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Applicable Model and Approaches for Technology Transfer in Developing Countries

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Abstract

There are various models and mechanisms for technology transfer. But it doesn't mean that all technology transfers models and mechanisms are fit to all types of technology. The model selections are based on the technology recipients and donors' interest, economic level and types of technology to be transferred. This study reviewed and examined the technology approaches and models and proposed the best applicable and appropriate technology transfer models and approaches in developing countries. The study conducted through literatures review on technology transfer models, and Mechanisms of fast developing and developed countries. The countries considered as best practice were China, Japan and South Korea. Some approaches were Trade or importing capital goods, licensing, foreign direct investment, joint venture, re-engineering, human capacity development, donation of the technology and innovation-based technology transfer. Here, the question is which one is/are fit to developing countries to receive technology? Though it is misleading to propose only one approach, it is possible to develop or select the best approach/approaches to transfer technology in developing countries. In this study the best appropriate technology transfer approaches and model were clearly identified & recommended.

Key words: Technology Transfer, Models, Developing Countries, Best Practice, Mechanisms

1. Introduction

1.1 Concepts of Technology and Technology Transfer

The main purposes of technology transfer are to create innovation, improve productivity and economic growth (Hailu,K.2012). Before immersing into technology transfer mechanisms, models and concepts, defining what is technology and technology transfer is very important. Different literatures and authors define technology differently. Even though the definitions are different in scopes and contextually, its basic concepts are not far from each other's.

According to (Kumar et. Al, 1999) technology consists of two primary components: Physical component which comprises of items such as products, tooling, equipment's, blueprints, techniques, and processes; and the informational component which consists of know-how in management, marketing, production, quality control, reliability, skilled labor and functional areas. According to Lovell (1998) and Bozeman (2000) the concept of technology does not only relate to the technology that embodies in the product but it is also associated with the knowledge or information of it uses application and the process in developing the product.

The latest definition given by (Mascus, 2003) has broadened the concept of technology where technology is defined as 'the information necessary to achieve a certain production outcome from a particular means of combining or processing selected inputs which include production processes, intra-firm organizational structures, management techniques, and means of finance, marketing methods or any of its combination (Wahab, S. A., Rose, R. C., & Osman, S. I. W. 2012)

Technology is Knowledge of physical processes which transform inputs into outputs together with social arrangements- that is organizational modes and procedural methods which structure the activities involved in carrying out the transformations. Technology may be codified in blueprints or unmodified that is known-how of engineers (Green Paper Science, Technology and Innovation Policy of Ethiopia, 2012).

By scrutinizing the technology definition from the literatures it is possible to define the technology contextually for this study report as:

Technology is tangible and intangible research findings play great roles in economic growth, security and society livelihood improvement. The tangible technologies comprised of machineries, equipment, military technologies, and related whereas intangible technologies are knowledge and techniques how to make and operate tangible technologies, and doing things system improvements. It is embodied in machines and tools, people, materials, cognitive and physical processes, and services.

Like technology, technology transfer or diffusion has different meanings based on its context and types of technology transfer. The technology transfer can be categorized as vertical and horizontal technology transfer. Transferring or commercializing the research finding technology is a vertical technology transfer, whereas transferring existing technology from technology owner countries or organization to other hosting countries or organizations is a horizontal technology transfer.

Technology Transfer' (TT) is typically defined as the process of transferring scientific findings from one organization to another, frequently through the licensing of IPRs, for further development and commercialization (Aridi, A., & Cowey, L. 2018).

Technology transfer is the process of transferring scientific findings or new knowledge and technologies for public use or for commercialization after validating their usefulness through participatory demonstration and evaluation with users. Technology transfer means using existing technology in a place where it has not been previously used (Farhadikhah, Z., & Husseini, S. M. H. 2015).

Technology Transfer is defined as the transfer of systematic knowledge for the manufacture of a product or provision of service. It is a process by which one party gains access to technological information and successfully learns and absorbs it into his production process or service provision. It involves sharing of skills, knowledge, methods of manufacturing, samples of manufacturing and facilities (Green Paper Science, Technology and Innovation Policy of Ethiopia, 2012).

This study defined the Technology Transfer as the process of transferring research findings or existing technologies from technology donors to host organizations or countries using appropriate technology transfer mechanisms and models for public use or commercialization. In Ethiopia the technology transfer activities have been practiced in many ways. Some of the practices were foreign direct investment, importing capital goods, industry parks, University- industry linkages and others. From the impact assessments and observations, those approaches were not satisfactory to transfer technologies in Ethiopia. Considering these issues into account this paper is intended to review and examine the applicable technology transfer model and approaches for developing countries. Specifically, to review the model and approaches of fast developing and developed countries technology transfer and propose the best model and approaches for economic development through productivity and innovation enhancement, and sustainable economic growth.

This paper will helpful for technologies in demand developing nations to understand the model and mechanisms to receive technologies. In addition, the technologists and researchers will use this research paper for their references during conducting related researches. This research paper is answered the following research questions:

1. What are/is the preferable technology transfer model and mechanisms for developing countries like Ethiopia?
2. What mechanisms and model used as best practices for developing and developed countries like China, Japan and South Korea to receive, adapt and adopt technology?
3. What were the challenges of technology transfer practices in Ethiopia?

2. The Study Methodology

This study is conducted through literature review, interview with technologist and benchmarks the fast developing and developed countries technology transfer approaches. More than 30 journal articles, reporting documents and others are reviewed. After the collection of data and literature reviews the paper were analyzed and interpreted using different diagrams, and organized in clear ways for the reader.

3. Literature Review

3.1 Technology Transfer Mechanisms

Technology flows easily across boundaries of countries, industries, departments, or individuals, provided that the channels of flow are established. The choice of a technology transfer method should be based on technology analysis, future strategy of cooperation with a company's supplier, investment resources and technical capacities of the company to implement the technology.

