transfer through short and long term training schemes.
- Establishing a mechanism of fund raising program through collaboration to other organization (both national and international).

2. Findings from research institutions

The questions developed for Research Institutions has three parts and a total of 20 questionnaires have been distributed. The data and analysis is presented as follows.

Part 1: The points listed in this part are used to get an insight from the employees working in Research institutions about the economic contribution of their organizations:
In what areas do you see your Research institution is making the greatest contribution to economic development?

Table A-20 Number and percentage of respondents for the economic contribution of research institutions

SN	Description	Appropriate	Percentage	Top three	Percentage
1	Innovation and Adopting new technology	19	95.0%	18	90.0%
2	Technology (knowledge)transfer	19	95.0%	19	95.0%
3	Supporting micro & small enterprises	19	95.0%	7	35.0%
4	Attracting inward investment to region	8	40.0%	2	10.0%
5	Research collaboration with industry	17	85.0%	6	30.0%
6	Strategic analysis of regional economy	4	20.0%	0	0.0%
7	Support for community development	14	70.0%	5	25.0%
8	Developing local partnerships	12	60.0%	0	0.0%
9	Meeting national skill needs	12	60.0%	1	5.0%

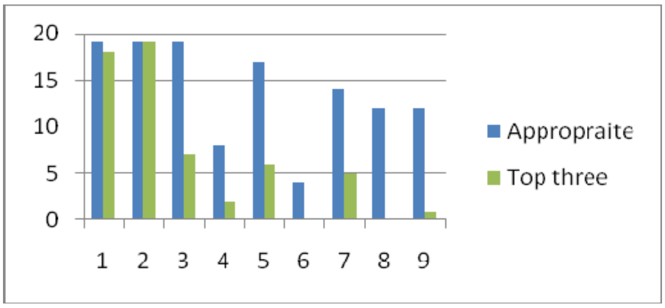


Figure A-6 Number of respondents for the economic contribution of research institutions

From the above data and figure, it is found out that, Employees of the research institutions agree for the economic contribution of their organizations as follows:

Considering the top three from the available lists,

90 % agree with Innovation and Adopting new technology

95 % agree with Technology (knowledge) transfer

Part 2: In this part, a number of points that are related to working with technology transfer have been mentioned and respondents show their agreement by selecting from the available choices.

What do you think are the problems towards working with research activities as a means of technology transfer in your institutions?

SA (strongly Agree), A (Agree), NS (Not Sure), DA (Disagree) and SDA (Strongly Disagree)

Table A-21 percentage of respondents to problems of TT in research institutions

Descriptions		(SA)	(A)	NS	(DA)	(SDA)
2.1	Lack of appropriate technology needs assessment	15.0%	75.0%	5.0%	5.0%	0.0%
2.2	Awareness of staffs about research and technology transfer	15.0%	45.0%	15.0%	25.0%	0.0%
2.3	Shortage of budgets or funds	50.0%	20.0%	15.0%	15.0%	0.0%
2.4	Paper work related to research fund acquisition and processing	5.0%	70.0%	5.0%	15.0%	5.0%
2.5	Capacity and capability of institutions in carrying out research activities	35.0%	40.0%	0.0%	20.0%	5.0%
2.6	Absence of technology transfer offices that facilitate research collaboration	40.0%	25.0%	25.0%	5.0%	5.0%
2.7	Research outcomes are not properly implemented as per the findings	15.0%	50.0%	30.0%	5.0%	0.0%
2.8	Absence of clear policies and procedures related to innovation and intellectual property right in the institutions	20.0%	35.0%	25.0%	15.0%	5.0%
2.9	Turnover of researches for different reasons	45.0%	45.0%	10.0%	0.0%	0.0%
2.10	research outcomes are not properly disseminated to the end user	25.0%	45.0%	15.0%	15.0%	0.0%
2.11	Weak interaction with other partners (university, industry, etc)	35.0%	50.0%	0.0%	10.0%	5.0%

