Advancing Technology Transfer for Sustainable Development

ECA

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Abbreviations

AAU..... Addis Ababa University
AfCFTA ..... African Continental Free Trade Area
ALLPI ..... African Leather and Leather Products Institute
CEO .....Chief Executive Officer
CSIR .....Council of Scientific and Industrial Research
EBTI .....Ethiopian Biotechnology Institute
ELICO .....Ethio Leather Industry PLC
ELIDI .....Ethiopian Leather Industry Development Institute
ESSS ..... Ethiopian Space Science Society
ESSTI .....Ethiopian Space Science and Technology Institute
ESTA .....Ethiopian Science and Technology Agency
ESTC..... Ethiopian Science and Technology Commission
ETB..... Ethiopian Birr
EthERNet..... Ethiopian Education and Research Network
FDRE.....Federal Democratic Republic of Ethiopia
FT.....Full time
GoE.....Government of Ethiopia
GPS .....Global Positioning System
IGSSA .....Institute of Geophysics, Space Science and Astronomy
LIDI .....Leather Industry Development Institute
ME.....Monitoring and Evaluation
MIDI .....Metals Industry Development Institute
MINT..... Ministry of Innovation and Technology
MoSHE.....Ministry of Science and Higher education
MoST..... Ministry of Science and Technology
MPL .....Multi-Crew Pilot License
MRO .....Maintenance and Repair Overhaul
RECs ..... Regional Economic Communities
RTOs..... Research and Technology Organizations
SDGs..... Sustainable Development Goals
STI ..... Science Technology and Innovation
TT..... Technology Transfer
TWA .....Transcontinental and Western Airlines

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1. Introduction

1.1. Background and context of the project

An effective technology transfer is now recognized in every country as one of the pillar enabler of sustainable development. Regardless of broad barrier among developed and developing countries on technology development, acquisition and diffusion, technology plays an important role in national development. Accessing new and improved technologies is key to driving innovation and entrepreneurship, firm growth, economic performance, environmental well-being and social improvements. Most developing countries rely heavily on technologies developed abroad to meet their development needs that could be new seed breeding technologies for agriculture, digital technologies, renewable energy technologies or new vaccine production technologies. Countries at the technology frontiers discover and develop most of the technologies that the rest of the world use. As such, technologies are highly guarded by the owners and often protected by home countries. Technology is thus neither free to acquire or accessible to all that can afford to pay and use it. Home countries of technology developers and owners may control which technology may be available for sale or use by other countries.

Host countries may also take positions to pursue or prohibit a given technology in their borders. Host countries' firms and institutions face different barriers and opportunities in accessing and using technologies. Governments may ensure certain technologies are accessible to a limited number of firms or institutions (e.g., nuclear, digital, biotech etc) or available to all with limited controls. What is obvious, however, is that countries growing at a rapid rate generally register increased acquisition of technologies which they need to continuously grow and improve productivity and efficiency of their firms and institutions, and enhance delivery of services.

Technology transfer remains a key element of national competitiveness, global and regional agreements and the main reason ban to access technology could slow down development of the targeted countries' industries. The commitment to enable developing countries access technology through successful technology transfer mechanism is seen as key to enable them achieve competitiveness in trade, attain their development aspirations and meet global commitments such as those of Climate Change. The concluded High-Level Political Forum restated this desire: "*We will continue to strengthen the science-policy interface through evidence-based policymaking, support for research and development, particularly harnessing science, technology and innovation, promoting voluntary technology transfer on mutually agreed terms, leveraging technologies to promote inclusive digital economy and connectivity and build resilience across sectors.*" Similar statements are noted in the various multilateral environmental, cooperation and trade agreements (e.g. those of WTO, WHO, Montreal Protocol, Paris Agreement, 2030 Agenda and Agenda 2063 as well as almost all Regional Economic Communities (RECs).

In developing countries technology transfer is still at the early stage relative to global best practices and has not adequately enabled the developing countries' international competitiveness. With global emerging trends and international commitments such as globalization, the development of technological innovation solutions, climate change, acceleration of digital transformation and industry 4.0, rapid innovation and businesses afloat, change in work habits and workplace, as well as covid-19 impacted countries' technology acquisition, provision and diffusion ecosystem. Moreover,

developing countries are not able to keep pace with rapidly changing wide global trends that necessitates and inviting more opportunities and challenges to research and technology organizations (RTOs). In this regard, technology transfer plays a critical role to harness full potential of using, creating, upgrading, and diffusing technologies.

In developing and developed countries, the RTOs play the lead role in research and development, innovation and they closely work with industries to translate new outputs into markets as well as craft innovative business models. However, the developing countries RTOs and industries has not yet made strong inroads into technology transfer in various. There are various factors related to technical and organizational attributes that highlight the key constraints impeding RTOs technology transfer and also there is a pressing need to suggest pathways to resolve these challenges.

2. Description of the study

This study focused on preferred modes and channels of technology acquisition by Ethiopian RTOs, the impact of technology transfer at firm-level and the government support measures that RTOs found helpful or encouraged technology transfer practice both from abroad and within the country. It looked at both market and non-market-based technology transfer processes and possible mode of technology transfer. Further, it reviewed national policies, strategies and incentives that encouraged technology acquisition or diffusion and the role that academia and RTOs played.

The main objective of this study was to identify potential areas that enable country better target its efforts to achieve the desired outcomes and areas that may be neglected but are key to achieving sustainable development in Ethiopia.

The study covered a wide range of activities focusing on the surveys of firms, RTOs, included multiple case studies, and desk review of national policies, strategies, literature and assessment of measures that may encourage firms to acquire technology. The appropriate methodologies for data collection were designed for both qualitative and quantitative data.

2.1. Ethiopian Science Technology and Innovation (STI) Landscape

Ethiopia has been exerting effort to harness the potential of science and technology, by formulating science, technology and innovation policies that aimed to promote sustainable development in the country at different times. Indeed, the history of government of Ethiopia (GoE) initiative on science and technology goes back to 1960s that milestones the establishment of Academy of Science. Formally, Science and Technology initiative institutionalized and commenced in 1975 through a Proclamation No. 62/1975 that set out the start of a Ethiopian Science and Technology Commission (ESTC) with planning, coordinating, developing, promoting, selecting and approving research activities mandates. In March 1994 with the issuance of the new economic policy ESTC was re-institutionalized by Proclamation No.91/94 with the objective to encourage, enhance and support science and technology activities that enable the rea1ization of the country's socioeconomic development objectives. A year later in 1995 the commission was restructured as the Ethiopian Science and Technology Agency (ESTA).

Ahead of the first 1993 Science and Technology (S&T) policy formulation an assessment conducted on the inducing of S&T, thus identified that there was lack of a clearly articulated S&T policy in Ethiopia. As a result, this was handicapped S&T endowment to the national growth and development in which the contexts were characterized by unnecessary duplication of efforts and continued dependency on foreign technology.

Ethiopia's first Science and Technology policy was released in December, 1993 [1][3] with the comprehensive objectives to building national S&T capability and making effective and efficient use of Technology for the realization of the country's socioeconomic development goals. At the same time, it was envisioned to reduce the level of dependency on foreign technology to increase the supply of locally required technology, the development of a planned technical infrastructure and skilled human capital to build the country's S&T capability, as well as to enhance their contribution to national economic development. The Ethiopian S&T landscape reformation spans

to the recent reshaping of RTOs such Ministry offices, research institutions and research centers that lead up to repealed them. Cognizant to the aforementioned, in the advancement process the abundance of science and technology is highly noted for sustainable development in the journey of Ethiopia to becoming a middle-income country by 2025.

2.1.1. Ethiopia's Science and Technology Policies and Strategies Priorities

Even though, the intent of the government is to promote balanced and integrated development, Ethiopia's S&T policies prioritized the basic and urgent problems of the citizens that positioned agriculture sector in the first place. Ethiopia's S&T policies also considered other sectoral policies and intervention to be formulated by taking it as an umbrella document.

In October 2006 ESTA publicized the revised STI policy with its intervention strategy. The policy is developed by revising the prior themes with the intuition that the 1993 S&T policy was not followed by detail implementation strategies and recognized to overcome the alignment gap between the national development plan and the S&T policy. The major outlined reasons for revising the policy were, there is a strong need to create national STI capability to benefit from the opportunities of the global advancement and rapid national changes in socio-economy, scientific knowledge and technology by RTOs within the national innovation system, and the existing STI was characterized by fragmented and uneconomic use of limited resources.

The revision of policy was based on the assessment of the prevailing STI situation of the country and the directions of the various sectoral policies, also took into consideration the Millennium Development Goals as well as the Science and Technology Programmes of the African Union Commission (AUC) and the New Partnership for Africa's Development (NEPAD). The revised policy outlined directives such as, ensuring adequate fund to build up STI capability, establishing a functional organizational structure for scientific and technological activities, strengthening of national capability for the development of indigenous technology, establishing and/or strengthening S&T institutes, R&D centers and whereas each directive followed by intervention strategies.

In order to achieve objectives and stated directives the policy aligned priorities to STI activities in the various sectoral and cross-cutting areas with the intuition that specific policies and programmes to be formulated by the respective sectors on the basis of national S&T policy as umbrella.

For a long period of time Ethiopia adopted a national economic policy that mainly focuses on realizing the Agricultural Development Led Industrialization (ADLI). As of October 2010 Ethiopian government disclosed the STI policy replacing the prior National S&T policy. The revised S&T policy envisioned to see Ethiopia undertaking coherent science and technology initiatives which eventually lead the country to begin developing and exporting its own technologies by the year 2025. Morever, contemporary proceedings such as safety in the generation and application of S&T, intellectual property rights, and national quality standards are addressed [4].

2.1.2. Ethiopia's STI Policy and Technology Transfer

Among of the critical policy issues addressed in 2010 STI policy the Technology Transfer (TT) is the top subject matter inscribed in the policy. The policy's TT direction proclaims TT in Ethiopia has to took place primarily by upgrading foreign technologies that are demanded by the domestic economy. It is recognized that, there is lack of systematic TT and weak technological capability for the effective absorption of foreign technologies. Accordingly, to tackle these hurdles the technology transfer intervention strategies were formulated to increase national technological capabilities. Subsequently, the priority programs are set to implement the policy through joint efforts of the various actors. The policy stressed the coherent need of S&T infrastructure, government research institutes, and cataloged essential national laboratories. The prioritized technology transfer strategies are:

- Import effective and appropriate foreign technologies and create capabilities of adaptation and utilization of these technologies in manufacturing and service providing enterprises;
- Establish and implement a system to search, select, adapt, utilize as well as dispose imported technologies;
- Establish and implement a system to use foreign direct investment and other ways of supporting technology transfer;
- Strengthen technology transfer among and between various manufacturing and service providing enterprises;
- Strengthen wide use of intellectual propriety, standards and other related information in support of technology transfer.

Ethiopia's STI policies priorities are aligned with continental Science Technology and Innovation Strategy of Africa and United Nation Sustainable Development Goals (SDGs), extensively continental initiatives and international commitment such as AfCFTA, climate change. As a national framework, the Ethiopia's STI policies acknowledge the role of technology in responding to the emerging needs of the country and aimed at enhancing the development of science and technology in Ethiopia. The policies also recognized the importance of science and technology in ensuring Ethiopia's future growth but, in particular, its ambition of becoming a middle-income country by 2025.

2.1.3. Research and Technology Organizations (RTOs) Landscape

After the progressive restructuring of the ESTC and ESTA resulted to the Ministry of Science and Technology (MoST) establishment in 2008 that became the top government S&T ministry for regulating, coordinating, supporting and encouraging science and technology activities. As part of national and political transformation MoST re-organized to Ministry of Innovation and Technology (MINT) in 2018 according to the Proclamation No.1097/2018 with powers and duties to prepare overall national innovation and technology R&D programs.

On the other hand, the Ministry of Science and Higher Education (MoSHE) is another science and technology actor established by proclamation 1097/2018 in October 2018. After nearly three years, MoSHE was repealed whereas Ministry of Education re-instituted to its long term historical responsibility, roles and privileges for all levels of education and RTOs in the country. Despite there are other Ministries get involved

in science and technology activities the mutual prevalent responsibilities of both MoE and MINT is to facilitate collaboration among the government, research institutes, and industries and to oversee R&D in the field of science, technology and innovation.

Cognizant to the above, following the study of Ethiopian Universities strategic location, center of excellencies and other countries experience Ethiopia's public universities are classified into four categories namely research, applied science, general and specialized institutions. The master plan and objective is to increase the quality of education system that helps Ethiopia's ongoing effort and to elevate Universities' excellencies. The classification targeted to produce the human capital that fulfill demand of manufacturing sector, to enhance research and development, to haul up STI.

Ethiopia had gone through historical research centers and research institutes establishment that goes back to 1960s and 1970s, for instance the establishment of Institute of Pathobiology, by the late Professor Aklilu Lemma in 1966 under the Addis Ababa University (AAU), the Armauer Hansen Research Institute founded in 1970 through the initiative of the Norwegian and Swedish organizations, Forestry Research Center in 1975 and Wood Utilization Research Center in 1979. Indeed, the Ethiopian RTOs reformation continued to the recent years, for instance the Proclamation No.1263/2021 that publicized as of 25th January, 2022 defined and repealed powers and duties of various RTOs and executive organs of Ethiopia. The Figure 1, exhibits the top progression of Ethiopia's STI policies and stakeholders are intended to help government bodies and private firms, R&D institutions in their respective S&T activities.

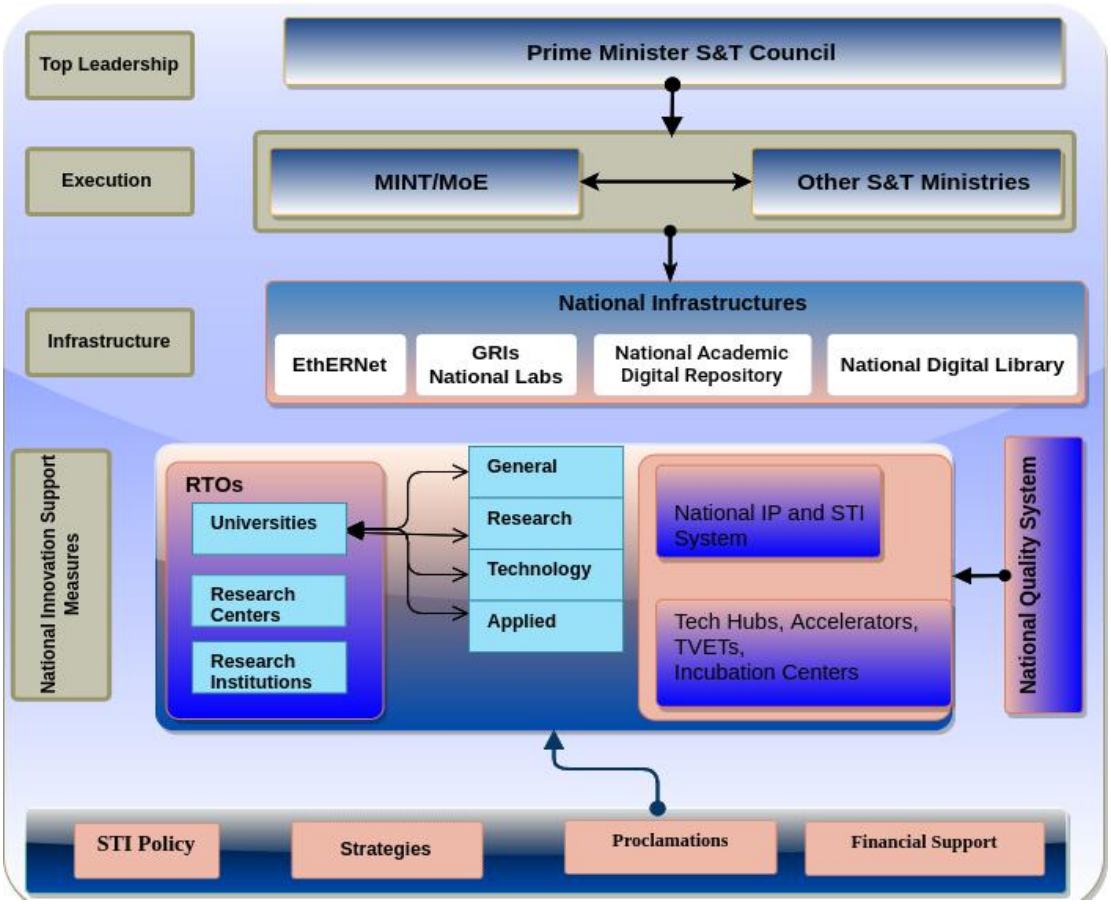

Figure 1: Ethiopian RTOs Landscape and National Innovation System

2.1.4. Literature Review on Technology Transfer

Technology transfer is the movement of new knowledge, discoveries, transferring skills, knowledge created by creators to end user that can be government or business, with aim to support and create new goods and/or services, for which the creator receives an agreed return [19]. In global arena RTOs are coming under a surge constraint to produce impactful technologies for societal benefit that contributes to socio-economic development.