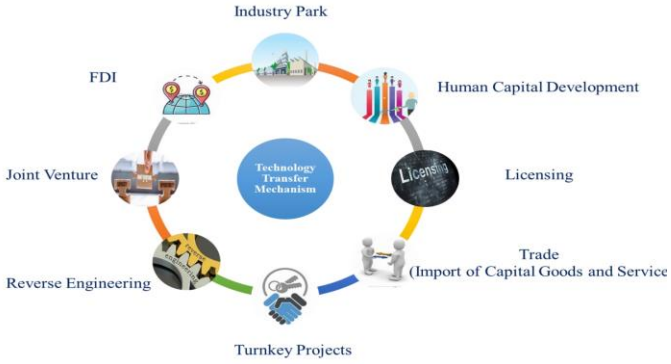


Fig. 1 Technology Transfer Mechanisms

3.1.1 Industry Park Zone

An important motivation for establishing industrial parks is the possibility for technology transfer and the dissemination of knowledge in the domestic economy through linkages and demonstration effects. And it's a place that creates opportunity to transfer technologies. Channels of knowledge transfer from foreign firms located in industrial parks to local enterprises includes: carrying out subcontracting work or providing inputs to foreign firms; joint venture between foreign and local investors; locals employed and trained in foreign firms leaving to start their own businesses or to work with local enterprises; and skilled expatriate workers leaving foreign firms to work as managers or technical experts in local firms (UNCTAD, W. 2014).

3.1.2 Foreign Direct Investment

It is a form of investment through which a great deal of technology can be transferred to the host country. FDI has a spillover effects in transferring technology for the local firms (Saggi, K. 2002). Considering into account the Ethiopia's absolute and competitive advantages in human capital availability and raw material resources attracting FDI is very important mechanism for Ethiopia's technology transfer. Thus, initiating different incentive scheme is recommendable.

3.1.3 Licensing

Licensing is an agreement under which the owner of a patent, trademark or other intellectual property (IP) gives permission to another company to use the own technology developed, in a certain area during a certain period of time. There are two main types of licenses: One which grants an exclusive right to use the technology and another with non-exclusive right, which implies that the patent owner may transfer the right to use the technology to other companies in the same area. The advantage of buying a license/patent is that it has lower costs, compared with other technology transfer methods. However, the purchase of a license requires sufficient knowledge, relevant expertise and manufacturing base for the further in-house technology implementation. In addition, it leads to dependency of host country on the patent or license owners.

3.1.4 Reverse Engineering

Reverse engineering is the process of discovering the technological principles of a device, object or system through analysis of its structure, function and operation (Cetin, 2009). Reverse engineering is a systematic approach for analyzing the design of existing devices or systems. We can use it either to study the design process, or as an initial step in the redesign process, in order to observe and assess the mechanisms that make the device work and study the inner workings of a mechanical device (Raei & Goodarzi, 2011).It needs basic knowledge of technology and techniques of multidisciplinary professionals from research institutes, universities and industries and it is very important to support by education policy.

3.1.5 Human Capital Development

International movement of people associated with nationals studying or working abroad for a limited period and applying their new knowledge when they return, or the inward movement of foreign nationals into the country is another potential channel for international technology transfer. A challenge for developing countries is to facilitate temporary movement abroad and to encourage returnees to undertake local research and business development (Hoekman et al., 2004). This mechanism is the basic mechanism to transfer, sustain and improve technologies through diaspora, immigrant and intellectual citizen involvement in technology and innovation development and management.

3.1.6 Turnkey Projects (Agreements)

In the case of turnkey projects, technology is acquired when foreign firms construct a certain factory. The general contractor is responsible for all the procedures related to technology transfer, such as technology design, financing, equipment supply, construction and commissioning. This type of technology transfer mechanism is relatively expensive mechanism for developing countries.

3.1.7 Imports of Capital Goods/Trade

One of the technology transfer mechanism Ethiopia practicing is Import of capital goods or machineries.100% exemption from the payment of import customs duties and other taxes levied on imports is granted to an investor to import all investment capital goods such as plant machinery and equipment, construction materials as well as spare parts worth up to 15% of the value of the imported investment of capital goods provided that goods are not produced locally in comparable quantity, quality and price.

The main objectives of the government to provide incentives for both local and foreign companies is to boost export earnings of the country in between the government is encouraging technology transfer. Meanwhile the annual total export earning of Ethiopia has declined to $2.857 billion in 2015/16 from $3.152 billion in 2011/12, according to the data from the Ministry of Trade and Industry of Ethiopia. Though the export performance is not satisfactory, the technology transfer activities are taking place by importing capital goods.

3.1.8 Joint-Venture

Foreign investment inflows through joint ventures especially with the Government of Ethiopia (GOE) are encourage-able. One of the criteria to welcome the joint venture in Ethiopia is Transferring and adaptation of needed technology into the country and Utilization and development of the country's resources, mainly the generation of local employment opportunities. It is the best technology transfer mechanisms for developing countries, and needs high transparency and trust between foreigner and domestic investors.

3.2 Technology Transfer Best Practices

Developing countries could learn valuable lessons from the successful experiences of some industrialized and newly industrialized countries. The successful experiences of these countries have shown that learning and transferring of technology at large scales have enabled these countries to add to their own productivities and as a result, this has led to their ever increasing industrial and economic growth (Soesastro & Pangestu, 1990).

Japan

Japanese experience shows that in the years 1950s and early 1960s, imported technologies played vital role to economic growth by enabling Japanese producers to acquire new and advanced knowledge. Japanese private companies rushed to pick up the new technologies brought from abroad, and improve their products quality. These transferred technologies in terms of trade made Japanese manufacturing products competitive and penetrate into the world market (Soesastro & Pangestu, 1990).