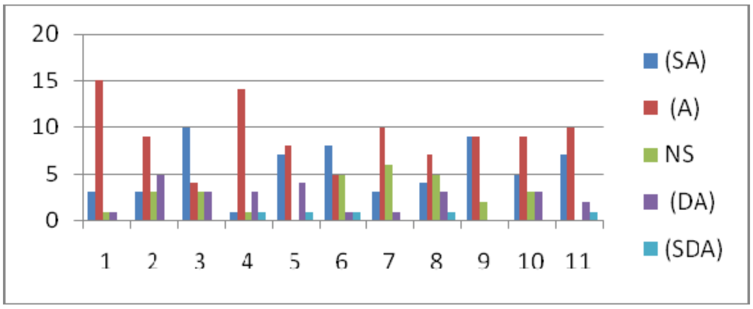


Figure A-7 Number of respondents agreed to problems of TT in research institutions

Part 3: in this section an attempt has been made to obtain a self assessment about the performance of the Research Institutions by staffs working in Research Institutions. The data obtained is presented in the table below.

Table A-22 percentage of respondents for self assessment in Research Institutions

Descriptions		Excellent	Very Good	Good	weak	No comment
3.1	Research collaboration with industries	5.0%	10.0%	20.0 %	65.0 %	0.0%
3.2	Research and publication	0.0%	0.0%	15.0 %	85.0 %	0.0%
3.3	Fund raising through institutional consultancy	0.0%	5.0%	10.0 %	85.0 %	0.0%
3.4	Collaboration with micro & small scale industries	0.0%	15.0%	35.0 %	50.0 %	0.0%
3.5	Collaboration with other organizations (university, research institute etc)	0.0%	10.0%	65.0 %	20.0 %	5.0%
3.6	Patent filling and grant	0.0%	0.0%	0.0%	85.0 %	15.0%
3.7	Establishing business as a result of research findings in your institutions (spin off)	0.0%	0.0%	5.0%	75.0 %	20.0%
3.8	Generating funds through consulting as an institutional activity	0.0%	0.0%	10.0 %	80.0 %	10.0%
3.9	Updating research capability of staffs through further training	5.0%	30.0%	30.0 %	30.0 %	5.0%
3.10	Benchmarking from other research institutes	15.0%	5.0%	35.0 %	40.0 %	5.0%
3.11	Carrying out well organized technology needs assessment	0.0%	0.0%	35.0 %	55.0 %	10.0%
3.12	Assessment if a technology has been properly transferred (successful transfer of technology) as per the plan? if not taking corrective actions	0.0%	0.0%	35.0 %	60.0 %	5.0%

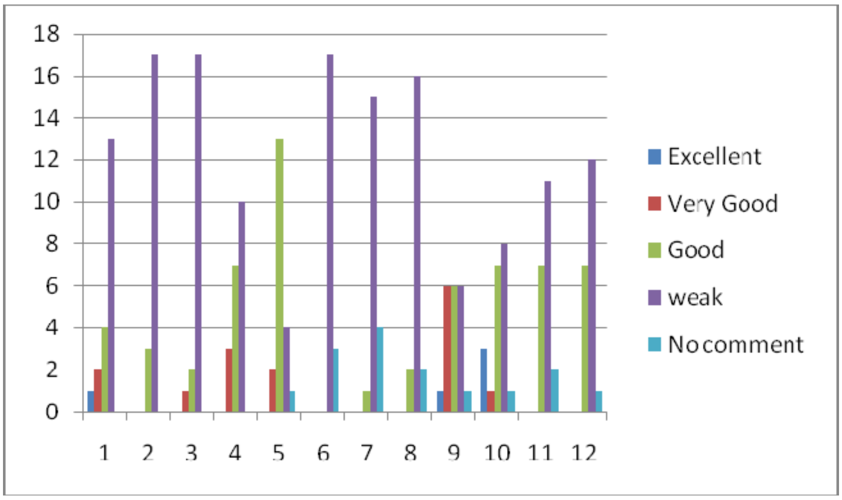


Figure A-8 Number of respondents for self assessment in Research Institutions

Interpretation: the above tables and figure revealed that there is lack of appropriate technology needs assessment, turnover of researchers, weak interaction with other organizations, weak patent filling and grant system. In order to improve the capacity of the research institutions in technology transferring using research activities, the author suggested that establishing technology transfer offices in research centers would play in a significant role. The office will carry out:-

- Technology needs assessment
- Facilitating interactions with different organizations
- Developing a system that will somehow reduce the paper works during research activities
- Facilitate proper distribution of research findings including patents filling and grant.

