ROLE OF INNOVATION AND TECHNOLOGY UPGRADING ON INDUSTRIAL AND EXPORT COMPETITIVENESS IN TANZANIA

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Abbreviations

ASIP	Annual Survey of Industrial Production
CAMARTEC	Centre for Agricultural Mechanization and Rural Technology
CDM	Crépon, Duguet and Mairesse model
EPZ	export processing zone
EPZA	export processing zones authority
ESCAP	Economic and Social Commission for Asia and the Pacific
FDI	foreign direct investment
FYDP	five year development plan
FYDP III	third Five Year Development Plan, 2021/22–2025/26
GDP	gross domestic product
GII	Global Innovation Index
GLS	generalized least squares
GMM	generalized method of moments
GVCs	global value chain
ICT	information and communication technology
IFPRI	International Food Policy Research Institute
ISIC	International Standard Industrial Classification
ITU	innovation and technology upgrading
LDC	least developing country
MCT	multi-crop threshing
MDA	Ministry, Department and Agency
MECI	Manufacturing Exports Competitiveness Index
MEL	monitoring, evaluation and learning
MHT	medium and high technology
NBS	National Bureau Standards
OECD	Organisation for Economic Co-operation and Development
OLS	ordinary least squares
RB	resource based
R&D	research and development
SEZ	special economic zone
SIDO	Small Industries Development Organization
SMEs	small and medium enterprises
SSA	sub-Saharan Africa
STI	science, technology and innovation
TANESCO	Tanzania Electric Supply Company Limited
TBL	Tanzania Breweries Limited
TIRDO	Tanzania Industrial Research and Development Organization
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNIDO	United Nations Industrial Development Organization
URT	United Republic of Tanzania
WB	World Bank
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

EXECUTIVE SUMMARY

This study aimed to examine the role of innovation and technology upgrading (ITU) in the competitiveness of Tanzania's industrial and export sectors. To achieve this objective, the study was structured as three complementary components. The first component focused on assessing the current status and trends in the technology and innovation profile through a situational analysis. Given the dearth of empirical evidence to support policy dialogue on ITU in Tanzania's industrial sectors, the second component was an empirical analysis of survey data from the Annual Survey of Industrial Production (ASIP) to identify the drivers of ITU at the firm level and assess its impact on firms' competitiveness using productivity outcome indicators. To shed light on how firms can practically leverage ITU, the third component was a case study analysis based on an in-depth study of the experiences of selected firms to identify and profile success factors and cases where ITU has dramatically improved performance and competitiveness. This report presents the key findings and recommendations based on these three components.

The situational analysis used the Global Innovation Index (GII), trade performance and survey-based indicators to gauge the level of innovation and technology in Tanzania. The results show that:

- Tanzania has performed relatively well in the GII ranking in innovation output compared with comparable low income countries in Africa. It was ranked 88th in 2020, topping the low income group in that year.
- Tanzania's merchandise exports are dominated by low technology, mainly resource-based products such as gold, while high technology products dominate imports. Nonetheless, in consistency with the overall improvement in innovation performance, the structure of exports has been changing to favour an increased share of high technology products.
- The majority of exports are from low technology firms, which account for 75% of total industrial manufacturing firms, while the rest (25%) are the medium and high technology.
- There is more innovation effort and input among the medium and high technology firms than in the low technology firms, which are mainly small and medium enterprises (SMEs) with limited capacity to undertake or invest in innovation activities. The share of SMEs among medium and high technology firms is much lower than among the low technology firms.

The empirical analysis of the drivers and impact of ITU on firms' competitiveness showed that:

- Investment in innovation has a positive impact on firms' productivity and that the likelihood of firms spending on innovation is positively related to their (i) age, with older firms being more likely to spend on innovation than younger firms, (ii) participation in international trade, (iii) foreign ownership, and (iii) size, with smaller firms being less likely to invest in innovation compared with larger firms, reflecting capacity constraints issues.
- Public innovation and technology partnerships or programmes have a positive impact in promoting ITU for industrial or export competitiveness, especially for SMEs.
- Firms receiving government subsidies are less likely to spend on innovation than are others, reflecting the potential adverse effects of subsidies crowding out private investment.
- Firms are more likely to invest in innovation or generate innovation output if they participate in international trade, are members of industry associations or face a competitive environment, which indicates that firms' exposure to the external environment is critical in enhancing innovation and technology ITU.

The analysis was complemented with results from a study by IFPRI (McMillan, Kweka & Ellis, 2019) to identify firm and owner characteristics that drive technology transfer and its impact on competitiveness that showed that:

- The most important benefit of technology transfer for Tanzanian industrial manufacturing firms was improvement in production technology and managerial practices, the extent of which depend on owner and firm characteristics.
- Contrary to expectation, previous worker experience with a foreign firm did not serve as a driver of technology transfer.
- The location of a firm in an industrial park or a special economic zone (SEZ) was not a significant factor in technology transfer, presumably because the enclave and exporting nature of firms in these zones limit their competition or direct observation by the domestic firms, that is the spillover effects.
- Technology transfer is more important in some sectors e.g. iron and steel, than others, e.g. food processing, and large firms do not need or benefit from technology transfer as much as do SMEs.
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Based on the analysis of information from the firms interviewed, though it was limited, the main findings show that:

- ITU is largely a customised and localised process in that no one size fits all. Although there was a wide variation in investment and experience in ITU among the firms, some common factors determined its extent, nature and ultimate impact, such as the fact that all firms are driven by competition for a bigger market that they address this through productivity and quality improvement.
- Although the level of ITU appears largely basic and reliant on technology transfer and adaptation from imports and external partnerships, it has a significant impact on firms' competitiveness. Despite the unavailability of reliable and quantifiable data to illustrate the impact, the interviews consistently confirmed that for the firms, ITU or its process led to a significant impact on performance. This is because most of the ITU initiatives targeted attaining bigger markets, improving quality and responding to market opportunities from particular challenges.
- For a firm's ITU to succeed, having a process for it is critically important. There is need for careful planning for ITU and for predetermined guidance. The firms highlighted their challenges in the process including the lack of the required finance, supportive government policies and expertise. Furthermore, research and technology transfer are crucial for the ITU process to generate the desired results.
- A policy and institutional framework is critical in achieving impactful ITU, but from the study its impact at enhancing ITU at the firm level has been limited. Research is needed to generate evidence on the role and effectiveness of institutional frameworks in promoting ITU.
- From the interviews with the firms on their experience with ITU, we identified some useful success factors and lessons that could inform how firms can successfully leverage ITU and provide inputs in policy review, dialogue or formulation of effective policies, strategies and programmes. These include the critical importance of having an ITU research and development (R&D) unit, conducting research before embarking on a full-fledged ITU process, having adequate financing especially from internal sources, embracing competition, benefiting from government support in the form of improved policy and regulatory environment, and leveraging government technology and innovation from institutions such as the Small Industries Development Organization (SIDO), Centre for Agricultural Mechanization and Rural Technology (CAMARTEC), Tanzania Industrial Research and Development Organization (TIRDO) etc.

The study makes the following conclusions with implications for policy:

- Although the trend in the level of ITU has been rising favourably for Tanzania over the last couple of years albeit from a very low base, its leveraging by businesses to support the country's much needed competitiveness has been limited. The ITU structure change has been small and the production and export baskets have been dominated by low technology sectors, mainly SMEs and resource-based goods and commodities.
- ITU is key for firms to remain productive and attain increased levels of competitiveness, but the government needs to provide an enabling environment through formulation of policies or strategies that promote innovation activities and technology transfer.
- The capacity and prospects for future investment in ITU are limited to large scale and foreign-owned firms, meaning that the majority of firms are left out, given the dominant share of SMEs. There is need for the government to invest in technology partnership programmes to support SMEs, promote technology and skills transfer by, among other mechanisms, fostering linkages among large or foreign firms with small or domestic firms, especially is such schemes as the SEZs or industrial parks.

The study identifies the government's role as being to:

- Review the policy and institutional framework for promoting ITU so as to fill the gaps and update or strengthen the role of the government or public institutions;
- Address the challenges limiting firms' ITU, the most pressing being the weak legislation for intellectual property rights that mitigates the risk of unauthorised copying or imitation of firms' innovation or invention, the weak enforcement of customs procedures and trade policy instruments for protecting local producers, the unreliable power supply, and the financing challenges;
- Strengthen existing institutions for promoting ITU, including instituting action to ensure their funding is adequate and raising awareness on their role in supporting firms in their ITU endeavours. These institutions include R&D institutions such as TIRDO; academic entities; technology institutions such as CAMARTEC, SIDO, and the Tanzania Commission for Science and Technology (COSTECH); and industrial promoters such as the Export Processing Zones Authority (EPZA), the Tanzania Investment Centre and the National Development Corporation etc.;
- Improve the quality of education and skills by enhancing the capacity of technical and vocational education and training institutions in delivering appropriate skills to meet the industry requirements;
- Undertake further study of the role and effectiveness of government policy, regulatory and institutional frameworks in promoting ITU.

1. INTRODUCTION

1.1 Background

The increasing pace and changing form of globalisation have necessitated developing countries such as Tanzania to formulate policies and strategies for enhancing the competitiveness of their economies and leveraging opportunities arising from the global economy. Clearly, firms face continued and fierce competition driven mainly by investment in innovation and technology upgrading (ITU). A number of empirical studies have shown evidence of the role of ITU in enhancing competitiveness, growth and development (see for example Sikharulidze & Kikutadze, 2017; UN-ESCAP, 2018). Developing countries have formulated favourable and mainly industrial and trade policies to support their firms' investment in ITU. In the case of Tanzania, the current development policy framework enshrined in the third Five Year Development Plan, 2021/22–2025/26 (FYDP III) recognises the role of innovation and technology in realising the key objective of building a competitive industrial sector (see URT, 2021). Nonetheless, the level of technological intensity in the country's manufacturing sector is still low in both relative and absolute terms.

While globalisation has helped to bring people around the world closer, it has also resulted in the rise in competition, where firms contend against one another for domestic and foreign markets. As a result, policy-makers in developing countries, including Tanzania, are increasing their attention as to how they can enhance the competitiveness of their economies and leverage such competitiveness to bring about inclusive and sustainable development. A number of empirical studies have shown evidence on the role of ITU in national competitiveness and economic growth and development (see Sikharulidze & Kikutadze, 2017; UN-ESCAP, 2018).

ITU has notable benefits and a strong impact, but its level in the developing countries, including Tanzania, is generally low, primarily owing to a myriad of challenges such as the difficulties in accessing finance and poor assistance from institutions that support innovation, among others (Haile, Srour & Vivarelli, 2013). The global dataset on country performance on ITU, the Global Innovation Index (GII), shows the performance of Tanzania to have improved recently. For instance, for 2018–2020, Tanzania improved more in innovation output, i.e. outputs that result from innovative activities, than in innovation input, i.e. elements of the national economy that enable innovative activities. As shown in Table 1, in 2020 Tanzania was ranked 88th out of 131, which is closer to other relatively high performing countries such as Kenya at 86th, Mauritius at 52nd, Tunisia at 65th and South Africa at 60th. This is an encouraging sign, indicating that Tanzania could leverage ITU to spur competitiveness and productivity, thus improving its ITU further. The study by Cornell University (see Cornell University, INSEAD, & WIPO, 2020) shows that Tanzania needs to improve the environment to enable, facilitate and accommodate its ITU activities.

Table 1: Rankings of the United Republic of Tanzania (2018–2020)

	GII	Innovation Inputs	Innovation Outputs
2020	88	112	67
2019	97	115	73
2018	92	106	71

Source: Cornell University, INSEAD & WIPO (2020)

Studies such as URT (2016; 2021) and Salam et al. (2018) have identified key constraints limiting innovation and technology improvement in Tanzania including the weak and unsupportive legal and regulatory environment, low access to credit, limited availability of skilled labour relevant to the innovation industry, and weak implementation of the policies supporting technology and innovation in the country. In addition to the low level of technology and innovation, knowledge on the role of ITU in industrial and export competitiveness is limited in Tanzania. Such a knowledge gap if left unaddressed will continue to limit policy initiatives and effectiveness of measures to harness technology upgrading and innovation to promote exports and industrial competitiveness.

Tanzania is an interesting case given the fact that it is rich in natural resources and factor inputs such as minerals and arable land, but these are yet to be exploited to realise industrial and export competitiveness and subsequently inclusive development (Diyamett, Makundi & Mwantimwa, 2012; World Bank, 2005). Indeed, some studies have argued for the need to promote ITU to spur industrial and export competitiveness in Tanzania (Diyamett, Makundi & Mwantimwa, 2012; Wangwe et al., 2014; Misati & Ngoka, 2021) but empirical evidence is missing on that relationship and the drivers and impact of ITU. REPOA commissioned this study to comprehensively fill this knowledge gap to support the government in articulating the role of ITU in realising the objectives of FYDP III.

1.2 Objectives

Our main objective is to examine the role of technology and innovation upgrading in industrial and export competitiveness in Tanzania. Specifically, the study aims at:

- Identifying the nature, extent and determinants of ITU in the Tanzanian manufacturing industrial sector;
- Examining the effect of ITU on industrial and export competitiveness. And using case studies, the study will provide a comparative assessment of selected subsectors, industries or firms that have succeeded to harness ITU to spur industrial competitiveness.
- Examining the effects of existing policy and institutional frameworks for trade, industrial development, and skills development in promoting technology transfer and adoption in Tanzania.

To achieve these objectives in a logical and comprehensive manner, we have organised the study into three components. The first component is a situational analysis. This part uses the available and relevant national or global databases and literature to provide the current status of innovation and technology in Tanzania, including the key features, performance over time and its relationship with industrial and export competitiveness based on estimates of relevant economic indicators to gauge industrial and export competitiveness impact of ITU. The second component is an empirical analysis based on ASIP survey data to assess the extent, drivers and impact of ITU on Tanzania's industrial and export competitiveness. The third component is the mapping of success factors in ITU initiatives using case studies of selected manufacturing firms. The purpose is to identify and profile a few successful cases where ITU has led to dramatic improvement in firm performance and competitiveness, in order to understand the role played by policy and institutional factors.

1.3 Literature review

1.3.1 Theoretical literature

Generally, three main theories explain the nexus between innovation and export competitiveness: the neo-technology models, the neo-endowment models and the endogenous growth models. Neo-technology models postulate that quality products and services of a firm determine its competitive advantage and lead to its increased exports (Grossman & Helpman, 1994). They hinge on the technology gap in the product life cycle theory (Posner, 1961; Vernon, 1966) and recognize the role of new technologies and the development of new products and services by firms and the national innovation system in export performance (Metcalfe, 1995). In contrast, neo-endowment models argue that factor endowments such as raw materials, capital, skilled and unskilled labour and technology determine competitive advantage (Davis, 1995). Accordingly, the significance of factor endowment is enhanced when there is a natural monopoly or abundance of a factor (Metcalfe, 1995).

The endogenous growth models famously promoted by Aghion et al. (1998) and Romer (1989) postulate that it is export that leads to innovation. The model provides three mechanisms on the nexus between export and innovation. First, intensive competition from foreign markets forces firms to invest in research and development (R&D) in order to improve the quality of goods and services and thus remain competitive internationally. Second, interactions in the international markets give rise to innovation through learning-by-exporting effects. And, third, economies of scale originating from large markets and increased sales may easily cover R&D costs and stimulate innovation (Love & Roper, 2015).

The technology and innovation perspective has also been used to describe industrial competitiveness. The innovation and learning process necessitates interactions among different institutions such as firms, the government, support institutions and other actors within the national innovative system.

This theory defines competitiveness as “the capacity of firms to compete, to increase their profits and to grow” (OECD, 1992). It is based on costs and prices and more vitally on the capacity of firms to use technology, plus the quality and performance of their products. At the macroeconomic level, it is the ability to make products that meet the test of international competitiveness while expanding real domestic income.

One of the measures associated with the Technology and Innovation approach is the manufacturing export competitiveness index (MECI) used to benchmark manufactured export competitiveness using data on the value and average growth of manufactured exports per capita over the medium to the long term, and technology-intensive exports as a percentage of the total merchandise exports. MECI is challenging to construct since it is difficult to determine the criteria used for selecting exports that are technologically intensive. Other measures under this approach include market share indicators such as a country’s exports to the world or the region. What is more important is to establish the key empirical findings in operationalizing the different approaches on ITU and what drives country differences in such studies.

1.3.2 Empirical literature

Considerable research has been conducted in innovation measurement at the country and firm levels, but the majority of the empirical work has evaluated the innovativeness of a firm based on the process, inputs or outputs (Romijn & Albaladejo, 2002; Marques & Ferrera, 2009). One of the key objectives in the empirical studies has dealt with the challenge of measuring innovation and technology. Notably, the level of R&D expenditures has repeatedly been used as the overall measure of innovativeness of firms (Adams, Bessant & Phelps, 2006). In fact, R&D is an input in the innovation process that does not necessarily lead to innovations (Kleinknecht, Van Montfort & Brouwer, 2002). In some instances, the use of R&D expenditures may overestimate the innovativeness capability measure since it does not take into account the unsuccessful R&D efforts. Furthermore, not all new products and processes are created in R&D laboratories. Innovations can originate from either a specific problem or a self-discovery idea that eventually turns into an unexpected profitable outcome. In that case, evaluating innovativeness through R&D expenditures would underestimate the level of innovativeness (Becheikh, Landry & Amara, 2006).

The R&D data used as an innovation indicator tend to favour large firms compared to SMEs owing to the fact that SMEs' R&D efforts are often informal, unrecorded and infrequent (Michie, 1998; Kleinknecht, Van Montfort & Brouwer, 2002). One of the intermediate output measures that have frequently been used as the global measure of innovativeness of firms is patent data, although patent measures inventions rather than innovations (Coombs, Narandren & Richards, 1996). Furthermore, the propensity to patent differs among industries. For instance, owing to the relatively high costs of imitation, some companies prefer to protect their innovations by other methods such as maintaining adequate lead time over rivals, adopting industrial secrecy, and ensuring technological complexity in innovations (Kleinknecht, Van Montfort & Brouwer, 2002). Since not all innovations are patentable, patent data are an imprecise measurement of innovation capability (Becheikh, Landry & Amaral, 2006).

Literature also identifies two output-based approaches for measuring a firm's innovativeness, namely innovation count and firm-based surveys. Innovation count can be considered an objective approach, as it allows information on innovations to be collected from various sources such as new product or process announcements, databases and specialised journals, and then counted. Firm-based surveys can be regarded as a subjective approach, as they involve surveys and interviews on innovations undertaken across firms (Becheikh, Landry & Amara, 2006). Both methods have limitations, though. In practice, the innovation count approach tends to favour product over process innovations and radical over incremental innovations (Tether, 1998). Firm-based surveys have the drawback that the answer rates have a vital role in the significance and the representativeness of the measurement results (Archibugi & Sirilli, 2000). In addition, they measure the newness or innovativeness of a firm by asking dichotomous questions, that is whether or not the firm has been involved in innovation activities (Becheikh, Landry & Amara, 2006).

Another key issue in the empirical literature is the estimation of the nexus among innovation, technology and export competitiveness, for which two main strands of work are notable. The first strand focuses on the complementarity between exporting and innovation. For instance, using unbalanced panel data, Golovko & Valentini (2011) found a robust complementarity between innovation and export in Spain. That study found that innovation positively affects exports while exports strongly influence innovation (Golovko & Valentini, 2011). Similarly, in Australia, by using propensity score matching Palangkaraya (2012) found that there was a significant and positive role of exports in influencing innovation, and there was evidence that a product innovator may have a high probability of becoming a new exporter. Using panel generalized method of moments (GMM) estimation in China, Raul et al.

(2019) found that there was significant complementarity between innovation and export such that domestic innovation had positive impact on exports, and international trade (exports and imports) influenced domestic innovation and industrial competitiveness. Using the global value chains model for Indonesia, Kadarusman & Nadvi (2013) found that technological upgrading influenced competitiveness for local firms.

The second strand on estimation of the nexus of innovation, technology and export competitiveness focuses on explaining the direction of causality between innovation and export competitiveness. For example, the study by Filipescu et al. (2013) on technological innovation and exports in Spain's manufacturing industry attests to the reciprocal causality between technological innovation and exports. However, Hahn & Park (2012) and Damijan & Kostevc (2010) found only one direction of causality between innovation and exports, i.e., innovation leads to exports. Márquez-Ramos & Martínez-Zarzoso (2010) found a positive effect of technological innovation on export performance.

Annex B provides a summary of empirical studies on the subject, from which some broad findings and issues can be highlighted. Foremost, a wide range of studies confirm the existence of a positive link between innovation and export competitiveness. That is, the level of industrial competitiveness and export growth of the country is influenced by technological innovation and upgrading (see Márquez-Ramos et al., 2010).
upgrading on export and industrial competitiveness. Technological upgrading influences competitiveness for local firms, suggesting that that firms learn from import links, which enables them to innovate products and to export. In line with this, exports enable firms to innovate further.

Despite the overall general positive picture on the relationship of innovation and export competitiveness, empirical evidence shows that the effect of technological innovation on exports varies with country, underlining the importance of focusing empirical work on individual country experiences (Márquez-Ramos & Martínez-Zarzoso, 2010). Presumably the policy environment, country characteristics and initial conditions pertaining to a country matter in determining the nature and extent of the relationships. For instance, in examining the main constraints to manufacturing export competitiveness in Tanzania, Misati & Ngoka (2021) found that foreign direct investment (FDI) and tariffs had a negative effect on export competitiveness.

Furthermore, Wie (2006) found that in Indonesia industrial policies did not have an effect on industrial competitiveness. On the contrary, Zhao & Zhang (2007) found that China's big jump in industrial competitiveness was largely associated with technology and innovation effects of participating in international production networks. In addition to the thematic findings, Annex B shows that most of the studies use panel regression analysis of cross-country data (for multiple countries) or cross- sectional data (for single country) as the main analytical technique.