South Korea

The Korean economy has grown significantly through strong government support and engaged people (high quality of human capital) since the early 1960s. Koreans have tried to accumulate a high quality of human capital through education because Korea has few natural resources. Koreans regarded the export of its industries as the only means to get above poverty the early 1960s. As a result, government and business leaders together fashioned a strategy of targeting export-oriented industries for development in the early 1960s. Textiles and light manufacturing were the first targeted industries, followed in the 1970s by such heavy industries as iron and steel and chemicals. Gradually, the focus shifted to the automotive and

electronics industries (Choi, H. J. 2009). The ability to import technology from developed countries, adapt for local use and imitate gave Korea leverage in building 'self-made' technology products.

China

The technology transfer experience has been started in China during the 1950s' and early 60s' were major through the turnkey project investment from the Union of Soviet Socialist Republics, United State and Western Europe; however, they were limited. The drawback of turnkey project was too costly and it limits technology capacities led to a review in 1978. The cautious market reform in China led to the creation of Special Economic Zones (SEZs) that had remarkable result though it was marked with investment in low-tech goods and light industries. This pushed further for the creation of Economic and Trade Development Zones (ETDZs); Free Trade Zones (FTZs) and High Technology Development Zones (HTDZs) which increased the flow of FDI into the country.

3.3 Technology Transfer Practices in Ethiopian

3.3.1 70:30 Education Policy

The Ethiopian government has been practiced 70:30 university acceptance quota that forces higher education institutes in the country to **en**roll 70 percent of their students under natural science field of study, and the remaining 30 percent for social science study. After evaluation of the performance of this quota in-terms job creation and students interest field of study areas and its impacts on unemployment reduction, the government amended the policy to 55 present natural science and 45 present for remaining fields which are currently on implementation **(**Ethiopia revises 70 / 30 college enrollment quota – New Business Ethiopia**).**

3.3.2 University Industry Linkage

University-industry linkage (UIL) became an important element in the higher education policy circle. It is the most effective mechanism where both the university and the industry act as complementary organizations to share resources to meet common goals and it is the major driving force in earnings of University and Industries. However it is not impact full as expected. To be successful in technology transfer through UIL all stakeholders should work together and develop the guideline/system on how to transfer technology from research academia to Industries.

3.3.3 Industry Park Development

Ethiopia's industrial parks are a core component of the Government's plan to make the country a leading exporter of manufactured goods in Africa and it is one of main technology transfer mechanism in Ethiopia. As Ethiopian investment commission report of 2019 - 2020 shows Ethiopia export 164,968,485 USD from industry parks. During this periods Industrial Parks share of total manufactured exports were covered 43%. It creates a job opportunity for about 80,802 people.

Criticism: industrial parks especially FDI companies are hire unskilled and semi-skilled employees which have adverse effects on technology transfer. Another problems observed in industry parks regarding to technology transfer has been lack of transparencies to transfer the important knowledge of the products or technologies such as design, basic maintenance of the equipment and others. As the strength they train the new employees from basic operation which helps to operate to the export standard products.

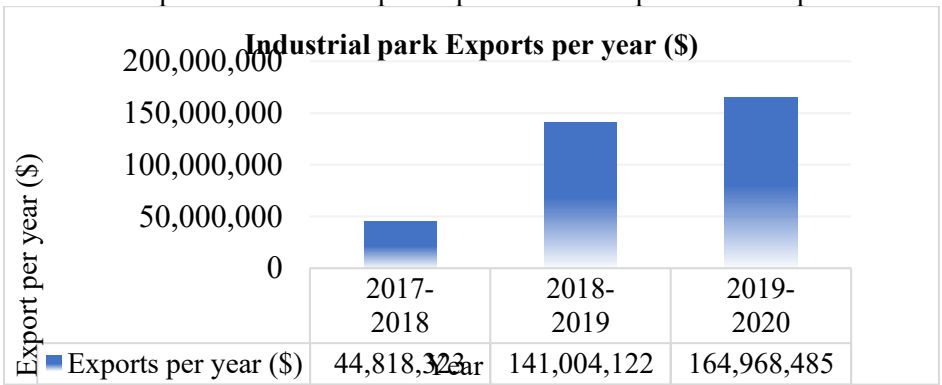


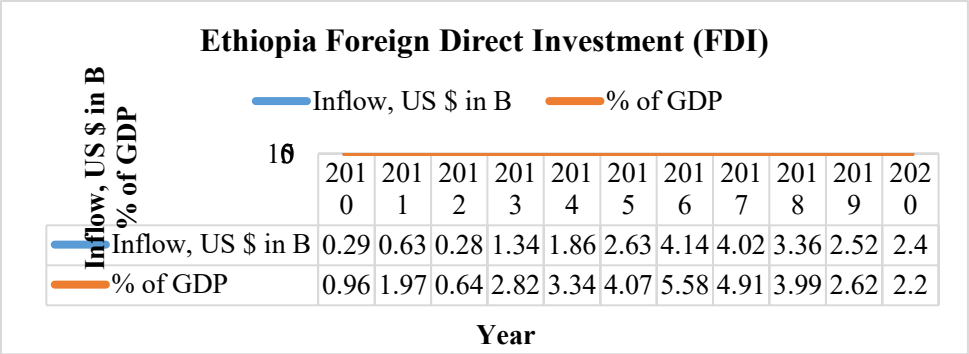
Fig. 2 Ethiopia Industrial Park Exports per year
Source: World Bank, 2021

3.3.4 Foreign Direct Investment

Foreign direct investment (FDI) is one of the more frequently used channels of technology transfer in Ethiopia. Increasing FDI flows could boost technology and knowledge transfer in export-oriented sectors. Motivated by favorable macroeconomic environment and tax and customs duty incentives foreign investors are increasingly their investment in Ethiopia. The lead in FDI activities in Ethiopia has been taken by Indian and Chinese companies with companies from Europe, the Middle East and the USA also engaged in investment efforts.

More than 123 companies with a combined investment capital of 11 billion birr have launched operations in Ethiopia since September 2011 creating more than 31,000 job opportunities. Since these FDIs come with more advanced technology, Ethiopia learns knowledge transfer in terms of training, skill acquisition, new management practices and organizational arrangements. Through direct involvement of foreign businesses and domestic producers, Ethiopian firms acquire new technology more directly.