Annex V

PhD Course/ Seminars and Major Activities Performed

No	Course Code	Course name	Credit
1	MEng 8303	Managing Global Competitiveness in Manufacturing and Service Industries	3
2	MEng 8302	Models and Methods of Industrial Production System Analysis	3
3	MEng 8301	Selected Topics in Industrial Ingineering (Warehouse Design Using Catia V5 Software)	3
4	MEng 8208	Seminar Course I	3
5	MEng 8308	Seminar Course II	3

Major Activities Performed During the Period of PhD Study

No	Activities
1	The researcher delivered different courses such as Operation Research, Supply Chain Management and Project Management for post graduate students of industrial engineering for the last three years. Moreover, a number of term papers have been advising in area of Total Quality Management, Plant Design & Errection, Statistical Quality Control, Project Management, Operation Research and Supply Chain Management.
2.	The researcher advices more than 20 theses of post graduate students as co advisor in area of technology transfer and clustering.
3.	The researcher published two articles in national magazines and one article selected for presentation on workshop. Moreover, four articles are in progress in international and national journals.
4.	The researcher contributed in Ethiopia Quality award (EQA) program as a technical committee to evaluate the status of business organization.
5.	The researcher participated and certified from different workshop such as on Proposal Writing, Clustering, Industry Week, University Industry Linkage, E – Waste And Incubation Center.
6.	The researcher has worked in Africa Investor Survey of 2009/10 as enumerator.
7.	A number of seminars had been attained in Politechnico Di Torino, Italy during the short stayed period.

Annex VI

Questionnaires

1. Questionnaire to Higher Education Institutions

Part I: Personal information

Name of the Institution ____

Title: (Ex: Graduate assistant, lecturer) __________________________

Position: ______________________ Years of experience: ______

Part II: Questionnaires

1. In what areas do you see your higher education institute is making the greatest contribution to economic development? (Please tick (√) all those appropriate and indicate which the top three are)?

	Appropriate	Top Three
1.1 Access to education	☐	☐
1.2 Graduate retention in local region	☐	☐
1.3 Technology (knowledge)transfer	☐	☐
1.4 Supporting micro & small enterprises	☐	☐
1.5 Attracting inward investment to region	☐	☐
1.6 Research collaboration with industry	☐	☐
1.7 Strategic analysis of regional economy	☐	☐
1.8 Support for community development	☐	☐
1.9 Developing local partnerships	☐	☐
1.10 Management development	☐	☐
1.11 Meeting regional skills needs	☐	☐
1.12 Meeting national skills needs	☐	☐

2. In the table below, there are lists of possible problems related to Technology Transfer. Please show your choice by putting a mark (√) in the cells available. The options appear as: - SA (strongly Agree), A (Agree), NS (Not Sure), DA (Disagree) and SDA (Strongly Disagree). What do you think are the problems towards working with research activities as a means of technology transfer in your institutions?

	Descriptions	SA	A	NS	DA	SDA
2.1	High intake of students					
2.2	Awareness of staffs about research and technology transfer					
2.3	Shortage of budgets or funds					
2.4	Paper work related to research fund acquisition and processing					
2.5	Capacity and capability of institutions in carrying out research activities					
2.6	Absence of technology transfer offices that facilitate research collaboration					

2.7	More emphasis is given for teaching activities					
2.8	Absence of clear policies and procedures related to innovation and intellectual property right in the institutions					
2.9	Student performance is highly rated based on written exams					
2.10	Previous research outcomes are not properly disseminated throughout the institution and to other organizations					

If there are other points you think are important to be included, please mention here ……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………

3. How are the workshops, laboratories, machine shops etc usually monitored and managed in your institutions? Who actually handle the practical sessions?