Indeed, a few countries also use descriptive analyses based on secondary or primary data.

Owing to the challenge of data paucity in developing countries, most of the empirical studies are based on industrialised economies. But the few studies on Africa show similar findings, for instance, Barasa et al.'s (2016) research on sub-Saharan Africa (SSA) and Mallinguh et al.'s (2020) work on Kenya. A review of existing studies shows clearly that there is a dearth of empirical evidence on the role of innovation and technology on industrial export and competitiveness in African countries. This study contributes to filling that gap by examining the case of Tanzania. Given the challenge of data and information on the subject, section 2 makes a comprehensive use of the available data from secondary sources and global databases to undertake a descriptive analysis of the current status, trends and performance of the innovation and technology sector and its relationship with export and industrial competitiveness.

1.4 Approach and analytical framework

This study used three complementary approaches to inform the analytical methodology – that is the quantitative, qualitative and case study approaches – to examine the role of ITU in Tanzania's export and industrial competitiveness. The quantitative approach was used to conduct the empirical analysis as detailed in section 3. The qualitative analysis was used to conduct a situational analysis (also for the case studies) based on the review of literature and descriptive assessment of the various indicators of ITU using relevant secondary data and global databases as shown in section 2. The case study approach was used for an in-depth study of the experiences of few selected firms to identify and profile success factors and cases where ITU had led to dramatic improvement of firms' performance and competitiveness.

The approach is detailed in section 4. The three complementary approaches, while informing our analytical strategy, also are generally linked with the corresponding broad outputs of the study. For this purpose, the study and its output are organised into three components as follows.

The first component is the situational analysis. This part provides the current status of innovation and technology in Tanzania, including the key features, performance over time and the relationship with industrial and export competitiveness. The study used available and relevant national and global data to provide estimates of relevant economic indicators to gauge industrial and export competitiveness impact of ITU. The three most familiar indicators are GII, trade, and survey-based indicators, which are described in detail in section 2.3.

The second component is an empirical analysis. Using existing ASIP survey data, this component of the study aims at identifying the drivers of ITU and their impact on firm competitiveness. For this purpose, the study used the nationally representative firm level ASIP dataset from 2008 to 2016 to assess the extent, drivers and impact of ITU on Tanzania's industrial and export competitiveness. The detailed description of the empirical model and data used for the analysis is shown in section 3.

The third component is a case study analysis. The study will identify and examine the mapping of the success factors in ITU initiatives using case studies of selected manufacturing firms. The objective is to identify and profile a few successful cases where ITU led to dramatic improvement in firm performance and competitiveness. The case study will benchmark key factors of success, including the role of policy and ITU institutions, to provide fresh insights into the understanding of how and to what extent firms have leveraged or need to leverage ITU to enhance their industrial and export competitiveness. This component is not yet complete and is not included in this report but will be presented as a standalone output of the study with a full outline of the sampling process and the sample used.

1.5 Organization of the report

This report is presented in five sections. Following the introductory section 1, section 2 presents the situational analysis, while section 3 focuses on the empirical analysis. The case study of a few selected firms' experiences is detailed in section 4. Section 5 concludes the report by highlighting the key messages and the implications for policy.

2. SITUATIONAL ANALYSIS: INNOVATION, TECHNOLOGY AND COMPETITIVENESS IN TANZANIA

This section provides as comprehensive a picture as possible of the current status and performance of the innovation and technology sector and how it has influenced export and industrial performance in Tanzania. The section leverages the currently available secondary data and global databases. It starts by articulating the current status, followed by an outline of the key mechanisms or approaches in which ITU influences export and industrial performance in Tanzania. Finally, the it describes the performance of ITU in relation to the indicators of export and industrial competitiveness.

2.1 State of ITU in Tanzania's industrial sector

The manufacturing industry in Tanzania is centred mainly around the processing of local agricultural goods (Matiko et al., 2019), while exports are mainly primary and semi-processed products, indicating the low share of technology intensive goods in the total manufactured exports. For instance, according to the World Development Indicators, the share of high technology goods in the total manufactured exports averaged 4.8% in the last decade.

Further, the literature shows that the majority of firms in the manufacturing sector fall under the low technology category with their innovation and technology largely at the basic level (Diyamett & Mutambala, 2015). The literature indicates further that the low level of technological intensity of firms across many sectors is a result of the financial inability of the firms to acquire the technology (Komba et al., 2013; Lunogelo, Gray & Makene, 2020; USAID, 2010). This micro-level picture is a reflection of the country's poor performance in GII. For instance, in 2020 Tanzania was ranked 88th out of 131 countries using the index.
Furthermore, the Tanzania industrial competitiveness report for 2015 shows that the capacity of manufacturing firms in value addition and to diversify their production output towards more advanced products lagged that of other countries including Mauritius and Kenya. Another key feature of the industrial sector in Tanzania is the low level of linkage between manufacturing and the agriculture sector and the low share of manufacturing value added in GDP.

At the firm level, the data from past studies show that most Tanzanian firms have little if any investment in R&D, hence the limited extent of new technology and product upgrading (Thomas, 2013). For instance, according to ASIP data, only 323 (13.1%) firms out of 2,462 had an R&D unit in their establishment in 2016. These firms spent approximately 0.9% of their annual turnover as expenses on R&D activities. Table 2 shows the R&D activities performed by the enterprises in 2016, based on the analysis of the ASIP data. They include technology commercialisation and market development (17%) and basic technology research (16.5%) as the main activities.

Notably, Tanzania has several research-intensive universities and technology intermediaries that could support product upgrading in the industries. However, cooperation between manufacturing firms and these universities is underdeveloped and unstructured (Matiko et al., 2019). Furthermore, the number of firms in the industrial sector cooperating with public technology intermediaries is small, estimated at 34%, while some establishments cooperate with private companies in conducting R&D activities. Over two-thirds of the firms that did not cooperate with or receive technology or production services from public technology intermediaries cited the lack of awareness of such institutions or services as the main reason.

Table 2: Proportion of firms participating in R&D activities in 2016

Technology and Innovation R&D	Percent	Production R&D	Percent
Technology commercialization & market development	17	Product standards quality improvement	20.2
Basic technology research	16.5	Maintenance, repair and operations (MRO)	19.9
Technology system test and demonstration	16	Product components redesign & reengineering	17.3
Technology validation in laboratory	15.4	Machines software re-programming	17.2
Technology prototype and scale up	15.2	Product functions redesign & reengineering	16.9
Technology system development	15.2	Interchangeable parts redesign	16
Technology demonstration	14.9	Re-engineering	15.8
			15.6

Source: Author's computation using the ASIP data for 2016

Firms that have cooperated with public technology intermediaries or private companies have had better ITU status. In terms of the institutional framework, literature shows that the industrial sector of Tanzania has all the necessary actors for promoting ITU. The major challenge is the weak coordination of the different actors. For instance, Diyamett et al. (2013) argued that R&D institutions were established three decades ago with a core objective that is not relevant to the current free marketand private sector-led environment.

Further, R&D acts and positioning have not been updated to cope with the current situation. This shows that, like in many other countries in Africa, the formulation and implementation of science, technology and innovation policies in Tanzania have focused on the supply side, i.e. investing more in science and research (public R&D), while neglecting the demand side, i.e. the industrial sector (Thomas & Wawa, 2019), thereby limiting the extent of industrial technology upgrading. Table 3 shows the nature of R&D-related services received by firms in 2016.

Table 3: Proportion of firms participating in R&D activities in 2016

Cooperated with Public Technology Intermediary	Percent
Process and operational improvements	57.9
Product quality improvement (testing, quality assessment, etc.)	57.8
Training for employees	54.3
New products development (prototyping, standardization, etc.)	36.7
New products commercialization (market analysis, marketing, etc.)	30.6
Cooperated with Private Company	**Percent**
New products development	57.3
New products commercialization and marketing	56.5
Sourcing/purchasing activities	49.3
Product components development	48.9

Source: Authors computation using the ASIP data for 2016

The extent to which policies and regulations have influenced the functioning of the innovation system is limited owing to the lack of clarity on how to facilitate such interactions or coordinate the actors and the low level of resources, leading to their weak implementation. Even where there has been progress, not much effort has been made to evaluate the impact or share the lessons on the experience, making such progress isolated cases of success (Diyamett et al., 2013). Such challenges motivated us to consider examining several proven mechanisms or opportunities for enhancing the role of ITU in firms' performance. These include FDI, trade (participating in global value chains – GVCs) and standard firm linkages. These approaches and mechanisms are ideally underpinned by their respective investment, trade or industrial policies.

2.2 Opportunities for ITU

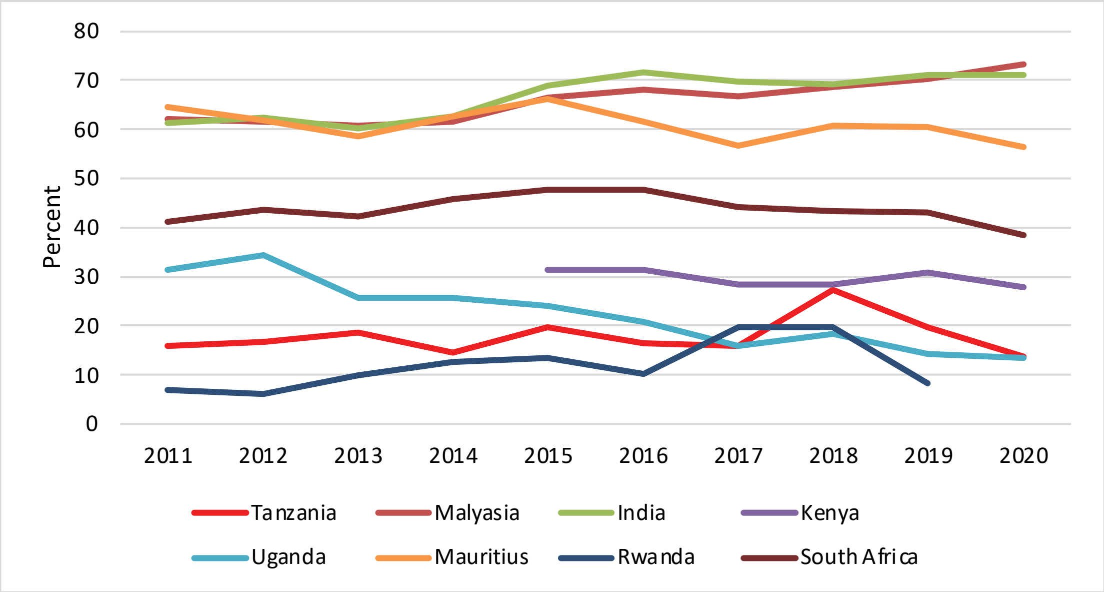
2.2.1 Export of manufactured goods

The increasing trends of the export of manufactured goods amidst growing FDI inflows provide a general opportunity for Tanzanian firms to adopt and upgrade their technology and innovation in fostering their performance and competitiveness. Using the export of manufactured goods as an indicator, we assess the status of ITU in the context of industrial and export competitiveness in two ways. First, we examine the trend in the overall performance of manufactured exports as a share of total exports for Tanzania and then compare these with other similar and more industrially advanced developing countries.

As shown in Figure 1, the share of manufactured exports in total merchandise exports for Tanzania has been increasing, albeit gradually, fromless than 16% in 2011 to an all-time peak of 27% in 2018, before dropping to 13% in 2020 due to the onset of the COVID-19 pandemic. An important point to note is that the growth happened from a very low base (13%) compared with countries such as Mauritius with a base of 64%, India with a base of 61% and South Africa with a base of 40%. Furthermore, the growth in the share of exports shows that Tanzania has experienced very little transformation compared with Rwanda. Notably, the countries with a high share of manufactured exports also performed better than Tanzania in GII ranking. More generally, Diao, X. et al. (2018) provides empirical evidence on Tanzania to show that, more than any other time in history of the country, small (largely informal) firms have had much more dramatic contribution to growth over the decade, mainly accounted for by significant growth of labour productivity.

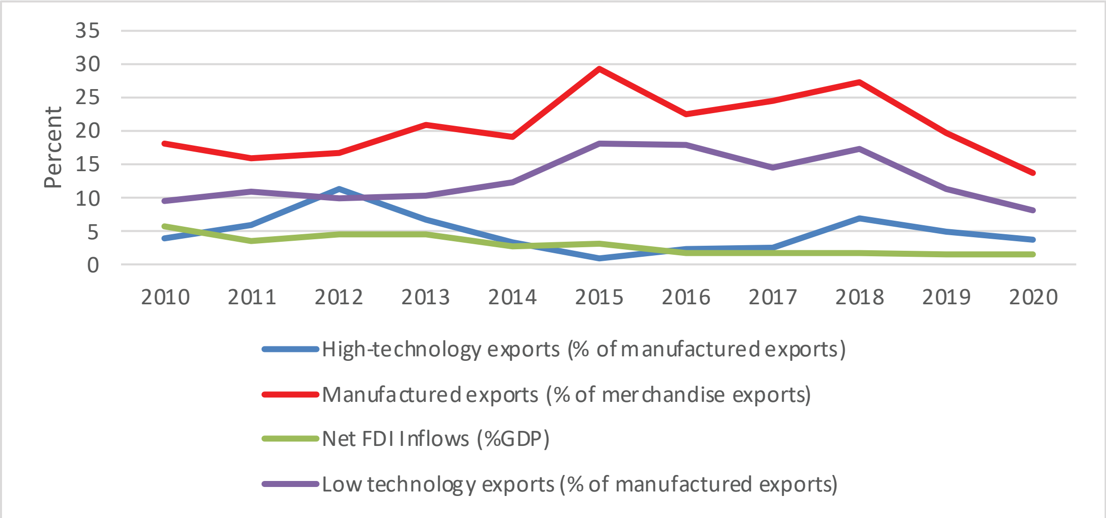
We examine the trends of the manufactured (merchandise) exports in terms of their technological intensity (or profile) to find out the extent to which the increasing growth in manufactured exports has been driven by or reflects the increase in innovation and technological upgrading over time. Figure 2 shows that for Tanzania, manufactured exports (% of total merchandise exports) have been growing in recent years driven largely by growth in the exports of low technology manufactures. Nonetheless, Tanzania still needs to strengthen its capacity to export manufactured products to take advantage of the increasing demand from the neighbouring countries and emerging African Continental Free Trade Area markets, especially for resource-based products (MIT & UNIDO, 2015).

Figure 1: Annual share of manufactured exports in total merchandise exports



Source: World Bank Development Indicators, 2022

Figure 2: Tanzania annual exports (2010–2019)



Source: World Bank Development Indicators database

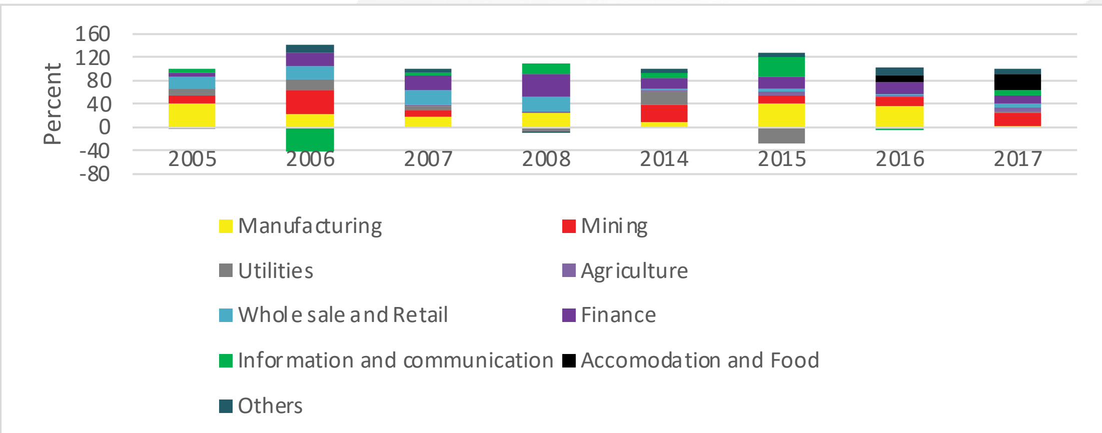
2.2.2 Foreign direct investment

Normally, FDIs possess higher technological capabilities than do local firms. Like any other low income developing country, Tanzania faces two related challenges as far as the relationship between FDI and innovation and technological upgrading goes. The first challenge is to attract sufficient FDIs to support the country's economic transformation, and second challenge is to device policies and strategies such as promotion of SEZs for enhancing the beneficial role of FDIs for the domestic enterprise sector (including skills and technological spillovers). Tanzania has been quite successful in attracting a significant number of FDIs, although the trend in net FDI as a share of GDP has been declining (Figure 2).

Nonetheless, the key question is whether FDI inflows go to the technology enhancing sectors or resource extraction.

Figure 3 shows FDI inflows for different sectors as a percentage of the total the FDI inflow. Four sectors dominate with 77% of the total FDI inflows, namely: manufacturing (24%), financial services (21%), mining (18.4%) and wholesale and trade (14%). The ICT sector appears to be also a significant recipient of FDI. The trend does not exhibit a consistent structure, but the share of FDI going to the mining, accommodation and food sectors (i.e. the sectors associated with a relatively low level of technology) has increased in the last five years.

Figure 3: FDI inflows in Tanzania by sector (% of total FDI inflow)



Source: Author analysis of data from URT (2009) and URT (2018)

The extent to which FDIs benefit local enterprises depends on factors internal or external to the firm. However, for technological upgrading to happen, the FDI firm has to have sufficient technological capacity and strong linkages have to exist between local firms and the FDI, such as forward and backward linkages through buying and selling. Such linkages would promote technology transfer and innovation for local firms through learning by seeing and imitating and through the labour movement. The technology transfer survey[1] carried out in 2017 for 2016 ASIP reveals the nature of technology transfer between FDI and local firms in the Tanzania manufacturing sector, including the channels through which knowledge is transferred from FDIs. A significant 32% of surveyed local firms indicated that they had at least one type of linkage with FDIs, including linkage through competition with foreign firms in output markets, hiring workers who Twere previously employed by a foreign firm, purchasing inputs from foreign firms and selling inputs to foreign firms. able 4 shows that production technology upgrading due to competition from foreign firms in the same industry is the most occurring mechanism of technology transfer. This implies that competition from association between local firms and FDIs is an important driver of technology and knowledge transfer in Tanzania. These results reveal the idea that knowledge and technology transfer occurs through somewhat indirect channels. Most firms that reported experiencing knowledge transfers of some sort from foreign firms indicated that it was either through directly observing foreign firms or responding to competition from foreign firms. These mechanisms do not necessarily require formal relationships such as customer or supplier linkages, but may still lead to sustained benefits.

Table 4: Mechanisms of technology and knowledge transfer in Tanzania 2016

Mechanisms	# of Firms	# of Firms
Horizontal - directly adopted production techniques/processing by observing/ copying from foreign firms in same industry	171	13%
Horizontal - upgraded production technologies due to competition from foreign firms in same industry	247	18%
Horizontal - benefitted from employing workers who previously worked in foreign firms in same industry	88	6%
Vertical - obtained technical support from foreign customers visiting production facilities	28	2%
Vertical - Customer relations required upgrading, led to tech transfers that normally came from foreign customers	24	2%
Vertical - Supplier relations required upgrading, led to tech transfers that normally came from foreign suppliers	81	6%
Tech specific - Licenses technology from foreign firms	86	6%
At least one of the above	463	34%

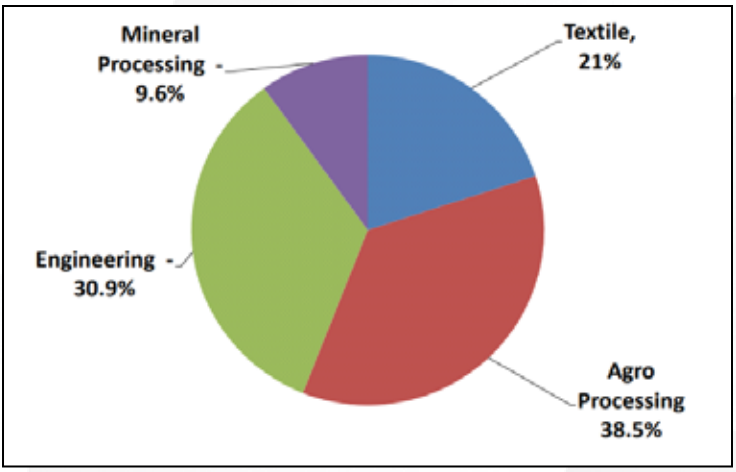
Source: McMillan, M., et al. (2019) based on the Technology Transfer Module of ASIP (2016).

1 This survey was administered by Tanzania's National Bureau of Statistics (NBS) in conjunction with their Annual Survey of Industrial Production (ASIP) in 2016. The survey was administered to plant managers and was designed to elicit information about (i) formal links between foreign and domestic firms; (ii) the mechanisms by which knowledge is transferred, and (iii) the benefits obtained from foreign firms. The survey collected data from a total of 1,558 manufacturing firms of which 1,354 were wholly domestically owned.

These linkages do not usually occur automatically and in some cases it has proven difficult to establish them. The literature identifies several factors that have hindered linkages between domestic firms and FDIs in the Tanzania manufacturing and industrial sector. These include the low capacity of the domestic industrial firms, which limits their ability to supply the quantity and quality of products required by foreign firms. In fact, a survey conducted under the Diyamett and Musambya (2014) study found that domestic firms with high production capacity and quality products found it much easier to form links with foreign investors. Kweka and Sooi (2020) found that SMEs in the Tanzania industrial sector with high production capacity were more likely to form linkages with large firms. Overall, the literature shows an uneven distribution of FDIs along major industrial regions in the country, where Dar es Salaam has the majority of the firms (Diyamett and Musambya 2014). The ASIP data show that approximately 65% of all foreign owned industrial firms operating in Tanzania in 2016 were located in Dar-es-Salaam, Pwani, Mwanza and Arusha. One way that domestic firms can find good foreign investors to partner with and learn from is through joining industry associations. However, according to the ASIP data, only 41% of the 2,461 firms were in the various associations in 2016. Further, 41% of the establishments were not aware of the various functions or services offered by the associations, which could be among the reasons why only a few firms were in them.