Interpretations: Ethiopia foreign direct investment for 2019 was $2.52B, a 25.12% decline from 2018, Ethiopia foreign direct investment for 2018 was $3.36B, a 16.35% decline from 2017, Ethiopia foreign direct investment for 2017 was $4.02B, a 3.04% decline from 2016 and Ethiopia foreign direct investment for 2016 was $4.14B, a 57.73% increase from 2015.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Inflow, US $ in B	0.29	0.63	0.28	1.34	1.86	2.63	4.14	4.02	3.36	2.52	2.4
% of GDP	0.96	1.97	0.64	2.82	3.34	4.07	5.58	4.91	3.99	2.62	2.2

Fig. 3: Ethiopia Foreign Direct Investments -FDI

For many years, Ethiopia attracted much less FDI than might be expected for a large and fast-growing economy with diverse investment opportunities in various sectors. FDI inflows in 2000–2005 were less than 2 per cent of GDP. The peak was 12 per cent of GDP in 2017 when FDI exceeded $4 billion. The contribution of FDI to national fixed investment also remained low until 2012–2013, rising after that as FDI aimed at export- oriented activities in the industrial parks increased. Since 2012, FDI inflows into Ethiopia have grown by 50 per cent per year on average, reaching $4.1 billion in 2017; much of this investment has occurred in export-oriented manufacturing activities (UNCTAD, 2017).

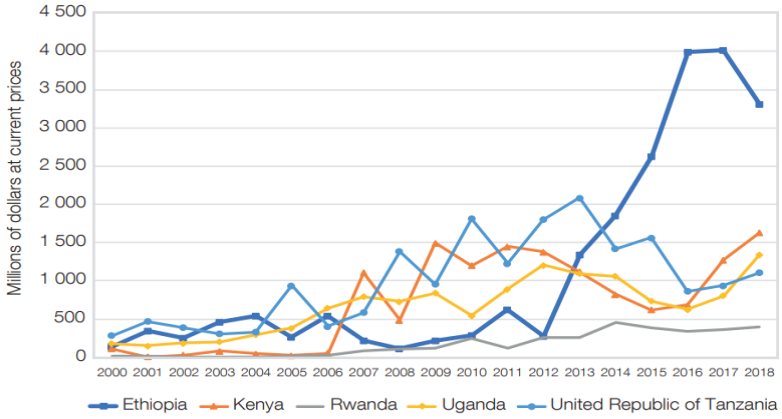


Fig. 4: FDI inflow, selected East Africa countries

Though Ethiopia attracts FDI to boost the export and technology transfer through implementation of FDI incentives available packages like fiscal incentives, non-fiscal incentives, financial incentives, and export incentives for past decades, its impacts are become declining since 2016. Domestic Industrial Park tenants engaged in the manufacturing sector can access an 85% start-up loan from the Development Bank of Ethiopia whereas 80% for foreign direct investors.

3.3.5 Imports of Capital Goods

In Ethiopia trade, particularly imports of capital goods, is the most important channel of technology transfer and innovation. Imports of capital goods for Ethiopian firms provide another way of acquiring the means of production without the transactional costs involved in FDI. Due to the fact that the Ethiopian government significant Tax Incentives such as customs import duty - 100% exemption on all import of investment capital goods (plant machinery, construction materials, etc.) including spare parts worth up to 15% of the imported investment capital goods; plus exemption for import of raw materials needed for the production of export goods, import of capital goods has seen an increase from time to time. This huge import of capital goods enabled Ethiopian firms to learn the technology embodied in the machineries.

This indicates both the continuing demand for imports of technologies and the importance that the Government attaches to technology transfer from abroad as compared to the generation of technologies locally. Capital goods importers investors are exempted from customs duties and other import taxes. Such incentives effectively encourage the acquisition of technologies from abroad instead of searching for alternative technologies locally or using the available R&D capacities to generate technologies. The country devotes a large proportion of the foreign currency earnings to the importation of technologies. This suggests that imports of capital goods/ technologies are a major contributor to the country's increasing external debt. Interestingly, the origin of interestingly, the origin of these imports has changed over the last 15years although whether this shift will have implications for technological learning is not clear at this stage.

Between 2000 and 2015, the proportion of capital goods imports to Ethiopia originating from developed countries has declined from 70% to 39.1%, while the proportion originating from other developing countries tripled from other developing countries tripled from 18.6% to 60.6%. This partly reflects the growing importance of south-south trade and investment relationship to Ethiopia (United Nation, 2020). This suggests that imports of capital goods/ technologies are a major contributor to the country's increasing well organized technology transfer. As data of world's top exports (Ethiopia's Top 10 Imports 2020 (worldstopexports.com)) shown Ethiopia import capital goods (Machinery including computers, Electrical machinery, equipment, Vehicles, Iron & steel) accounts about 30% total import goods.

3.3.6 Technology Road-Maps

A technology roadmap is a plan that matches short-term and long-term goals with specific technology solutions to help meet those goals. It is a plan that applies to a new product or process, or to an emerging technology. The document incorporates process of different technology area, situational analysis of Ethiopia different industries, assessment of major inputs for priority technology development, world and Africa countries technology status, gap analysis and major development of manufacturing, agriculture, ICT, construction and health sector technology in Ethiopia are the main issues explained in the document. The road map helps to reach a consensus about a set of needs and the technologies required to satisfy those needs, provide a mechanism to help forecast technology developments, and provide a framework to help and coordinate technology developments. By 2030 Ethiopia shall have fully developed capability in carrying out mining of iron ore and steel production technology compatible with world standard.

In general, the roadmap document addresses the role of an industry's suppliers in creating the desired future, human resource needs, governmental and non-governmental barriers and other topics like the effect on environment and industrial networking. By the time, the roadmap has been aligned with government strategic plan priority, GTP II, and STI Policy. However, currently the national strategic priority areas are replaced by Agriculture, manufacturing, Information technology, mining and truisms. The GTP II is replaced by ten years national plan and STI policy is revised. Taking these into consideration the roadmap shall be revised based on the government strategic plan priorities.