On another hand, firms need strategic ways of exploiting technological products or services for continuous competitive profit margin. For internal exploitation of technological assets, firms can apply drafting, designing, developing, manufacturing, deploying, and commercializing products or services whereas they can use external exploitation approach through technology transfer via diversified joint collaboration models [5]. Finally, purchasing and installing in demand technologies are only a small amount of efforts of technology transfer process.

A) Technology Transfer Models and Methods of Inquiry

Firms can acquire technology either through research and development or by getting already developed technology using technology transfer modality. It is pertinent to note that technology transfer is not a simple process rather it involve multitudinous staged processes and mechanisms. These include searching and identifying appropriate new technologies, evaluation, protecting technologies, marketing and licensing. Further, the stages for technology transfer can cover evaluation of know-how and technical expertise within the beneficiary firm, the capability of firms to own acquired technology specification and lease of technology elements along with technical cooperation arrangement for sustainable functioning of the technology. This can be achieved via a continuous process that needs prolonged engagement between the parties based on the extent of complexity. The engagement affects the lifetime of the acquired technology either to die or grow in consequence. Most of the time unsubstantiated or doubtful technologies can fade into obsolescence quickly. As twenty first century there are convincing arguments that suggest that instead of gradual process of technology transfer there is a need for strategic leapfrogging by the consuming firms to enable them to catch up dynamic behaviour of technology and innovation.

B) Technology Transfer Process

The process of transferring technology is long process and based on the agreement of parties from one entity to other for the purpose of further development or commercialization that permits the flow of technology from an owner to a beneficiary. Technology transfer process can be arranged based on contexts such as formal licensing or donation of technology to end users that can be achieved across set of stepwise activities, actions and procedures shown in figure 2 here below.

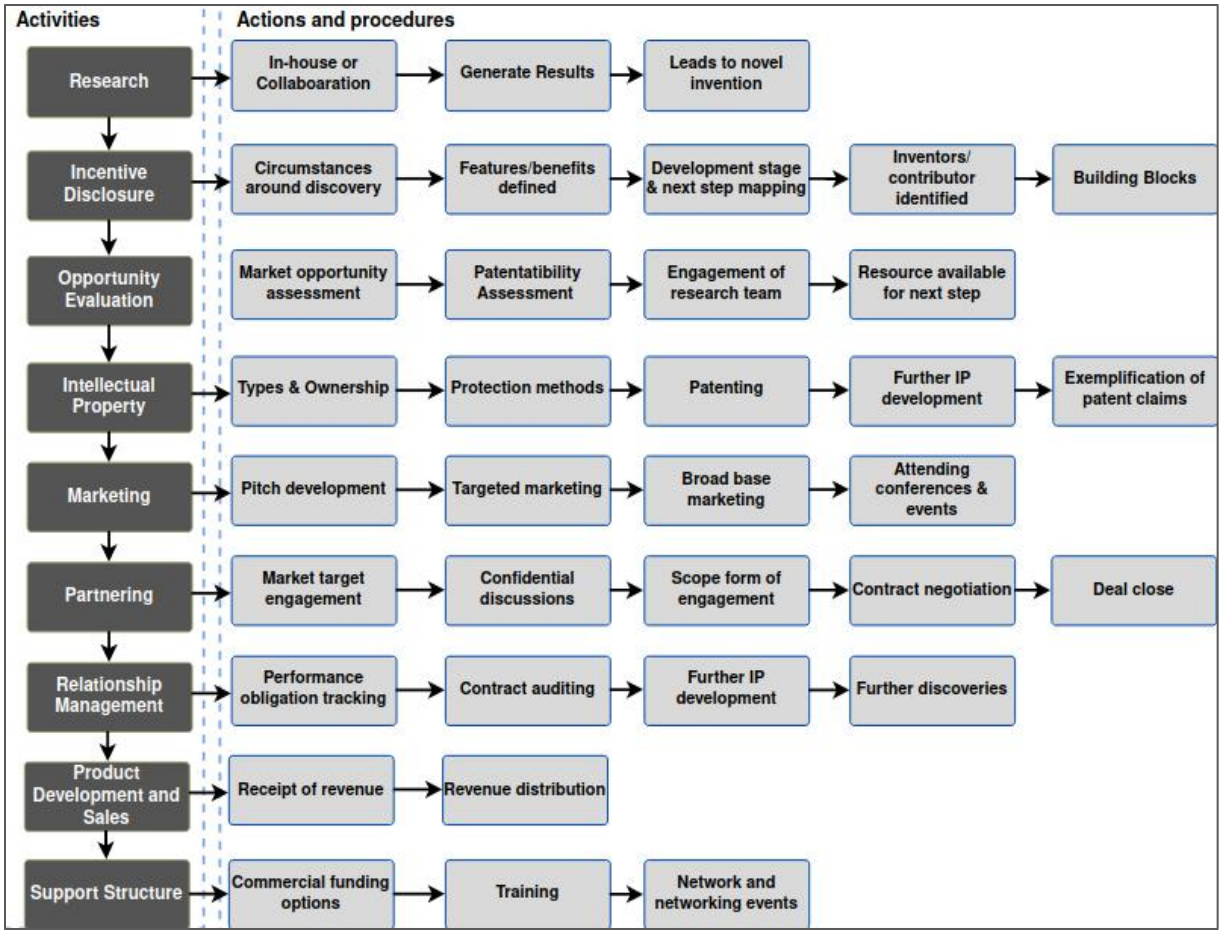

Figure 2: Overview of the technology transfer process activities and actions [20]

C) Technology Transfer Cost

For either multinational or domestic TT that can be product or process it is common to deduce that the cost of technology transferring to other firm is much less compared to the average cost of original R&D. At the same time, the considerable attributes of TT cost covers both the transmission and absorption costs. It is pointed out [6] that the cost of TT fall into four (4) categories. The first one is the cost of pre-engineering technological information exchanges which covers to expose the basic characteristics and theoretical insights of the technology. The second category costs included the engineering design costs and the associated process. The third is the R&D costs associated with solving unexpected problems and adapting the technology. The last category costs are the pre-production training costs and the operating skill and knowledge transfer cost. Further, the last category cost could include the cost of debugging, testing, maintenance, performance tuning and extra supervisory costs.

D) Channels of Technology Transfer

The possible TT channels can occur through trade in products, trade in knowledge that involve export has some potential for transmitting technological information wherefore on the import side through imported capital goods and technological inputs [7]. The second TT channel is foreign direct investment that comprises the investment of multinational firm to transfer technological information to their subsidiaries in other country, in due course this discloses technological information into the hosting country. Finally, intra-national and international movement of experts is another way of TT, this may occur within firms, among joint ventures, or between unrelated firms.

3. Methodology

3.1. Study Setting and Design

In order to study the technology transfer ecosystem and conduct the work packages of the assignment, appropriate methodology was required which involved framing the target population of the study, determining the sampling technique, deciding on sample size, identifying the types of data to be collected, preparing and validating data collection instruments, identifying the data analysis techniques, etc. Specifically, the methodology focused on how to approaches the **three communities** work packages of the assignment

1) Firm level practices on technology transfer,
2) Practices of academia and RTOs on diffusion of publicly funded technologies and,
3) Public sector support for technology acquisition by firms and other institutions.

Accordingly, desk review, primary research and data gathering with regard to advancing technology transfer were undertaken. The study employed both quantitative and qualitative data collection methods to gather information from key technology actors. It also assessed the human qualities required in terms of competencies and knowledge with regard to technology transfer, practices and measures and global emerging trends that assess technology transfer activities.

3.1.1. Sampling Method for quantitative approach

For purpose of this assignment there were various considered actors in technology transfer ecosystem such as firms, Universities, and intermediaries (i.e. technology hubs, accelerators, incubators, parks, industry zones, clusters, funders). In order to gather quantitative data purposive sampling technique used to enable selecting elements from the population based on the purpose of the study with the objective to capture the best use cases. Purposive sampling was used to highlight a specific category of the Universities, RTOs, firms and others. Thus, this technique was selected for this study because it ensures the fair presence of the population from each category and specialization areas, even helped to decide the rational sample size. The main intuition of applying this techniques is to produce a sample that can be logically be representative of aforementioned targets.

3.1.2. Sampling Frame

The purpose of a sample frame was to create a clear list that enables to target the representative sample of study. Based on the data collection, analysis and reporting duration given, it creates challenges of meeting deadline to exhaust the data collection from all Universities, RTOs, firms, unless additional manpower is deployed with additional cost. Hence, an option to determine sample size judgmentally and sampling technique purposively used as indicated in Table 1. Accordingly, the the sample frame was taken judgmentally 28 from RTOs (government Universities and research institutes), 29 from firms and intermediaries totaling a sample size of (n=57), and each of the participants selected purposively, based on those who have experience and fertile exposure in the technology transfer activities.

Table 1: Distribution of population and sample by category

Type of Business	**N1** RTOs	**N3** Firms & intermediaries	**Total sample**
RTOs and Firms	28	29	57

3.1.3. Sources of data

Variety of techniques was used to get both quantitative and qualitative data directly from the respondents. Quantitative tools offer statistically significant and therefore reasonably accurate as well as best for providing a picture of reality in the technology transfer landscape. However, qualitative information is not statistically significant and therefore might not yield an accurate picture of the whole assessment. On another note, qualitative information is most useful for gaining a depth of understanding about issues and it helps to understand what the technology transfer landscape looks as it does and interpret the trends. Finally, A case study on Universities, RTOs, firms has been made to bench mark technology transfer practices, incentives/investment and its management. In general, the data collection tools for this advancing technology transfer for sustainable development comprised document review, followed by a questionnaire survey, and case studies.

3.2. Document review and Multiple Case Studies

Proper assessment was made on important documents, policies, strategies, and researches related to the advancing technology transfer. An extensive review of different related documents also being conducted that focused on comprehending the current ecosystem of the technology transfer in Ethiopia. The review also included identifying and summarizing experiences and best practices of Universities, RTOs and firms practices on technology acquisition, development, and diffusion.

Moreover, the developed case studies from RTOs, firms and technology service provide are intended to explore best technology transfer practices and challenges whereas they are selected judgmentally based on best practices with the potential to be model.

3.3. Data collection procedures

The overall field activities guided by a standard data collection procedure with a broad set of actions implemented sequentially that covered physical distribution and field visit to respondent respective address and also reached via email as well as phone for questionnaire distribution and filling. The data collection procedure applied to ensure that the data collection conducted following acceptable ethical procedures.

4. Case Studies Analysis and Discussion

In order to facilitate the qualitative data analysis process topics are arranged into themes based on the data obtained from case studies, desk review, and analyzed the contents accordingly. For qualitative study key informant interview and multiple cases were developed. Accordingly, among of proposed methodologies with justifiable and purposeful criteria eight (8) cases were selected and appropriately analyzed. The multiple case studies were made on technology transfer topics that targeted technology transfer landscape, partnership, challenges, and experiences of the firms.

To develop the case studies the first criteria was focused on selecting RTOs who have fertile exposure and successful technology transfer experience. Secondly, focused to the biggest RTO who is global player with experience in technology transfer that could be bench-marked by other countries. It was emphasized that the selected cases provided comprehensive insight regarding experience they shared and how they successfully managed the technology transfer.

4.1. The Born of Ethiopian Airlines and Strategic Partnership

In the early years of independence and at juncture of African countries struggle against anti-colonialism, right after the Second World War, Ethiopia was the only independent African sovereign nation, and a founding member of the United Nations. The Ethiopian government, as part of a modernization initiative, committed to establishing a commercial airline to integrate the country politically and economically. In June 1945, the Ethiopian delegation attending the United Nations founding conference in New York met with US State Department representatives and requested technical assistance in establishing a commercial airline in Ethiopia, primarily for domestic flight with rational justification, economically feasible and cost-effective strategy because of the Ethiopia's rugged geography and mountainous terrain and inadequate or absence of roads and railways infrastructure. Subsequently, the US state department organized an initial meeting with Transcontinental and Western Airlines (TWA). As the result, the Ethiopian government signed a partnership agreement with TWA in September 1945, and the new airline was founded by a charter on December 26, 1945, with an authorized capital of ETB 2.5 million [9] divided in 25,000 shares that entirely financed and owned by Ethiopian government.

The Airline inaugurated its operation on 8 April 1946 and purchased five war-surplus aircraft on an domestic and international service that operated with American pilots, technicians, administrators and accountants, including American General Manager. However, the Airline was led by Ethiopian president and chairman [9,10].

The strategic agreement partnership with TWA was the important leapfrogging step in establishing a small domestic flights and later transforming it into a successful internationally operating airline. Including the commencement of the operation with TWA Ethiopian Airline has made five tailored partnership with TWA within thirty years to develop strategic technological capabilities, successful technology transfer and business competitiveness in the aviation industry (see Table 2).

Table 2: Ethiopian Airline and TWA agreements

Agreement	Year	Objective and content of agreement
First	1945	Partnership, established EAL, the procurement of aircraft and started full operation
Second	1953	Stated clearly the ultimate objective of Ethiopianization
Third	1959	Reinforced the urgency of the Ethiopianization agenda
Fourth	1966	Transferred management from TWA to EAL and appointed an Ethiopian deputy CEO
Fifth	1970	Shifted TWA's role from management to advisory until 1974

Partnership for Domestic Human Capital Development (Ethiopianization)

The agreement of 1945 gave TWA full authority to establish and manage the new airline that helped the Ethiopian Airlines to lay foundation to build internal capacity. The agreement between TWA and Ethiopian Airline foreshadowed arrangements such as TWA to take responsibility for selecting and procuring all aircraft and the technology needed to start an aviation industry. To successfully manage purchased technologies and aircraft through technology transfer packages TWA provided advisory services for all training and technical Aviation technology facilities established in Ethiopia [9]. In the second agreement of 1953 the Ethiopianization policy to handover the technology and operation was formalized, which stated, 'The ultimate aim is that Ethiopian Airlines shall eventually be operated by Ethiopian staff and TWA knowledge transfer built local capacity thus Ethiopians gradually took over posts held by foreigner. Almost after fourteen years, the third agreement in 1959 reinforced the localization of expertise, while the fourth in 1966 marked a major milestone, transferring management and appointing the first deputy Ethiopian CEO in November 1971. The fifth agreement in 1970 articulated the shift of TWA's role from operating and managing to advising. The partnership ended after thirty years in 1975 when TWA found the venture less attractive and continued to provide services to Ethiopian Airline on request [9].

Strategic institutionalized technology transfer for self sufficiency

For nearly eight decades, Ethiopian Airline has been a pioneer of African aviation as an aircraft technology leader and most profitable airline in Africa. From its establishment Ethiopian Airlines is well known with its effective strategy and currently implementing a 15-year strategic plan of 2025 that envisioned to become the leading airline group in Africa with seven strategic business units and almost achieved its vision ahead of 2025. Besides its strategic business units the Airline has various strategic institutions under its umbrella such as Multi-Crew Pilot License (MPL), Maintenance and Repair Overhaul (MRO), Aircraft Maintenance Technicians School, Pilot Training School and others. Among of these the aviation academy is the largest,

successful and the most modern academy in Africa recognized as International Civil Aviation Organization regional Training Center of Excellence. After the fourth partnership of EAL with TWA in 1966 with notion of "Ethiopianization agenda" the Aircraft Maintenance Technicians School established in 1967 and has specialized in aviation maintenance training for nearly 55 years and consistently offering the highest industry standard maintenance technicians training. Now a day, the academy is operated by Ethiopian professionals as well equipped with modern tools and technologies.