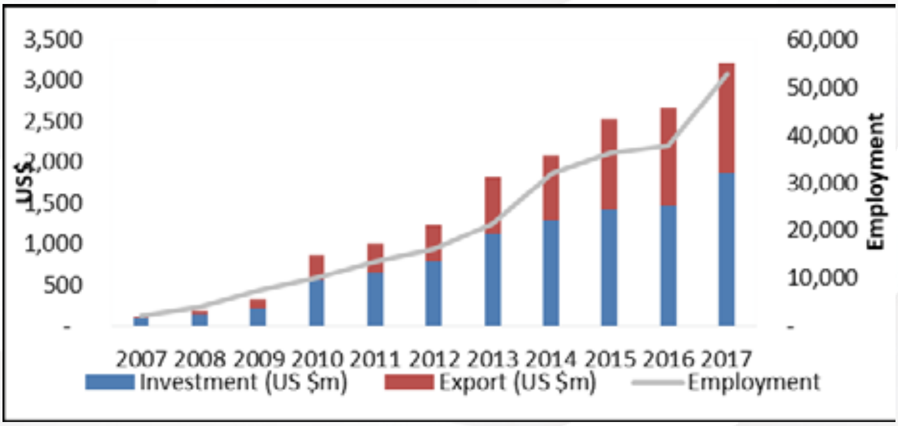
We also examined the sectoral distribution of investment made through the SEZ schemes. Some previous studies show that Tanzania's EPZ firms belong to low technology sectors (see Figure 4). Most of the investors in EPZs deal with agroprocessing, assembling, renovation of imported used cars and textile. Most people working in these firms have basic level of education, indicating that the technology utilised tilted towards the lowest end. Despite this, as shown in Figure 5, the EPZ impact has been phenomenon in enhancing export growth, investment and employment.

Figure 4: SEZ/EPZ investments by sector, 2016 (%)



Source: EPZA data (2016)

Figure 5: Key trends in SEZ development, 2007–2017



Source: Calculated based on data from EPZA

2.2.3 Participation in global value chains

Several empirical studies have shown that interactions between global buyers and local firms in developing countries within GVCs often generate learning and innovation opportunities (Humphrey & Sturgeon, 2005). For local firms to enter into the GVCs, they are required to meet some often stringent international standards related to production, product quality and delivery, as well as any other quality requirements imposed by lead firms. Consequently, to meet these requirements local firms have to learn and innovate (Pietrobelli & Rabellotti, 2011). This is stimulated by the lead firms through direct investments in local firms, by providing training, and by explicit technology transfer to local firms, as well as by providing feedback through continuous interactions.

However, reaping such benefits is not a straightforward and automatic process. There are challenges around the governance structures of the GVCs that affect learning mechanisms. According to the GVC theory, the governance structure adopted by the lead firm is the one that determines the type of learning that occurs within GVCs.

2.2.4 Leveraging industrial linkages

Based on the literature review, some countries have leveraged inter-firm linkages to enhance technology and innovation in their manufacturing sector (examples are available upon request). In Tanzania, linkage initiatives, which are mainly a part of government and donor programmes, have been used to help SMEs adopt better production technologies and acquire managerial know-how. Through linkages with large firms, SMEs learn of better technology and get assurance of a market for their products, which can incentivize their increased investment in better production technology among other things. Majority of the large firms consider SMEs as less qualified or prepared to enter into such relationships, given their challenges of informality, use of outdated technology and weak capacity (Oyen & Gedi, 2013).

A few successful cases can illustrate the usefulness and impact of such linkage initiatives. A typical case as documented in Bekefi (2006) is the linkage between Tanzania Breweries Limited (TBL) and Kioo Ltd. In manufacturing beer, TBL saw an opportunity to source for inputs locally at lower costs by building the capacity of local suppliers. TBL invested in upgrading the capacity of its potential local suppliers of glass, barley and labels, which became important suppliers for TBL. For instance, before the partnership with TBL, Kioo Limited manufactured bottles whose standards were poor with a high breakage rate. After TBL assured Kioo Limited that it would buy all its bottles if they were of the required quality, Kioo Limited invested heavily to improve its production technology and enhance the quality and quantity of its bottles. Consequently, Kioo Limited became the primary glass manufacturer in Africa, supplying 100% of TBL bottles and for other beverage firms.

Another example was the initiative involving Kilombero Sugar Company Limited, International Finance Corporation and Africa Project Development Facility to support small scale outgrowers. This initiative saw outgrower farms moew than double in its first two years, growing from 2,760 to 5,000 and their annual cane harvest tonnage increased by 42.5%. Furthermore, the financial inputs of the project to the local community increased from TZS 7 billion to TZS 11 billion during the first year of the project (Bekefi, 2006).

Linkages can also be in the form of collaboration among private, public and academic sectors, known as the triple helix model. There is limited information on this type of partnership in Tanzania's industrial enterprises. One advantage of such a linkage is the availability of support, information, access technology etc. In Tanzania, most firms and especially SMEs obtain information about possible linkages with other firms through their membership associations, but only 41% of the enterprises in the industrial sector belong to such associations and 34% of them had received technology or other production services from public technology institutions, but over 60% of the firms did not interact with public technology institutions owing to the lack of awareness of their value.

2.3 Performance of ITU

2.3.1 Performance indicators

To assess the performance of ITU in influencing competitiveness, we employed multiple indicators to measure innovation and technology intensity of firms. The three most familiar indicators were GII, trade, and survey-based indicators. GII is prepared by the World Intellectual Property Organization (WIPO) in partnership with Cornell University, INSEAD and other organisations to rank the performance of the innovation ecosystem of economies around the globe each year while highlighting innovation strengths and weaknesses and particular gaps in innovation metrics.

These organisations have been publishing annual GII estimates since 2007 through GII reports. GII comprises around 80 indicators, including measures on the political environment, education, infrastructure and knowledge creation of each economy. The different metrics that GII offers can be used to monitor performance and benchmark development against economies within the same region or income group classification.

GII is founded on two sub-indices that are both equally vital in presenting a complete picture of innovation: the innovation input sub-index and the innovation output sub-index:

- The innovation input sub-index captures the elements of the economy that enable and facilitate innovative activities. It has five enabler pillars: institutions, human capital and research, infrastructure, market sophistication, and business sophistication.
- Innovation output sub-index measures the result of innovative activities within the economy. It covers two pillars, i.e. knowledge and technology outputs and creative outputs. Although the output sub-index includes fewer pillars than the input sub-index, the two have the same weight in calculating the overall GII scores.

We draw data from reports covering the 2011–2020 period to not only help identify the factors that affect innovation but also to shed light on the progress made by Tanzania in the desire to achieve a higher level of innovation.

Trade indicators are essentially the exports and imports indicators for Tanzania. We used such indicators to examine merchandise exports from Tanzania to get a picture of the technology level of goods from the country's industrial sector. The analysis of merchandise imports is a good proxy for what the country's industrial sector is lacking and therefore needs for production. We obtained trade data from the ITC Trademap database, which provides trade data disaggregated by products.

The analysis involved disaggregating trade data into low technology, medium technology, medium-high and high technology products[2]. We analysed the trends of each type of traded manufactured product i.e., the low, medium and high technology products, and their shares including how they have evolved over time. The aim is to identify the innovation and technology intensity of manufactured exports from and imports to Tanzania, which types of products form the largest share of Tanzania exports and imports and which type of products have improved or suffered as the total Tanzania trade has been changing, i.e., increasing or decreasing. The challenges with this indicator include the difficulty of establishing the cut-off point between high-medium and low manufactures.

2 Table 6 provides information on the type of activities/manufactured goods belonging to each of Low, Medium and Medium-High and High technology product group.

Survey-based indicators are derived from survey-based data that include information on firm's technology and innovation. Typical indicators of technology and innovation include the share of R&D spending in the total sales, amount of investment in technology and innovation (percentage of total production), innovation count (new product, process etc.), firm cooperation with another firm/institution for R&D activities or to develop new products, and the number of patents. In this study, we will use ASIP data to derive these indicators. ASIP data are available as a panel covering 2008–2016.

However, although survey data are available for 2008–2016, data for technology and innovation indicators is available for only 2015 and 2016. This is because most of the technology and innovation variables were included in the ASIP instrument only in 2015. The 2016 annual survey conducted in 2017 included a module on technology transfer providing a detailed dataset with which to analyse technology and innovation issues[3]. Out of the 2,462 firms surveyed in 2016 through ASIP, 1,558 responded to the technology transfer module. So our empirical analysis is executed using the 2016 ASIP data.

The use of multiple indicators is warranted given the recognition that each indicator has its pros and cons. For example, GII has been criticised for giving excessive significance to factors that are not integral to innovation. For instance, the ease of paying taxes, electricity output (half-weightage), ease of protecting minority investors and to a country's business environment. On the other hand, indicators used in firm surveys as listed above reflect more the firms' innovation and technology than the general business environment. Notwithstanding the benefits of firm survey-based indicators, their main drawback is that the newness or innovativeness of a firm is estimated using dichotomous (yes or no) questions whereby all the innovations reported by the firms are assumed to have the same magnitude. Thus, it does not provide any information about degrees of innovativeness (Becheikh, Landry & Amara, 2006).

2.3.2 GII

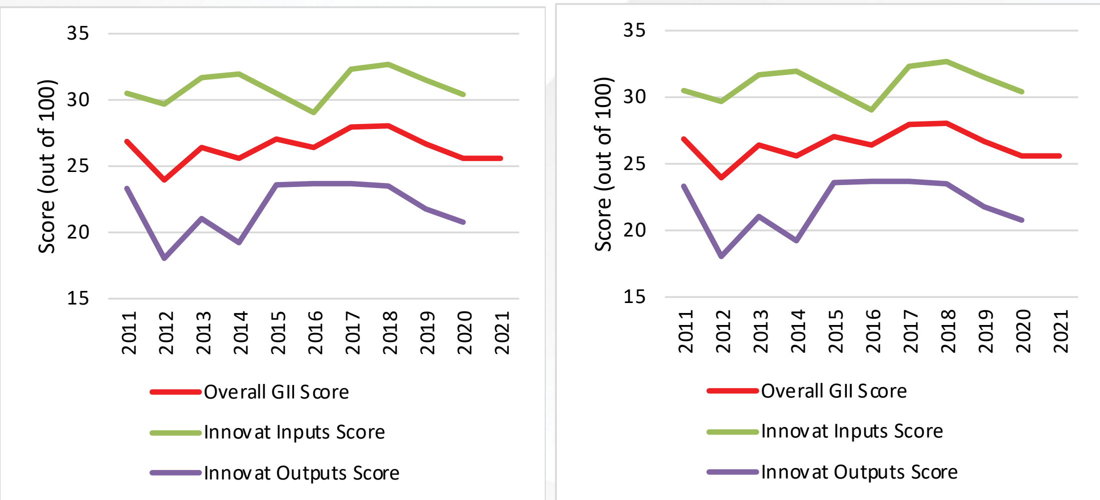
In recent years, Tanzania has seen a good improvement in GII rankings. In 2020, it was ranked 88th, gaining 9 positions from 2019 and becoming one of the top countries in the low income group. Notably, its innovation input rose from 115th to 112th, while its output index rose from 73rd to 67th (see Figure 6). In particular, a remarkable improvement was observed in market sophistication and creative output pillars. There was a slight performance decline to the 90th position in 2021, which was characterised by a fall in innovation input ranking from 112th in 2020 to 120th in 2021. However, there was a slight improvement in innovation output ranking from 67th to 65th.

Figure 6 shows that while the overall GII score during 2011–2021 declined, Tanzania's ranking in GII improved, implying that other countries' score declined relatively much more than Tanzania's. Another explanation could be that the number of countries in the ranking changed so that the countries

3 The additional module that specifically collected data on technology transfer was a collaborative initiative by the Johns Hopkins University School of Advanced International Studies ("SAIS"), the Tanzania National Bureau of Statistics (NBS), and IFPRI.

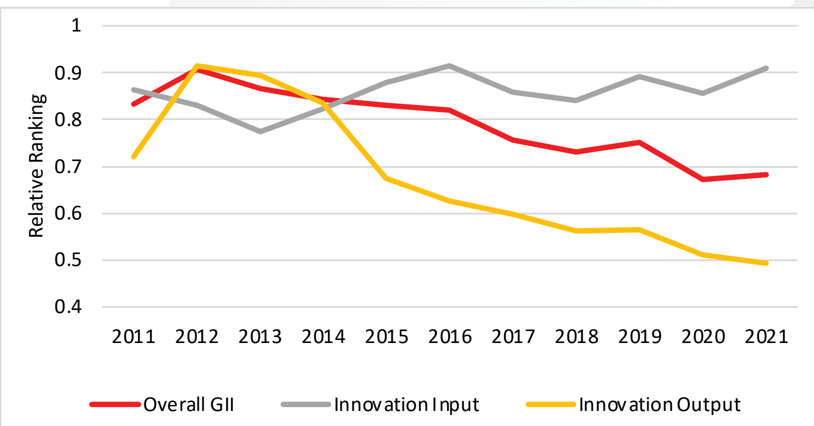
that were ranked better than Tanzania in a certain year were not covered in the report in the subsequent year, giving Tanzania a higher position. We investigated this explanation by adding a variable of the total number of countries in the GII, and the result is shown in Figure 7. It indicates that the years where Tanzania experienced a remarkable improvement in GII ranking were associated with a significant reduction in the number of countries covered by the index. In addition, as Figure 7 shows, the estimated rank per total number of countries indicates Tanzania's position relative to other countries for which we observed similar trend as in Figure 6. Thus, the difference between the GII score ranking is more likely caused by a decline in GII performance in other countries compared to that of Tanzania. Furthermore, Tanzania's improvement in the overall GII performance was mainly driven by a combination of a significant rise in innovation output and a decline in innovation input.

Figure 6: Tanzania performance in GII



Source: Author construction of data from various GII reports for 2011–2021.

Figure 7: Tanzania relative GII ranking

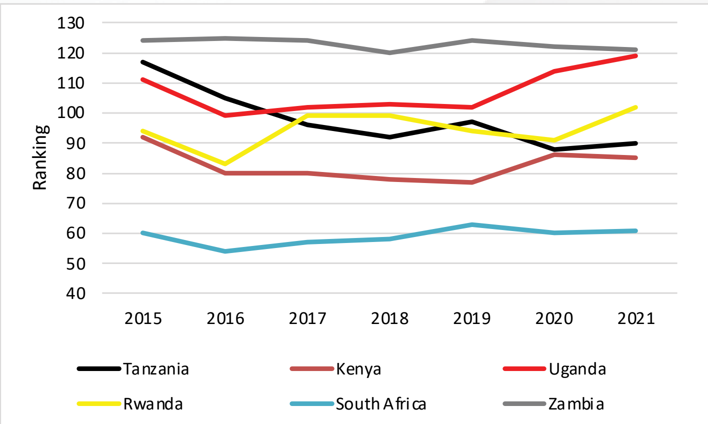


Source: Author analysis of data from various GII reports for 2011–2021.

To enhance the reliability of the results, our analysis of GII also involved a comparison of Tanzania's ranking with those of other selected countries. For this purpose, we selected six countries from the Southern Africa Development Cooperation and the East African Community regional blocks, i.e. Rwanda, Kenya, Uganda, Mauritius, South Africa and Zambia. As shown in Figure 8, on the one hand, Tanzania ranks better in GII than Uganda post-2016, Zambia and Rwanda, albeit only in some years. South Africa and Kenya performed much better than Tanzania throughout the 2015–2021 period. These two countries also have relatively more developed industrial and private sectors than Tanzania.

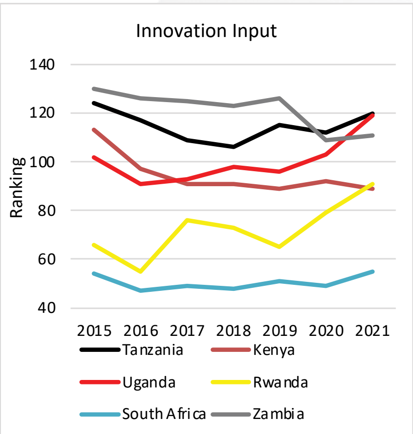
We extended the comparison to assess performance in terms of the innovation input and output sub-indices. As shown in Figure 9, Uganda, Rwanda, Kenya and South Africa performed better than Tanzania in innovation input while Tanzania performed better than Uganda, Rwanda and Zambia in innovation output sub-index. In addition, while Tanzania had lower innovation output ranking than Kenya and South Africa for majority of the years in the 2015–2021 period, the country surpassed these countries in since 2020.

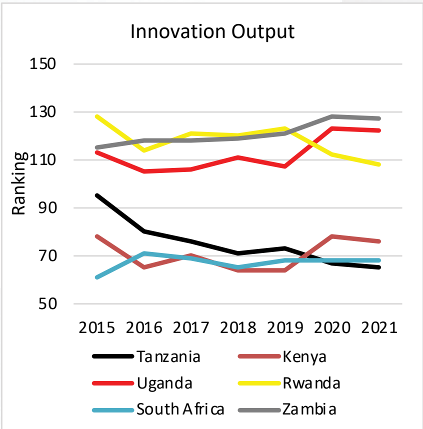
Figure 8: Comparison of Tanzania GII ranking with that of other countries



Source: Author construction based on GII data

Figure 9: Tanzania's ranking in innovation vs. other countries (2015-2021)





Source: Author construction based on GII data

In addition to the score and ranking, the GII reports also show the areas of strength and weakness for each country covered. In the last three years, Tanzania's strengths have commonly been in such areas as cost of redundancy dismissal, gross capital formation (% GDP), university-industry R&D collaboration, innovation linkages, trade in high technology products, gross domestic expenditures on R&D (GERD) financed abroad (% GDP), labour productivity growth, and creative goods exports. The country's common weaknesses have been in areas of tertiary enrolment, QS university ranking, computer software spending (% of GDP), graduates of science and engineering, ICT use, knowledge-intensive employment and online creativity.

2.3.3 Trade-based indicators

One of the strategies in FYDP III for achieving Tanzania's goals of building a competitive country and achieving middle income status is promotion of ITU by leveraging trade. The role of trade in promoting innovation and technology can be achieved through imports, i.e. technology transfer, and exports, uplifting technology and innovation to produce goods that can compete in export markets.

Our analysis of trade data is based on product disaggregated imports and exports data from ITC Trademap database, which provides unique harmonised system (HS) codes for each traded product. There are two commonly used approaches: the OECD and the UNIDO frameworks. The OECD framework is based on the R&D intensity indicator, i.e., the share of R&D expenditure in value added (see OECD 2011) as shown in Table 5. The UNIDO framework is founded on commodity classification (ISIC Rev 4) based on the technological intensity nature of the product, and is not limited to the R&D expenditure as shown in Table 6. The OECD classification is primarily applicable to highly industrialised economies, hence is not very relevant for developing countries. For instance, some of the high technology manufacturing industries such as production of airplanes and spacecraft machinery are rare in developing economies (see UNIDO, 2021). For this reason, our categorization followed the UNIDO (2021) framework. That framework combines high technology and medium to high technology industries.

For convenience, we will refer to MHT goods as high technology (HT) goods. The framework classifies industrial products based on the International Standard of Industrial Classification Revision 4 (ISIC Rev 4) and maps the products into different levels of technology groups as shown in Table 6. However, one challenge remains, that of mapping the HS codes of each traded product to its respective ISIC Rev 4 product and subsequently to the different technology levels. To address this challenge, we use the HS Codes to ISIC Conversion key developed by the OECD STAN databases team, the directorate for Science, Technology and Innovation.[4]

4 See the link to the conversion key: https://www.oecd.org/sti/ind/ConversionKeyBTDIxE4PUB.xlsx

Table 5: Classification of manufacturing industries based on R&D intensities

High-technology industries	Medium-high-technology industries
Aircraft and spacecraft Pharmaceuticals Office, accounting and computing machinery Radio. TV and communciations equipment Medical, precision and optical instruments	Electrical machinery and apparatus, n.c.c. Motor vehicles, trailers and semi-trailers Chemicals excluding pharmaceuticals Railroad equipment and transport equipment, n.e.c. Machinery and equipment, n.e.c.
Medium-low-technology industries	Low-technology industries
Building and repairing of ships and boats Rubber and plastics products Coke, refined petroleum products and nuclear fuel Other nonmetallic mineral products Basic metals and fabricated metal products	Manufacturing, n.e.c.; Recycling Wood, pulp, paper, paper products, printing and publishing Food products, beverages and tobacco Textiles, textile products, leather and footwear

Source: OECD (2011)

Table 6: Manufacturing industries by technological intensity

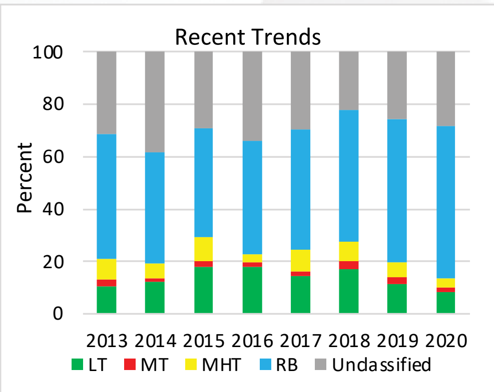
Medium-high and high technology	Low technology
Division 20 Chemicals and chemical products	Division 10 Food products
Division 21 Pharmaceuucals	Division 11 Beverages
DIvIsIon 26 Computer, electronic and rodes	DIvision 12 Tobacco Products
Division 27 Electrical equipment	Divison 13 Textiles
DIvision 28 Machinerv and equoment n.e.c	Division 14 Wearing apparel
DIvision 29 Motor vehicles, trailers and semi-trailers	Division 15 Leather and related products
Divsion 30 Other transport equioment excent shins and boars	Division 16 Wood and cork
Medium technology	Division 17 Paper and paper products
Division 22 Rubber and plastics products	Division 18 Printing and reproduction of recorded media
Division 23 Other non-metalic mineral products	Division 19 Coke and refined petroleum products
Division 32 Other manufacturing except medical and dental instruments	Division 25 Fabricated metal products except weapons and ammunitonz
Division 33 repair and installation of machinery and equipment	Division 31 Furniture

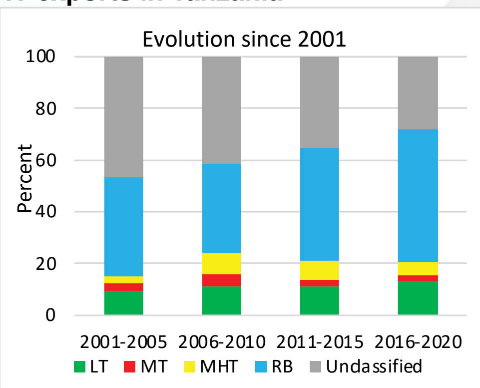
Source: UNIDO (2021)

Figure 10 shows Tanzania's merchandise exports classified into LT, MT and HT groups. Initially, we found the share of manufactured exports (i.e. the sum of LT, MT and HT) in the total merchandise exports to be much higher than the figures reported in other data sources or literature. This is because the UNIDO classification includes natural-resource based manufactured products, which alone constitute a very large share of the Tanzania merchandise exports (see Figure 10). Therefore, we adjusted the UNIDO framework slightly to separate resource-based (RB) products from LT, MT and HT products so that our data are consistent with what is reported in other data sources.