3.3.7 STI Policy

The roles of technology for economic and social development is measured when it diffused to the society and supported by innovation. STI policy mentioned as there is no guideline or system for technology identification, transfer, human capital development and disposal of outdated technology. For future action the STI policy set goals and strategies to play its roles in the economic development and security of the country. Some of the identified goals and strategies are: Identify technology, transfer technology, human capital development, utilizing and disposal of the technology capacity building and Secretarial developed technology transfer cluster development and the tactics to achieve goals: some of the tactics shall be implemented are:

- Technology identification, transfer, utilize and disposal of outdated technology system development
- Technology codification and price estimation activities
- To be competent or lead the world technology Prioritizing strategic technologies and implementation

3.3.8 Technology Assessment and Scale up

To transfer productivity enhancement technologies Ministry of innovation and technologies has been conducted existing technology assessment for last 3years for selected manufacturing industries. The studies have been made on textile and garment, chemical, construction, metal, leather and leather products and agro Processing. The assessment findings were outdated technology, maintenance problem and spare parts, shortage in highly skilled man power and finance issues to import new capital goods.

3.4 New Technology Selection Criteria

Before transferring technology to host countries or organizations technology receiver countries or organizations shall set the purposes of demanded technology in short and long term plan. To make sure that the technology is efficient and meets the needs of the organization, it is crucial to have clear evaluation criteria (Orjuela-Garzon, W. A, 2021).The evaluation factors should be clear, quantifiable, and doable. They ought to be revised as new knowledge becomes available. The efficacy of technology can be assessed using a variety of factors, such as price, functionality, sustainability, and many others. How well a piece of technology achieves the intended result should be the basis for evaluating it. Additionally, the evaluation criteria should be able to take into consideration a number of variables, including price, usability, and security (Mourtzis, D at el., 2016).

Evaluation criteria to select new technology,

1. Features: to what extent do the features meet our current requirements?
2. User Friendly: How intuitive is the technology's user-interface and user-experience?
3. Security: can we trust that our data are safe on the technology?
4. Flexibility: how easy can we adopt the solution as our organization and requirement involves. Imagine in the future, five years from now. Will technology be advancing new concepts and methods of operation, or will it be lagging behind as the organization develops and changes? (Orjuela-Garzon, W. A, 2021).
5. Interoperability: How well does it integrate with the tools that staff members use on a daily basis? How conveniently can data move from this instrument to others, or the other way around? How well does it integrate with other tools that employees currently use and plan to continue using (such as those for email, documents, statistics, etc.)? (Mourtzis, D at el., 2016).
6. Innovation: How much money and work is being put into implementing the technology? How frequently does the technology issue new versions, and how useful are they?
7. Ecosystem: How well-established and interconnected is the technology's customer and partner community? How accessible is knowledge that will aid in technology implementation improvement or troubleshooting? (Orjuela-Garzon, W. A, 2021).
8. Setup Costs: How much will it cost us directly and indirectly to design, configure, and rollout?
9. License Cost: What do we need to pay each year to license this technology?
10. Maintenance Cost: What will it take and what will it cost to support and adopt this technology over time? How well-established and interconnected is the user and partner group surrounding the technology? How accessible is knowledge that will enable you to troubleshoot or enhance your technology implementation? (Orjuela-Garzon, W. A, 2021).

3.5 Technology Transfer Models

The researchers have offered so many Technology transfer models and methodologies, since the early 1970s. These models involve both quantitative and qualitative models. They are able make easy the effective planning and implementation of technology transfer projects (Khabiri, N., Rast, S., & Senin, A. A., 2012). The researchers proposed three main components of technology transfer: Technology supplier's component, transaction mechanism component and technology receiver's component. Some of the technology transfers steps in models are reviewed as follows.

Kathuria's Model

Kathuria (2002) has provided a seven-phase process model of technology transfer to India as a developing country. According to this model, the various steps involving technology transfer to developing countries are: assessing needs, selecting technology, selecting the appropriate entry mode of technology transfer, utilizing technology to its designed capacity and performance, adapting technology to specific local conditions, improving technology beyond its designed performance (e.g. capacity stretching and quality improvement), and developing new technology. It is important to note that in this model the selection of technology is a function of the resource endowments of a country. Kathuria (2002) emphasizes the importance of the fourth stage utilizing technology to its designed capacity and performance.

The main strength of this model is the attention towards optimal utilization of transferred technology, technology adaptation which is one of the main activities of technology adoption and long-term development of technology; which are the main milestones in technology transfer to developing countries. The study considered both technology implementation and adoption into one. Therefore, there is relatively less attention to the multidimensional aspects of these activities. However, the major drawbacks of this model are little attention to the technology absorption stage, and the absence of an evaluation mechanism in the proposed model (Kumar, U., Movahedi, B., & Lavassani, K., 2008).

Awny's Model

Awny (2005) recommend the following steps for the effective transfer of technology: needs assessment, needs specification, technology selection, procurement, negotiations, implementation, and adaptation. However, Awny (2005) introduces additional steps recommended for the transfer process in developing countries: absorption of technology and development of technology. Absorption of technology includes understanding and absorbing hidden details of the technology (e.g., the know-how, tacit knowledge, and experience). Development of technology by developing countries means further modifying and developing the TT. Awny's ITT model is one of the relatively more comprehensive models of ITT. The main strength of this model is that it identifies different aspects of the assessment and negotiation stages. However this model fails to address the activities involved in the implementation, adoption, and evaluation stages of the ITT process (Awny, M. M., 2005).

Di Benedetto et al. Model

Di Benedetto et al. (2003) ITT model is merely concerned with the technology adoption aspect of ITT. As a result, little attention is paid to the assessment, negotiation, absorption, long-term development, and evaluation stages of the technology transfer process. Also in this model the implementation and adoption stages are combined as a single stage (Kumar, U., Movahedi, B., & Lavassani, K., 2008).