On another hand, as part local capacity building and technology transfer the Pilot Training School is commissioned in 1964 and development of this training facility has made Ethiopian Airlines self-sufficient in meeting its strategy to operate its aircraft by Ethiopian pilots. This was accomplished through the engagement of highly qualified and experienced Ethiopian Airlines training staff. Over the last nearly 60 years, the Pilot training school has trained pilots for over 52 countries in Africa, the Middle East, Asia and Europe. The Pilot Training School currently offers accredited training programs for Commercial Pilot License by highly experienced Ethiopian instructors for both flight and ground training.

Cognizant to the above, MPL training at Ethiopian Aviation Academy aims to replace the traditional application and it provides MPL training for an airline based on its own operating procedures this helped MPL graduates can perform as a co-pilot on any multi-engine multi-crew airliner without the need to go through extensive light aircraft experience. MRO operation at Ethiopian is breathtaking in which it it is largest MRO service in Africa and serves Africa and the Middle East. The MRO service was established in 1957 and it provides Line Maintenance services at all stations where Ethiopian flies and extends the services to other operators at some of the stations. Ethiopian MRO offers world-class technologically supported services to its customers and helps make Ethiopian Airline one of the most dependable and safest airlines in the world.

Lessons Learned

Practices on Technology Transfer and partnership with TWA: Ethiopian airlines has passed through national hurdles and tough international competition however, the turbulence did not take hold of its successful journey due to bold footing technology transfer arrangements. The available evidences confirm that the Ethiopian Airline has overcame the technological distance of the Aviation industry from the global frontier and scored track of records in knowledge transfer, capacity building, leadership, consistently realizing its strategies. In addition, the technology selection and know-how transfer from TWA to Ethiopian Airline was based on the demand driven, purchase of technologies, progressive and tailored local operational requirements. Ethiopian Airline incorporated world class emerging aviation technological advancement as well evidenced by its continued strategic and courageous pioneering decisions in acquiring and operating latest aircraft technologies. Throughout the last seventy seven years, the airline has established itself proficient in all dimension of the aviation industry with strong technology transfer, bold leadership, integrity, network expansion and aviation technology mentoring.

Despite being 100% government-owned, Ethiopian Airlines success factors are tied to that it operates commercially with the leadership assignments are merit based not political assignment. This granted the airline a freedom to perform every professional decisions on relevant technology acquisition without any interference of the

government that helped it to use or exploit potential technologies without any limitation. Thus, it is possible to conclude that the national support and government restrain from interference in the government owned business helps domain experts to lead and apply or use systematic professional decisions that amplify and advance the technology transfer for institutional sustainable development.

Strategic Technology Institutional Arrangement: Ethiopian Airlines and Ethiopian Aviation Academy has aligned history and it is a world class Airline equipped with state of the art. It built best in class Air crafts, self-oriented talented professionals, training equipment and technology offering full range of aviation services due to proper set up at its early establishment with the aviation schools such as MPL, MRO, Aircraft Maintenance Technicians School, Pilot Training School and others. This strategic underpinning technology institutions led Ethiopian Airline to be self sufficient and technologically strong institution.

Intra-institutional technology transfer and human capital development: Ethiopian Airline passed through multifaceted knowledge, skill and technology transfer stages that acquired from the foreign staff and international partners. Even though the Ethiopian Airlines operates a fleet of Airbus, Boeing and Bombardier Dash aircraft, with their respective technology licenses there are abundance of evidence that Ethiopian airline is operating with Ethiopian experts in all aspects of its services locally and globally. Through spectacular growth the airline successfully transferred technology and skill that made it self-sufficient and productive that minimized the foreign technology dependency both to operate and maintain the aircraft technologies. In addition, the Airline narrowed the gap between itself and leading global players in the aviation industry technologies by upgrading its technological, organizational, and management capabilities. From its partnership evidences Ethiopian Airlines has given much attention to invest in human capital development for sustainable technology transfer that enabled the Airline to be competent as well enabled it in providing the knowledge transfer service for latecomer countries and developed countries.

4.2. Ethiopian Space Science and Technology Institute (ESSTI)

The history of Ethiopia's geophysical observatory goes back in 1957 that at the convention on the International Geophysical Year in Rome, it was issued by the scientific community to establish Geophysical Observatory in Ethiopia at University College of Addis Ababa current AAU to conduct research and scientific operations, then the observatory institutionally inaugurated its scientific operations in 1958 and in February 1959 research programs in seismology were started [11]. The Geophysical Observatory transformed into an Institute of Geophysics, Space Science and Astronomy (IGSSA) in 2005 [11].

Practices on Technology Transfer and Collaboration

IGSSA has been collaborating with various international institutions such as Technical University of Darmstadt and the Federal Agency for Cartography and Geodesy of Germany, Universities of Purdue and Massachusetts Institute of Technology (MIT), Bristol University (UK), Ardhi University (Tanzania), University of Edinburgh (UK) on different level of engagement and with different scopes. Further more, in 2007 IGSSA established the first permanent GPS station that provides real-time data as well as twenty four (24) continuously operating GPS reference stations in collaboration with Ethiopian local Universities and international partners.

Cognizant to the above, the evolving of Ethiopia's space science brought the Ethiopian Space Science Society (ESSS) citizen association in 2004 with 47 founding members as non-profitable organization that comprises members from Astronomy, Astrophysics, Space Science and technology and interested individuals. The society capacitated to mobilize 10,000 individual members, 28 branches associations, 52 institutional members and 100 school space clubs. ESSS contributed in organizing and realizing the establishment of Entoto Observatory and Research Center at Entoto mountain (Addis Ababa) in 2014 in collaboration with 32 Ethiopian public Universities and one private University.

In 2016, the Ethiopian Space Science and Technology Institute came to existence under the regulation No. 393/2016 with the approval of Ethiopian council of ministers. ESSTI is established to lead Space Science and Technology from end to end research in all horizon of space applications, space infrastructure development, satellite development and operation, and international collaboration in Astronomy and Astrophysics, space science and application, satellite technology, Aeronautics and astronautics, earth observation and related space and science technologies.

Government Support Measures

Beyond the research operations and national responsibilities ESSTI started M.Sc and Ph.D. programs in collaboration with Addis Ababa University and Addis Ababa Science and Technology University in several fields with a goal of national capacity building in the sector. Besides, to promote and maintain high-quality research, ESSTI established linkages with national, regional, and international organizations for sustainable sector wise development [12].

The gradual evolution of Ethiopian Space program and Ethiopia's effort in its space science programs open to launch its first satellite in December 2019 called ETRSS-1. The China Academy of Space Technology developed the satellite in collaboration with 21 Ethiopian technicians, trained on the project as part of the technology transfer agreement.

For the second round launch ESSTI prepared the preliminary design of the satellite and the critical design. Chinese Smart Satellite handled the manufacturing, assembly, integration and testing in close consultation with the ESSTI team. As of December, 2020 the joint team of ESSTI and the Chinese Smart Satellite Technology developed and launched ET-SMART-RSS (EthSat6U) the second high resolution Earth observation nano satellite. The primary mission of the Ethiopia's satellite program is to expose Ethiopian engineers and scientists to hands-on experience and demonstrate the Institute's capability, skill and technology transfer in integrating nano satellite subsystems locally [13].

Ethiopia Space Policy

In December 2018 ESSTI publicized the space policy with the intuition to guide Ethiopian space program for research and development that envisioned to study the earth from space and to analyse the space from the earth. The basic policy vision is to guide gathering the data by coordinating satellites for communication. The policy is enacted to ensure the sector development and to enable space science and technologies contribution to the country's development. The policy is used as the governing document for direct and indirect stakeholders in the sector. Moreover, the primary vision of the policy is to see capable national space science and technology that respond to Ethiopian development demand. The Ethiopia's Space Policy has the bold pillar strategies and practical interventions that emphasize space science technology for multi-purpose benefits. The policy document emphasized that the space science has significant contribution for sustainable development of the country and solution for the global challenges such as, addressing social, economic, environmental, and climate change challenges.

In general, it is notable that the space science and technology are valuable in addressing developing countries' challenges and advancing countr ability to meet the aspirations of agenda 2030 as well as agenda 2063, also input for SDGs.

Lessons Learned

- The collaboration of IGSSA with national and international RTOs brought internal capacity in space science technology research and development that yielded to create strong space science technology institute in Ethiopia, this is due to the long time demand, capacity and strategic national supports measures.
- The joint collaboration between China and Ethiopia helped Ethiopian scientists to design preliminary and critical design of the ET-SMART-RSS (EthSat6U) satellite that successfully launched December, 2020 signifies the successful technology transfer through partnership.
- The Ethiopian space science policy significantly helped the sector growth since the industry is able to be guided by space science technology strategic interventions thus greatly increase the effectiveness of a technology transfer.
- It is notable that, from the history of ESSTI and national stakeholders, when RTOs persistently stay in the research and development, they can create better human capital and succeed in technology transfer.

4.3. Infrastructure Case of Ethiopian Education and Research Network

Technology and research information sharing infrastructure facilitates to establish networked international and national institutions to access information that involve public and private sector. Ethiopian Education and Research Network (EthERNet) was initiated in 2001 as part of Ethiopian government national capacity building program that comprises SchoolNet and WoredaNet projects that aimed to provide high inter-networked and intended to provide connectivity infrastructure for efficient service delivery given by education, research institutions and other stakeholders [17].

It is evident, that the scientific and technological information flow is required for domestic R&D activities that have to be undertaken to adapt foreign technologies and to generate new insights. However, Ethiopian higher education institutions to acquire

the technologies were very limited to process and disseminate scientific and technological information for research community and have been managing in fragmented manner. Therefore, it is noted that it is essential to establish a networking platform that brings together scientific, technological, and industrial information easily accessible to stakeholders.

Adopting Technology to the Ethiopian Experience: EthERNet is largest national hub of Ethiopian educational and research institutions throughout the country significantly contributing to the connectivity of research institutions in Ethiopia. The focus of EthERNet is not limited to create network of institutions, but to meet the entire needs of the R&D institutions by hosting and providing relevant infrastructure and information to their communities. EthERNet provides research and technology development infrastructure services such as web and shared hosting, High Performance Computing infrastructure for Big Data and Artificial Intelligence research.

Government Support Measures

EthERNet owned by the former MoSHE and currently lead by Ministry of Education whereas strong organizational framework is involved to engage the stakeholders to be active users and supporters of the services rendered by EthERNet. It provides education technologies and research solutions dissemination to institutions nationwide. Further more, EthERNet aimed to build and deliver high performance hub that interconnects education and research institutions to enable them to share resources as well to aid national and international collaborations.

Lessons Learned

- Research and development, technology transfer succeed best when information collection, organization, dissemination, and stakeholders work in collaboration.
- The ICT common infrastructure helps RTOs to acquire and share research and technology results that are pertinent to development needs targeted to share national stock of technology information.
- Common infrastructure can enhance and enable RTOs to share and access technology information centrally as well as greatly increase the effectiveness of a technology transfer.

Conclusion

The important take away of EthERNet shows that collecting, processing, accumulating and disseminating of targeted researches' and technologies' information can be achieved through a national science and technology information system that allows a smooth and effective flow and use of information. It plays a pivotal role in networking and coordinating the research and technologies institutions. The broad impact of the EthERNet intended to increase collaboration between Ethiopian researchers and their local, national, and global partners in order to stimulate technology transfer and research and development.

4.4. Leather Industry Development Institute and TT Activities

Ethiopian leather industry has an estimated age more than 90 years whereas Ethiopian Leather Industry Development Institute (ELIDI) established in 2010 by regulation No. 181/2010 with the responsibility to establish policies, strategies, programs that assist the sector in the facilitation of leather and leather products. To realize its mission, it has set out to strength the capacity of the sector through international, continental, domestic and intra-institutional collaborations as well as it has set forward goals to work on research and technology transfer with leather industries. The following cooperation are the significant moves it has made.

International Collaboration

Ethiopian Leather Industry Development Institute and Council of Indian Scientific and Industrial Research Central Leather Research Institute Chennai have entered into Twinning program since 2011. The aim is to bring about capacity building of LIDI and thereby effectively serving the Ethiopian Leather Sector and for that Indian success can be emulated and mistakes could be avoided as a result saves resources for Ethiopia Leather sector.

Continental Collaboration

On another note, LIDI and African Leather and Leather Products Institute collaborated to provide a framework of cooperation on strategic issues that aims at the development of leather sector, satellite studios and incubation centers in Ethiopia. African Leather and Leather Products Institute (ALLPI) have recognized ELIDI as a key institution to assist the Ethiopian leather sector development and competitiveness of the sector in the global arena.

ELIDI and ALLPI have agreed to work in partnership in the areas of strategic collaboration such as the development of satellite design studios and incubation centers involving technology transfer, conduct collaborative research activities, regional integration, gender parity, joint resource mobilization efforts and cooperation & partnership in all areas of mutual interest.

Domestic Collaboration with RTOs

LIDI has signed numerous memorandum of understanding with various domestic Universities for instance LIDI signed MoU in March, 2022 with two local Universities Jimma University and Mettu University that aspire to work on capacity building, R&D and technology transfer.

Apart from the above, in Ethiopia there are numerous Leather industries that are producing leather and leather products from sheep, goat, and cattle hides and skin. However, for a long period of time the large volume of waste products produced by factories has been recorded as the sector hurdles on the environmental impact, climate change and long time resistance from the communities. To solve these challenges LIDI has conducted study in collaboration with private leather industry named ELICO Awash and they found a technology that converts the solid waste to the organic fertilizer. The finding conforms the environment protection and approves physio-chemical changes in the natural fertilizer and the expected heavy metals amount standards. As a result, it is achieved to use waste products to produce the organic fertilizer and the technology was transferred to compost producers private enterprise through training and prototype demonstrations.

Private Leather Industries Technology Transfer Activities

Ethio Leather Industries (ELICO) is operating since 1997 and it produces and exports various types of leather garments and articles. ELICO used various modalities to facilitate technology transfer such as exhibitions and expo like so to acquire new technologies ELICO team regularly attended the Asia Pacific Leather Fair, Lineapelle shows, Meet in Africa showcases and all Chinese Leather exhibitions. It also partnered with South African Leather Research Institute, Indian Institute of Leather Technology and BLC Leather Technology Centre on technology transfer to modernize the leather industry.

Furthermore, as private firm ELICO set an objective to enhance the technological efficiency with foreign partners who have international experience, exposure and solid technical background targeted to acquire technology, knowledge and training. The technology transfer and training modality envisaged the sending of selected personnel in the above mentioned partners. In favor of, local technology transfer intra-institutional technology transfer by senior ELICO experts was implemented. As the result of technology transfer effort technicians at Tannery have managed to turn the fleshing waste into a crude glue, which is then sold on the local market.

Lessons Learned

The international, continental and domestic collaborative arrangements at LIDI transitively brought and enabled the potential Ethiopia has to benefit from the Leather Industry.

- The strategic twinning initiative helped LIDI in a manner replicating international success in forming a better organizational structure, to take the success factors of international Leather Industry best practices by avoiding the mistakes developed industry experienced during its path to technologically self-sufficient sector.
- The scientific input comes from scientists and technologists through local Universities collaboration can eradicate challenges and can transform industry into modern technology oriented industry.
- The emergence of applied research of Leather industry in Ethiopia shows the effectiveness of the industry-led R&D to create technology that is in need both at industry ground and government, this case underscores the collaboration of firms on research and technology yields promising results.
- The technology transfer approach envisaged the sending of selected experts abroad, partnering with in country institution, and using the intra-institutional technology transfer model benefit the firms to sustainably operate and innovate technologies.
- The leather industry in Ethiopia cascaded technological capacity building through intra-institutional technology transfer scheme that eventually allowed intra-institutional technology acquisition, creation and diffusion to use their own skill to solve the institution, sector and societal problem. TT Practice
- Technology oriented Leather industry has the capacity to enhance the socio-economic and it generates large number of job opportunity for the citizens principally it helps the vulnerable community women and youth.