By Technical assistant (Diploma holders) ☐
By Graduate assistant ☐
By Assistant lecturers ☐
By Lecturers and above ☐

4. How do you rate the performance of your institutions with the following activities?

	Descriptions	Excellent	Very good	Good	Weak	No comment
4.1	Teaching and learning process					
4.2	Research and publication					
4.3	Public service					
4.4	Collaboration with industries					
4.5	Collaboration with micro & small scale industries					
4.6	Collaboration with other organizations (university, research institute etc)					
4.7	Information of students after graduation (their whereabouts)					
4.8	Establishing business as a result of research findings in your institutions (spin off)					
4.9	Utilization of resources in workshops, laboratories, etc					
4.10	Generating funds through institutional consultancy					

Any comments
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………

THANK YOU

2. Questionnaires to Research Institutions

Part I: Personal information

Name of the Institution ______________________________________

Title: (Mr, Dr, senior researcher etc) ______________________________

Position: ___________________________ Years of experience: ______

Part II: Questionnaires

1. In what areas do you see your research institute is making the greatest contribution to economic development (please tick (√) all those appropriate and indicate which are the top three)?

		Appropriate	Top Three
1.1	Innovation and Adopting new technology	☐	☐
1.2	Technology (knowledge)transfer	☐	☐
1.3	Supporting micro & small enterprises	☐	☐
1.4	Attracting inward investment to region	☐	☐
1.5	Research collaboration with industry	☐	☐
1.6	Strategic analysis of regional economy	☐	☐
1.7	Support for community development	☐	☐
1.8	Developing local partnerships	☐	☐
1.9	Meeting national skill needs	☐	☐

2. In the table below, there are lists of possible problems related to Technology Transfer. Please show your choice by putting a mark (√) in the cells available. The options appear as: - SA (strongly Agree), A (Agree), NS (Not Sure), DA (Disagree) and SDA (Strongly Disagree) What do you think are the problems towards working with research activities as a means of technology transfer in your institutions?

	Descriptions	SA	A	NS	DA	SDA
2.1	Lack of appropriate technology needs assessment					
2.2	Awareness of staffs about research and technology transfer					
2.3	Shortage of budgets or funds					
2.4	Paper work related to research fund acquisition and processing					
2.5	Capacity and capability of institutions in carrying out research activities					
2.6	Absence of technology transfer offices that facilitate research collaboration					
2.7	Research outcomes are not properly implemented as per the findings					
2.8	Absence of clear policies and procedures related to innovation and intellectual property right in the institutions					
2.9	Turnover of researches for different reasons					
2.10	research outcomes are not properly disseminated to the end user					
2.11	Weak interaction with other partners (university, industry, etc)					

3. How do you rate the performance of your institutions with the following activities?

Descriptions		Excellent	Very Good	Good	weak	No comment
3.1	Research collaboration with industries					
3.2	Research and publication					
3.3	Fund raising through institutional consultancy					
3.4	Collaboration with micro & small scale industries					
3.5	Collaboration with other organizations (university, research institute etc)					
3.6	Patent filling and grant					
3.7	Establishing business as a result of research findings in your institutions (spin off)					
3.8	Generating funds through consulting as an institutional activity					
3.9	Updating research capability of staffs through further training					
3.10	Benchmarking from other research institutes					
3.11	Carrying out well organized technology needs assessment					
3.12	Assessment if a technology has been properly transferred (successful transfer of technology) as per the plan? if not taking corrective actions					

Any comments
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……….