Putranto et al. Model

In a case study of ITT and distribution and development of local technology capabilities in Indonesian firms, Putranto et al. (2003) proposed a transfer model that focuses on upgrading the technology capability of the recipient firm in the developing country. The model encompasses four stages: the preparation stage(goals setting, identification of strengthens and weaknesses, assessment of managerial resources and infrastructure, specification of the technologies needed, search for and selection of the alternatives, evaluation, and negotiation), the production stage (the activities linked to design and engineering), the operation stage(use or operation of the products resulting from the transfer process), and the evaluation stage (creates a feedback loop in a transfer process). The model recognizes the importance of an evaluation mechanism for a successful ITT process and this model fails to consider the assessment and negotiation (Kumar, U., Movahedi, B., & Lavassani, K., 2008).

Rolle and Satin's Model

Rolle and Satin (2002) have proposed a TT model for developing countries. Their model consists of five phases: assessment of the country situation, selection of an appropriate scale and level of technology, implementation, demonstration and dissemination of the technology, and facilitation of access to the technology. Improvement in technical, marketing, and business skills of recipient firms can be accomplished by training through workshops, short courses, and demonstrations of the technology. Once the technology is adopted, it may be necessary to assist entrepreneurs in acquiring the technology and in developing both technology and product marketing plans. This model is one the most comprehensive ITT models in the literature. The main weakness of Rolle and Satin's ITT model is the absence of an evaluation mechanism and little attention is paid to the adoption and long-term development stages of the ITT process (Kumar, U., Movahedi, B., & Lavassani, K.,2008).

Table 1 Technology Transfer Model Steps

Models	Steps						
	1	2	3	4	5	6	7
Kathuria's Model	Assessing needs	Selecting technology	Selecting the appropriate entry mode of TT	Utilizing technology to its designed capacity and performance	Adapting technology to specific local conditions	Improving technology beyond its designed performance	Developing new technology
Awny's Model	Needs assessment procurement	Needs specification	Technology selection	Negotiations	Implementation	Adaptation	Absorption and development of technology (for developing countries)
Di Benedetto et al. Model	Assessment	Negotiation,	Absorption& Implementation	Long-term development	Evaluation stages	-	-
Putranto et al. Model	The preparation stage	The production stage	The operation stage	The Evaluation Stage	-	-	-
Rolle and Satin's Model	Assessment of the country situation level	Selection of an appropriate scale and technology	Implementation,	Demonstration and dissemination of the technology	Facilitation of access to the technology.	-	-

Technology Transfer Model of Oxford University and ISIS Innovation- UK

The basic idea of new technology or innovation transfer is start from technology generators, pass through the technology facilitators and ends at technology commercialization. The common technology generators are Universities, research institutes, SME, large companies and start-ups whereas the technology facilitators are government, research funders, investors, industrial parks and Technology Transfer offices. It can be shown in simple diagram as follow.

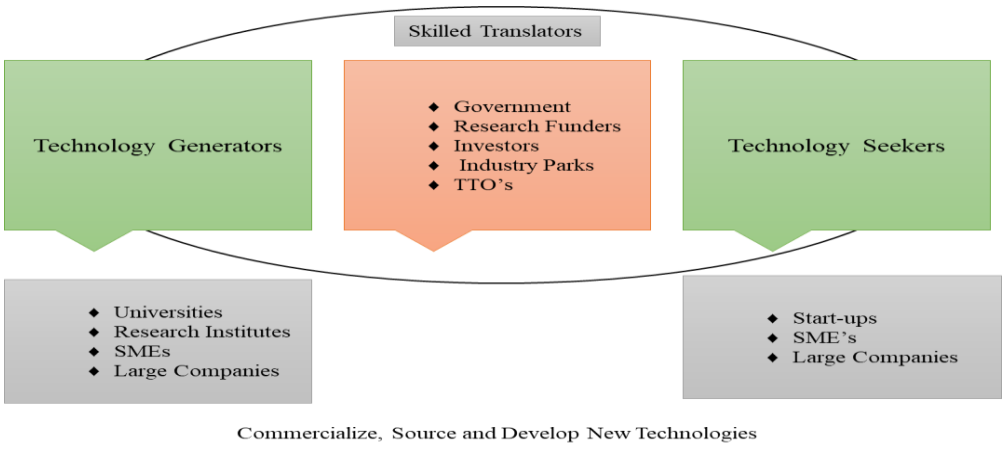


Fig. 5: Technology Transfer Model of Oxford University and ISIS Innovation- UK

The Traditional Technology Transfer Model

Traditionally since 1980's the technology and innovation transfer were from research and development department. It was closed technology and product development. The technologies ideas, technology and product developments were within a company. The way to transfer the developed technologies and products were merger or acquisition of the company by paying high money. This type of technology optimizes the internal flows of knowledge and information for the innovation. The following diagram shows the way closed technology or products are developed internally.

Traditional or Closed Technology and Product Development

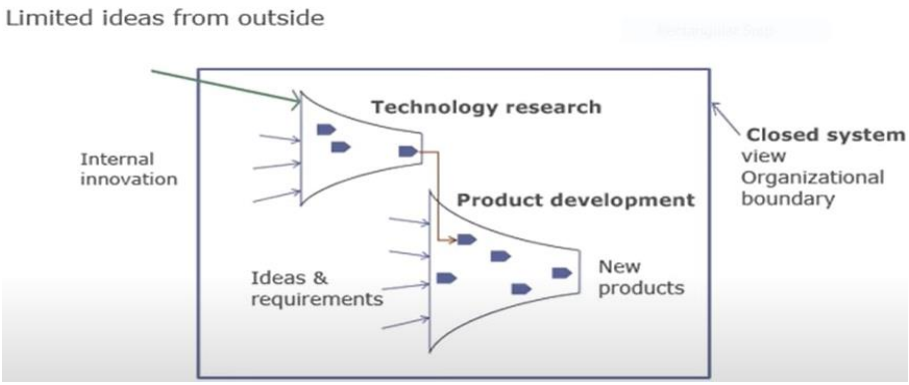


Fig. 6: Traditional technology transfer model

Experience of Oxford Model of Technology Transfer

The model of Oxford University for technology transfer is the university innovate demand based new technologies that can commercialized. The new technology innovated in the university is transferred to Isis Innovation for patent & materialization. The accepted technologies are licensed back for the university to use for education, research and non-commercialization purposes, as the mandate of technology transfer and commercialization is given to Isis Innovation the licensed technologies are commercialized to industries/start-ups/SMEs for business. The amounts of royalties gained from technology commercialization are funded back to the university, Isis Innovation, and researchers.