Conclusion

As a conclusion, besides collaboration for technology transfer, research and development, the sector needs to formulate bold policy and strategy to develop internal capacity that will adopt, generate and create technologies to uplift the country's leather industry technology acquisition, development and diffusion. The potential of Ethiopia leather industry can take up an outstanding share in country's economy as well as will be a cornerstone for the societal growth. Therefore, it is noticeable to strength the international and regional collaboration on research and development, technology creation, technology transfer with other developed countries in similar sector to emulate the success factors and take up opportunities of international industries by avoiding mistakes and errors.

4.5. Metal Industry Development Institute and TT Practice

The Metals Industry Development Institute (MIDI) established with proclamation No. 82/2010 and it has undergone various reestablishment and restructuring due to Business Process Engineering (BPR) and named with different names with different times such as Engineering Design and Tool Enterprise, Basic Metals and Engineering Industry Agency and Metal Products Development Center and Metals Industry Development Institute for new mission and vision. Most recently, as of 2022 it is renamed and restructured to new name Manufacturing Technology and Engineering Industry Research Development Center. It is mandated to formulate policy, to collect data and do research in the sector, disseminate information and to provide practical training on technology transfer and other technical matters.

As part of technology transfer and capacity building in the sector MIDI signed long term contract with Indian Council of Scientific and Industrial Research (CSIR) in June, 2017. The agreement objective is to enable Ethiopia in acquiring excellence in light manufacturing in Africa, initiating heavy engineering industries, human resource development through technology transfer and to enable intellectual manpower for the Ethiopian metals and manufacturing sectors. CSIR provided training on short term and long term packages on human capital development and technology transfer for MIDI's experts and industry. Accordingly, CSIR gave technology transfer support for MIDI experts and the MIDI's experts subsequently applied the TT to Ethiopian firms.

Figure 3: MIDI and CSIR Knowledge and Technology Transfer Approaches

As part of this initiative it is recognized that MIDI earned effective short term training on technology transfer, as well as for long term technology transfer packages. There are notable human capital development activities including M.Sc. and PhD capacity building package.

MIDI's Collaboration with RTOs and Industry

MIDI works in collaboration with Universities, TVETs and Industry for instance Jimma University collaborated in the study of *"Manual interlocking brick Machine"* finally they created a machine in which it is transferred to Jimma University for production. Cognizant to this, MIDI works in collaboration with other industries, one exemplary technology created in cooperation with Leather Industry Development Institute which is titled *"Jacketed chemical Reactor for Leather Solid Waste Treatment"* after the validation it is transferred to a firm named *"Abyssinia Leather Industry"*. Further more, MIDI conducts research and development, technology development and produced significant number of technologies such as heat reactor, manual hot logo stamping machine and transferred to the industries.

Lessons learned

- The partnership allowed the Ethiopian Metal industry to gain the knowledge and skill required to design, model and adopt a suitable technology in collaboration with other countries institution, in country higher education, RTOs and firms.
- The MIDI's collaboration with international and domestic RTOs and industry demonstrates the extent of collaboration of RTOs, industry and government support can increases the success rate of technology acquisition, creation and diffusion.
- Bringing or linking knowledge producing RTOs, technology consuming firms with potential dissemination can help to overcome the technology demand barrier and the intimacy of industry and RTOs.

Conclusion

It is noted that various technologies are transferred from MIDI to other Industries however, there is a need to have sector wise intellectual property licensing guidelines to provide guidance for the new product diffusion or clear mode of technology transfer. It has to stated the requirements and standards that the new technology should comply with which in turn are influenced by the needs of the industry. The sector has take into consideration IP licensing, MIDI has to set strategic direction of imitating and innovating technologies from partners that being focused in technology transfer to build internal capability and diffuse those technologies into industries.

4.6. Ethiopian Biotechnology Institute Research and TT Practices

Ethiopian Biotechnology Institute (EBTI) established in 2016 with the objective to facilitating resources, enacting regulations and policies, guiding biotechnology research and coordination of stakeholders. Since its inauguration the institute is undertaking remarkable activities on R&D, Technology innovation and Technology transfer supports. Among of the various technology transfer initiatives the following are considered for the case study.

Vermicomposting of Coffee Husk for Organic Fertilizer

The Ethiopian agriculture heavily contributing to the national economy and GDP. In contrary, the sector is facing agricultural soil resource degradation and nutrient depletion challenges. On another hand, Ethiopia is among the top coffee exporting countries in Africa. Coffee waste products have serious threat to the environment, human and livestock also harmful to the ecosystem. To address this challenges EBTI

partnered with Debre Berhan University to conduct the study on Coffee Husk to produce vermicompost. EBTI awarded financial grant for the project and as the result the finding of the study yielded promising technology. The created technology is scaleable and cost-efficient as well as biological way to manage organic waste generated from agricultural processing industries that capable to reduce the waste burden on the environment. The technology uses earthworms that manage organic waste by producing nutrient-rich compost (vermicompost).

Technology Transfer Arrangement to Industry

Coffee biowaste collected from coffee processing industries and appropriate technology is developed by Debre Berhan University in partnership with EBTI. The product of technology is transferred to flower factories in Debre Zeit and to community to produce affordable biofertilizer and feed for poultry industry which enhances productivity, nutritional and food security. For the successful technology transfer EBTI has intellectual property directives for the grants it provides, and the collaboration it arranges with the stakeholders. However, there is no modality from private industry to fund R&D or technology development. This project got another national and international partner such as International Livestock Research Institute, Kenya; Selian Agricultural Research Institute (SARI), Tanzania; Wondo Genet College of Forestry & Natural Resources, Ethiopia. In addition there is on going activities to transfer this technology to Habesha Beer Brewery and Sun Chips in Ethiopia [14].

Lessons Learned

- Engaging the Industry, RTOs and government help the sector to identify demanded technology thematic areas.
- National support, end to end industry collaboration and accelerating the diffusion of environment-friendly technologies help countries to adapt to the effects of industry waste product on the environment.
- Solved a real problem in the real world with adequate human, technological and institutional capacity through national support measures.
- The created technologies are results of RTOs, government and industry thus do not create other problems due to full engagement of all stakeholders.

Conclusion

The Vermicomposting project has achieved promising success by taking in account Ethiopian conditions. This achieved through government support, Local University collaboration, EBTI guide, domestic industries and Ethiopian researchers engagement. Transfer of technical know-how for prototype development and production is achieved due to the participating stakeholders end to end engagement that created a sense of ownership for the implementation of vermicomposting technology. At the same time the technology licensing, intellectual property right demarcation among the stakeholders, mode or cost of transferring technology to industry or end user needs clear guide line or intervention strategy.

5. Survey Data Presentation and Analysis

Data collection was made to assess institutional survey of respondents mainly from key research and technology organizations such as Universities, research institutes and firms. The data collection was made using two approaches: The soft copy shared and communicated to more than 63 email addresses during the period of February, 15, 2022 to March 12, 2022. However, the response obtained via online were only eighteen (18).

As an alternative option 84 questionnaires were duplicated and distributed to RTOs and firms. Total of 84 questionnaires distributed and enumerator based data collection, significant number of questionnaires were not returned due to non-response or loss from the respondents within expected time or inappropriately filled.

The collected data from survey thoroughly audited, transcribed, translated, cleaned, transferred, and analyzed by using SPSS software. The quantitative data was summarized and descriptive statistics is used to interpret the TT activities of RTOs' responses for each variable on Advancing TT for Sustainable Development.

5.1. Limitations

As of January 8, 2020 at the meeting of the Reform Council of Higher Education, the MoSHE disclosed the study classified Ethiopian universities into four categories, 8 Universities categorized under research institutions, 15 under applied, 21 under general, and 3 under specialized (technology) institutions.

Out of eight (8) Universities under research category in Ethiopia six (6) of them included in the survey and out of three (3) technology/specialized institutions two (2) of them included in the survey. On another hand, few Ethiopian Universities established or started operation after 2015 were excluded due to few survey questions need data starting from fiscal year 2015, at them same time number of Universities are excluded due accessibility issues. Accordingly, total of 76 respondents (Universities = 24, Research Institutions = 8, Firms = 44) are included in the survey. Whereas the screened usable data is (Universities = 22, Research Institutions = 5, Firms = 32) in total 59. During the analysis it is noted that few questionnaire has imposed challenges on the respondents due to context, lack of organized data that fit questions and the calender or fiscal year difference thus Ethiopia uses different calender, consequently the respondents left the questionnaire empty. To fill this limitation secondary data were collected from various sources and analyzed quantitatively.

5.2. Data Screening and Response rate of RTOs and Firms

Among of the 76 respondents who filled and returned questionnaires 59 of the responses were screened and used, all of respondents are located in Ethiopia and the respondents were Universities' research vice presidents, Research directors, TT directors, senior researchers and firms' managers /senior experts.

Table 3: Data Screening and Response rate

Data Screening and Response rate	
Proposed sample size	57
Distributed data	147
Collected data	76
Discarded Data	17 (> 50% missing value and outlier response)
Total usable data	RTOs (27) + Firms (32) = 59
Usable response rate	40.1% (However, the collected data is > sample size)

As it is shown in table 3, a total of 59 questionnaires identified as usable data and entered to SPSS software for further analysis.

5.3. Research and Technology Organizations (RTOs) response analysis

As stated in the methodology part, in this survey there are two principal target group which are RTOs and firms in this section the response of twenty seven (27) RTOs (Universities = 22, Research Institutions = 5) response is discussed.

5.3.1. Demographic Data Analysis

Table 4: Respondent Address

Respondent Address				
		Frequency	Percent	Valid Percent
Country	Ethiopia	27	100.0	100.0
City	Addis Ababa	9	33.3	33.3
	Others	18	66.7	66.7

As shown in table 4, of the total respondents the significant number were from Addis Ababa (33.3%) and other cities in combination cover 66.7% in which all of them operate in Ethiopia.

Table 5: Institutions Year of foundation

	Frequency	Percent
Before 1960	4	14.8%
From 1961 to 1980	2	7.4%
From 1981 to 2000	4	14.8%
After 2001	17	63%
Total	27	100.0

Table 5 shows that there are largest number (63%) of respondents founded after 2001whereas there are significant number of institutions founded between 1961 to 2000 that accounts in total 22.2%. On another hand, there are oldest institutions that founded before 1960 (14.8%).

Table 6: Institution Affiliation

Institution Affiliation				
	Frequency	Percent	Valid Percent	Cumulative Percent
Yes, Parent Same Country	8	29.6	29.6	29.6
No, we are independent	19	70.4	70.4	100.0
Total	27	100.0	100.0	

Respondents were asked, as depicted in table 6, whether they are affiliated parent same country or independent organization and majority of the respondents, 70.4% negatively responded, by stating that they are independent, whereas 29.6% of them replied they are branch and their parent is affiliated the same country.

5.3.2. Technology Transfer Strategy and Partnership of the RTOs

The survey also covered to assess the technology transfer activities of the institution to explore insights about strategy, TT guidelines, TT office, monitoring and evaluation, whether institutions use TT outputs as a performance appraisal criterion and the response is summarized in table 8 here below.

Table 7: Technology Transfer Strategy

TT Strategy and Management	No	Yes
Does the institution have a formalised TT strategy	3.7%	96.3%
Is there a dedicated team/ unit for handling TT issues	3.7%	96.3%
Is there ME system in place for TT activities.	11.1%	88.9%
TT outputs are included as a performance appraisal criterion of R&D staff of the institution.	22.2%	77.8%
Institution regularly conducts satisfaction survey on TT partners.	74.1%	25.9%

As depicted in table 7, Almost all (96.3%) the respondents replied they have technology transfer strategy in the form of a strategic plan or policy or guidelines and the same amount (96.3%) of respondents positively replied that they possess TT department that can be TT office or licensing office or industry liaison office. Table 7, also shows that 88.9% of RTOs have monitoring and evaluation (ME) mechanism whereas 11.1% of them do not possess ME.

On another hand, the use of TT outputs as key performance indicator criteria to evaluate the transferred technology was another important question raised and majority (77.8%) replied positively. This indicates the existence of large follow up in the usage of technology transfer as performance appraisal criteria for staff. Another question was to know if the RTOs conduct technology transfer satisfaction survey and most of them (74.1%) responded negatively, implying huge gap in evaluation of the transferred technology perception of the partners to evaluate the outcome of TT whereas few of them (25.9%) regularly conducts satisfaction survey.

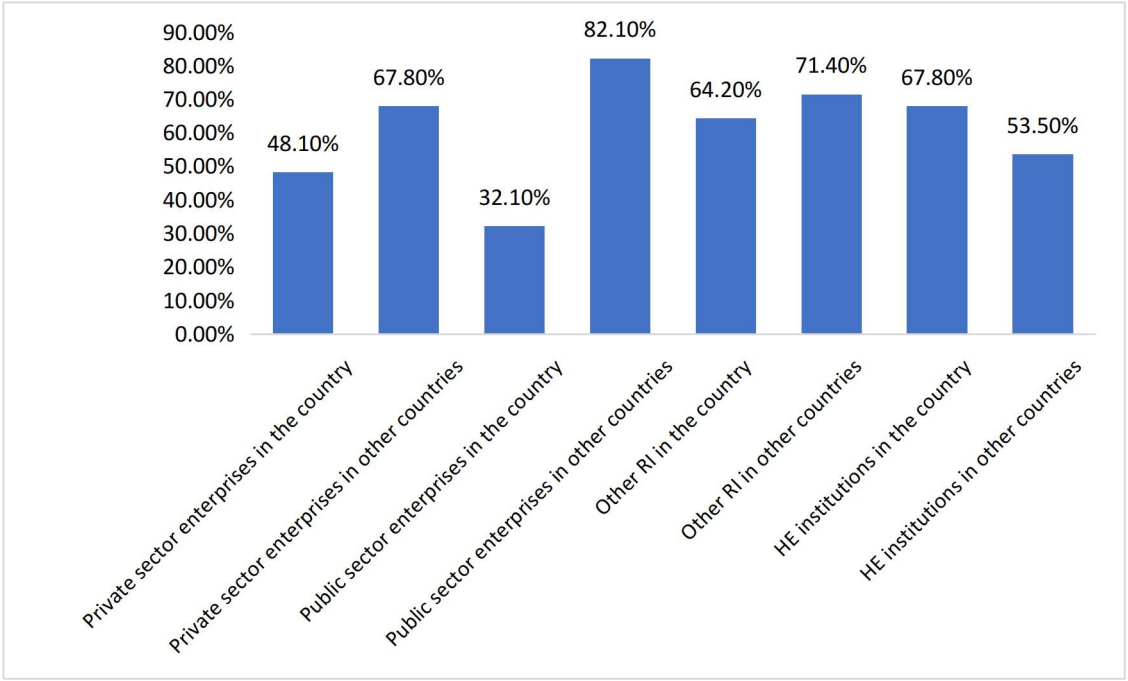

Figure 4: Technology Collaborative Partnership

RTOs were also asked to rate the percentage change from 2018 in technology collaboration and partnership, as portrayed in figure 4, the majority (82.10%) of them had responded there is no change in the partnership with Public sector enterprises in other countries, private sector enterprises in other countries (67.8%), higher education institutions in the country(67.8%), other research institution in the country (64.2%). The least respondents (32.1%) is there no change in collaboration with public sector enterprises in the country that entails there is relatively increased number of engagement between RTOs and public sector in Ethiopia.