The results are reported in Figure 10 and show that Tanzania's exports are dominated by RB goods,[5] which are followed by LT, HT and MT goods. The RB category's share averaged 48.1% during 2013–2020 and attained its highest level of 58.1% in 2020. This group constitutes such goods as gold (HS 710812), which alone contributed 32.6% of the merchandise exports during 2013–2020, while the rest of the RB products contributed only 15.5%. The share of LT exports, the second largest, averaged 13.7% with the highest level of 18.1% attained in 2015. This group is dominated by tobacco, bran and frozen fish fillets each of which constituted more than 7% of the total LT exports for 2013–2020 (see Table 7). The share of the HT group in the total merchandise exports averaged 6.3% and was dominated by such products as apparatus, soaps and beauty/makeup preparations. The MT group had the least share among the groups, averaging 2.1% and was dominated by waste and scrap, flat-rolled products of iron and household articles.

Figure 10: Performance of LT, MT and MHT exports in Tanzania





Source: Author Construction based on ITC Trademap data 2022

5 The RB group includes products from agriculture, forestry, fishing, hunting and trapping, mining, oil and gas extraction.

Table 7: Top 10 exported products for each technology group (2013-2020)[6]

Low Technology (LT)			Medium Technology (MT)			Medium High and High Technology (MHT)		
HS Code	Product	Share in total LT Exports	HS Code	Product	Share in total MT Exports	HS Code		Share in total MHHT Exports
240120	Tobacco	29.4	720410	Waste and scrap	9.7	852872	Recep-tion ap-paratus	14.3
230230	Bran, sharps and other resi-dues of wheat	8.0	721061	Flat-rolled products of iron	8.1	340119	Soap	6.0
30489	Frozen fish fillets	7.4	392490	Mousehold articles and toilet articles	79	330499	Beau-ty or make-up prepara-tions	5.3
560729	Twine, cordape, ropes and cables	6.5	710399	Precious and semi-grecious stones	7.0	320120	Wattle extract	4.0
30499	Frozen fish meat	6.3	391590	Waste, parings and scrap of plastics	4.8	843143	Parts for boring or sinking machin-ery	2.6
630491	Articles for in-terior furnishing	4.5	392410	Table ware and kitchen ware	4.3	310230	Ammo-nium nitrate	2.6
30449	Fresh or chilled fillets of fish	3.4	740400	Waste and scrape of copper	3.7	880240	Aero-planes and other powered aircraft	2.3
630533	Sacks and bags	3.2	721049	Flat-rolled products of iron	3.6	310210	Urea	2.0
520300	Cotton	3.1	730661	Tubes and pipes and hollow profiles	2.9	310590	Min-eral or chemical fertilisers	2.0
30572	Fish heads, tails and mawasa	2.8	721041	Flat rolled products of iron	2.8	890690	Vessels, incl. tifetxoats	1.7

Source: Author's construction based on ITC Trademap data for 2022

6 These were calculated as share of each product's total 2013-2020 export as percent of total exports in that particular product export group (whether LT, MT or MHT) for the same period.

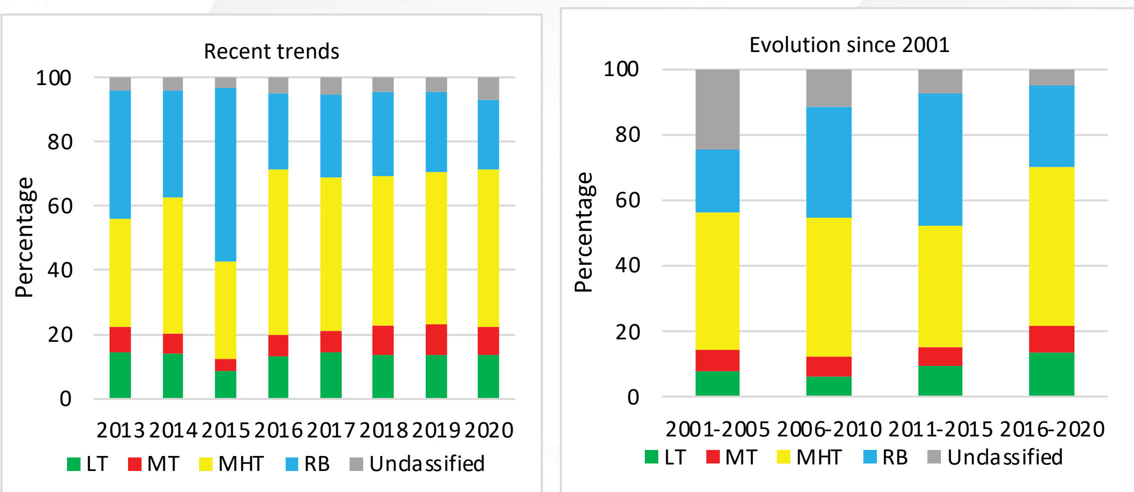
The structure of Tanzanian export composition has been changing over time (see Figure 10). This change allows the assessment of the extent and rate of the transformation in favour of the more technologically intensive goods. Figure 10 shows that both LT and HT exports' shares in total merchandise exports have increased over time, going from 9.6% and 2.4% in 2001–2005 to 13.3% and 5.5% during 2016–2020, respectively. On the other hand, MT exports declined from 3% to 2.1% during that period, while the RB exports had the highest increase, rising from 38.4% to 51.3%. The share of manufactured exports in total merchandise trade also increased.

The results for imports are reported in Figure 11. They show that the HT category dominated throughout the 2013–2020 period with their share in the total merchandise imports averaging 43.7%. They were followed by RB imports at 31.2%, LT imports at 13.1% and MT imports at 7.3%.

In addition, manufactured imports, i.e. the total of LT, MT, MHT and RB imports, constituted the majority of the merchandise imports, averaging 95.3%, a big contrast with merchandise exports. Table 8 reports the top 10 imported products for each of the technological intensity category. LT imports were the least diversified, as oils and preparations account for almost half (47.6%) of all the LT imports, while HT imports were the most diversified, taking up 23% of the top 10 imports.

As shown in Figure 11, the structure of Tanzania's imports also has been changing, albeit not as dramatically as for the exports. For instance, the share of HT imports increased from 42.2% to 48.5%, and of LT from 8.1% to 13.7%, while that of MT decreased from 6.2% to 5.2%. The share of RB imports in the total merchandise imports increased from 18.8% to 24.4%. These trends show that Tanzania experienced a strong demand for HT products during the period and indicate an opportunity exists for increased technology transfer.

Figure 11: Performance of LT, MT and MHT imports in Tanzania



Source: Author's construction based on ITC Trademap data for 2022

Table 8: Top 10 imported products for each technology group (2013–2020)

Low Technology (LT)			Medium Technology (MT)			Medium High and High Technology (MHT)		
HS Code	Product	Share in total LT Imports	HS Code	Product	Share in total MT Imports	HS Code	Product	Share in total MHT Imports
271012	Light oils and preparations	47.6	720839	Flat-rolled products of iron	14.8	300490	Medicaments	5.9
730890	Structures and parts of structures	2.6	901890	Instruments and appliances	4.7	870120	Road tractors	3.0
732611	Grinding balls	1.5	720827	Flat-rolled products of iron	4.5	870323	Motor cars	2.9
730820	Towers and lattice masts	1.5	730690	Tubes, pipes and hollow profiles	4.3	871120	Motorcycles	1.9
640299	Footwear	1.4	721420	Bars and rods	4.1	870421	Motor vehicles	1.8
961900	Sanitary towels	1.3	721070	Flat products of iron	4.1	390120	Polyethylene	1.8
731100	Containers of iron or steel	1.2	721041	Flat-rolled products of iron	2.9	390210	Polypropylene	1.5
520852	Plain woven fabrics of cotton	1.2	721391	Bars and rods	2.8	330210	Mixtures of odoriferous substances	1.4
732690	Articles of iron	1.1	720719	Semi-finished products of iron	2.7	870210	Motor vehicles	1.4
731815	Threaded screws and bolts	0.9	721049	Flat-rolled products of iron	2.6	870333	Motor cars	1.4

Source: Author's construction based on ITC Trademap data for 2022

2.3.4 Survey-based indicators

Based on ASIP data, we use the UNIDO framework (see Table 6) we used in disaggregating trade based on technology content. The framework covers only the manufacturing sector, leaving out mining, electricity and water sectors in the ASIP data.

Table 8 shows the categorization of the manufacturing firms by their technological intensity following the. The application of the UNIDO framework on ASIP data is shown in Table 9, which shows that the share of LT firms in the total industrial manufacturing firms is 74.5% while MT and MHT firms constitute 25.6%. The total observations in the three groups are 1,558. As will be seen in the next sections, the classification of firms based on their technology content is an important aspect of our empirical analysis.

Given the importance of the technology content of firms in empirical analysis (see Verspagen, 1995), we also provide summary statistics of firms in the three categories as shown in Table 10. Tables 8 and 9 show that there is more innovation effort or input among MT and HT firms than LT firms. In particular, the share of firms that invest in innovation and the average investment in innovation are higher among MT and HT firms than LT firms. This may be because firms in MT and HT groups participate more in international trade relative to LT firms, as innovation enhances their efficiency and competitiveness. Indeed, Table 10 shows that the proportion of firms participating in trade in MT and MHT groups at 26% is higher than that of the LT group at 18%. Table 10 also shows that the share of SMEs among MT and HT firms is smaller than among LT firms. The figures for innovation output are generally similar. Notably, 14% of the firms in the LT group engaged in process innovation compared to 12% for MT and HT groups.

The share of firms engaging in complex innovation is slightly higher among LT firms (41.8%) than MT and HT firms (41.2%). Other characteristic features of ASIP data show that age is slightly higher among LT firms than MT and HT firms and that firms that are members of industry associations are relatively more among MT and HT groups than LT group. On the other hand, the share of LT firms in technology partnerships is higher than that of MT and HT firms, which is presumably a reflection of government efforts to target firms with less access to technology and SMEs (URT, 2016).

Table 9: Characteristics of firms in LT group and MT and MHT groups

Variable	LT firms				MT and MHT firms			
	Obs	Mean	Min	Max	Obs	Mean	Min	Max
Innospend_emp	1,160	161,006.6	0	28,900,000	398	194,399.2	0	11,000,000
dinnospend	1,160	0.312	0	1	398	0.327	0	1
Process innovators	1,160	0.142	0	1	398	0.123	0	1
Complex innovators	1,160	0.418	0	1	398	0.412	0	1
age	1,160	10.947	1	111	398	10.548	1	69
trade	1,160	0.137	0	1	398	0.259	0	1
association	1,160	0.311	0	1	398	0.342	0	1
tech1	1,160	0.305	0	1	398	0.271	0	1
sme	1,160	0.908	0	1	398	0.882	0	1
private	1,160	0.953	0	1	398	0.945	0	1
foreign	1,160	0.096	0	1	398	0.209	0	1
govsubs	1,160	0.268	0	1	398	0.096	0	1
finacce	1,160	0.436	0	1	398	0.487	0	1

Source: Author's analysis of ASIP data for 2016

3. EMPIRICAL ANALYSIS

3.1 Overview

Having examined the trends and structure of technology and innovation in the Tanzania trade and industrial sectors, one needs to understand what factors drive the innovation and technology status of firms or changes thereof and to what extent such status is critical for firms' growth and competitiveness. To enhance this understanding, this section presents the empirical analysis component of the study. It starts by outlining the empirical model and data, followed by the presentation and discussion of the results. In particular, the section analyses the determinants of firm level ITU in Tanzania and assesses the effect of ITU on firm competitiveness.

3.2 Determinants and role of innovation

3.2.1 Model and data

Our empirical model is based on a modified Crépon, Duguet and Mairesse (1998) model (hereinafter the CDM model) as used by Le (2020). The CDM model proposes that certain firm-level factors, such as firm size, market share, diversification, demand conditions, and technological opportunities influence firms' decisions to engage in innovation activities and their outcomes. The model is made up of three stages: (i) the firm's decision to invest in research activities and the intensity of the innovation investment, (ii) the knowledge production function linking innovation investment (measured by R&D intensity) and innovation outputs, and (iii) the output production function determining the impact of the knowledge produced on firm productivity or performance. Essentially, our assessment of the determinants of firm innovation involves the first two stages, while the last stage is focused on the analysis of the effects or impact of ITU on competitiveness.

The first stage assesses innovation inputs. It involves two equations. One estimates the determinants of a firm's propensity to invest in innovation (Equation 1) and the other one estimates the determinants of a firm's intensity of innovation efforts (Equation 2). The Heckman selection equation (Heckman, 1979) estimates the probability that firms will engage in innovation efforts. Since enterprises are engaged in different innovation activities and at a varying extent, the second equation estimates the intensity of innovation efforts.

$$R_{1i} = 1(R^*_{1i} > 0) \text{ where } R^*_{1i} = \sum^{n}_{1i=1} \alpha Z_{1i} + \varepsilon_{1i} \quad \text{.............................. (1)}$$

$$R_{2i} = R^*_{2i} = \sum^{n}_{2i=1} \alpha Z_{2i} + \varepsilon_{2i} \text{ If } R^*_{1i} > 0 \text{ and zero otherwise} \quad \text{.............................. (2)}$$

Supposing that R_{1i}^* is an unobserved variable representing a firm's decision to invest in innovation and R_{2i}^* is the unobserved level of a firm's investment in innovation, R_{1i} and R_{2i} are their observable counterparts in the two equations. In our estimation, innovation investment (innospend) is the sum of firm's spending on such activities as engineering and technical services, market (intelligence) studies, patents and IPRs (intellectual property rights), and Research and Development (R&D).

FADHILIEDIT Following our firm's decision to invest is a dummy variable i.e. dinnospend with values 0 if innospend equals 0 (the firm decided not to invest on innovation) and 1 if innospend>0 (the firm has invested in innovation). In the equations 1 and 2 above, $\sum_{1i=1}^{n} Z_{1i}$ and $\sum_{2i=1}^{n} Z_{2i}$ are the vectors of explanatory variables and the corresponding parameters that explain the effects of different determinants on the decision to engage in innovation investment and the level of innovation investment. Variables $_{1i}$ and $_{2i}$ are the error terms, which have a mean of zero, constant variance, and are not associated with the independent variables.

Assuming that the error terms of Equations 1 and 2 are bivariate normal with zero mean and variance equal to unity, the two equations can be estimated using the maximum likelihood method. In the literature, this model is sometimes referred to as a Heckman selection model (Heckman, 1979) or a Tobit type II model (Amemiya, 1984).

Before estimating the Heckman selection model, we performed a non-parametric test for the presence of selection bias in the innovation intensity equation (see Das, Newey & Vella, 2003). In doing so, we first estimated a probit model in which the firm's decision to invest in innovation, *dinnoinves*, is regressed on a set of firm characteristics: *empsizeTZ* - firm size i.e., small, medium or large[7] , *lage* - *log* of firm age, private - whether the firm is privately owned or not, foreign - whether the owner is a foreign investor or not, and *govsubsid* - whether the firm received government subsidies or not; and a set of control variables including region - firm location and sector – firm's sector of operation. In estimating the model, we obtain each firm's predicted probability of investing in innovation and the corresponding Mills' ratio. Then we estimate a simple linear regression model using OLS for innovation investment intensity, adding to this equation the predicted probabilities from the innovation investment decision equation, the Millsratio, their squares, and interaction terms. Our innovation investment intensity variable - *innoinves_emp* - is measured as the ratio of Our results for the selectivity bias test are reported in Annex A, which shows that the probability terms in the innovation intensity model are not significant. This implies that there is no selectivity bias and, therefore, we can adopt and estimate a simple OLS model for innovation intensity.

7 This study adopts the firm size definition from Tanzania's micro, small and medium enterprises' policy of 2002, which categorizes firms into micro, small, medium and large sizes based on the number of employees. That is micro (1-4 employees), small (5-49 employees); medium (50-99 employees) and large (100+ employees).

The second stage assesses the determinants of innovation output. Our innovation output variable – innotyp - is categorical with value 0 if a firm has no innovation output, 1 if the firm introduces a product innovation, 2 if the firm introduces process innovation, and 3 if the firm introduces both product and process innovations[8]. The analysis of the drivers of innovation output involves estimating Equation 3 as follows.

$$G_i^* = a_i r_{2i} + \sum_{i=1}^{n} \alpha Z_{3i} + \varepsilon_{3i} \quad \dots\dots\dots\dots (3)$$

where G_i^* is an innovation output measure (*innotyp*) that cannot be observed completely with values 0 to 3, $\sum_{i=1}^{n} \alpha Z_{3i}$ is the set of explanatory variables, including firm characteristics in particular: sector, lage, foreign, trade (whether the firm participates in international trade or not). Other variables include association (whether the firm has association membership or not), tech1 (whether the firm has cooperated or received technology and production services from pPublic technology intermediaries[9] or has partnered with private companies in R&D activities or not), and *linnospend_* emp –- firm investment in innovation per worker; and their parameters, while ε_{3i} is the error term that is assumed to be iid ~ N(0;σu). r_{2i} is a variable for innovation investment and a_i is its coefficient.

Hall, Lotti & Mairesse et al (2009) notes that, micro, small and medium enterprises MSMEs in developing countries tend to engage in informal knowledge production activities based on sources other than R&D or innovation investment. Such activities are difficult to capture in surveys even if they are very relevant. Therefore, the use of investment in observable innovation activities (i.e., the innovation investment estimates obtained from the survey data) in our innovation output model estimation might be biased because it might fail to take into account the effect of informal innovation activities. Therefore, rather than using firm innovation investment data as reported in the survey data, we used the predicted value of all innovation investments, following other studies (Hall, Lotti & Mairesse et al., 2009; Alvarez, Bravo-Ortega & Navarroet al., 2010; Crespi &, Zuniga, 2012). To model all available innovation outcomes, we apply the multinomial logit model (MNL), which is estimated using the standard maximum likelihood estimation procedure. For this MNL model, the base category/comparison group is non-innovators, including firms without any innovation outcomes.

8 In the literature, innovation types are sometimes described as simple innovations if the firm introduces only a product or only a process innovation, and a complex innovation when a firm introduces both product and process innovations. However, for convenience, we just refer to the substantive categories of product, process and both innovations.
9 These include Tanzania Automotive Technology Centre, Tanzania Bureau of Standards and others.

The third step of the CDM model is about analysing the effect of innovation output on firm productivity. To accomplish this, we use the following simple equation:

$$LnY_i = \gamma + \sum^{n}_{i=1} \alpha X_i + \sum^{n}_{i=1} \beta N_i + \varepsilon_{it} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where LnY _i is an indicator of firm productivity (ratio of firm sales to employment in logarithm form); X_{it} is a vector of innovation output indicators; N_i is a vector of other factors determining firm productivity including association to membership (*association)*, spending on training (*train*), foreign ownership (foreignown), private ownership (*private)*, log of firm age (*lage*) and log of capital (*lK*); is the constant term; and _i is the random error term. In order to address the possible endogeneity issue concerning the knowledge inputs, (i.e., innovation output), we use their predicted probabilities that were estimated from the knowledge production function (the second stage). This equation is estimated using the simple OLS technique.

As noted earlier, our empirical analysis is based on ASIP data. The dataset is preferred as it is the only nationally representative firm level dataset on various industrial sectors available in a panel spanning 2008–2016. The alternative is the World Bank Enterprise Survey data, which have limited coverage and are much more outdated. However, given the limitation of the technology and innovation module, the analysis will use data for the year 2016 only. To provide the context for the empirical results, we first describe a firm's innovation and technology profile, including identifying the relevant firm characteristics.