Fig. 7: Oxford University and Isis innovation Industry linkage model

3.6 Challenges

During the practices of technology transfer in Ethiopia the following challenges have been faced;

The 70:30 education policies weren't effective and impact full as per the expectations to create innovators, job opportunities and entrepreneurs. The reasons to fall to success has been the low quality of education, maturity of market demands for science and technology students, less awareness of science and technology students on the business or entrepreneur ideas. There were limitations in the technology transfer modality or guideline and limitations on the clarity of mandates how to transfer technology vertically (from R& D to commercialization from university to industry) and horizontal technology transfer (international, intra & Inter Company).

The gaps observed in industry park to transfer the technology as per the expectations are the industry park hires unskilled and some skilled manpower those have no strong educational background and skills. The capital goods import has been the implemented technology transfer mechanism, but it is expensive approach and recommended for short term plan implementation only. The drawback of capital goods is not only about its cost but also it has adverse effects on the government income because of incentives schemes.

The other activities have been performed by ministry of innovation and technology in 2016 was manufacturing industries technology road map preparation. It is obsoleted without any implementation and awareness creation for stakeholders. And the other activity has been the productivity enhancement technologies on existing situation assessments. It is not comprehensive and inclusive for the conclusion of the Ethiopian manufacturing and construction sector technology current status.

4. Findings and Discussions

In this topic the gaps in technology transfer models and mechanisms are clearly identified, discussed and interpreted.

As it is observed in the table 1 in the literature the models have 4 to 7 steps to transfer technology effectively. However, each model has its own strengths and limitations. The common strengths were all models contain basic technology transfer models from assessment needs to implementation phases. The limitations were almost all models were ignored the post implementation steps post implementation evaluations, sustainability and outdated technology disposal strategy. Considering these gaps into account the study designed the best model for Ethiopia.

Accordingly, Existing technology assessment, new technology demand assessment and prioritization, sources of technology identification, identifying Technology Transfer Mechanism, negotiation, adoption and Implantation, post implementation evaluation, suitability and outdated technology disposal strategy development model is designed.

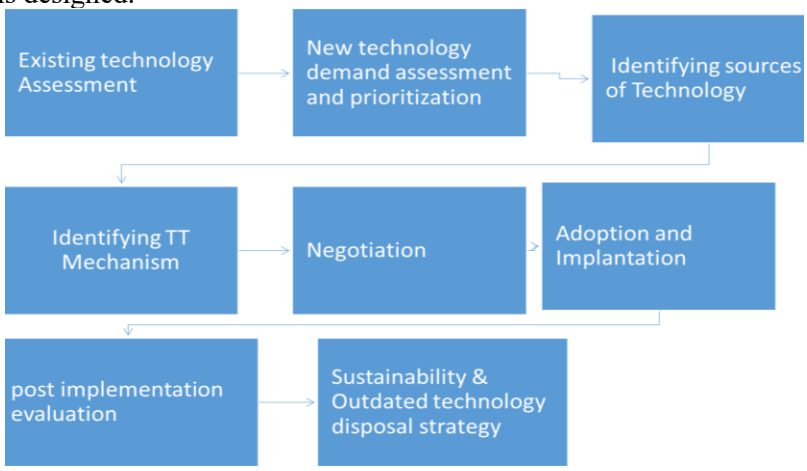


Fig. 8: designed technology transfer model

5. Proposed University- Industry linkage Model for technology transfer in Ethiopia

Considering reviewed models and evaluation criteria in account the selection or developing new technology transfer model is next step. From the models reviewed the Oxford university and ISIS innovation

technology transfer model is preferred and effective for our country. In fact, it needs customization to our existing situations.

For Ethiopia's technology transfer purpose this study considered the five models reviewed as the steps to be passed through to transfer technology and the Oxford universality and Isis innovation models as University-Industry model for technology transfer. This model is preferred based on national technology status, private interest and the mandates have been given to each main stakeholder. It is the responsibilities and mandates of the government to promotes, incentives and support the national technology transfer. In developing countries the private companies haven't interest to join challenging businesses. So, this study developed the new steps/model to transfer technology and select the Oxford and Isis Innovation model by customizing it to Ethiopian context. The following diagram shows the proposed technology transfer model for Ethiopia.

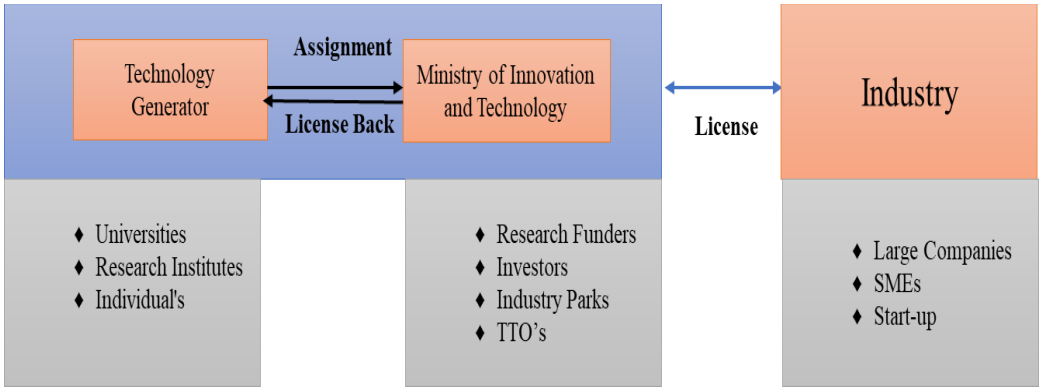


Fig. 9: Proposed models by Authors

In this model technology generators are Universities; research Institutes, TVET colleges, Industries, Start-ups/SMEs and Individuals. The responsibilities and mandates of these technology generators are conducting research, product development, managing funds provided by fund providers and finally request Ministry of Innovation and Technology for technology commercialization and legalization (Patents).