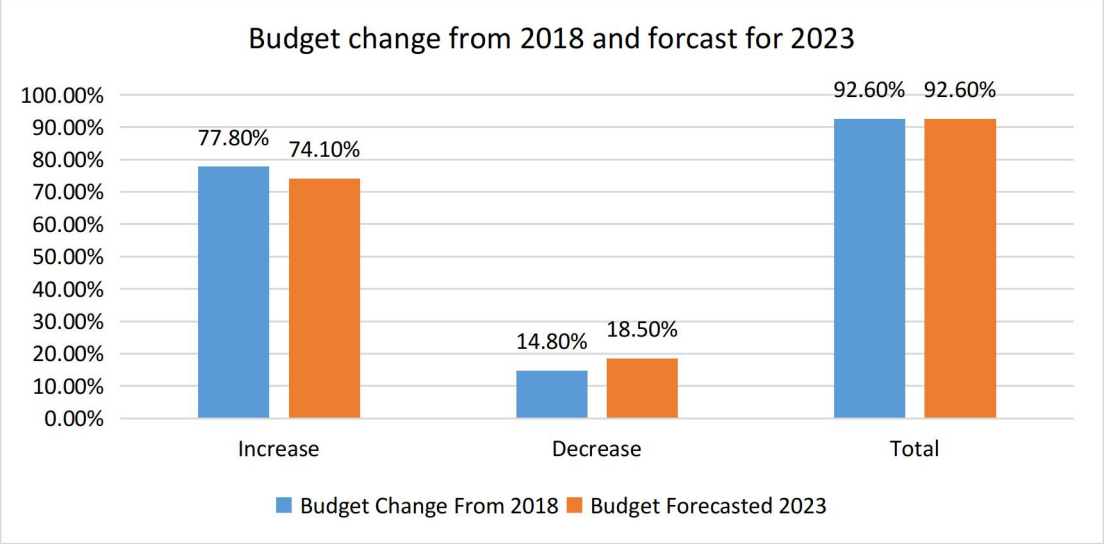

Figure 5: Budget change to developing technology transfer activities

As shown in figure 5, respondents were asked on budget change from 2018 and to forecast the future budget until 2023. Accordingly, for the budget change from 2018, 77.8% responded budget increased where as 14.8% replied the budget change from 2018 is decreased. On another hand, respondents also asked to forecast the budget allocation for period of 2023 and almost 74.1% predicted the budget for technology transfer will increase and 18.5% forecasted the budget will decrease. The RTOs' response implies there is progressive improvement and promising expectation in budget allocation for technology transfer activities in Ethiopia.

Table 8: Use of Open-Source Technologies

Frequency of use of open-source technologies by the Institution					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Don't know this source	3	11.1	11.1	11.1
	Low	5	18.5	18.5	29.6
	Sometimes	9	33.3	33.3	63.0
	Often	8	29.6	29.6	92.6
	All the Time	2	7.4	7.4	100.0
	Total	27	100.0	100.0	

As shown on table 8, the frequency of open source usage responded of 33.3% use it sometimes, often users is 29.6% and low usage accounts (18.5%) of the respondents. The positive response rate shows that there is a promising activities related to usage of open source technologies considering few (11.1%) of them never used open source technologies.

Table 9: Comparison of TT activities of previous 3-year period (2015-2017)

Comparing to the previous 3-year period (2015-2017), the institution's	Significantly Increased (over 50%)	Increased (up to 50%)	No Change	Decreased (up to -50%)	Significantly Decreased (Over -50%)
Total technology acquisition activities have	22.2%	55.6%	18.5%	3.7%	0.00%
Total technology provision activities have	22.2%	59.3%	14.8%	3.7%	0.00%
TT activities with private sector enterprises have	25.9%	25.9%	40.7%	7.4%	0.00%
TT activities with public sector enterprises have	18.5%	44.4%	29.6%	7.4%	0.00%
TT activities with other research institutions (excl. higher education institutions) have	44.4%	25.9%	25.9%	3.7%	0.00%
TT activities with higher education institutions have	25.9%	48.1%	25.9%	10.5%	0.00%
Intra-institution TT activities have	48.1%	37.0%	14.8%	0.0%	0.00%
Use of open-source technologies has	18.5%	51.9%	25.9%	3.7%	0.00%

As shown in Table 9, RTOs were asked to compare the previous 3-year period (2015-2017) their respective total technology acquisition and provision activities, TT with private, public, research institutions, higher education, and intra-insitutional TT activities. As a result, most of the respondents replied that technology acquisition (55.6%), technology provision (59.3%), open source technology usage (51.9%), TT activities with higher education institutions (48.1), and TT with public sector (44.4%), increased up to 50% response. Whereas, TT activities with other research institutions and intra-institutional TT activities respondents replied significantly increased up to 50%. On another hand, significant number of respondents response steer there is no change of TT activities with private sector, public sector enterprises and higher educations. The over all responses show that there is a demand for TT acquisition, provision and progressive increase.

Table 10: Forecasted TT activities in the next 3-years period (2021-2023)

Forecasted TT activities in the next 3-years period (2021-2023)					
	Significantly Increased (over 50%)	Increased (up to 50%)	No change	Decreased (up to -50%)	Significantly Decreased (Over -50%)
technology acquisition activities in total have	22.20%	51.90%	22.20 %	0.00%	0.00%
technology provision activities in total have	37.00%	44.40%	14.80 %	3.70%	0.00%
TT activities with private sector enterprises have	33.30%	44.40%	22.20 %	0.00%	0.00%
TT activities with public sector enterprises have	25.90%	55.60%	11.10 %	7.40%	0.00%
TT activities with other research institutions (excl. higher education institutions)	37.00%	48.10%	11.10 %	3.70%	0.00%
TT activities with higher education institutions have	37.00%	44.40%	11.10 %	7.40%	0.00%
intra-institution TT activities	59.30%	25.90%	7.40%	7.40%	0.00%
use of open-source technologies	33.30%	44.40%	18.50 %	0.00%	0.00%

As portrayed in Table 10, RTOs were asked to forecast the three years (2021-2023) technology transfer activities and it noted that the TT activities of intra-institutional (59.30%) will significantly increase, TT activities with public sector enterprises (55.60%) is expected to increase and 51.9% respondents forecasted technology acquisition activities will increase. Whereas small number of respondents forecasted there could be no change as well as there are very few respondents predicted there could be a decrease on TT activities. According to this predictive perception survey the increase of TT activities with public sector, private, research institutions, higher education and intra-institutional moderately more positive in coming three years.

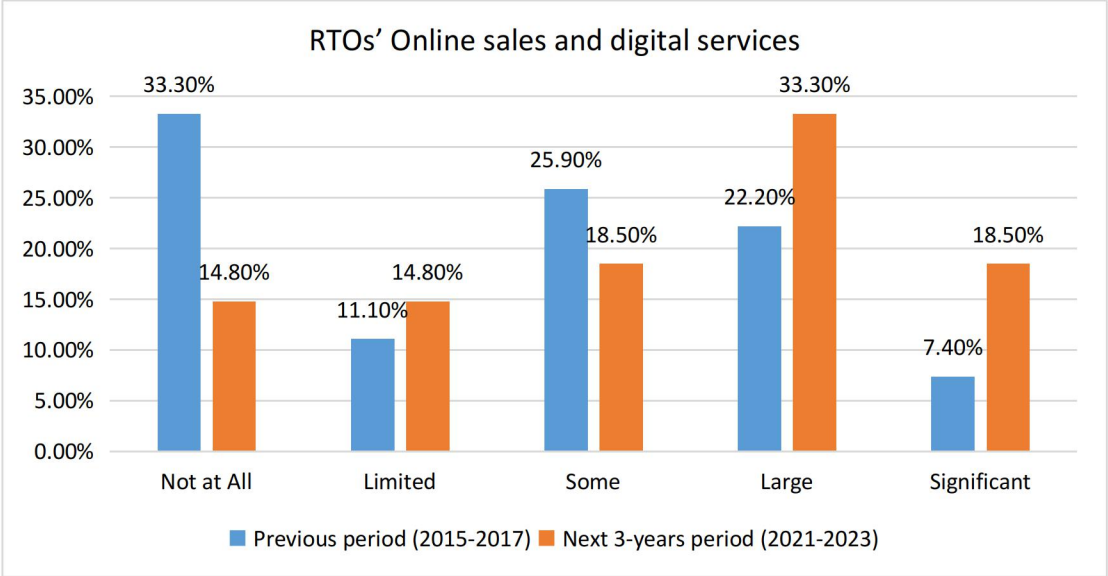

Figure 6: The RTOs' Online sales and digital services deployment comparison

As depicted in figure 6, for a period of 3 years (2018-2020), RTOs responded there were no online sales and digital service at all (33.3%) or limited (11.1%) practices whereas some (25.9%), large (22.2%), and significant (7.4%) respondents get engaged online sales and service deployment. On another hand, the overall forecasted engagement predictions show positive expectation except few (14.8%) of them not expect to start at all during a period (2021-2023).

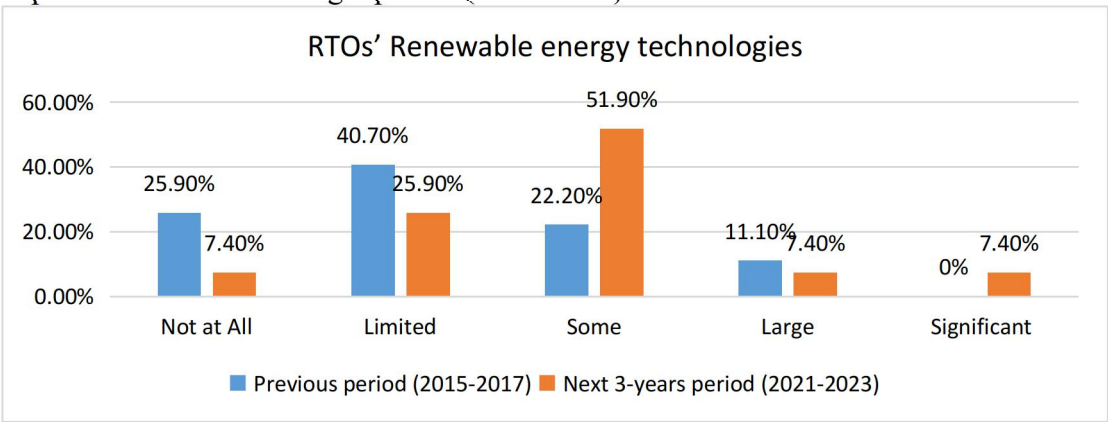

Figure 7: The RTOs' renewable technologies deployment comparison

As portrayed in figure 7, the respondents said in their response 25.9% of them not acquired at all or have limited (40.7%) renewable energy technologies deployment activities. At the same time, some of the respondents have renewable technology deployment initiatives at different levels that accounts some (25.9%), large (22.2%)

and significant (7.4%). The respondents predicted for a period of (2021-2023) the renewable technologies deployment will increase in their service that accounts some 50.9%, limited 25.9% and significantly 7.4%.

Table 11: Access of government incentives for TT activities in Ethiopia

Access of government incentives for TT activities in Ethiopia				
	Frequency	Percent	Valid Percent	Cumulative Percent
We are not aware of any incentive	18	66.7	66.7	66.7
No government incentive in the country.	2	7.4	7.4	74.1
No, the institution has not applied to any incentive	1	3.7	3.7	77.8
Yes, there are government incentives for this purpose	6	22.2	22.2	100.0
Total	27	100.0	100.0	

Respondents were also asked to rate their access of government incentives for TT activities in Ethiopia with four options listed in table 11, hence 66.7% of respondents are not aware of any government incentives on technology transfer activities. The positive response with "Yes, there are government incentives for this purpose" accounts 22.2% is more less number in comparison. This entails there is no significant incentive package for RTOs engaged in technology transfer activities in Ethiopia.

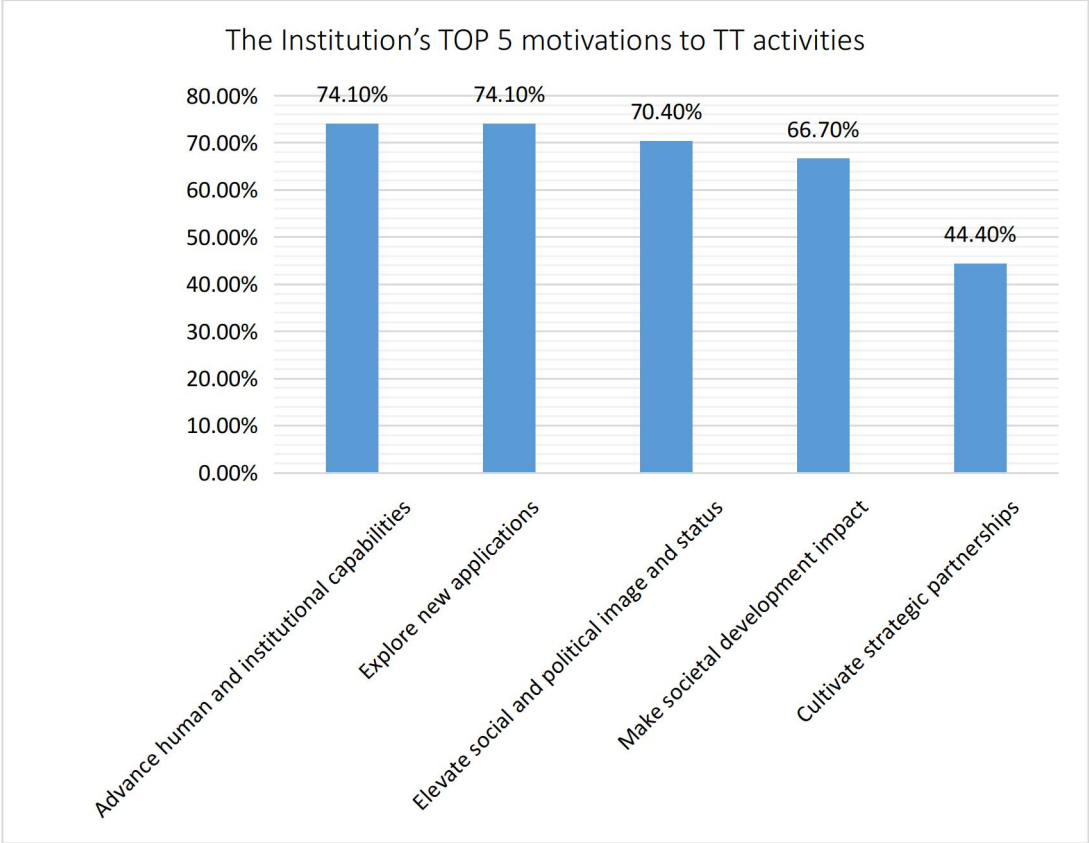

Figure 8: Institution's TOP 5 motivations to TT activities

As shown in figure 8, respondents were asked what are top motivation to technology transfer activities. Accordingly, the first motivation is advance human and institutional capabilities (74.1%), on the second explore new applications (74.1%), thirdly to elevate social and political image and status (70.4%), forth is to make

societal development impact (66.7%), and fifth is to cultivate strategic partnerships (44.4%) top five (5) motivation of RTOs for technology transfer activities whereas the smallest respondents escorted safeguard intellectual properties and avoid infringement and related litigation. These confirm that there is a potential demand to advance human capital development and use new opportunities to impact societal development through strategic partnership, whereas there are lack of awareness to safeguard intellectual properties, enforcing policy, and unclear intellectual property rights awareness.