Table 10 reports the summary statistics of variables used in the empirical analysis. The statistics reveal that 30.1% of firms reported spending on innovation where the mean spending per worker per annum was approximately TZS 194,036. However, the total share of the firms that claimed to have made some innovation output (either simple or complex) was 56%, which was much higher than the share of firms that made spending on innovation inputs. An explanation of this is that some firms may receive help from the government or a donor organisation that may boost their innovation effort but ultimately will not count as firm's own innovation spending. On the other hand, the literature (see Griffien et al., 2006) reveals that while every firm may have carried out its own innovation effort (spending), only a few firms report it, while others, particularly SMEs, are highly likely not to report it. Indeed, the ASIP data show that the share of SMEs that reported zero innovation spending among all SMEs was 38%, compared with 32% for large firms. Note that other descriptive statistics in relation to the technological intensity of firms were reported in section 2.

Table 10: Descriptive statistics of all variables used in empirical analysis

Variable	Obs	Mean	Min	Max
innospend_emp	1,884	194,036.1	0	68,300,000
dinnospend	1,885	0.301	0	1
Process Innovators	1,885	0.181	0	1
Complex Innovators	1,885	0.383	0	1
age	1,885	10.893	1	111
trade	1,885	0.145	0	1
association	1,885	0.376	0	1
tech1	1,885	0.336	0	1
sme	1,885	0.906	0	1
private	1,885	0.924	0	1
foreign	1,885	0.108	0	1
LT firms	1,558	0.745	0	1
MT and MHT firms	1,558	0.256	0	1
govsubs	1,885	0.096	0	1
finacce	1,885	0.416	0	1

Source: Author's analysis of ASIP data for 2016

3.2.2 Determinants of firm innovation

We adopted a simple OLS model for innovation intensity to perform three sets of regressions. That is, regression covering the entire sample in the survey data; one that covers only the low technology firms (LT) and one that covers the combined medium technology (MT) and high technology (HT) firms. This is because the determinants of innovation and its impact on firm productivity can vary with the technology content of an industry. We combined HT and MT firms in one group because the HT group had only 92 observations, which were very few and would be difficult to generate sufficient degree of freedom in the estimation. In all regressions we added both firm location (region) and sector of operation as control variables.

The results are reported in Table 11. They show that innovation and technology spending intensity is significantly determined by a firm's age, collaboration with technology intermediaries in R&D activities, participation in international trade, foreign ownership, and government subsidies. In particular, the results show that a 1% increase in a firm's age increases innovation spending intensity by 19% for the entire sample and by 33% in the MT and HT groups. Firms that have cooperated with or received technology and production services from public technology intermediaries such as the Tanzania Automotive Technology Centre, Tanzania Bureau of Standards and others or have partnered with private companies in R&D activities spend 56% more on innovation than firms that do not.

This is not surprising, because production process improvement and inventing new products or improving the quality of old products are some of the firms' activities in these technology partnerships. ASIP data show that in 2016, 32% of the 579 firms that engaged in technology partnerships collaborated or received assistance on new product development while 59% received services or support in product quality improvement, 63% in production process improvement and 58% in employee training.

The results in Table 11 show also that technology partnerships' effect on innovation spending intensity is significant for LT firms, where firms that participate in such partnerships spend 57% more on innovation than those that do not. Consistent with this, the comparison of firm characteristics between LT and MT/HT firms in Table 12 shows that technology partnerships exist more among LT firms than MT/HT firms. Firms participating in international trade spend 52% more on innovation than those that do not. Indeed, the literature highlights the fact that for exporting firms, the expected return on innovation investments can be larger than for non-exporting firms because of their larger market size; exposure, including the ability to learn from knowledge spillovers in the foreign country; or competitive pressure from exporting firms based in other countries. This is why the literature warns that restrictions on trade limit access to these factors and reduce firms' innovation investments (Maican et al., 2021).

Foreign ownership is significant in both LT and MT/HT regressions in which the results show that foreign-owned firms are associated with 36% more innovation spending than those owned by domestic investors. Subsidy is significant but negative, showing that firms receiving government subsidies spend 43% less on innovation than those that do not get subsidies, which presumably reflects the adverse effects of subsidies on private investment.

Table 11: Determinants of firm's innovation spending intensity (Stage 1)

Variable	All firms	LT firms	MT and MHT firms
	linnospend_emp	linnospend_emp	linnospend_emp
lage	0.194*	0.158	0.333*
	(0.0907)	(0.101)	(0.184)
compet	0.0392	0.151	-0.0287
	(0.205)	(0.237)	(0.418)
tech1	0.568**	0.572***	0.267
	(0.187)	(0.215)	(0.400)
trade	0.521*	0.369	0.413
	(0.228)	(0.256)	(0.475)
finacces	-0.0241	-0.0650	-0.0165
	(0.178)	(0.200)	(0.386)
trainspend	0.00694	0.137	0.182
	(0.225)	(0.246)	(0.481)
association	0.126	0.262	0.0876
	(0.191)	(0.222)	(0.437)
private	0.109	-0.0851	0.738
	(0.392)	(0.492)	(0.808)
foreign	0.358*	0.302*	0.401*
	(0.202)	(0.175)	(0.242)
govsubs	-0.426*	-0.537*	0.126
	(0.252)	(0.333)	(0.537)
sme	0.458	0.524	0.230
	(0.255)	(0.323)	(0.534)
Region dummy	Added		
Subsector dummy	Added		
_cons	9.671***	10.37***	9.462***
	(0.656)	(0.658)	(1.079)
N	566	362	130
adj. R-sq	0.182	0.126	0.126

Standard errors in parentheses: * p<0.1; ** p<0.05; *** p<0.001

Source: Author's analysis of ASIP data for 2016

Stage 2: Following the estimation of the determinants of innovation spending intensity, we estimate a knowledge production function, i.e., determinants of firm decision to invest in different types of innovation, but like Hall, Lotti & Mairesse (2009) and Griffin et al. (2009), we do not restrict the estimation to only firms that spend on innovation. We do this in order to account for that part of innovation activity that has not been formalised. This means that rather than using innovation spending intensity (log of innovation spending per worker) as obtained from the survey data, we use the predicted value of innovation spending intensity obtained from the estimated model in Table 11. We use multinomial logit where firm characteristics are regressed against a dummy variable for different types of innovation a firm is engaged in, if it is purely product, purely process and complex i.e. it is a mixture of both product and process innovation, or if it is none of the two. Our data do not have firms that engaged in purely product innovation and therefore our dependent variable innotyp is comprised of values 0 for firms that did not do any type of innovation; 2 for firms that made purely process innovation, and 3 for firms that made product and process innovation. We show the results of the multinomial logit estimation in Table 12. The non-innovator category (innotyp=0) is our base/omitted category.

Table 12 shows that firms of higher age are more likely to conduct complex innovations relative to not innovating. A one-year increase in firm age increases the likelihood of firm doing complex innovation relative to not innovating by 3.6%. Firm's participation in technology partnerships increases the likelihood of doing purely process innovation and complex innovation (relative to not innovating) by 5% and 8%, respectively. Firms that participate in international trade are 6% more likely to conduct process innovation relative to not doing any form of innovation than those that do not. Being a member of an association is associated with 11% more likelihood to engage in complex innovation than not being a member of association.

Firms experiencing both foreign and local competition are 7.2% more likely to engage in complex innovation than those not innovating. Receiving government subsidy is associated with 9.2% more likelihood to engage in process innovation. Although government subsidies had a negative effect on innovation spending intensity, we believe that its positive impact here is associated with a firm's decision to use the subsidy (as a substitute to private innovation spending) for making an innovation output. SMEs are associated with 4% and 7% less likelihood to engage in process or complex innovation (relative to not innovating), respectively. Similar to other studies (see Savrul & Incekara, 2015; Griffin et al., 2006; Le, 2020) the innovation spending intensity has a positive effect on the likelihood of a firm to make either process or complex innovation.

3.2.3 Effect of firm innovation on productivity

The third stage of the CDM model examines the effect of firm innovation on productivity. In this stage we estimate a simple model of firm productivity and its determinants among which we include the types of innovation undertaken by the firms. Since each of the types of innovation, i.e. product, process or both, enters the productivity model, we need to address the possible endogeneity issue. For this purpose we use the predicted probabilities for each of the innovation types variable as shown in Table 12. Since our data had no firms doing only a product innovation, we generated two predicted probabilities of innovation, one for process innovation alone and one for mixed (process and product) innovation. For convenience of interpretation we refer to the two innovations as simple (only process) or complex (both simple and product). Our dependent variable is labour productivity measured by log of value added per worker and log of sales per worker. The results are presented in Table 13.

Overall, the results show that firms' innovation outputs, whether process or complex, are positively associated with labour productivity. In particular, process innovation is positively and significantly associated with both sales per worker and value added per worker. Process innovation has significant and positive impact on labour productivity especially for LT firms. Furthermore, LT firms are much more likely to engage in process innovation than are MT/ HT firms. Indeed, compared with MT/HT firms LT firms often use less efficient and more outdated production technologies, as they have less ability to afford new or modern machines or upgrade their existing technology. Instead, they appear to focus on improvement in worker skills and working premises to increase productivity. Complex innovation is also associated with more sales per worker and value added per worker.

However, given our interest to understand the role of technology profile of firms in the estimation, we distinguished the sample into LT and MT/HT. Our expectation was that the high technology (HT) firms would be associated with complex innovation compared to the LT firms. On the contrary, the results show that the positive effect of complex innovation disappears when we distinguish the technology categories. These results are consistent with those from similar studies including Kurt and Kurt (2015) and Sithole and Buchana (2022), which confirm the positive impact of ITU on firms' growth/productivity performance.

Table 12: Multinomial Logit Regression results for Innovation Output by types

Variable	Simple Process Innovation (Type 2)		Complex Innovation (Type 3)	
	Coefficient	Marginal effect	Coefficient	Marginal effect
lage	0.0659	-0.00304	0.187***	0.0359***
	(-0.0708)		(-0.0562)	
tech1	0.643***	0.0511***	0.565***	0.0798***
	(-0.164)		(-0.134)	
trade	0.611*	0.0643*	0.289	0.0229
	(-0.257)		(-0.186)	
finacce	-0.2	-0.0253	-0.029	0.0066
	(-0.146)		(-0.111)	
association	0.243	-0.00632	0.613***	0.116***
	(-0.17)		(-0.135)	
private	0.45	0.0421	0.294	0.0343
	(-0.34)		(-0.251)	
foreign	-0.0903	0.00241	-0.229	-0.0433
	(-0.269)		(-0.203)	
compet	0.162	-0.00289	0.389**	0.0729**
	(-0.197)		(-0.143)	
govsubs	0.742**	0.0916**	0.139	-0.0176
	(-0.236)		(-0.207)	
sme	-0.557*	-0.0414*	-0.534*	-0.0788*
	(-0.276)		(-0.218)	
Predicted innovation spending intensity	0.312**	0.0272**	0.235**	0.0304**
	(-0.114)		(-0.0897)	
Sector Dummy	Added			
Region Dummy	Added			
_cons	-4.447***		-4.553***	
	(-1.297)		(-1.026)	
Number of Obs	1885		1885	

Standard errors in parentheses: * p<0.1; ** p<0.05; *** p<0.001

Source: Author's analysis of ASIP data for 2016.

Table 13: Effect of Firm innovation on labour productivity (Stage 3)

Variable	All firms	LT firms	MT and MHT firms	All firms	LT firms	MT and MHT firms
	lsale_emp	lsale_emp	lsale_emp	lvapw	lvapw	lvapw
innotyp11	0.0711	2.44**	0.843	1.193	3.341*	4.525
	(2.609)	(0.926)	(2.823)	(2.715)	(1.701)	(8.144)
innotyp22	2.348**	1.905	1.943	2.098*	-0.416	2.194
	(0.991)	(1.577)	(2.769)	(1.207)	(1.957)	(3.206)
lage	-0.270*	-0.188	-0.252	-0.0975	0.0919	0.312
	(0.111)	(0.212)	(0.313)	(0.119)	(0.230)	(0.333)
tech1	0.376	0.122*	0.0998	0.0210	-0.267	0.299
	(0.391)	(0.055)	(0.979)	(0.419)	(0.606)	(1.035)
finacce	-0.188	0.121	-0.194	-0.259*	-0.0536	-0.0700
	(0.103)	(0.149)	(0.238)	(0.103)	(0.161)	(0.252)
association	-0.333	0.117	-0.126	-0.170	0.870	0.212
	(0.280)	(0.591)	(0.858)	(0.298)	(0.638)	(0.911)
private	-0.131	-0.776	0.333	0.0893	-0.366	0.914
	(0.258)	(0.341)	(0.604)	(0.270)	(0.368)	(0.637)
foreign	0.709***	0.514*	0.635*	0.680***	0.468	0.521
	(0.147)	(0.234)	(0.310)	(0.173)	(0.253)	(0.330)
compet	-0.491*	-0.0708	-0.775	-0.265	0.412	-0.186
	(0.209)	(0.381)	(0.576)	(0.229)	(0.411)	(0.613)
govsubs	0.453	-1.036*	-0.0364	0.774**	-0.868	0.254
	(0.232)	(0.473)	(0.666)	(0.245)	(0.508)	(0.704)
sme	0.054*	0.094*	0.047	0.285	0.343	0.217
	(0.025)	(0.037)	(0.010)	(0.265)	(0.405)	(0.652)
Sector dummy	Added					
Region dummy	Added					
_cons	13.41***	11.51***	13.17***	6.924***	7.192***	6.150***
	(1.334)	(2.008)	(3.360)	(1.415)	(2.174)	(3.583)
N	1856	1137	395	1822	1125	375
adj. R-sq	0.342	0.369	0.373	0.234	0.219	0.293

Standard errors in parentheses: * p<0.1; ** p<0.05; *** p<0.001

Source: Author's analysis of ASIP data for 2016

3.3 Determinants and role of technology transfer

3.3.1 Data and analytical approach

The subject of technology transfer in the Tanzania manufacturing sector was recently examined in a study by an IFPRI team (McMillan, Kweka & Ellis, 2019) that aimed at analysing the mechanisms for technology and knowledge transfer. The study was based on the technology transfer survey conducted in 2017 as an additional module for the 2016 ASIP data. The survey elicited information on the mechanisms by which technology or knowledge is transferred and the benefits obtained from such transfer, among other things. The aim was to explore the linkages and mechanisms of knowledge transfer between domestically owned and foreign firms in the Tanzania manufacturing sector with a particular focus on the Chinese FDI and to understand the benefits of these relationships. Owing to the fact that our empirical component is based on the same dataset, there is no need to redo the analysis but rather to complement it with some fresh estimations to fit the context of the current study.

It is important that we describe the analytical framework used in the IFPRI team's study to enhance articulation of the results. To identify the characteristics of firms that are more likely to experience and benefit from technology transfer originating from FDIs, the IFPRI team constructed five dummy variables (dependent variables). The first dummy variable had values equal to 1 if the firm reported receiving any benefit (production technologies, managerial practices, organisational structure, or knowledge of exporting as a result of their labour or customer-related transfers from foreign firms, or transfers from local foreign-owned firms) from technology transfer, and 0 if the firm had not received any such benefit. The rest of the four dummy variables represent each benefit in the manner that we have one dummy variable for each of the benefits (production technologies, managerial practices, organisational structure, and knowledge of exporting as a result of their labour or customer-related transfers from foreign firms or transfers from local foreign-owned firms) with the value equal to 1 if a firm had received a particular benefit and 0 if it had not.

Each of the constructed dummy variables was regressed on a set of entrepreneur and firm characteristics, using the following linear probability model (Equation 5)

$$y_{ig}=\beta_{ig}+(\gamma_{ig}(male)+\delta_{ig}\,(experience)+\alpha)_{ig}\,(export)+\sigma_{ig}\,(park)+\phi_{ig}\,(location)+\omega_{ig}\,(emp)+\mu_{ig}\,(sector)+\theta_{g}\,(region)+\varepsilon_{ig} \quad \text{.....................} (5)$$

where γ_{ig} is a dummy variable equal to one 1 if the firm i in region g obtained a benefit from the knowledge transfer from a foreign firm. γ_{ig} estimates the coefficient for the firm having only male owner(s) and δ_{ig} estimates the coefficient for the firm owner having prior experience in an FDI firm. α_{ig} estimates the coefficient for the firm exporting production, σ_{ig} estimates the coefficient for the firm being in an industrial park, φ_{ig} estimates the coefficient for whether the location is rural, urban, or peri-urban, ω_{ig} estimates the coefficient for the firm's employment size, and μ_{ig} and estimates the coefficient for the firm's sector. θ_{g} controls for regional effects and ε_{ig} is the error term.

In presenting the results, we firstly report the summary statistics to show the nature of technology transfer among manufacturing firms, followed by identification of the drivers of technology transfer (mainly the familiar firm and owner characteristics), and. Llastly, we present the results of our own fresh analysis to understand the outcome of technology transfer by assessing whether the firms benefiting from (or identified with) technology transfer are also associated with higher levels of productivity compared to those that are not benefiting from technology transfer, (since this was not one of their objectives of the IFPRI team).

Some of the basic descriptive statistics were presented in the situational analysis in section 2, so we do not reproduce them in this section. Rather we focus on reporting the statistics showing the incidence of the benefit from technology and knowledge transfer (Table 14). The results show that out of the 463 firms that reported to have experienced some type of technology transfer, only 222 reported obtaining at least one type of benefit from the technology transfer. As shown in Table 13, out of these firms, for 54% the benefits were related to production technologies, for 21% they related to managerial practices, for 13% they related to knowledge on how to export, and for 8% they related to organisational structure.

Table 14: Benefits of knowledge transfer

	Labor-related transfer		Customer-related transfer		Transfer from local foreign firms		At least one type of transfer	
	# of firms	% of firms	# of firms	% of firms	# of firms	% of firms	# of firms	% of firms
Production technologies	51	58%	25	51%	55	57%	120	54%
Managerial practices	17	19%	15	31%	18	19%	47	21%
Organizational structure	6	7%	2	4%	9	9%	17	8%
Knowledge of how to export	11	13%	3	6%	13	13%	29	13%
Others	3	3%	4	8%	2	2%	9	4%
Total	88	100%	49	100%	97	100%	222	100%

Source: McMillan, M., et al. (2019) based on Computed from the Technology Transfer Module of ASIP (2016).

In addition, the identified benefits of technology transfer were disaggregated based on the type of technology transfer experienced by a firm, i.e. benefits arising from hiring labour that was previously employed by foreign firms; benefits arising from their most important customer responsible for knowledge transfers; and benefits gained from foreign firms operating in the same local area. The technology transfer benefits were obtained mainly through having foreign firms located in the same area, which was the case for 97 firms, labour transfers, which was reported by 88 of the firms, and customer-related transfers, which was the case for 49 firms.

Generally, the types of benefits attained through labour and locality-related transfers were quite similar, whereas customer-related transfers were more distinct. Table 14 shows that production technology benefits were the most common across all the three types of transfers. Benefits on managerial practices were more commonly transferred through customer-related actions, which was reported by 31% of the firms, than through either labour- or locality-related transfers, which were reported by 19% of the firms each. Customer-related transfers were less likely to result in organisational structure benefits (4%) than were labour-related transfers (7%) or locality-related transfers (9%). The same is true for benefits on knowledge of how to export where just 6% of customer-related transfers led to this type of benefit compared with 13% for labour-related transfers and 13% for locality-related transfers.

3.3.2 Drivers of technology transfer

The technology transfer survey report identified the types of firms that were more likely to benefit from experiencing technology transfer from FDI. This was done by regressing the benefits received from technology transfer, i.e. production technologies, managerial practices, organisational structure, or knowledge of how to export, against a set of firm characteristics including gender of the owner (whether male or female); whether the owner had experience working in an FDI firm; whether the firm exported or not; whether the firm was located in an industrial park; location of the firm, whether rural, urban or peri-urban; and employment size of the firm and sector of the firm.

The results of this regression are provided in Table 15. They show that firms with male owners are 2.2% more likely to benefit on managerial practices. However, gender is not significantly associated with any other type of benefit. Prior experience of the firm owner in an FDI firm has no significant relationship with any of the benefits of knowledge transfer. Exporting firms are either 12.2% more likely to receive benefits related to managerial practices or 17.2% more likely to receive any of the benefits. Firms located in an industrial park do not have a statistically significant relationship with any type of benefit, while those located in an urban area are 3% more likely to receive managerial practice benefits than those in rural areas.

Table 15 also shows that firm size is related to the benefits a firm receives through production technology and any benefit transfers. In particular, bigger firms are likely to experience benefits to production technologies or any benefit compared to small firms. There is, however, no relationship between size and the likelihood of experiencing improvements in managerial practices. Firms with 100–499 employees are 2% less likely to obtain benefits for organisational structure than firms with 10–19 employees. This may be because such large firms already have a well-organised firm structure. Firms with 500 or more employees are less likely to receive benefits related to knowledge on exporting than firms with 10–19 employees. The fact 63% of the firms with 500 or more employees were exporters compared with only 2% of the firms with 10–19 employees indicates that the majority of the large firms already had exporting knowledge, which was not the case for small firms.

3.3.3 Effect of technology transfer on firm productivity

To assess the impact of technology transfer on firm productivity we added a technology transfer variable to the productivity model estimated in Table 15. Our technology transfer variable (techtransfer) is binary with values 1 if a firm experienced technology transfer from an FDI supplier or customer or both and 0 if it did not. The results are presented in Table 16, which shows that firms that experience technology transfer have 15.3% higher value added per worker than those that do not. The effect of technology transfer is also significant for LT firms, which have 24.6% higher value added per worker from technology transfer than those do not experience technology transfer. The effect of technology transfer on value added per worker is insignificant for MT and HT firms. This shows that technology transfer is relatively more beneficial to LT firms, as generally they use old production techniques. Among the firms experiencing technology transfer, production technology was the most common benefit, which partly explains why technology transfer variable is significant and positively associated with value added per worker. The effect of technology transfer on sales per worker was insignificant across all firms regardless of the technology profile.