3. Questionnaire to basic metal and engineering industries

A. Profile of the Respondent

Your Position in the Company :--------------------------------
Experience in Years :--------------------------------
Level of Education :-------------------------------

B. Introductory Questions

1. Among the total employees in your industry (100 %), roughly what percent of them have Technical and Engineering background at ;
   1. Masters level ------------------------
   2. B.Sc level ------------------------
   3. College Diploma and TVET level -----------------------
2. How do you rate your capital equipments and production processes modernity in comparison with available processes and technologies in the developed world?
   - Extremely outdated
   - Highly outdated
   - Outdated
   - Slightly outdated
   - Latest Technology
3. If you believe that your capital equipments and production processes' are old and unsuitable, please give us some reasons why it is difficult for your company to upgrade your capital equipments and processes to the latest technologies available in the foreign market? e.g. lack of finance , management commitment
   1. ---
   2. ---
4. How do you rate the awareness level of the top management and senior engineers in your company in knowing the basics and the importance of technology transfer to enhance the company's performance or in a broader sense for our country to catch up the developed world in science and technology?
   - Extremely Aware
   - Highly Aware
   - Aware
   - Slightly Aware
   - Almost there is no any awareness

   If the awareness level is weak, what do you think as a main reason for that?
   - Lack of basic training on the subject matter
   - Low level of education both at technical and managerial level
   - Shortage of information on Technology Transfer
   - Others, please specify -------------------------

C. Industry- Industry Collaboration

5. How do you see the importance of your company for other similar or complementary industries in serving as a hub or as a source of technological knowhow far from the direct contribution of your products and services?

    - Extremely Valuable
    - Highly Valuable
    - Valuable
    - Slightly valuable
    - Doesn't have much importance

If you believe that it is important for others, please give us the technological contributions which your company made towards other companies

1.---
2.---

6. How do you evaluate the collaboration of Ethiopian firms in sharing technological software and hardware for mutual benefit out of the usual rough competition?

    - Excellent level of collaboration
    - Very good collaboration
    - Fair
    - Limited collaboration
    - Extremely poor

If your level of collaboration is limited, what a reason could you forward as a major constraint (e.g. culture, lack of trust, etc)?

1.--
2.--

D. Industry - Institution Linkage

7. How do you assess the effectiveness of the different institutes in Ethiopia (e.g. GiZ, JAICA, ECBP,UNIDO etc)which specifically work with the objective to upgrade the nations technological capability ?

    - Extremely efficient
    - Highly efficient
    - Efficient
    - Slightly efficient
    - Not efficient at all

If you are not satisfied with these institutions, what do you think should be done to get things in the right order?

1.------------------------------------
2.------------------------------------

8. Do you collaborate with higher institutions in a way to get technical assistance from them or to share what you have to these groups of people? ☐ Yes ☐ No

    i. If your answer is "No" please give a reason why you don't make any noticeable collaboration so far.

    1.--
    2.--

ii. If "yes" how do you understand your level of collaboration

- Excellent level of collaboration
- Very good collaboration
- Fair level of collaboration
- Limited collaboration
- Almost no collaboration

iii. Besides this, how do you rate the problem solving nature of your collaboration?

- Extremely helpful
- Very helpful
- Helpful
- Slightly helpful
- Almost helpless

9. How do you evaluate young graduates from engineering universities and technical colleges in satisfying your needs and their capability to encounter challenging tasks?

- Extremely efficient
- Highly efficient
- Efficient
- Slightly efficient
- Not efficient at all

If you are not satisfied with them, what a recommendation could you made to get young graduates capable of solving present and future problems of the industry?

1.-------------------------------------

2.-------------------------------------

10. Do you have a new product or process which is developed in association with academicians, postgraduate student, or graduating class students at the university?

- Yes
- No

If "No" , please give a reason why you failed to get in touch with these group of people,

- Lack of faith on these group of people
- They are inaccessible or poor university-Industry linkage
- Others ,please specify ------------------------

E. Level of Local Technological Capability

11. Technological capability could be defined as the ability to make effective use of imported technologies, ability to maintain, capability to design and manufacture spare parts etc, in this context, how do you understand your companies capability to use imported technologies at full extent or without any technological difficulty to use the imported technology?