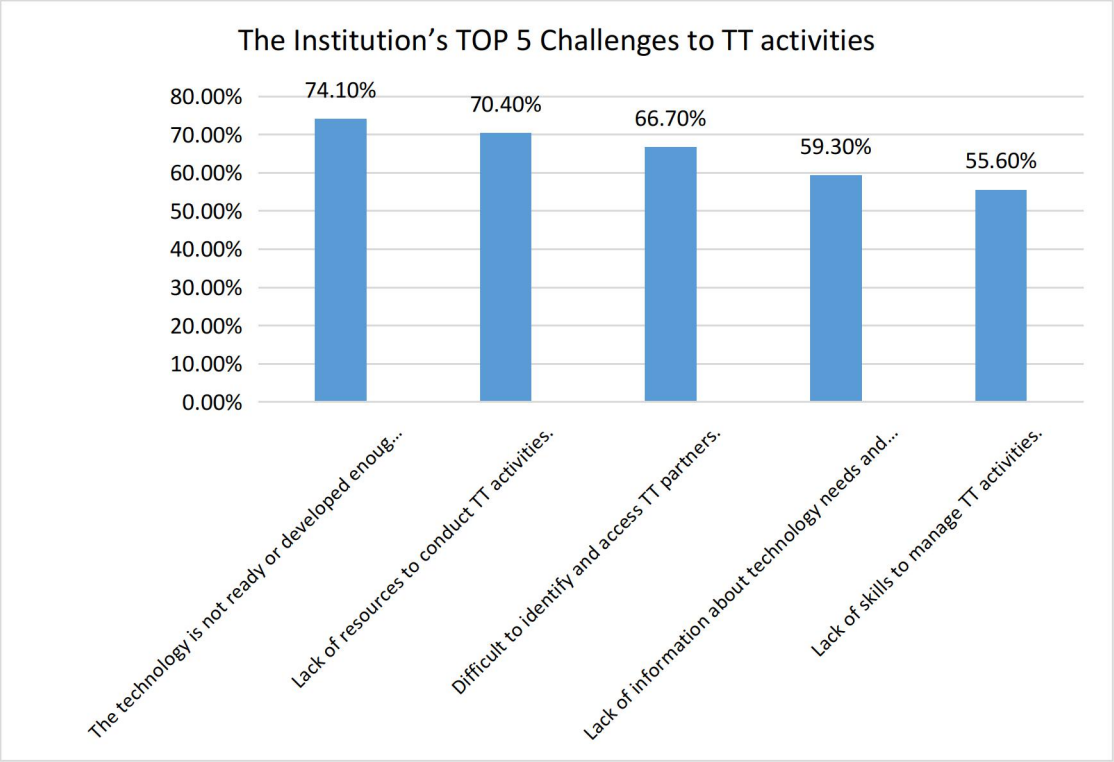

Figure 9: Technology or Market-related Top Challenges

As depicted in figure 9, very significant number of respondents mentioned their first challenge is technology is not ready or developed enough to be transferred (74.1%), seconded (70.4%) lack of resources to conduct TT activities, thirdly difficult to identify and access TT partners (66.7%), fourthly lack of information about technology needs and availability in the institution (59.3%) and the fifth to challenge is lack of skills to manage TT activities (55.6%).

Table 12: RTOs Comparison themselves with the closest institutions

Comparing to the Closest Institution					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Significantly Higher	1	3.7	3.7	3.7
	Higher	2	7.4	7.4	11.1
	Similar	14	51.9	51.9	63.0
	Lower	10	37.0	37.0	100.0
	Total	27	100.0	100.0	

Respondents were also asked to compare themselves with peer institutions in Ethiopia their overall technology transfer activities in a four levels. Accordingly, all of the respondents perception shows similar (51.9%), Lower (37.0%), and higher (7.4%). This implies most of the RTOs are in much of close level on technology transfer activities.

5.3.3. R&D and Technology Transfer Activities Resource Allocation

The survey data collected by (TechIN, 2016/17) from total of 51 RTOs (research institutions, research center and universities) show the level and pattern of Ethiopian government spending on education, scientific and technological activities shown in figure 10 here below.

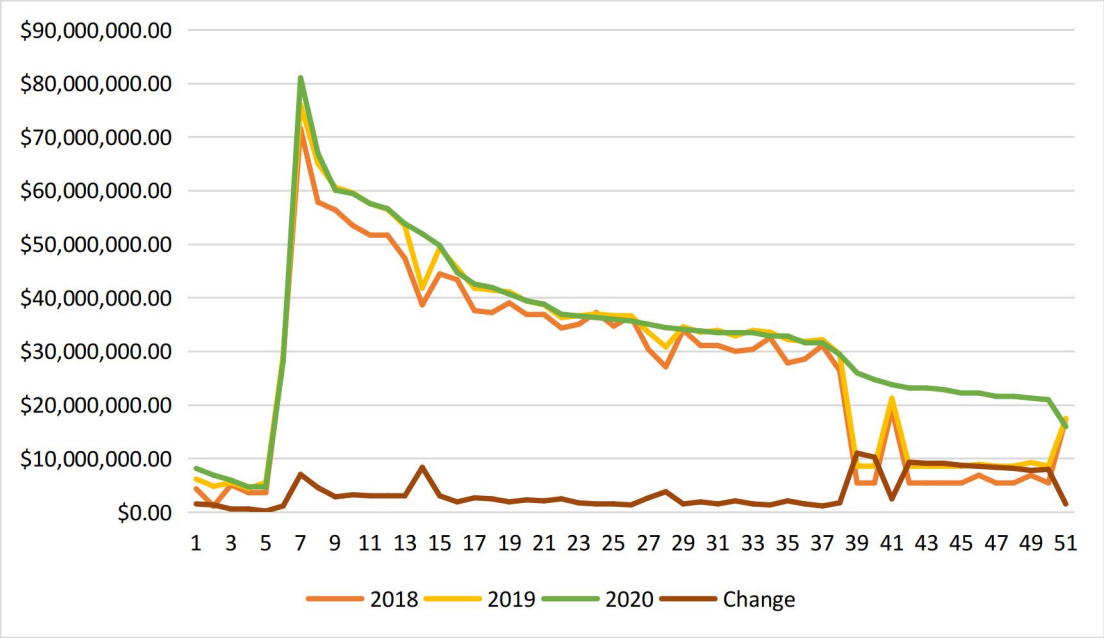

Figure 10: Total Education, R&D Budget of Ethiopian RTOs

Figure 10 shows the survey of 51 Ethiopia's RTOs budget for education, science and technology activities. The data demonstrates the proportion of change of each institutions' budget during 2018-2020 is increasing. Based on this analysis, it can be safely interpreted that, the government support, budget allocation and commitment to enable R&D activities and advancing technology transfer activities favorably rated promisingly increasing in Ethiopia's RTOs landscape.

Table 13: Number of total FT Employees and Proportion (%) of the FT Employees

Occupation By gender In number (in %)		Doctorate of equivalent level ISCED level 8(PHD)	Masters of equivalent level ISCED level 7 (MSC)	Bachelor's (BSC)	Short-cycle education ISCED level 5 (Diploma)	All qualifications ISCED 4 and upper secondary	Total
Researchers	Male; n(%)	2,317(15)	7020(45.4)	3.994(25.8)	253(1.6)	100(0.6)	13,684(88.5)
	Female ; n(%)	209(1.4)	835(5.4)	605(3.9)	76(0.5)	55(0.4)	1,780(11.5)
	Total; n(%)	2,526(16.3)	7,855(50.8)	4,599(29.7)	329(2.1)	155(1)	15,464(100.0)
Technicians	Male; n(%)	41(0.9)	216(4.7)	860(18.7)	911(19.8)	1483(32.2)	3,511(76.1)
	Female ; n(%)	11(0.2)	41(0.9)	265(5.7)	235(5.1)	548(11.9)	1,100(23.91)
	Total; n(%)	52(0.17)	257(0.82)	2,125(3.61)	1,146(3.68)	2,031(6.52)	4,611(14.79)
Supports	Male; n(%)	13(0.1)	376(3.4)	1,629(14.7)	1516(13.7)	4,080(36.8)	7,614(68.6)
	Female ; n(%)	0(0)	46(0.4)	939(8.5)	885(8.0)	1,613(14.5)	3,483(31.4)
	Total; n(%)	13(0.1)	422(3.8)	2563(23.1	2401(21.6)	5,693(51.3)	11,097(100.0)
Total	Male; n(%)	2394(7.68)	7612(24.42)	6485(20.8)	2680(8.6)	5,663(18.17)	24,809(79.59)
	Female ; n(%)	220(0.71)	922(2.96)	1809(5.8)	1196(3.84)	2216(7.11)	6,363(20.41)
	Total; n(%)	2,591(8.33)	8534(27.38)	8292(26.6)	3,876(12.4)	7,879(25.3)	31,172(100)

It can be seen from table 13 (TechIN, 2016/17), that the the proportion of academic rank of the total researchers for both gender 16.3%, 50.8%, and 29.7% were PhD, Masters, and Bachelor respectively. Out of this, the ratio of the female researchers were PhD (1.4%), Masters (5.4%), Bachelor (3.9%). These data show the proportion of gender for R&D activities was very marginal that female researchers holds the least share of around 10.7% whereas the male researcher percentage accounts 86.1%.

To further deeply explore the R&D stakeholders most of Ethiopian RTOs posses research and administrative wing that facilitate the overall R&D. In order to capture the full picture it is compelling to see full-time equivalent (FTE) approach to explore the shared responsibilities of employees. FTE is the ratio of working hours actually spent on R&D during a specific reference period divided by the total number of hours conventionally worked in the same period by an individual [18].

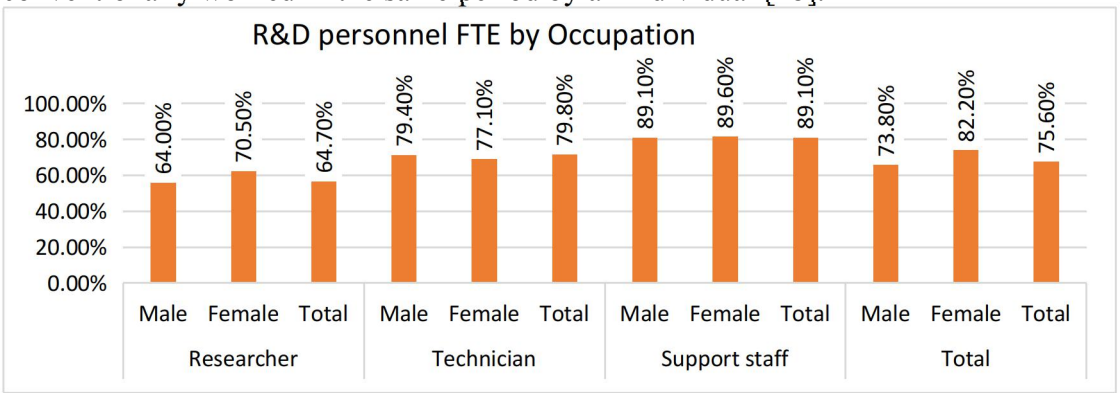

Figure 11: R&D personnel FTE by Occupation

Based on the information provided in figure 11 shows the distribution of R&D personnel FTE by occupation. Accordingly, the FTE of researchers was 64.7%, while the FTE of support staff and technicians were 89.1% and 79.8% respectively. Based on the head count (HC) number in figure 11 and the proportion FTE of R&D personnel gender like so more women devoted their time to R&D activity than their men counterparts.

Table 14: Total R&D Funding (in US$)

Source of fund	Per cent
Own fund	9.9%
Direct grants from national, federal state, provincial and local government	5.8%
Government research institutes and agency funding	2.9%
Industry and domestic business	0%
Foreign sources	15.5%
Government or general university	65.9%
Total R&D expenditure	100%

Source: (TECHIN, 2016/17)

As shown in table 14, the amount and sources of fund for higher education is total of 1,402,609,589.8ETB (estimated $62,924,944.14) with exchange rate of 05 Jan 2017 for R&D activities. The largest fund share was from general university fund 65.9%, On another hand, the other funds sources such as *foreign sources*, *own fund,* and *government research institutes* were 15.5%, 9.9%, and 0.7% respectively. The data also depicts there is lack of fund from industry or domestic business.

Licensing of Technology

Research and technology organizations were asked to share the total number of valid patents, new patents applications made, new patents granted in 2020 and planned number in the next 3 years of intellectual properties registration of their institutions technologies and the R&D outputs data collected by (TECHIN, 2019) presented in table 18.

Table 15: Intellectual Properties and R&D outputs of RTOs of fiscal year 2016/17

R&D Outputs	2014/15	2015/16	2016/17	Change
Paper published in national or international Journals	522	1255	1881	58.7%
Patents filed & Sealed	4	18	28	34.3%
Copyrights obtained	24	30	46	27.3%

Source: (TECHIN, 2016/17)

As shown in Table 15, there has been an increase in the number of R&D outputs throughout 2014/15 to 2016/17. Both the patents and copy right intellectual property activities show progressive change.

5.4. Firms survey response analysis

As it is mentioned under the section of the RTOs survey analysis there are 32 firms included in this survey using tailored questions that access the technology transfer landscape at firm level and the analysis is presented in this section.

5.4.1. Firms demographic data analysis

Table 16: Respondents Address and country

Respondents Address, affiliation and stock market status					
		Frequency	Percent	Valid Percent	Cumulative Percent
Cities	Adama	7	21.9	21.9	21.9
	Addis Ababa	25	78.1	78.1	100.0
Country	Ethiopia	32	100.0	100.0	100.0
	For Profit	31	96.9	96.9	96.9
	Others	1	3.1	3.1	100.0
Firms affiliation	Yes, Parent Same Country	17	53.1	53.1	53.1
	Yes, Of Parent another Country	4	12.5	12.5	65.6
	No, we are independent	11	34.4	34.4	100.0
Stock market status	No	32	100.0	100.0	100.0
Operation In Other Country	No	26	81.3	81.3	81.3
	Yes we have subsidiaries	6	18.8	18.8	100.0
Does the Firm Export?	No	24	75.0	80.0	80.0
	Yes we Export	6	18.8	20.0	100.0
	Total	30	93.8	100.0	
	Total	32	100.0	100.0	

As shown in table 16, all of the respondents are from Ethiopia's cities Addis Ababa (78.1 %) and Adama (21.9) in which all of them are operating for the profit. On another hand, more than half (53.1%) responded firms have parent institution in Ethiopia and significant number of the firms are independent (34.4%) whereas there are few firms that their parent institution located out of Ethiopia which implies the dominant number of firms are affiliated to Ethiopia. It is also noted that, all of the firms are not subscribed to the stock market. At the same, it is shown that most of the firms do not operate in other countries (81.3) whereas 18.8% have subsidiaries out of Ethiopia. Firms were also asked if they do export the products and 75.0% of them do not export their products, but 18.8% responded they export products, implying there is gap on technology products export out of Ethiopia.

5.4.2. Technology Transfer (TT) Strategy and Activities of the Firms

Most of countries guide the firms and technology transfer ecosystem by the policies, procedures, directives and values of each stakeholders involved in the technology transfer process.

Table 17: Firms' dedicated R & D

Firms' dedicated R & D				
	Frequency	Percent	Valid Percent	Cumulative Percent
No we are not involved in RD	20	62.5	62.5	62.5
No, we do not have dedicated Unit but RD is a firm wide activity	4	12.5	12.5	75.0
Yes, we have dedicated RD team	8	25.0	25.0	100.0
Total	32	100.0	100.0	

Table 17 shows that the firms did not give more attention to R&D and 62.5% replied negatively we are not involved in RD, those who have dedicated R&D team accounts 25.0%. Few of the respondents (12.5%) mentioned that they do not have dedicated unit but R&D is a firm wide activity.

Table 18: Technology Transfer (TT) Strategy and Activities of the Institution

Technology Transfer (TT) Strategy and Activities of the Institution		
	No	yes
TT Strategy	43.8	56.3
TT Dedicated Team	65.6	34.4
TT Monitoring and Evaluation	28.1	71.9
TT Outputs as staff performance criteria	71.9	28.1
Partners TT Satisfaction Survey	81.3	18.8

Firms were asked, as depicted in table 18, whether they have technology transfer strategy in their organization and majority of the respondents (56.3%) positively responded by stating that they have a formalized TT strategy that can be a strategic plan, policy, guidelines or others. This implies, technology transfer activities guiding foundations moderately got attention in firms. Team of technology transfer to handle TT's activities was another important question raised to respondents and most of them replied there is no dedicated team (65.6), significant majority (71.9%) of the respondents replied there is technology transfer monitoring and evaluation, similar per cent (71.9%) of them responded they do not use TT activities as performance evaluation criteria. Finally, partner satisfaction survey response is very negative (81.3%). This finding from the survey indicates the existence of huge gap in the firms technology acquisition, diffusion and performance monitoring and evaluation in Ethiopia.

Table 19: Technology collaborative partnership

Technology Collaborative Partnership					
		Frequency	Percent	Valid Percent	Cumulative Percent
TCP Budget Change From 2018	Increased	32	100.0	100.0	100.0
	Decreased	0	0	0	0
TCP Budget Forecasted 2023	Increase	31	96.9	100.0	100.0
	Decrease	0	0	0	0
	System	1	3.1		

As shown in table 19, there is a comparable level of capital budget changed or increased from 2018 and huge number of respondents (96.9%) forecasted the budget will increase for coming 3 years between a period of 2021-2023.