The Ministry of Innovation and Technology has the responsibility to commercialize the new technology, legalizing innovated technology by Research institutes, licensing back the technologies to technology generators for education, research and non-commercial purposes. The Ministry of innovation and technology will commercialize the new technology innovated by Research center to Industries through license and approving the new technologies innovated by Industries.

6. Designed Technology Transfer Mechanisms

Industrial park zone is considered as facility to domestic, FDI and Joint-Venture investors. So, it's the best option or place to transfer technology in form of investment. Ethiopia has the comparative and absolute advantages in the work force availability and resources of raw materials on the area of leather, coffee, textile and agribusinesses. These resources have the advantage of attracting investors in form of FDI, joint venture or domestic investors. From the literature review above and other countries practices the investments in industrial park is the priority mechanism to transfer technology, create job opportunities and improve the economy of the country.

The second better options are human capital transfer or development and Reverse engineering which needs knowledge and skills. Before proceeding to reverse engineering technology transfer mechanism implementation, it is necessary to work on human capital development. Thus, these mechanisms have to implement in medium to long term plan. Another mechanism that is expensive, and could be applied for short term technology transfer is capital goods import. Licensing patent to technology transfer may take time as it requires knowledge and techniques in short term plan for technology transfer, but it may work in short plan for service industries and trade. In short

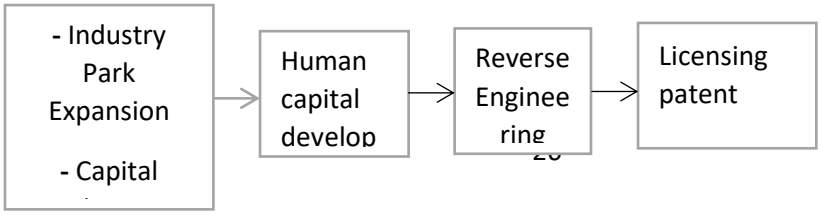


Fig. 9: Proposed technology transfer mechanisms by Authors

7. Conclusion

The main purposes of technology transfer are to improve productivity, create innovation and economic growth. Technology can be transferred vertically or horizontally. Transferring or commercializing the research finding technology is a vertical technology transfer, whereas transferring existing technology from technology owner countries or organization to other hosting countries or organizations is a horizontal technology transfer. Ethiopia has been practiced to transfer technology in different mechanisms for past decades.

However, the effectiveness was not as per an expectation and still it is far from fasting developing countries and developed countries in technology transfer. From the success story of South Korea, China and Japan technology transfer, starting from light industry technology such as textile & garment, and leather & leather products to heavy industries is preferable mechanism to transfer technology. Well managed University-Industry collaboration is very important and recommended to transfer technology or research findings from universality to industry and inbounds research ideas/issues from Industries to academia (Universities, TVET colleges & research Institute). This study tried to review international trends of technology transfer models and mechanisms and finally proposed suitable technology transfer model, and mechanisms for technology transfer policy development input.

8. Recommendations

1. Based on the study findings from literature reviews, international experiences, current status and future prediction the following points are recommended to transfer technology into developing countries (Case Ethiopia).
2. Ministry of Innovation and Technology should develop comprehensive national technology transfer mechanisms, model, and guideline for both University-Industry linkage and horizontal technology transfer by taking this study as baseline.
3. The integration of FDI and Industrial park with Academia and domestic industries will play great role in technology transfer through acquiring techniques, knowledge and experiences. To realize this Ministry of innovation and technology in collaboration with stakeholders should initiate FDI, Domestic industries and academia collaboration system.
4. Revise and finalize the preparation of the implementation protocols of the 22 technology road maps. By the time of preparation the roadmap has been aligned with government strategic plan priority, GTP II, and STI Policy. However currently the national strategic priority areas are replaced by Agriculture, manufacturing, Information technology, mining and truisms. The GTP II is replaced by ten years national plan and STI policy is revised. Taking these into consideration the roadmap should be revised based on the government strategic plan priorities and needs to be implemented.
5. As it is observed from Japan, South Korea and china success history, it takes time to have self-made technology. The experiences show, these countries were started from light industries to heavy industries through different mechanisms and models. From the best practice the effective short term technology transfer mechanisms suitable for Ethiopia are human capital development, FDI attraction, joint venture and collaborating FDI with domestic industries, academia and capital goods import.
6. There is no an absolutely right mechanism or models to transfer technology, it is only about the prioritizing and using the opportunities and potential. Licensing IPR is one of the technology transfer mechanism require knowledge and techniques. Before proceeding to licensing mechanism human capital development is important.
7. The important, but needs knowledge and skills to imitate or adapt technology is reverse engineering. It helps to have self-made technology and sustain home grown economy. Thus, in parallel with human capital development the reverse engineering is the best mechanism to technology transfer. It has been practiced for last two decades through supporting the education system by 70:30 and enhancing and expanding the TVET colleges. For further recommendation the impacts of TVET colleges and

education system on self-made technology creation and transfer as well as impacts on the economy of the country has to be assessed.

8. As a country the stakeholders or technology users expect technology data base, and consultancy from MInT, however there is no registered technology on the sector. To bridge this gap the study recommend the registration of technology, assessment, select and transfer for community use and disposal of outdated technology strategy development.

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