- Extremely efficient
- Highly efficient
- Efficient
- Slightly efficient
- Not efficient at all

If there is a difficulty to use imported technology, what do you think as a cause for the problem?

1.-------------------------------------

2.-------------------------------------

12. How do you rate the flexibility and capacity of your company to adopt itself to the changing nature of products & services in the global market which in turn needs some sort of adjustment at your company shop floor ?

 Extremely flexible Slightly flexible
 Highly flexible Totally unable to change products and processes
 Flexible

If your flexibility is too low , please forward the main reasons for that ,

1.-------------------------------------
2.-------------------------------------

13. The locals technological capability to absorb, improve, emit and re-sell the once transferred technology is sometimes referred as the matured state of technology transfer , in this context how do you rate your capacity to re-sell or modify the once acquired technology?

 Extremely capable Slightly capable
 Highly capable Totally unable
 Capable

If it is difficult for your company to re-sell or modify the once acquired technology, please give us the main obstacles to do such activities (e.g. technical difficulty , copy right issues , or others)

1.---
2.---

F. Level of Reverse-Engineering in Ethiopia

14. Do you use any modified (Modefic) product or equipment which is designed and manufactured by Ethiopians? Yes No

If "yes "how do you rate the locals ability to participate in reverse engineering?

 Extremely capable Slightly capable
 Highly capable Totally unable to participate in RE
 Capable

15. The number of legal patents awarded and the type of their invention or discovery could often to be used as an indication on the scale of local technological capability, in this regard, does your company or any one on your company claimed or filed a patent at the Ethiopian Science and Technology Agency or somewhere abroad?

 Yes No

G. Management Commitment and Technology Transfer

16. The management could sometimes take the blame for the stagnation of the industry (industrial growth), in this sense, how do you rate the role of the management in your industry:
    a. The management's effort to achieve latest technological hardware's and process knowhow despite constraints
    - Excellent
    - Very good
    - Good
    - Fair
    - Poor

    b. The support and determination of the management to solve spare part and capital goods problem through Reverse Engineering?
    - Extremely determined
    - Highly determined
    - Determined
    - Slightly determined
    - No effort and interest at all

    c. The management's effort to establish and fund research and development activities
    - Excellent
    - Very good
    - Good
    - Fair
    - Poor

    d. The helpfulness and insightfulness of the management to encourage young engineers and technologists to RE
    - Extremely helpful and insightful
    - Highly helpful and insightful
    - Helpful and insightful
    - Slightly helpful and insightful
    - No vision

H. Level of Training and RD Activities in the Industry

17. Have you ever hired temporarily or permanently a foreign national as a trainer or consultant , just ooking for a technical assistance? Yes No
    If 'yes' how do you express the importance and the efficiency of foreign nationals as a means to transfer foreign technology to Ethiopians?
    - Extremely efficient
    - Highly efficient
    - Efficient
    - Slightly efficient
    - Not efficient at all

18. Do you arrange training programs to your employees both internally and externally to upgrade their technical skill?

Yes No

If "yes" , please list out the type of trainings conducted in the past with the objective to upgrade the technological capability of your staffs.

1.-------------------------------------

2.-------------------------------------

19. Do you have a research and development activity in your company or industry?

 Yes No

If "yes", how do you understand the outcomes of these research and development activities

 Extremely Valuable Slightly valuable
 Highly Valuable Not valuable
 Valuable

Roughly what percent of your revenues you spent on activities related to these? -----

20. Does your company ever hired an employee who have been working on another similar industry with the intention to know the working knowhow of the rival firm? Yes No
21. Do you know someone who left your company and established or join a rival firm (similar) to yours which you consider as a major flow of technological knowhow from your company to others? Yes No

I. Government Policy and Technology Transfer

22. How do you measure the government's effort in assuring the participation of local engineers and technicians during the implementation of technology intensive projects and industries in association with foreign firms with the objective to build local technological capability?