Table 20: Frequency of Open-source technology usage

Frequency of Open-source technology usage					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	3	9.4	9.4	9.4
	Low	6	18.8	18.8	28.1
	Sometimes	22	68.8	68.8	96.9
	Often	1	3.1	3.1	100.0
	Total	32	100.0	100.0	

As shown on table 20, the frequency of open source usage was found to be significant as reflected by notable majority responded of 68.8% use it sometimes, low usage is 18% and often accounts (3.1%) of the respondents. The response rate show that there is a promising activities related to usage of open source technologies consider few (9.4%) of them never use open source technologies.

Table 21: Geographical Spread of The Institution's Technology Transfer Partners

Geographical Spread Proportion of Inward (acquisition by the institution)					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Africa	2	6.3	8.0	8.0
	Middle East	1	3.1	4.0	12.0
	Europe	4	12.5	16.0	28.0
	Asia	18	56.3	72.0	100.0
	Total	25	78.1	100.0	
Missing	System	7	21.9		
Total		32	100.0		

As per table 21, significant number of respondents get technology from Asia (56.3%), Europe also constitutes response rate of 12.5%, followed by few number of respondents (6.3%) who stated they get technology from Africa.

Table 22: Comparing to the previous 3-year period (2015-2017)

Comparing to the previous 3-year period (2015-2017), the firm's	Significantly Increased (over 50%)	Increased (up to 50%)	No Change	Decreased (up to -50%)
Technology acquisition activities have	12.5%	71.9%	15.6%	0
Technology provision activities have	9.4%	65.6%	25.0%	0
TT activities with other firms have	3.1%	43.8%	53.1%	0
TT activities with public sector enterprises have	3.1%	25.0%	71.9%	0
TT activities with own subsidiaries have	21.9%	46.9%	31.3%	0
TT activities with universities have	18.8%	21.9%	59.4%	0
use of open-source technologies has	18.8%	81.3%		0
In the next 3-years period (2021-2023), it is forecasted that the firm's				
Technology acquisition activities will	3.1%	93.8	3.1%	0
Technology provision activities will	6.3%	84.4%	9.4%	0
TT activities with other firms will	6.3%	65.6%	28.1%	0
TT activities with public sector enterprises will	6.3%	65.6	28.1%	0
TT activities with own subsidiaries will	18.8%	59.4%	21.9	0
TT activities with universities will	21.9	71.9%	6.3%	0
Use of open-source technologies will	6.3%	71.9	21.9	0

As shown in table 22, out of the respondents who returned questionnaires significant number of respondents responded the open source (81.3%) technology usage, technology acquisition (71.9%) and technology provision (65.6%) increased up to fifty per cent between 2015-2017. The respondents also stated that there is no change for TT activities with public sector enterprises (71.9%) engagement as well as engagement on TT activities with Universities (59.4%), 53.1% respondents replied there is no change on TT activities with other firms. Most (84.4%) of respondents predicted the technology acquisition will increase up to 50% for duration (2021-2023). On similar fashion the respondents positively predicted the technology transfer activities will increase on technology provision, activities with other firms, public sector, universities and open source technology usage expected to increase.

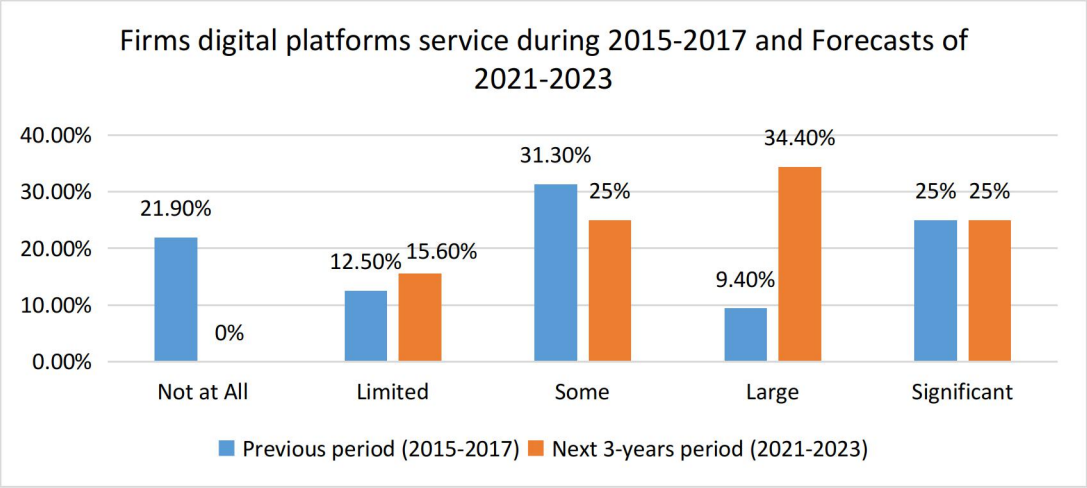

Figure 12: Digital platforms deployment comparison

As shown figure 12, respondents were asked the extent their institution used online sales and digital services for a period of (2018-2020) and moderate number of the institutions use online sales and digital services sometimes (31.3%), those who use largely and significantly account 9.4%, and 25.0% respectively. However, 21.9% of them do not use online sales and digital services, implying there is gap in digital technology use in the firms service provision. On another hand, the forecasted online sales and digital services predictions show positive expectation at different level hence limited (15.6%), some (25%), large (34.4%), and significant (25%) of them deploy digital service and online sales.

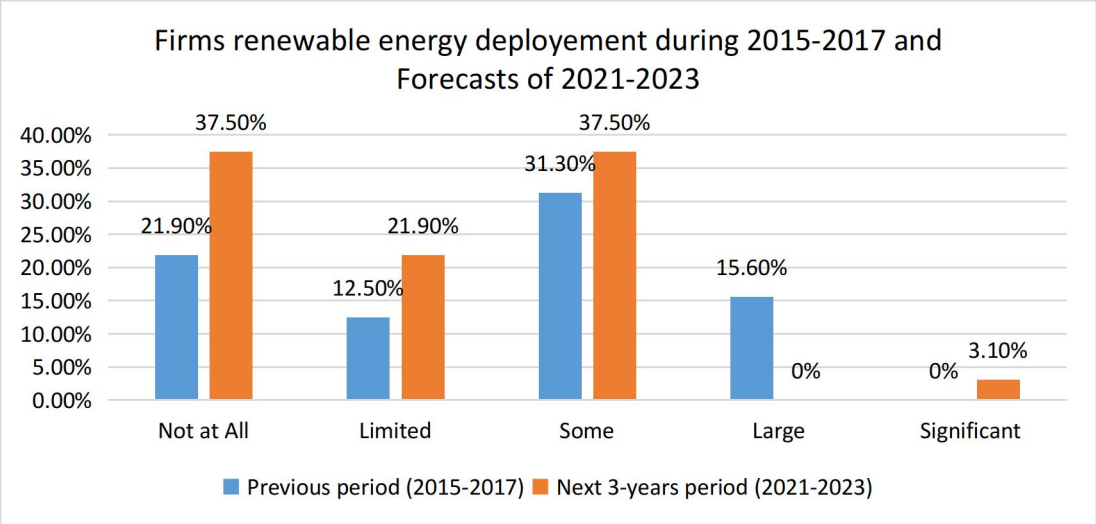

Figure 13: Firms renewable energy deployment comparison

As depicted in figure 13 for a period of 3 years (2018-2020) the RTOs' respondents said in their response 25.9% of them not acquired at all or have limited (40.7%) renewable energy technologies initiatives. On another hand, few number of respondents deployed renewable technology activities that accounts some (25.9%), large (22.2%) and significant (7.4%). Their predictions shows most of them expected to deploy the renewable energy with different levels limited (21.9%), some (37.5%), and significant (3.1%).

Table 23: Access Government Incentives for TT activities

Access Government Incentives for TT activities					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	We are not aware of any incentive.	15	46.9	48.4	48.4
	Yes, there are government incentives for this purpose	16	50.0	51.6	100.0
	Total	31	96.9	100.0	
Missing	System	1	3.1		
Total		32	100.0		

As portrayed in table 23, respondents were also asked to rate their access of government incentives for TT activities in Ethiopia and 46.9% of respondents were not aware of any government incentives on technology transfer activities. The positive response with "Yes, there are government incentives for this purpose" (50.0%) is more better number in comparison. This entails there is moderate government support for firms engaged in technology activities in Ethiopia.

Table 24: Frequency of Open source technology

Frequency of Open source technology					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Never	3	9.4	9.4	9.4
	Low	6	18.8	18.8	28.1
	Sometimes	22	68.8	68.8	96.9
	Often	1	3.1	3.1	100.0
	Total	32	100.0	100.0	

As shown in table 24, use of open source technologies to run their business was another important question raised to respondents and majority (68.8%) of them replied they use sometimes and 18.8% responded their usage is low. There is small amount of respondents replied they never (9.4%) used open source technologies. This finding from the survey indicates the existence of open source technology usage to provide relevant technology services in Ethiopia.

Table 25: Geographical Spread of in bound technologies

Geographical Spread of inward technologies					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Africa	2	6.3	8.0	8.0
	Middle East	1	3.1	4.0	12.0
	Europe	4	12.5	16.0	28.0
	Asia	18	56.3	72.0	100.0
	Total	25	78.1	100.0	
Missing	System	7	21.9		
Total		32	100.0		

As depicted in table 25, number of respondents replied they use technologies from other countries located in Asia (56.3%), Europe (12.5%), Africa (6.3) and middle east (3.1%). The Asian's countries technology inward rate took the largest share and most of Ethiopian firms imports technologies from other countries.

Table 26: Geographical Spread of outward technologies

Geographical Spread of outward technologies					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Africa	5	15.6%	55.6	55.6
	Europe	1	3.1%	11.1	66.7
	Asia	3	9.4%	33.3	100.0
	Total	9	28.1%	100.0	
Missing	System	23	71.9%		
Total		32	100.0%		

It is shown in table 26, only 28.1% of the respondents replied their technologies out bound flow is to Africa, Europe, and Asia.

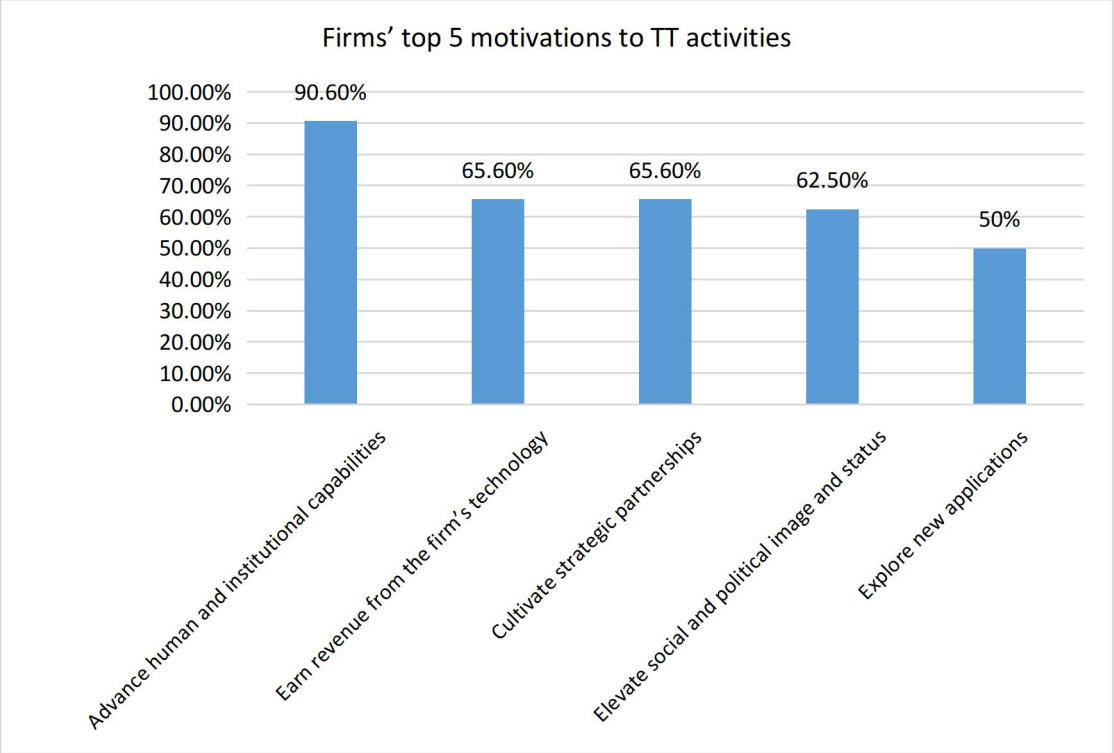

Figure 14: Institution's TOP 5 motivations to TT activities

As illustrated in figure 14, respondents were asked what are top motivation to technology transfer activities. Accordingly, the first motivation is to advance human and institutional capabilities (90.6%), the second is to earn revenue from the firm's technology (65.6%), third to cultivate strategic partnerships(65.6%), on the fourth elevate social and political image and status(62.5%), and finally the fifth motivation is to explore new applications (50.0%). The firms responses substantiate that there is a potential to advance human capital development and earn revenue from the firm's technology through strong strategic partnership, whereas there is low motivation to become a global technology leader in the sector and low motivation to safeguard intellectual properties and avoid infringement and related litigation that imply there is a gap on intellectual property rights awareness.

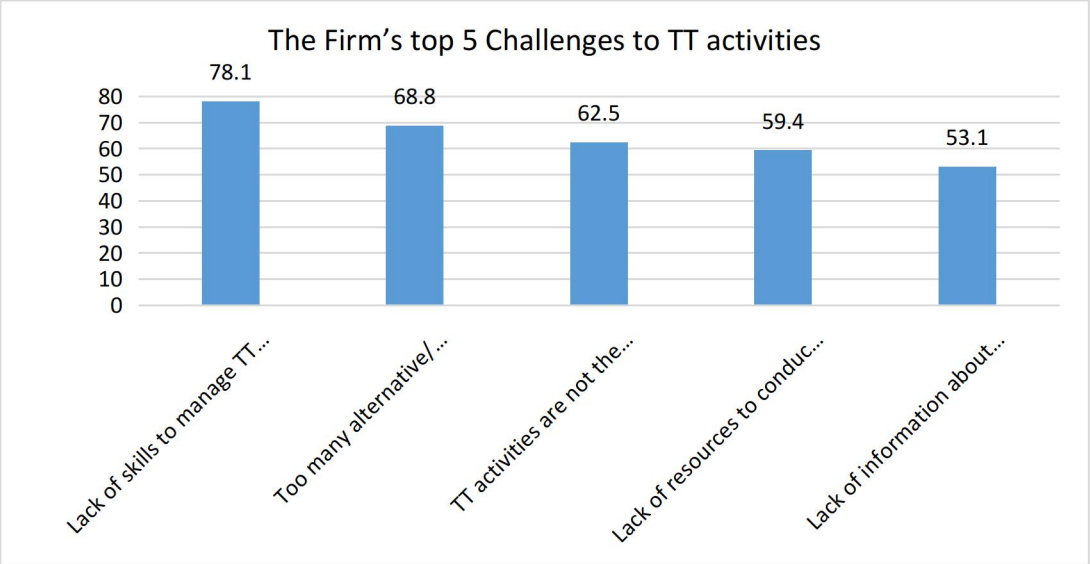

Figure 15: The Institution's top 5 Challenges to TT activities

As portrayed in figure 15, overall firms' top five challenges to TT activities are lack of skills to manage TT activities (78.1%), too many alternative/ substituting technologies available in the market (68.8), TT activities are not the priority of the institution (62.5%), lack of resources to conduct TT activities (59.4%) and lack of information about technology needs and availability in the institution (53.1%). In nutshell, lack of skills to manage TT activities and substituting emerging technologies usage, and lack of priority of the firms are regarded as the top challenges of the respondents TT activities assessment. Gaps are reflected in firms' low score of the likelihood on the perceived weak protection of IP and afraid of losing technological edge if technology is transferred out.