Table 15: Firm characteristic determinants of technology transfer

Variables	Any benefit	Production technologies	Managerial practices	Organisational structure	Knowledge of exporting
Firm owner(s) male	0.00137	-0.0361	0.0219*	0.00788	0.000489
	(0.0271)	(0.0243)	(0.0127)	(0.00797)	(0.00759)
Prior experience in FDI firm	0.0699	0.00834	0.0161	0.00915	0.00538
	(0.0445)	(0.0339)	(0.0247)	(0.0158)	(0.0183)
Firm exports production	0.172**	0.00270	0.122**	0.00969	0.0616
	(0.0733)	(0.0564)	(0.0487)	(0.0155)	(0.0400)
Firm is in industrial park	0.0117	0.0229	-0.00765	-0.00942	-0.00511
	(0.0225)	(0.0186)	(0.0115)	(0.00683)	(0.00888)
Location type -					
Urban	0.0122	0.00234	0.0303***	-0.0110	0.00824
	(0.0327)	(0.0253)	(0.0116)	(0.0109)	(0.0152)

Peri-urban	0.00126	0.0136	0.0136	-0.0132	-0.00496
	(0.0341)	(0.0268)	(0.0151)	(0.0111)	(0.0147)
Size (number of employees)					
20-49 employees	0.0506*	0.0394*	0.0199	0.00559	0.00974
	(0.0277)	(0.0223)	(0.0146)	(0.0107)	(0.0120)
50-99 employees	0.113**	0.0882**	0.0185	0.0172	-0.00289
	(0.0519)	(0.0431)	(0.0294)	(0.0178)	(0.0219)
100-499 employees	0.216***	0.205***	0.0308	-0.0199**	-0.0241
	(0.0615)	(0.0563)	(0.0344)	(0.00928)	(0.0213)
500+ employees	0.260*	0.345***	-0.0391	-0.0189	-0.0492*
	(0.136)	(0.132)	(0.0657)	(0.0136)	(0.0294)
Sectors					
Beverage & tobacco	0.0212	0.0384	0.00930	0.0159	0.00700
	(0.0683)	(0.0598)	(0.0384)	(0.0270)	(0.0276)
Textiles	-0.0633	-0.0145	-0.00734	-0.0103	-0.0272**
	(0.0652)	(0.0565)	(0.0370)	(0.00698)	(0.0111)
Apparel, leather and foot-wear	0.0542	0.0534	0.0456	0.0175	-0.0276**
	(0.0880)	(0.0730)	(0.0568)	(0.0332)	(0.0116)
Wood products	-0.0780**	-0.0467*	-0.0268**	-0.0105	-0.000870
	(0.0344)	(0.0277)	(0.0118)	(0.00842)	(0.0185)
Paper & products	0.160**	0.108*	0.0285	0.0555	0.00511
	(0.0717)	(0.0619)	(0.0377)	(0.0380)	(0.0223)
Chemical products	0.0256	0.0660	-0.0179	0.000509	-0.0216**
	(0.0704)	(0.0665)	(0.0285)	(0.00584)	(0.00902)
Glass & cement products	0.0198	0.0333	0.0139	-0.0102	-0.0267***
	(0.0332)	(0.0275)	(0.0201)	(0.00662)	(0.00803)
Iron, steel, & other metal products	0.0941*	0.0962**	-0.0504***	0.0127	0.0246
	(0.0499)	(0.0417)	(0.0142)	(0.0173)	(0.0251)
Machinery	0.133*	0.0668	-0.00614	0.0859	0.0155
	(0.0809)	(0.0686)	(0.0345)	(0.0525)	(0.0360)
Other manufacturing	-0.0358	-0.0302	-0.00883	-0.0128	-0.0245**
	(0.0606)	(0.0396)	(0.0354)	(0.00802)	(0.0115)
Repair	-0.124***	-0.0863**	-0.0281	-0.00808	-0.0196*
	(0.0358)	(0.0340)	(0.0189)	(0.0140)	(0.0116)
Constant	0.150**	0.160**	-0.0451***	0.0320	0.0280
	(0.0727)	(0.0688)	(0.0160)	(0.0279)	(0.0294)
R-squared	0.144	0.116	0.113	0.058	0.038

Robust SEs in parentheses. *** p<0.01, ** p<0.05, * p<0.1

Source: Technology Transfer Survey (2016).

Table 16: Effect of technology transfer on firm productivity

Variable	All firms	LT firms	MT and MHT firms	All firms	LT firms	LMT and MHT firms
	lsale_emp	lsale_emp	lsale_emp	lvapw	lvapw	lvapw
Process Inno	2.814	3.97**	0.0239	0.358	3.66**	-1.610
	(1.510)	(1.539)	(2.704)	(1.577)	(1.075)	(2.959)
Complex Inno	1.74***	4.396	2.030	4.38***	0.195	1.465
	(1.357)	(3.160)	(3.692)	(1.432)	(3.388)	(3.958)
techtransfer	0.0983	0.181	-0.0375	0.153**	0.246*	0.0459
	(0.0787)	(0.100)	(0.162)	(0.0444)	(0.108)	(0.177)
lage	-0.435	-0.303*	-0.298	-0.342	-0.198	0.0612
	(0.2671)	(0.145)	(0.176)	(0.1708)	(0.155)	(0.189)
tech1	0.082***	0.036***	-0.0429	0.08***	0.06**	-0.0301
	(0.0209)	(0.003)	(0.0775)	(0.0218)	(0.0093)	(0.0401)
finacce	-0.135	0.102	-0.249	-0.160	-0.0540	-0.0834
	(0.0905)	(0.146)	(0.218)	(0.0966)	(0.157)	(0.235)
association	-0.202	-0.210	-0.122	-0.135	0.0678	-0.340
	(0.183)	(0.459)	(0.565)	(0.194)	(0.492)	(0.604)
private	0.384*	0.0796**	0.373	-0.279	-0.727	0.728
	(0.195)	(0.0253)	(0.385)	(0.207)	(0.671)	(0.412)
foreign	0.579**	0.592**	0.340	0.40***	0.633**	0.673*
	(0.234)	(0.228)	(0.294)	(0.145)	(0.244)	(0.318)
compet	-0.760***	-0.272	-0.812*	-0.69***	-0.117	-0.641
	(0.141)	(0.284)	(0.381)	(0.150)	(0.303)	(0.410)
govsubs	0.362	-0.897	-0.0272	0.504*	-0.775	0.147
	(0.185)	(0.472)	(0.622)	(0.197)	(0.503)	(0.671)
sme	0.234*	0.030	0.347	0.068*	0.172	0.00400
	(0.124)	(0.267)	(0.329)	(0.0399)	(0.287)	(0.0358)
Sector dummy	Added					
Region dummy	Added					
_cons	13.93***	10.40***	13.45***	6.52***	4.09***	4.464**
	(0.708)	(1.129)	(1.433)	(0.741)	(1.209)	(1.541)
N	1856	1137	395	1822	1125	375
adj. R-sq	0.352	0.361	0.379	0.244	0.239	0.29

Standard errors in parentheses: * p<0.1; ** p<0.05; *** p<0.001

Source: Author's analysis of ASIP data for2016

4. CASE STUDY OF FIRMS' EXPERIENCE

4.1 Approach and Methodology

This section provides a case study of firms' experience in ITU in Tanzania based on interviews covering 28 manufacturing firms of different sizes and from different sectors. The section complements the preceding parts of the study by identifying successful cases where ITU has led to dramatic change in productivity or competitiveness and examines the key drivers, including the role of policies. The analysis is an important step in showing how manufacturing firms can leverage ITU to enhance competitiveness and in identifying key success factors, challenges and prospects facing the firms. Such information is not available in the ASIP database. Below we outline the approach and methodology for the case study, including how we selected the 28 firms, plus the analyses of the responses.

A key challenge was how to identify the firms for the sample in a logical and consistent way to avoid selection bias as well as obtain the appropriate firms with useful experiences. One approach was to seek information on firms within the manufacturing sector that had undergone significant innovation or technology upgrading to include in our sample. This approach was not successful since such developments are not necessarily public information. We also developed a framework for selecting a few representative firms from which we created a benchmark for determining the intensity and performance on ITU. The framework is described in the following three-step process.

In the first step, we interrogated the ASIP data for 2016 to identify the important sectors that had performed well across several innovation and technology indicators. Then we ranked and identified the top 10 sectors that had performed well across several technology and innovation indicators. These indicators included (i) share of firms doing production and technology R&D in the total number of firms(%); (ii) share of export in total production (%); (iii) technology and innovation service expenditure (% of total expenditure); (iv) share of R&D spending in the total sales, and (v) firms holding a patent in a particular sector). In particular, we ranked sector i's performance in each indicator then we calculated the average ranking for sector i across all indicators. The results are shown in Table 17.

In the second step we categorised the sectors where the industrial manufacturing firms operated according to their technological intensity, i.e. if they were high, medium, or low in technology using the UNIDO framework as shown earlier in Table 6. In the third step, we identified a few firms that were representative of the respective sectors that the case studies were drawn from. Since the ASIP dataset does not disclose the name of a firm, we had to resort to arbitrary selection of familiar firms in those sectors. For the convenience of the reader we have combined the list of ranked sectors and the respective firms selected from them in Table 17. In addition to the firms identified through the UNIDO framework, we also relied on our informed knowledge on the firms that were likely to fall in a particular technology category.

Subsequently we conducted key informant interviews in the selected firms. The interviews took place through face-to-face meetings with the chief executive officers or managing directors, as well as specific functional managers, and preferably the production manager (the questionnaire is available on request). The list of the firms interviewed is shown in Annex C. In terms of the analysis, we examined the firms' experience in ITU by identifying common and/or unique characteristic features, including the description, drivers and impact of the ITU undertaken, the process of technology transfer and the challenges encountered. To do this, we outlined in Table 18 the ITU experience of each interviewed firm in order to compare and contrast such experiences and identify the common or unique issues or factors. In addition, we selected some illustrative cases of successful leveraging of ITU, where such investment in ITU led to a positive dramatic impact in sales, productivity or competitiveness. Overall, the experiences from the selected firms provided useful lessons that could inform our list of policy recommendations.

Table 17: Top 10 performing sectors across several technology and innovation

Ranking	Sector	Firms in ASIP 2016	Technology classification	Sampled Firms	Location
1	Computers, electronics, and optical products	3	Medium-high and high technology	Morogoro Wire Rolling Ltd	Morogoro
				Baobab Energy Systems Tanzania Ltd	Dar es Salaam
				BAFREDO Electronics	Dar es Salaam
2	Leather and related products	28	Low technology	Moshi Leather Industries Ltd	Moshi
				East-Hides Morogoro	Morogoro
				Woiso Original Products	Dar es Salaam
				Shah Industries	Moshi
3	Basic metals	48	Medium technology	East Africa Cables Ltd	Dar es Salaam
				M. M. Integrated Steel Mills	Dar es Salaam
				Nampak Tanzania Ltd.	Dar es Salaam
4	Pharmaceuticals	6	Medium-high and high technology	Zenufa Pharmaceuticals	Dar es Salaam

				Shely's Pharmaceuticals Ltd.	Dar es Salaam
				Tanga Pharmaceutical and Plastics Ltd	Tanga
5	Machinery and equipment	14	Medium-high and high technology	Tanalec Ltd	Arusha
				Hans Agriculture Machinery Ltd	Dar es Salaam
				META Plant and Equipment Tanzania	Dar es Salaam
				Imara Tech	Arusha
6	Beverages	67	Low technology	Tanzania Breweries Ltd	Dar es Salaam
				Kilimanjaro water (Bonite Bottlers Ltd)	Moshi
				Hill Packaging Limited	Dar es Salaam
				Sayona Drinks ltd	Dar es Salaam
7	Rubber and plastics products	58	Medium technology	Pan Africa Enterprise Ltd	Dar es Salaam
				Silafrica Tanzania Ltd	Dar es Salaam
				Morogoro Plastics Ltd	Morogoro
				Metro Plastic Industries	Dar es Salaam
8	Other manufacture (except medical and dental instruments)	45	Medium technology	Banjul Ltd	Dar es Salaam
				Tembea Tanzania	Dar es Salaam
				Cubic Business Solution	Dar es Salaam
				The Tanzanite Experience	Arusha
9	Wood and wood products	116	Low technology	Keko Modern Furniture	Dar es Salaam
				Temic Co. Ltd	Dar es Salaam
				Homes Desire	Dar es Salaam
10	Textile and apparel	42	Low technology	Tanzania Tooku Garments Ltd	Dar es Salaam
				21st Century Textile	Morogoro
				OpenSanit Ltd	Dar es Salaam
Added firm based on prior knowledge	Other non-metallic and mineral products		Medium technology	Tanga Cement Ltd	Tanga
				Twiga Cement	Dar es Salaam

Source: Author's calculations using ASIP data for 2016

Table 18: ITU and its impact on the firm's competitiveness

Company name	Sector/activity	ITU description and rationale	Impact
1. Hans Agriculture Machinery Ltd	Agricultural machinery and implements	From technology transfer through importing to manufacturing of low cost farm implements	Expanded to a market that was previously out of reach
2. Meta Plant & Machinery Tanzania Ltd	Machinery and equipment	Learning from foreign engineers facilitated technology transfer that turned Meta from being a mere import agent to a manufacturer of similar products	ITU helped Meta to establish itself in Tanzania and win the market in East Africa
3. Watercom Ltd	Bottled drinking water: Afya brand	Unique bottle design and quality improvements as strategy for market penetration	Successfully established as an important supplier of bottled water in Tanzania
4. Imara Technology Company Ltd	Machinery and equipment	Linkage with innovation accelerator (Twende Hub) led to a successful development of a multi-crop threshing machine with dramatic growth in productivity of (particularly) smallholder famers	Increased production capacity to 20 multi-threshing machines per week and secured a bigger workshop space
5. Anjari Soda Factory Ltd	Soft drinks and bottled water (Anjari brand)	The desire to increase efficiency and productivity in production pushed investment in modern and automated technology in a soft drink industry	Significant improvement and efficiency in the production process, and increased productivity
6. BAFREDO Electronics Ltd	Design and fabrication of electronic circuits/systems	Leveraging the University Innovation Centre and entrepreneurship to promote ITU in electronics industry	Production volume increased by 35%, including the number of products, the latest being SIM 800C communication module. Increased efficiency and customers.
7. Baobab Energy Systems Tanzania Ltd	Production of electricity meters	Strong clientele and partnership with a foreign, globally reputable company facilitated ITU in the supply and production of electricity meters	Production increased from 300,000 to 500,000 meters per year, hence increased productivity, efficiency and sales revenue
8. Silafrica Tanzania Ltd	Multi-plastic products, e.g. storage tanks. SIM Tanks brand	Massive investments in technology to respond to market needs coupled with good leadership to support the company's multi-product diversification thrive	Increased sales as the company became a major supplier of vending, distribution and brand promotion equipment for Coca cola
9. 21st Century Textile Ltd	Manufacture of textile and garments	Coupled with financial ability of the private investor, the ITU facilitated diversification of the products of a once state-owned enterprise into a vibrant textile firm with increased productivity, sales and, hence, profit	Diversification into knit fabrics such as t-shirts, vests, underwear etc. Increase in production from 16 M to 60 M meters per annum, and increased productivity from 1,000 to 4,000 pcs per person
10.Twiga Cement PLC	Manufacture of cement: Twiga Cement brand	To remain competitive in the market, the company combined investment in distribution (chain supply) and quality, which bolstered sales and profit performance	Increased production by 66% from 1.2 Mta of cement to 2 Mta. Pre-tax profit rose by 25% cent from TZS 85.87bn (US$ 37.0 million) in 2019 to TZS 107.42bn (US$ 46.3 million) in 2020 following increased turnover.

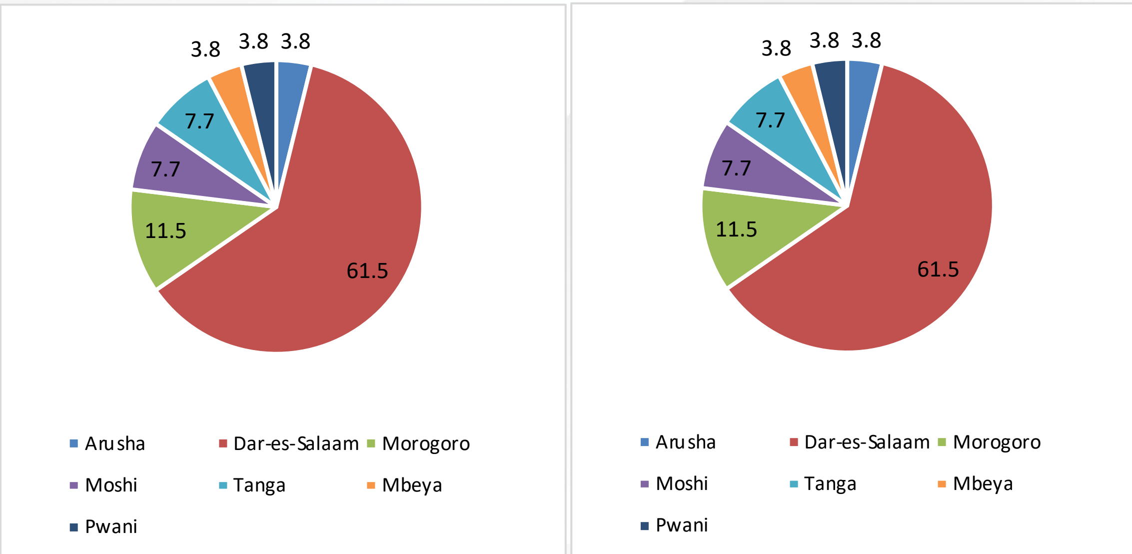
Company name	Sector/activity	ITU description and rationale	Impact
11. Laylow Ltd	Garment making	Interactions with other garment making SMEs facilitated acquisition of modern and automated machinery that is more efficient	Improved quality and speed of the finishing phase and reduced time taken to supply customer order from 2 weeks to 9 days
12. Tanzania Tooku Garments Company Ltd	Garment making; Wrangler Jeans brand	Massive investment in modern industrial production technology where it acquired automatic pocket setter machines and shifted from the traditional one; and training that bolstered quality and productivity	Increased productivity (output per hour) from 1,800 pieces of garments per hour to 2,300 pieces and bolstered quality and competitiveness in the export market
13. OpenSanit Company Ltd	Making uniforms, tents and supply of safety gear, e.g. personal protective equipment	Harnessing opportunity to supply market needs for protective gear and alternative packaging materials (due to the ban on plastic bags) that necessitated ITU by interacting with other firms, conducting R&D and training	Helped the company to further diversify her revenue stream while ultimately increasing total revenues
14. Hill Packaging Ltd	Bottled drinking water; Hill Water brand	Unique bottle design to provide palm fit and winsome experiences in addition to natural taste and strong branding enabled the firm to conquer the market	Increased markets, production and sales. The number of employees jumped from 150 to 200 (33%) with increased productivity
15. Tanga Cement PLC	Manufacture of cement: Tanga Cement brand	Investment in superior technology introduced new product that caters for multiple customer needs. The company invested in a system that will ensure smooth operation even when there is power interruption	Investment in ITU would lead to increased clinker capacity from 0.5 Mta to 1.25 Mta, and improved operational efficiency
16. Homes Desire	Furniture making and interior design	Homes Desire created an online system to help customers place their order from anywhere they are. The system also provides information on price, initial instalment and how to make the payment	The system reduced transaction costs for customers and attracted more customers, hence a bigger market

Source: Author analysis of case study data.

4.2 Profile of the firms interviewed

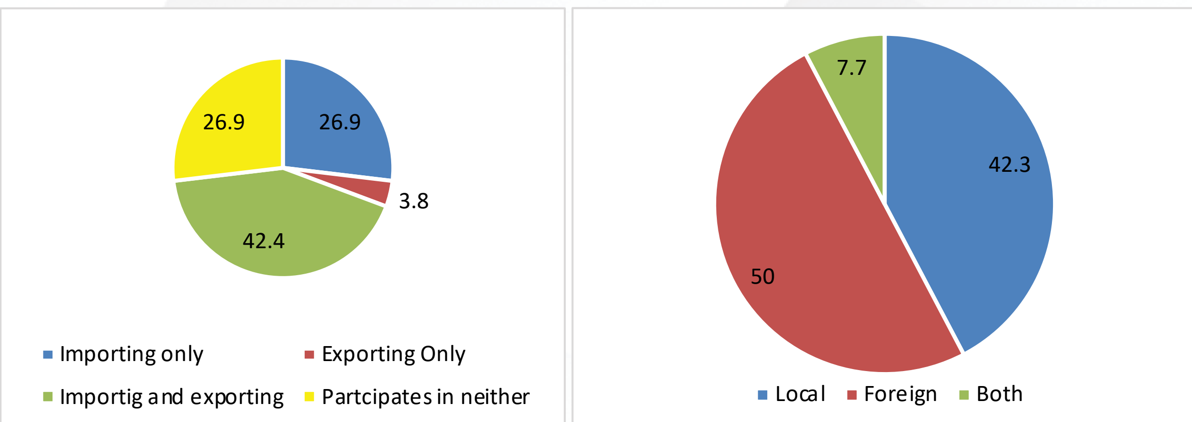
Forty firms were identified for the case study survey but the firms that accepted to interview were 28, generating a 70% response rate. Figure 12 provides the distribution of the firms by sector and location. Except for a few firms in Tanga, Moshi, Coast and Arusha, the firms were located in Dar es Salaam and mainly operating in rubber and plastics, textile, food, technology and machinery sectors. Some 73.1%, of the firms participated in international trade, among which 36.8% engaged in import trade, 5.3% in export trade and 57.9% in both import and export trade (Figure 13). In terms of ownership, 42.3% of the firms were owned by a local investor, 50% by a foreign investor and 7.7% by local and foreign investors.