 Extremely efficient Slightly efficient
 Highly efficient Not efficient at all
 Efficient

If the level of participation is low, what do think should be implemented to boast the level of participation?

1.-------------------------------------
2.-------------------------------------

23. How do you understand the technical and economic incentives available in particular to industries that have the potential to make critical and major contributions to technology transfer to the country (High tech industries)?

 Extremely encouraging Slightly encouraging
 Highly encouraging Not attractive
 Encouraging

24. What is your view of the national policy in association with engineering capacity building program, TVET program , the 70-30 school enrollment scheme, etc in facilitating the desired technological capacity building process?

 Extremely optimist Slightly optimist
 Highly Optimist Don't think as a solution
 Optimist

25. How do you see the idea of clustering engineering industries with the objective to establish a cooperative and collaborative partnership between similar industries and key stake-holders with the objective of enhancing technology transfer?
    - Extremely optimist
    - Slightly optimist
    - Highly Optimist
    - Don't think as a solution
    - Optimist

J. Intellectual Property Rights and Technology Transfer

26. Intellectual property rights could be viewed both as barriers and facilitators for technology transfer , in this regard how do you see the importance of the availability of strong intellectual property rights in our country to foster technology transfer activities by:

    a. Encouraging local innovators to participate in research and development activities
    - Extremely Encouraging
    - Slightly encouraging
    - Highly Encouraging
    - Not valuable
    - Encouraging

    b. Encouraging foreign firms to go to licensing or selling their technology to firms in Ethiopia
    - Extremely Encouraging
    - Slightly encouraging
    - Highly Encouraging
    - Not valuable
    - Encouraging

K. Availability of Foreign Technology

27. How do you understand the helpfulness and the openness of the developed world in sharing their valuable knowledge and technology:

    a. At a reasonable price ?
    - Extremely expensive
    - Slightly expensive
    - Highly expensive
    - Fair

    b. With a limited bureaucracy?
    - Extremely Bureaucratic
    - Slightly bureaucratic
    - Highly Bureaucratic
    - Almost there is no bureaucracy
    - Bureaucratic

L. Technology Transfer Evaluation and the Presence of Relevant Organizations

28. How do you evaluate the presence of relevant organizations , institutions and agencies to participate on technological needs assessment and identification of the enabling environments of a given technology before any transfer attempt at the national level made?

- Extremely available
- Slightly available
- Highly available
- Totally no institution in the area
- Available

29. Sometimes it is necessary that , the growth and expansion direction of firms to be compatible with the nations economical ,social , political , and environmental policy. In this regard, how do you rate your intended technology transfer initiatives with respect to the government's industry policy ?

- Extremely compatible
- Slightly compatible
- Highly compatible
- Not compatible at all
- Compatible

30. Technology transfer could be conducted in different ways (turn key projects, international technology co-operation, joint ventures, hiring technical assistant , training employees abroad, trade in goods , reverse engineering etc) .Which mode technology of technology transfer have you used at time of your major investments?

1.--
2.--
3.--
4.--

31. Technology transfer is usually done through different steps , from the technology need identification to the adoption stage, in this regard, do you assess alternative technologies available on the market based on their reliability from the point of environmental soundness, economical importance, and their overall social impact? ☐ Yes ☐ No

If "yes" how do you rate the successfulness of your previous pre-assessment works?

- Extremely Successful
- Slightly successful
- Highly Successful
- Almost a failure

32. If you evaluate transferred technologies on the bases of their output, what is your objective of doing that?

- To provide accountability
- To facilitate the process of technology transfer in the future
- To demonstrate the usefulness or the effectiveness of the transferred technology
- Other:-----------------------------------

L. Concluding Remark

33. Most technologies imported in the past with the country's limited resources are stagnant to be adopted, improved, re- engineered, and disseminated to other similar industries for one or more reasons , in your side , what do you think is the main problem of Ethiopian industries to build up their technological capability ?

1.---------------------------------------
2.---------------------------------------
3.---------------------------------------

. we are exceptionally grateful for your co-operation .