Table 27: Comparing To the Closest Institution

Comparing to the Closest Institution

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Significantly Higher	1	3.1	3.1	3.1
	Higher	8	25.0	25.0	28.1
	Similar	19	59.4	59.4	87.5
	Lower	4	12.5	12.5	100.0
	Total	32	100.0	100.0	

Comparing to the firm's main competitors, the firm's overall TT activities are shown in table 27, respondents rated among key technology service providers, on who is likely their main competitors. Accordingly, in a descending order, similar (59.4), higher (25.0%), lower (12.5%) and significantly higher (3.1%). Based on the above response, technology firms are in similar pro-tech.

6. Summary of Major Findings

The main objective of this works is to examine underpinning practices of technology transfer at firm level as well as to do investigations on the practice of RTOs on diffusion and public sector support for technology acquisition by firms. All needful data was collected from primary and secondary sources. Through case studies and quantitative instruments the essence of both the practices and measures on technology transfer activities and its impact on economic, social and environmental were assessed.

6.1. Practice and Hurdles for Technology Transfer

From qualitative analysis the Ethiopia's science, technology and innovation has passed though various stages that covers the first stage characterized by the research and development conducted by experts without well organized science and technology ecosystem (i.e. absence of STI policy and institution). The second phase is the stage institutionalized R&D activities formally engaged the commencement of science and technology institution and policy formulation. On the third phase the institutionalized science and technology set up (i.e. institutional arrangement, policies and strategies) encored to be devised and consequently reformed. The last phase comprises devising science and technology policy, re-arranging institution that can be creating new RTOs or dissolving them.

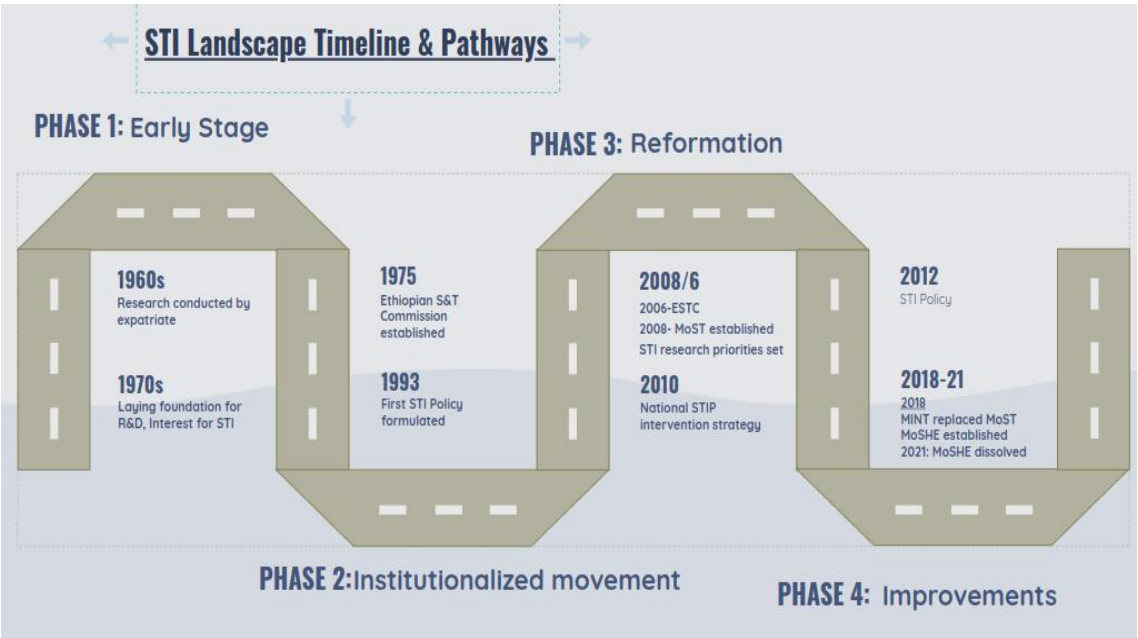

Figure 16: STI landscape timeline and pathways

6.1.1. Ethiopia's STI Policy and Technology Transfer Practice

Among of the critical policy issues addressed in 2010 STI policy, the Technology Transfer was the top subject matter inscribed in the policy. The policy's TT direction showcases, TT in Ethiopia has to took place primarily by upgrading foreign technologies that are demanded by the domestic economy. Accordingly, to achieve these the technology transfer intervention strategies ere formulated to increase national technological capabilities. Subsequently, the priority programs are set to implement the policy through joint efforts of the various actors. The document

stressed the coherent need of science and technology infrastructure and government research institutes. It is noted that there were frequent/eventual improvement in the S&T policies that targeted to make it inclusive, to improve and devise the policies implementation strategies, to align the policy intervention with the national development plans/global trends, to exploit the development of indigenous technology, to establish/strengthen RTOs, to benefit from global opportunities scientific knowledge and technology advancement, to consider AUC S&T Programmes and Millennium Development Goals.

6.1.2. Public sector support for technology transfer activities

Ethiopian government has formulated policies and strategies as well frequently restructured the RTOs to create conducive environment for technology transfer. Besides the government measures on the capacity building through collaboration with local and international stakeholders the technology acquisition, transfer and diffusion remains low across the case studies due to factors related to policy implementation, weak skilled human capital for the adoption of technology staff turnover. It is also noted that government incentives for TT activities in Ethiopia not significantly known that resulted low number of firms or RTOs aware of any government incentives on technology transfer activities.

6.1.3. Practices of RTOs on technology transfer activities

In the advancement of S&T the abundance of technology transfer is highly noted for SDG of Ethiopia to becoming a middle-income country by 2025. Thus, various S&T policies are enacted, RTOs are re-institutionalized, TT activities are inaugurated, re-institutionalized RTOs have set strategic packages and modalities with the local and international collaborators focusing on R&D, human capital development, technology transfer. Also, remarkable number of RTOs have TT team, strategy and prioritized technology transfer approaches through joint efforts of Universities and firms along with importing effective and appropriate foreign technologies

The RTOs institutional rearrangement efforts and practice helped them to mutually or separately take the responsibilities for developing mechanisms for supporting, incentivising and rewarding individuals and institutions that contributed to science, technology and innovation that resulted into successful technology transfer. Finally, the RTOs and firms with efficient collaboration and organizational structure provide a suitable R&D and their TT activities progress frictionlessly as compared with RTOs having frequent reformation.

6.1.4. Firm level practices on technology transfer

Technology transfer practiced in the form acquiring new technology with its skill and knowledge that can be better production processes, how to operate new machinery, using digital platforms and purchase of advanced machinery that embodied with technology transfer package. There is also a solid amount of evidence on the common technology transfer in Ethiopia is through collaboration with foreign or local firms and RTOs. From both quantitative and qualitative analysis there is remarkable collaborative partnership practice for in bound and out bound technology transfer activities. The collaboration is guided by a formalized technology transfer strategy that can be a strategic plan, policy, guidelines or other. Firms have motivation to

advance human and institutional capabilities and to earn revenue from their technology strategic partnerships that can elevate social and political impact.

On another note, it is noticed that firms did not give more attention to R & D and few of them have dedicated R & D team, thus almost they do not conduct partner satisfaction survey. These practice amplified the gaps in the firms technology acquisition, diffusion and performance monitoring and evaluation in Ethiopia.

6.2. Perspective Challenges on Technology Transfer Practice

Even though, there are factual progressive updates in Ethiopian STI policy legislature and governance structure, yet the technology transfer and innovation contribution for national growth and development is insufficient. The failure in meeting national needs has are challenges relate to the following lists:

6.2.1. Unstable and Rapidly Changing RTOs Institutional Arrangement

Since 1975 Ethiopian S&T institutions have undergone various frequent institutional reformation in leadership, scope, mandates, organizational structure, etc. The rapid institutional reformation that touched ministries, research institutes and research centers lags implementing the technology development and technology transfer policies and strategies due to the change of organizational structure affecting roles and responsibilities. There are a lot of initiatives that pinned to each institution life time and when those institutions obsolete or repealed the initiatives had gone together, that resulted to unsustainable S&T landscape.

On another hand, inadequate science and technology policy intervention frameworks, insufficient assessment of technology needs, implementation plans, unsustainable and unstable RTOs' organizational structure are the challenging practices as well as inadequate infrastructure, lack of technical standards and supporting institutions, low technical capabilities and technology knowledge base.

6.2.2. Weak collaboration and coordination with partners

From the case studies and quantitative analysis there is a weak collaborative framework for technology transfer and lack of a formally bonded collaboration system between RTOs and industry. Further more, due to the fragmented collaboration of the government, private sector and academia in technology development landscape, it has resulted in insufficient funding for technology transfer for instance there almost no industry fund for R&D. On another note, from most of the collaborations it is recognized that, there is lack of systematic TT and weak technological capability for the effective absorption of foreign technologies and there is lack of monitoring and evaluation, lack of follow up or lack of satisfaction survey.

6.2.3. Lack of resource and skilled human resource

It is noted that from the case studies and quantitative analysis there significant fragmentation and disintegration in regards of sustainable human capital development and resource for R&D. There is no smooth means of R&D as well as technology transfer diffusion mechanism as the result of lack of well organized skilled human resource and resources for TT activities. More recently, national initiatives such as EthERNet are inaugurated to solve the fragmented resource sharing on science, innovation and technology. It is being moderately responded by Ministry of Education and Ministry of Innovation through national research infrastructure sharing and

coordination. Furthermore, there are noted technology transfer activities challenges such as lack of skills to manage technology transfer activities, too many alternative or substituting technologies available in the market, and significant number of firms did not give priority for technology transfer activities.

6.2.4. Lack of moderate funding mechanisms and incentives for researchers

All RTOs (Universities and research institutions) are mandated to conduct research and participate on technology transfer based on the funds from own source, funds from government, funds from industry, funds from national and funds from external sources. In addition, there is no known incentives for technologist that work on the research grants that consequently discourages the researchers from devoting their effort on research and development that impacts science, technology and innovation. Further more, it is identified that private industry funding is insignificant due RTOs and industry partnership packages.

6.2.5. Weak TT information flow, alignment between policy and implementation

There were countable key messages noted in the regard of Ethiopian STI landscape [1], for instance mismatch between "policy formulation" and "policy implementation" that shows the a gap between formulation of policies and an intervention problem in reality. Secondly, there is high-level economic growth that require skill and innovation but low-level of technology transfer practice persisted, this depicts that even though Ethiopia is among of fast growing economy there is a gap on technology transfer activities. Thirdly, there is lack of systematic TT and weak technological learning capability for the effective absorption of foreign technologies due to lack of TT information flow. Further, Gaps are reflected in firms' low score of the likelihood on the perceived weak protection of IP and afraid of losing technological edge if technology is transferred out due to lack of information about technology needs and availability.

7. Conclusion and Recommendations

From the applied quantitative and qualitative methodologies the following conclusion is drawn in Ethiopia RTOs activities on Technology transfer.

7.1. Pathway to Developing Technology, Diffussion and Implementation Plans

The sector regulatory bodies has to set out governing generic approach to technology transfer that can be ruled out by the landscape of the RTOs engagement, sector policy, industries and practitioners. To implement a technology transfer initiatives identifying the appropriate sectors that would benefit most from a technology and selecting the most appropriate technology inline with the national and sectorial policies should have to be the first steps in technology transfer pathways.

It is necessary to conduct gap assessment to identify the available technical human capital to identify, develop and operate the most demanded technologies in each sector that helps country to plan and deploy that would yield strategic sustainable technology development. There are practices to be magnified such as strategic sustainable long-term partnership that allows RTOs, and firms to exploit or use foreign technical assistance through twinning programmes to fill the technical skill gaps.

7.2. Recommendations

Successful technology transfer do not depend only on the need of the stakeholders or not on the value of the technology, but also on it depends socio-economic, technological and political factors. Accordingly, RTOs, firms and key stakeholders need to consider the following for successful technology transfer activities.

7.2.1. Recommendations on institutional requirement for technology transfer

The emergence of various research institutions and their collaboration on various technology transfer packages in Ethiopia show the necessity of the industry RTOs linkage, functioning as both a technology transfer and innovating technologies. The institutional arrangement at firm level needs to be equipped with R&D, technology transfer organizational structure that can moderately works on the technology transfer activities with a mission to monitoring, evaluation, regular satisfaction survey, knowledge exchange, set performance appraisal criterion of R&D staff of the firm/institution, technology licensing, and promote intellectual properties of the firm/institution.

7.2.2. Recommendations for RTOs and firms

One of the alternative ways of technological transfer is collaboration with international RTOs, from both qualitative and quantitative analysis there are notable number collaboration between Ethiopia's RTOs and international collaborators. However, there are low number of RTOs operate out of Ethiopia as well there are small number of international technology firms, this entails the room for technology transfer is very limited. On another note, Ethiopia has significant number of Industry parks, IT park, research institutes, and Universities. At the same time it is noted that most of the firms do not have technology transfer unit in their operation. Accordingly,

Ethiopia's technology development and transfer demands enhancing the practice of technology transfer through strategic partnership, enhancement of policies' strategies that enforce firms to set up and strength innovation and technology transfer systems/units in their organizational structure.

7.2.3. Recommendation for Government Support

The government of Ethiopian has been frequently restructuring the RTOs, indeed, it is important to structurally reform institutions to tune the current trend at the same time it very crucial to ensure the prior technology initiatives are moderately transferred coherently to the new institutional arrangement, thereby it helps to sustain RTOs' productivity and legitimacy. There is low government support to incentivize technology firms through tax reduction for the acquired technology licenses, R&D expatriates incentives, reduction or exemption of import duties, subsidies for investment in resources and assets either for RTOs or firms. It is highly recommended to incentivize through outline packages those firms and technologies engaged in technology development and technology transfer activities.

7.2.4. Recommendation for Realizing the Implementation of STI Strategies

Ethiopia has long time experience in STI policy formulation, the impact of the policies relies heavily on the appropriate implementation intervention strategies. Accordingly, besides the policies formulation and strategies the implementation mechanism of the strategies has to relevantly lined up to achieve the desired results of policies' in technology transfer. Furthermore, the strategies has to moderately encompasses the applicable mechanism such as directives that guide the RTOs to have formalized R&D, technology transfer organizational structure that warrants RTOs incentives for the R&D findings and technology innovation at RTOs level. As another strategy intervention, it is important to develop and share national stock of technology information system in each sector with available demands and their respective opportunities.

7.2.5. Recommendation for other Players

There various actors in the technology development and technology transfer ecosystem such as technology hubs, incubators, accelerators, industry and technology parks, entrepreneurs, and funders. The commitment and awareness of these players can play a critical role in acquiring, creating, and transferring the technology either at institution level or country wise. The technology transfer players should supplement each other through strategic collaboration by mutually setting up measures to assimilate, modify, and localise the technologies to their respective common benefits/needs.

To strength these players collaboration, technology innovation, technology transfer activities it is important to set incentive packages such as tax reduction/ rebate for the acquired technology licenses, common infrastructure, regulated funds, subsidies for investment in R&D, technology innovation resources and assets that enhance and enable them to acquire, develop, and diffuse technologies. These can be realized through tangible intellectual property rights they posses/register as monitoring and evaluation mechanism to insetivize them for prescribed packages.

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Annex I: Explanation of key concepts and terms

Transfer of Technology (ToT): the transfer of systematic knowledge, technologies, training on how to use, how to maintain and upgrade the technologies and skills for the *manufacture of a product, for the application of a process or for the rendering of a service*. It *excludes* sale or purchases of technology items/products (e.g. computer, vaccines, cars).

Intra-institution transfer of technology: Refers to technology transfer between entities that belong to the same group such as between affiliates, and between parent institution and its affiliates

Inter-institution transfer of technology: Refers to technology transfer between two or more entities that are not within its group of institution.

Inward transfer of technology: Refers to technology transfer **INTO** your institution be it from an affiliated entity or third parties.

Outward transfer of technology: Refers to technology that your institution has transferred **OUT** to other entities regardless of whether they are affiliates, subsidiaries or headquarters or third parties.

R&D: Stands for "basic and applied *research* and experimental *development".*