Figure 12: Firm distribution by location and sector (%)



Source: Author analysis of survey data (2022)

Figure 13: Firm distribution by trade participation and nature of ownership (%)



Source: Author analysis of survey data (2022)

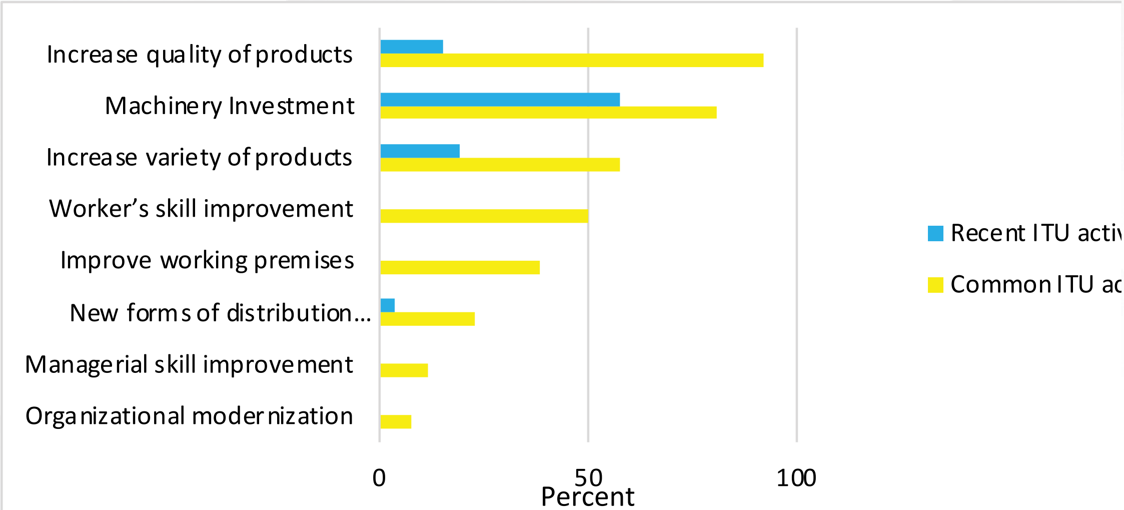
4.3 Firms' ITU experience: practices, impact and challenges

4.3.1 Description of ITU practices

Generally, manufacturing firms engage in various types of ITU, the most common of which include investment in machinery, increasing the variety of products and improvement of workers' skills (Figure 14). What does matter the most is not the type but the motivation and the process of implementing a particular ITU. In this case study, the majority of firms revealed that they usually engaged in ITU to increase the quality of their products (92.3%) so that they could maintain or improve their competitive position in the market. To get a good understanding of the need and anticipated change due to ITU, we asked the firms to identify one recent and significant ITU they had conducted. Some 57.7% of the firms chose to focus on machinery investment, 19.2% on their increase in the variety of products, 15.4% on product quality improvement and 3.8% on new forms of distribution and marketing channels.

Therefore, in addition to machinery investment, the ITU initiatives mentioned by the firms included process improvements such as the adoption of a more modern online marketing system, product quality improvement process, innovative retail vending, and distribution and brand promotion. The motivations for such processes included the need to attract more customers and the goals of helping customers to easily place their orders, improving productivity and reducing the adverse environmental impacts.

Figure 14: Types of ITU activities of sampled firms



Source: Author's analysis of survey data (2022)

As an example, Laylow Ltd started the process of buying new embroidery and button sewing machines once it was able to afford them, i.e., there had been no plan to buy the machines at that point. OpenSanit Company's process of becoming a paper bag supplier came after of an increased demand for paper bags was created by the government's decision to ban plastic bags in 2019. In some unique cases, ITU process can begin at the time the company is established. While this points to some flexibility in the process, which is a positive trait, it is generally agreeable that the process will benefit more from prior planning and having a predetermined process and guidance.

In some cases, the ITU process can stall for some time, mostly because of the missing of some requirements such as unavailability of experts or funds. For instance, Homes Desire faced delays when creating its online system for collecting customer orders owing to a lack of funds to pay the system development expert. Generally, all these characteristics point to the ad hoc nature of ITU activities among firms in developing countries, a feature well known in the literature (see Kleinknecht, Van Montfort & Brouwer, 2002; Hall et al., 2009). However, the integration of ITU in the business strategies of three firms demonstrates that ITU is indeed an important element in their respective market penetration strategy, and this helped them to successfully build a sustainable business in Tanzania.

> *"To penetrate the Tanzania market, we designed bottled water that compared to others but had more volume per bottle, had improved pH scale and had better bottle design. This was an essential element of our market penetration strategy."*
>
> Watercom respondent

Generally, the process begins with the emergence of an existing opportunity or a challenge that motivates firms to conduct the ITU, for which the respective firm conducts research to find out how it can penetrate the market before investing in the ITU. In the case of Hans Agriculture Machinery, leveraging the demand for imported machinery became a motivation to invest in ITU to help create an improved import substitute to match the local conditions.

Although knowing the existing challenges and opportunities is necessary, the sufficient condition for carrying out an ITU is identification, including through research, of how the ITU can become a solution. Essentially this is how a firm identifies a new product, say by improving an existing one or introducing a new one. For instance, after plastic bags were banned in Tanzania, OpenSanit identified paper bags as a new line of business that would bring revenues. To help farmers afford agriculture machines, Hans Agriculture Machinery came up with the idea of replacing the fuel consuming motor of a machine with a manual lever that could be operated by hands or feet.

The firms' experiences show that for the ITU to be successful there is a need for a firm to make adequate preparations for the investment in it. Such preparations vary from case to case. An example of the preparation activities needed is identification of the requirements to design the new product or improve the quality of the old product and their sources, taking into account the required finance, expertise, markets or equipment. For instance, Laylow Ltd had to determine where to obtain the button sewing and embroidery machines it needed and at an affordable price before going to buy the machines. OpenSanit had to find an off-taker market, buy necessary machines, create space for the machines and identify experts to train workers on how to produce paper bags before starting their production. Moshi Leather Industries had to train its workers on using their new auto-spray machine. Once all the preparations are set, the new product can be created, the new machines bought installed or new system developed.

Testing and quality standards assurance are critical ahead of rolling out the process or the product in the market. The complexity and scale of testing depend on the nature of the ITU. For instance, food products or beverages require laboratory testing. Watercom Ltd used their laboratories to test their bottled water. Although Hill Packaging Ltd does not have an R&D department, its product quality is enhanced by integrating laboratory and marketing departments. The critical role of a laboratory facility is also evident in other sectors. For instance, in the cement industry, one key factor in the successful ITU by Twiga Cement was that the product quality was controlled stringently by harnessing the function of an in-house, modern, well-equipped laboratory. Zenufa Pharmaceuticals, a pharmaceutical manufacturer, invested heavily in laboratories to test its new medicine products.

Other testing for quality assurance occurs as a result of customer feedback, which underlies the role of monitoring, evaluation and learning (MEL) in the ITU process. MEL based on customer feedback is a very important aspect in reassuring firms that the ITU has the required standards and can reliably help penetration of the market. However, some firms, especially small ones, do not conduct testing because they lack the laboratory and other requirements needed.

Investment in ITU is expected to bring benefits to the firm, including improved productivity and increased revenue or even by improving environmental protection, such as was the case of Moshi Leather Industries, which used new water treatment machine to reduce water pollution. But although some cases show that MEL and customer feedback play an important role in making an ITU successful, not all firms use them. In particular, only a few firms monitor their ITU by collecting customer feedback or observing certain key performance indicators such as sales, lead time, productivity etc. More generally, none of the interviewed firms conducts a technical evaluation to gauge the impact of the investment in ITUs. That is why most firms found it difficult to provide quantitative figures to account for the impact of their ITUs.

4.3.2 Impact on firms' performance

The firms were asked about the impact of the investment in ITU. The question required quantitative responses such as the percentage increase in production, sales, productivity or quality outcomes. However, most firms declined to provide such numbers, giving details of qualitative impacts instead. This might be a reflection of the lack of evaluations to attribute certain output to the ITU activities. But also it might be related to the general unease of firms to provide information that has commercial implications. The few respondents who provided quantitative figures of the impact, gave mostly estimates. Generally, the impacts of ITU revolve around expanded markets for products, new or improved skills and productivity, improved product quality or environmental protection.

Penetration and expansion of the market and increased sales: The new innovations helped firms to capture more markets including for exports. For instance, the multi-crop threshing machine created by Imara Technology Company has attracted buyers from Rwanda and Zambia. The innovative retail vending, distribution and brand promotion equipment produced by Silafrica has helped the company attain more revenues and a permanent customer in Coca Cola. For Watercom Ltd, the new bottled water product helped the firm penetrate the local Tanzanian market and to some extent smoothly establish itself in Tanzania. According to Zenufa Pharmaceuticals, the production of its new drug could increase its total sales by 4% to 10%.

Increased firm productivity: This was more relevant for firms that added new machines in their factories. The productivity improvement came in the form of an increase in output per unit time, a reduction in the average lead time and an increase in output per worker. For instance, the new machines bought by Tanzania Tooku Garments Ltd increased the firm's productivity output from 1,800 pieces of garments per hour to 2,300 pieces. The embroidery and button sewing machines introduced by Laylow Ltd helped reduce the average lead time from 14 to 9 days because they increased the speed of button and pattern sewing on cloth. The new machines bought by 21st Century Textile helped to increase production of fabric from 16 million meters per annum to 60 million meters, and fabric production per worker from 1,000 meters to 4,000 meters. Some firms revealed that the installation of new machines helped them reduce interruptions during operations, which has led to enhanced productivity.

Enhanced technical skills and experience of employees: Firms' investment in ITU has helped employees acquire new skills to be able to operate new machines or produce new products. For instance, OpenSanit Company's production of paper bags required the firm to train its workers most of whom did not know how to produce paper bags. Malebu Company's employees acquired new skills as they produced new furniture designs. Employees of Moshi Leather Industries acquired knowledge and skills on how to operate the newly installed auto-spraying machine from the training they received from the firm. Employees of Laylow Ltd and Tanzania Tooku Garments gained new knowledge on how to operate their newly installed machines through training.

Improved quality of output: This was more evident for firms that bought new machines. For instance, Laylow Ltd used to have buttons and patterns on garments sewn by hand, which was not good for quality. The purchase of a button sewing and embroidery machine helped to improve the quality of this work. For Moshi Leather Industries, the newly installed auto-spraying machine helped to improve the quality of produced leather. The new machines bought by Apex Resources contributed to the improved quality of smelted gold. Simba Lime Factory bought a new milling machine to enhance the quality of the produced lime.

Reduced environmental pollution and improved working conditions: The negative environmental impacts caused by production activities have led to calls for the use of environmentally friendly technologies in production (see Eichhammer & Walz, 2014). This case study found examples of firms that had bought new machines to reduce environmental pollution, the most notable of which was Moshi Leather Industries, which bought a water treatment machine. The firms that acquired new machines to protect employees from pollutants inside the factory included Simba Lime Factory, which acquired a dust blower system to protect its workers from air pollution.

4.3.3 Experience on technology transfer

Knowledge transfer is a critical element of firms' growth strategy. It helps firms to acquire skills, technology, and tacit knowledge related to production, including the management and organisational practices that can contribute to productivity growth (Munyai, Nyakala & Mbohwa, 2017). The Government of Tanzania, through FYDP III, has planned to allocate a bigger budget to research, innovation and technology transfer to be used to finance mass training for the development of rare and specialised skills for industrialisation and human development, for example for artisans, technicians and professionals (see URT 2021). The survey sought from the selected firms information on the nature of their technology or knowledge transfer activities and how helpful they had been. Generally, it was that knowledge transfer that was a central element in the ITU processes and activities, as it enabled the firms to successfully take advantage of the technology. In other instances, we observed that knowledge transfer could be an important driver in enhancing the skills of employees in a factory and thus contribute to ITU.

Nature and channels of knowledge transfer by firms: Generally, the knowledge transferred between or to the firms interviewed included technical know-how on producing quality products, good factory practices and managerial and organisational information, for example training on forward thinking and strategic planning, problem solving, decision-making, time management etc. Based on the survey responses, firms used three main channels to share or acquire knowledge:

- **Training: Training was on or off the job.** On the job training was more relevant when it involved providing technical skills to employees, while off the job training was used to impart organisational and management skills. Most small firms used on the job training to enhance the technical skills of their employees because this method did not require much funding. Large firms such as Tanzania Tooku Garments used both on the job and off the job training to deliver technical and organisational and managerial skills to their employees. Such firms have enough capital to finance training, which SMEs do not.

Where there was inadequate funding, firm owners asked their friends working in other firms to help conduct the training, especially for practical knowledge on the operation of newly acquired machines or technology, e.g. this happed at Laylow Ltd.

- **Interactions with other firms:** Some firms received knowledge from other firms through interactions and imitation. For instance, Malebu Company obtained knowledge on more marketable furniture designs by observing and imitating furniture designs of fellow firms operating in its Keko Furniture cluster. Firms operating in a cluster sometimes share important information on better production and marketing techniques, source of quality raw materials and machinery, and quality demands of the market. Although the literature shows that firms can learn from FDI (Calabrese, 2017), none of the interviewed firms showed such experience.
- **Interactions with customers and suppliers:** Some firms monitored customer feedback to gain knowledge of how to serve them better. Almost all the firms revealed that they monitored customer feedback to help them improve the quality of their products and how they serve customers. Some firms made calls to customers, while others had suggestion boxes to collect such feedback in writing.

Importance of knowledge transfer: The firms indicated that knowledge transfer had helped them in their ITU endeavours. Some of the newly installed machines or newly invented products required employees training to help them use the machines or produce the new products. For instance, in order to produce paper bags, OpenSanit Company had to train its workers on how to operate the machines. Some firms had regular training to help employees enhance their skills.

4.3.4 Challenges constraining ITU

The firms in the survey identified several challenges that hampered their ITU endeavours. They included the following:

- **Inadequate funds and difficulties accessing external funds.** Financing difficulties were the challenge most mentioned by the firms, and especially the SMEs. Inadequate funding made it difficult to acquire the required machines or expertise. Funding shortfalls could occur at any stage in the ITU process and could delay it. For example, the creation of a customer order collection system by Homes Desire Ltd was delayed owing to the lack funds to pay the system expert. Laylow Ltd had to buy used machines because it could not afford new ones. And it also had to find a supplier who was willing to sell the machines by instalments, a challenge that caused delays in the ITU process. In addition, firms found accessing finances from financial institutions difficult owing to the costs and tough requirements.

- **Ad hoc nature of ITU as is not formalised in company organisational structure.** One characteristic of ITU activities in developing countries is their ad hoc nature, where there is no department or unit within companies to manage and oversee ITU or R&D issues. Such a unit would promote investment, solicit for funding and spending on R&D and establish guidelines for conducting ITU activities. Usually such units are generally referred to as R&D units (Egbetokun et al., 2016; Barasa et al., 2018). About 70% of the firms interviewed did not have such a unit or department and only 7.7% hade a point person to oversee ITU or R&D issues. Such ill-equipped organizational structures limit the ability of firms to effectively leverage ITU for their growth. Some firms have integrated the ITU and R&D functions into production or marketing departments, where often such functions are overshadowed by the department's primary functions.

"ITU and R&D responsibilities were allocated to the Strategic Planning Department and I am the only person working in that department. But then I am not specialised in the ITU field. To effectively leverage ITU we need employees specifically for that area"

OpenSanit employee

- **Low level of education and skills of workers:** Training of operative workers on how to use a particular new machine requires a certain minimum level of knowledge or skills. This challenge was flagged in some relatively small firms such as Malebu Company, a furniture making outfit, that revealed that it spends more money and time training workers to use the new machines owing to their relatively low level of knowledge and skills, a challenge that delays its ITU process. A similar challenge was noted by Tanzania Tooku Garments, which, although is a large company, has most of its workers as unskilled labour with low levels of education, which makes it difficult to train them. In both cases, the respondents highlighted that education institutions, particularly TVET institutions, were ill-prepared to provide the education or skills of the quality required in the labour market. Most of them have outdated training equipment and machines and allocate little time for practical training.
- **Stiff competition especially from imports.** This challenge was particularly evident for SMEs in the clothing, leather and furniture industries. The market preference for foreign products, which sell at relatively low prices, wipes out the competitive advantage of locally made products, which unfortunately face higher costs of production than the imports. In addition, the raw materials for production are of relatively lower quality and limited supply, oftentimes because of the high cost of transporting from the source to the factory site. One element in the high production cost is the high tax and other statutory

In addition, the trade and industrial policy instruments appear less effective in protecting local producers. For leather products, for instance, the taxes charged on imported second-hand products are low and do not protect the local producer. The furniture making SMEs noted that imported furniture had better designs but was constructed with low quality timber, which lowered its price and made it attractive to consumers.

"We can improve our machines and buy more machines but more machines won't address the problem of short supply of quality fabric. So, our final cloth has high price and we cannot compete with the price of imported clothes."

Laylow Ltd respondent

"The market still prefers foreign made furniture, which is from poor quality timber, because of its low price and better designs. We cannot compete with that. We can adopt and create some of their designs but we use hard timber which is more expensive than what they use"

Temic Company respondent

- **Importation of required machines and materials is difficult:** Some firms noted that importation of machine was difficult because the import duties were high, as they duties are charged on the price quoted on the internet not the price on the receipt. The COVID-19 related challenges disrupted supply chains including for imports of machines and materials.

- **Covert copying that discourages investment in innovation:** This was an challenge that Watercom confronted, where its improved design for its mineral water bottle was copied by other firms, affecting the benefits from its investment. In the particular case of Watercom, the imitation created a two-faced problem: it reduced the profits from the innovation and it challenged the firm to continually make new innovations. This problem is discussed further in the literature, where the debate is largely inconclusive.[10]
- **Difficulties obtaining work permits for foreign experts:** The requirements for hiring foreign experts in Tanzania are considered unfavourable. This challenge was put forward by Tanzania Tooku Garments, which noted that processing work permits for foreign experts is very expensive, costing US$ 3,500 to S$ 4,000. Furthermore, some of the requirements are onerous. For instance, the process requires the applicant to submit hard copies

10 The literature is not clear on the relationship between innovation and imitation. While Schumpeter (1944) argues that imitation reduces the reward for developing new technologies and therefore must dampen innovation (see Zhou, 2009), Arrow (1962), argues that the relationship is not so clear. Imitation reduces a firm's profit if it does not innovate more. Thus, imitation may serve as a stick that stimulates more innovation. Aghion, Harris & Vickers (1997) demonstrated that indeed such stimulation may prevail and as a result imitation can be growth enhancing.

of primary and secondary school certificates, which are difficult to find. Some of the respondents believed that the requirements were made difficult deliberately to discourage foreigners in efforts to retain job opportunities for national experts, who, unfortunately, are either not available or do not have the required level of skills or competency.

The respondents were also asked to provide recommendations on how the challenges could be addressed. However, to ensure the coherence of such recommendations with the emerging policy implications, the respondents were also asked to provide their view of how useful the existing development policy and institutional framework were in promoting firms' investment in ITU.

4.3.5 Role of policy and institutional frameworks

The case study aimed to examine, among other things, the extent to which the existing policy and institutional frameworks for trade and industrial and skills development had helped in promoting ITU for Tanzanian manufacturing firms. We asked the selected firms to indicate whether they were aware of such policies and institutions and to what extent they had contributed to the firms' investment and impact of ITU.

The responses showed that the majority of the firms (95%) were not aware of the existing institutional and policy frameworks for promoting ITU for firms. On the one hand, this implies that government initiatives to sensitize industry about the role of the government in general and in policy and institutional initiatives for promoting ITU in particular were inadequate and ineffective. On the other hand, the low level of awareness was an indication of the lack of or inadequacy of initiatives by the private sector to actively engage with the government for support, information or knowledge on such frameworks. The firms that were aware of the existing institutional and policy frameworks highlighted certain policies that played an important role in promoting ITU or their competitiveness. Such policies included:

- The Special Economic Zones (SEZs)/Export Processing Zones (EPZ) policy, which had significantly helped to attract foreign investment and which was an important driver of technology transfer.
- SIDO technology incubation and overall institutional support. For instance, by being a member of SIDO, Temic Company received knowledge on markets for furniture. The survey found that firms had memberships in associations such as Tanzania Chamber of Commerce, Industry and Agriculture, CTI and SIDO, even though the value of

- Some firms highlighted the decision of the government to enter into regional trade agreements such as the African Continental Free Trade Area agreement and the East African Community-European Union Economic Partnership Agreement as instruments of trade policy that had and would help Tanzania attract more FDI and thus facilitate technology, skills and knowledge transfer.
- Certain sectors or firms had benefited from exemptions in import duties as part of the government policy to promote technology transfer and adaptation in Tanzania. That is, some firms were able to identify instances where they had received or observed government support that helped knowledge transfer, which is an illustration of policies and institutional frameworks being useful in promoting firms' investment in ITU. Some firms indicated that they were able to receive tax exemptions on imported agriculture machinery.

"We import agriculture machinery at low prices because we get tax exemptions."

Hans Agriculture Machinery respondent

- TVET institutions were recognized for seeking practical training opportunities for their students in the firms as a way of helping their students to acquire practical skills.

While these examples demonstrate instances where policy and institutional frameworks had been helpful with ITU, the firms felt that there were opportunities to do more. For instance, the Tanzania Tooku Garments respondent noted that there were still weak linkages between SEZ and domestic non-SEZ firms that limited technology transfer. Such a view is supported also by the literature. Kinyondo, Newman and Tarp (2016) found that interactions between firms within special zones and with the local community were dismal, implying that there were few benefits of the zone firms flowing to non-zone firms. Kulaba (2015) found that there had been little if any technological transfers spilling over within the Tanzania special zones or outside them. This is exacerbated by the fact that SEZ firms often operate as industrial enclaves with limited linkage with the rest of the economy. While this limitation is not specific to SEZ firms, studies such as the one by Kweka & Sooi (2019) indicate that the linkage between large (FDI) and small (SME) firms was limited. This points to the weak policy environment to support linkages between SEZ and none-SEZ firms.

The low awareness on policy and institutional frameworks and the inability of most firms to identify cases of government support in technology transfer and adoption indicate that generally the government's support to ITU for firms is still low.

4.4 Lessons from selected cases

Of the 28 firms sampled for the survey, 17 were considered to have been successful in leveraging ITU to bring dramatic positive impact in productivity or competitiveness to their business. The 17 firms are listed in Annex D with details depicting the ITU they undertook, the key drivers or factors that made them successful, the challenges they encountered and their recommendations. The 17 firms varied in size, the sector to which they belonged and the nature of their ITU initiatives. From their varying success and based on our understanding of the ITU experiences described in the previous section, we have identified a number of lessons worth highlighting for policy discourse on their potential for replication across the industrial manufacturing sector. The lessons reflect some emerging factors on the success in leveraging ITU, key cross-cutting challenges limiting ITU efforts and the potential role of the policy and institutional frameworks.

Lesson 1: An ITU or a R&D unit is a catalyst for a company's continuous investment in ITU to support its growth

One characteristic challenge limiting firms' continued investment in ITU in developing countries such as Tanzania is the failure to establish a unit responsible for ITU or R&D issues. This challenge is particularly prevalent among SMEs, given their relatively weak capacity and limited resources. The case of Silafrica Tanzania Ltd is quite informative on the importance of such as a structure. The company manufactures and sells plastic products, including innovative retail vending, distribution and brand promotion equipment for Coca Cola Company. The R&D unit, or Innovaxis, specializes in the design and development of innovative retail vending and brand communication equipment with a strong focus on the beverage, telecommunication and tobacco sectors (see Figure 15). The company employed people with innovative skills to work in the unit and tasked them with only one responsibility of identifying innovative products to secure the market for the company. Silafrica was able to secure a permanent buyer, Coca-Cola, for its products. Underlying the importance of such a unit is the fact that most of the interviewed firms indicated that not having an ITU or R&D department was a hindrance to their ITU efforts.

Figure 15: Innovative products produced by Silafrica

Source: Silafrica (2015)[11]

11 Innovaxis - Silafrica (Simba Plastics) - PDF Free Download (Docplayer.Net)

Lesson 2: Conducting prior research is important

This lesson arises from the experience noted in almost all selected firms that, although the opportunity and motivation for undertaking ITU may be instant, the process for ITU is not. The fact that the process is gradual and sequential in terms of the key steps, requirements and actual lessons, conducting proper research ahead of carrying out ITU is critical. Firms vary significantly in how they leverage the research factor owing to the different nature of the ITU and its requirements. For some, it was mainly an issue of studying the market to properly comprehend the challenge in order to get the solution right. For others it was about searching for the appropriate equipment, raw materials or experts. Yet for others the research experience was about visiting other firms to learn and finally studying the feedback from customer experience.

The ITU carried out by Watercom Ltd resulted from hiring a consultant to carry out research on what kind of product would easily penetrate the bottled water market. The research came up with three areas of focus: quality, volume and design factors for bigger market penetration. Malebu Company, a furniture making SME, was able to find new furniture designs by researching other firms operating in its Keko cluster. And Laylow Ltd used friends who work in other garment making SMEs to identify the best but affordable button sewing and embroidery machines.

Lesson 3: Availability of internal funding leads to smooth and timely ITU processes

To carry out ITU, funding is a critical requirement, especially to acquire other requirements such as raw materials, machines and experts. Being able to source the needed funding internally facilitates timely investment decisions and enhances a firm's ability to control the process. Tanzania Tooku Garments provides a strong example of this. The company was able to carry out a number of improvements in its operations because it had the required finance internally. Subsequently, it managed to grow into a large garment manufacturing factory exporting to the AGOA market. It expanded from just 250 workers in late 2012, the year it started operating in Tanzania, producing 35,000 pieces of jeans monthly in one factory to over 3,200 employees currently with six factories.

Lesson 4: Competition is an important lever for ITU

Throughout the sampled cases, competition stood out as a key factor in necessitating firms to carry out ITU. This study identified competition as a significant and positive driver of ITU. As shown in Annex A, competition motivates firms to improve their products or processes so as to secure their current or a new market position. For instance, Watercom had to come up with an improved bottled water product to be able to penetrate the market. Tanzania Tooku Garments continually invested in modernizing its industrial technology to beat the fierce competition from producers in Kenya, Ethiopia, Lesotho and Cambodia in garment making. Its experience confirmed the finding in the literature that firms that face competition are more innovative than those that do not (Ayyagari, Demirgüç-Kunt. & Maksimovic, 2011).

Lesson 5: Firms need help from support institutions or other firms for their ITU to be successful

The government has a key role of creating a favourable policy environment for promoting the country's competitiveness through support to ITU activities. The evidence from the survey shows that the relatively smaller firms expect more tangible support from the government, including in funding and expertise. Support can occur in two types of environments. One evirnonment is where there no existing relationship between the supporting institution and the firm. A good example is the case of Imara Technology Company which leveraged the support of Twende Innovation Accelerator Hub for its ITU[12] following which it developed a multi-crop threshing machine that could thresh nine cereal crops (see Figure 16). The machine brings efficiency to the farming process in the sense that it is 75 times faster than manual methods and it can save around 90 hours of labour per 2 acres of farm. The company has secured a big market for the machine including in Rwanda and Zambia.

Figure 16: Multi-threshing machine for cereal crops

Source: Case study survey (2022)

12 Twende Accelerating Social Innovation is a Tanzanian based social innovation and learning centre that empowers communities to design and make their own technologies to solve their problems. The firm provides a number of services including creative capacity building workshops, technology incubation, technical mentoring, workspaces and resources to innovators. Twende Innovation has partnered with several other stakeholders that include COSTECH, Segal Family Foundation, Southern Africa Innovation Support (SAIS) to support innovation activities of firms. Apart from financing the multi-crop thresher of Imara Tech, it has successfully financed other projects in Tanzania such as those to create an avocado oil pressing machine, a multipurpose wheelchair, a bar soap cutter, a modern hand cart, a solar heater, and a washing machine.

The second environment is where there is an existing relationship. For example, in support of its ITU endeavour, OpenSanit Company received an affordable loan from CRDB Bank that helped it to buy the machines it required and raw materials and pay for expertise. This was possible because the firm is in a mutually beneficial relationship with CRDB Bank which it supplies with garments at negotiated prices, while the bank provides it loans under preferred terms. Such a mutual relationship is rare, but it addresses a challenge that is a pertinent constraint for many firms. An ITU process for firms that are not in such a relationship such as Laylow Ltd could be difficult. This firm was unable to raise funds from banks or other institutions for its ITU activities, which delayed their implementation.

Another example is the case of Baobab Energy Systems Tanzania Ltd, a partnership venture between a Singaporean company (EDMI Ltd) and a Tanzania firm (Comfix & Engineering Ltd). The company's partnership with EDMI Ltd, which is one of the big five reputable companies in the world, based in Singapore, was among the main factors that helped the firm emerge among the first local manufacturers of innovative and technologically advanced energy meters and metering systems.

Lesson 6: Government policies have a role to play in promoting ITU

It might appear that ITU initiatives are solely the result of efforts of firms without the support of the government. This was the case in this study where, except for a few instances, the firms did not receive support from the government and were unaware of its supporting policy and institutional framework. The reality is far from that. The government support to firms undertaking ITU may be direct or indirect. Broadly, it comes through four channels:

- The government maintains peace, order and a policy environment where private enterprise can establish and thrive. This is why a good country environment is critical in attracting FDI.
- The government creates strategies and programmes for promoting firms' competitiveness, with such initiatives as SEZ or EPZ schemes as the most obvious examples and are the important factors explaining the success of firms such as Tanzania Tooku Garments.
- The government may offer direct support in training, credit or even technical knowledge for SMEs through such programmes as SIDO. In addition, initiatives to seek preferred market terms such as AGOA or other regional or continental trade agreements, or even for firms to have access to more efficient sources of technology, raw materials and skills are meant to maintain the firms' competitive edge.

- In the competitive global economy, the country's trade and industrial policies provide a general support environment (including protection) for firms to acquire competitiveness. For instance, the government policy to promote agricultural mechanization qualified Hans Agriculture Machine Ltd to obtain import duty exemptions. This way the firm was able to sell its products at affordable prices and ultimately expand its market reach to small farmers. Through the EPZ scheme, the government facilitates industrial activity through fiscal (tax holidays) and regulatory incentives and infrastructure support. Direct government support was also notable in the case of Baobab Energy Systems Tanzania Ltd, which became among the first local manufacturers and suppliers of electricity meters mainly because the government assured it of a market for its meters in the form of the Tanzania Electric Supply Company Limited (TANESCO).

4.5 Conclusion and recommendations

This report presents the case study component of a broader study on the role of and experience in ITU in enhancing firms' competitiveness and productivity improvement in Tanzania. The case study followed the previous empirical analysis component that had focused on identifying the drivers and impact of investment in ITU on competitiveness using existing Annual Survey of Industrial Production (ASIP) data. Owing to the limitations of the ASIP data in providing detailed information on firms ITU experiences, the case study was based on a survey of 28 selected manufacturing firms of different sizes and from different subsectors. Subject to the limitations on data and information provided by the firms, this report discusses the firms' ITU experiences in terms of the nature, drivers and impact of the ITU, and highlights the emerging challenges and lessons. The report also discusses, albeit sparingly, the role of policy and institutional frameworks in promoting ITU in Tanzania.

From the analysis and subject to the scope of information made available by the firms, a number of conclusions were made. First, ITU is a largely customised and localised process in the sense that no one size fits all. Although firms have quite a wide variation in their investment and experience on ITU, some common factors determine the extent, nature and the ultimate impact of an ITU initiative. These include the fact that all firms are driven by competition to acquire a bigger share of the market through productivity and quality improvement. Although all firms undergo a certain level of ITU, SMEs largely do not have adequate capacity and their ITU is more informal compared to the larger firms with more structured approaches and adequate capacity for ITU.

Second, although the level of ITU appears largely basic and reliant on technology transfer or adaptation from imports or external partnerships, it has a significant impact on firms' competitiveness. The most common forms of ITU are the acquisition of modern machinery or machinery modification to fit local conditions and process improvement. Despite the unavailability of reliable and quantifiable data to illustrate the impact, the firms interviewed consistently confirmed that the ITU undertaken or its process had a significant impact on their performance. This is because most of the ITU was targeted at attaining bigger markets, improving quality and responding to market opportunities created by particular challenges.

Third, to a ensure firm's success, the process for ITU should be an integral part of the ultimate results. The ITU process ensures careful planning and constitutes a predetermined process and guidance for conducting ITU. The need for a process for ITU underscores the importance of research and technology transfer in reaching the ultimate results. This includes regular training to help employees cope with new technology, regular interactions with partners with technology sources, and learning from customer feedback. The firms interviewed highlighted the challenges they faced in developing the ITU process as including the lack of the required finance, supportive government policies, and expertise.

Fourth, although a policy and institutional framework is critical in achieving impactful ITU, the extent to which it has been harnessed by the government and firms for significant enhancement of ITU levels has not been established. The majority of the firms interviewed were not aware of the existing policy and institutional frameworks and were not very positive on the possible role the government could play in promoting ITU. Nonetheless, the few ITU firms that had had linkages with a government institution gave a positive contribution of the role of the public institution in determining the success or results of their ITU. Further research is needed to obtain clear evidence on the role and effectiveness of the policy and institutional setup in promoting ITU among firms.

Fifth, although limited in scope, the lessons generated from the case study are largely applicable across industries. Based on the firms' experience with ITU, we identified some useful lessons that could inform how firms can successfully leverage ITU. The lessons could also inform policy reviews or dialogues or the formulation of more effective policies, strategies or programmes to support the increase in firms' investment in ITU.

5. CONCLUSION AND POLICY IMPLICATIONS

Using the Annual Survey of Industrial Production (ASIP) for 2016, this study examined the role of ITU on competitiveness of Tanzania's industrial and export sector. The study conducted a situational analysis, undertook empirical analyses complementing it with a case study of a few selected firms to identify the drivers and effects of ITU on Tanzania's industrial and export competitiveness.

The findings show that, although for Tanzania the trend in the level of ITU over the last couple of years has been rising favourably, albeit from a very low base, the leveraging of this trend to support the country's much-needed competitiveness has been limited. Despite the small change in its structure, the country's production and export baskets have been dominated by low technology sectors and mainly SMEs and resource-based goods and commodities. The study confirmed that ITU has a role in industrial performance in that it has a positive impact on firms' performance and is a requirement for firms to remain productive and increase their level of competitiveness. Nonetheless, the capacity and prospects for future investment in ITU are limited to the large scale and foreign-owned firms, leaving out the majority of the SMEs. This implies there is need for the government to invest further in technology partnership programmes to support SMEs, promote technology and skills transfer by promoting linkages between large or foreign-owned firms with small domestic firms, especially is such schemes as SEZs or industrial parks, plus other mechanisms.

The study identified improvement in production technology and managerial practices as the two most important benefits for firms from technology transfer. The owner's and the firm's characteristics were the key drivers of technology transfer. Contrary to the expectation, the results showed that previous worker experience with a foreign firm, location in an industrial park or SEZ were not significant factors in technology transfer. This was presumably because the enclave and exporting nature of the firms in the special zones limited competition and spillover effects and direct observation by the domestic firms. The findings also show that technology transfer was more important to some sectors such as iron and steel more than to others such as food processing, and that large firms did not need or benefit from technology transfer as much as did SMEs.

The findings and lessons underscore the need for the government to review the policy and institutional framework for promoting ITU so as to fill the gaps, strengthen the role of public institutions, and address the challenges limiting firms' ITU. The most pressing of challenge include weak legislation on intellectual property rights that mitigate risks of unauthorised copying or imitation of other firms' innovation or invention, weak enforcement of customs procedures and trade policy instruments for protecting local producers, financing shortfalls, and unreliable supply of power. The study recommends the improve the quality of education and skills by increasing investment in capacity enhancement for technical and vocational education and training institutions to help improve the skills of graduates and help manufacturing firms acquire appropriate skills. Clearly, the findings point to the need for further research on the role and effectiveness of the government in promoting ITU for firms' competitiveness in Tanzania.

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Annexes

Annex A: Non-parametric selectivity test

Variable	dinnospend	innospend_emp
trade	0.528***	5224577.6
	(-0.106)	(-6380967.6)
private	-0.0587	-603155.2
	(-0.152)	(-726661.2)
foreign	0.191	2335185.4
	(-0.109)	(-2309432.6)
govsubs	0.398***	3642122.8
	(-0.109)	(-4811644.8)
Firm Size (small is base)		
Medium	0.501***	4725715.4
	(-0.117)	(-6064457.9)
Large	0.330**	3091648.8
	(-0.12)	(-3991780)
Probability Terms		
dinnospend_hat		5.44E+10
		(-6.20E+10)
dinnospend2		-1.27E+10
		(-1.45E+10)
inversemills		7.42E+10
		(-8.44E+10)
invermills2		7.16E+09
		(-8.24E+09)
interr		1.28E+09
		(-1.41E+09)
Controls		
Region dummy	Added	
Subsector dummy	Added	
_cons	-0.716***	-6.38E+10
	(-0.165)	(-7.26E+10)
N	1885	1884
R-Squared or Pseudo R Squared	0.1307	0.0174

Note: Standard errors in parentheses: * p<0.1; ** p<0.05; *** p<0.001
Source: Author's analysis of ASIP data for 2016

Annex B: Summary of empirical studies

No.	Study	Country/region	Main objective	Method of analysis	Findings
1.	Raul et al. (2019)	China	To investigate the impact of different aspects of technology innovation on export performance of industrial enterprises	Panel-generalized method of moments estimation	Domestic innovation and foreign investments have a significant positive impact on China's industrial export performance
2.	Xie, Zang & Wu (2019)	Emerging countries	To examine the relationship between innovation activity and manufacturing upgrading in emerging countries	Ordinary least squares, fixed effects and random effects models	Technical, product and institutional innovation have a significant positive effect on manufacturing upgrading
3.	Misati & Ngoka (2021)	Tanzania	To examine the main constraints to manufacturing and export competitiveness in Tanzania	Simple fixed effects estimator	FDI and tariffs have a negative and significant effect on export competitiveness in Tanzania, while infrastructure, total investment, labour productivity, and high institutional quality enhance manufactured exports
4.	Palangkaraya (2012)	Australia	To investigate the relationship between export market participation and innovation in Australia	Propensity score matching	There is a significant positive relationship between export and innovation. There is evidence that a current product innovator may have higher probability of becoming a new exporter
5.	Brancati et al. (2021)	Italy	To explore the main drivers of firms' external competitiveness in times of crisis	Random-effect probit models	There is a positive relationship between innovation and internationalization that changes the attitude of Italian firms towards these strategies
6.	Mallinguh et al. (2020)	Kenya	To examine the effect of capital budget's proportion for acquiring new technology and sales performance	Ordinary least squares	The amount of capital budget set aside for acquisition of technology has positive effects on sales performance
7.	Xi & Ming (2020)	China	To examine the role of scientific investment and technological innovation in the development of high-tech industry in Shenzhen	Desk review	Development of science and technology enhances high-tech export products in Shenzhen
8.	Zhu & Fu (2013)	Global cross-country	To analyse the determinants of export upgrading using cross-country panel data	Panel generalized least squares	Capital deepening, engagement in knowledge creation, transfers via investment in education and R&D FDI and imports influence export upgrading
9.	Golovko & Valentini (2011)	Spain	To test if innovation and exports are complementary strategies for SME growth	Fixed effects and Arellano-Bond regression	The study confirms the existence of complementarity between innovation and exports
10.	Wie (2006)	Indonesia	To examine the determinants of Indonesia's industrial competitiveness	Desk review and descriptive statistics	Industrial policies did not have an effect on industrial competitiveness in Indonesia. However, industrial and technology upgrading would attract FDI and improve a country's industrial competitiveness
11.	Barasa et al. (2016)	sub-Saharan Africa (SSA)	To examine the nexus between innovation and export in SSA	Logistic regression	Innovation has positive effects on exports
12.	Zhao & Zhang (2007)	China	To study China's industrial competitiveness using international perspectives and comparisons	Multiple regression	China's competitiveness depends significantly on innovation and industrial upgrading; and specifically its participation in international production networks
13.	Márquez-Ramos & Martínez-Zarzoso (2010)	Developed and developing countries	To examine the relationship between technological innovation and international trade	Gravity model	There is a positive effect of technological innovation on export performance
14.	Kadarusman & Nadvi (2013)	Indonesia	To explore the nexus between technological upgrading and competitiveness in global value chains	Global value chains model	Technological upgrading through the global lead firms influences competitiveness of the local firms
15.	Sikharulidze & Kikutadze (2017)	USA	To examine the effect of innovation on export intensity	Descriptive statistics and probit regression	Product innovation determines export intensity
16.	Damijan & Kostevc (2010)	Spain	To explore the learning effects from trade (exports)	Propensity score matching	Firms learn mostly from import links, which enables them to innovate and export products. In line with this, exports enable firms to further innovate
17.	Hahn & Park (2012)	Korea	To examine the bi-directional causal relationship among exporting, innovation and productivity	Propensity score matching and panel VAR model	There is a positive relationship between exporting and introduction of a new product

Annex C: Firms and people met in the survey

S/n	Name	Firm name
1	Kiran Shah	Pan Africa Enterprises
2	Jackline Baruti	Temic Co.
3	Abdallah	Simba Lime Factory Ltd
4	Allan Magoma	Baobab Energy Systems Tanzania Ltd
5	Venugopal Sriram	Metro Steel Mills Ltd
6	Baraka Mariseli	BAFREDO Electronics Limited
7	Juma Mohamed	Metro Plastic Industries Limited
8	Clement Samwel Munis	21st Century Textile Ltd
9	Nobert Kiwango	Moshi Leather Industries
10	Joseph Kimogele	Apex Resources
11	Emmanuel Wawa	Silafrica Tanzania Ltd
12	Rigobert Massawe	Tanzania Tooku Garments
13	Bhavin Yethra	Morogoro Wire Rolling Ltd
14	Noah Mwalusamba	Laylow Ltd
15	Kelvin Mlay	OpenSanit
16	Emmanuel Zacharia	Imara Tech
17	Allen Emily	Malebu Company Ltd
18	Turuka Eliya	Meta Plant & Equipment (T) Ltd
19	Mariam	Zenufa Laboratories Ltd
20	Bhavin Yethra	Morogoro Plastic Ltd
21	Diana Nkya	Hill Packaging Ltd
22	Idrissa Juma	Watercom Ltd
23	George Masaka	Hans Agriculture Machinery Ltd
24	Richard Mushi	Homes Desire
25	David Shah	Shah Industries
26	Hatim Anjari	Anjari Soda Factory Ltd
27	Julian Jones	Twiga Cement
28	Alfred Babatunde	Tanga Cement

	Position
	Chief Executive Officer
	Chief Executive Officer
	Managing Director
	Deputy General Manager
	Production Manager
	Chief Executive Officer
	Administrator
	Production Manager
	Finance Officer
	Operations Officer
	Administrator
	Assistant General Manager
	Financial Controller/Administrator
	Manager
	Marketing Manager & Strategic Planning Analyst
	Technical Engineer
	Chief Executive Officer
	Chief Accountant
	Administrator
	Financial Controller/Administrator
	Administrator
	Sales Manager
	General Manager
	Production Supervisor
	Managing Director
	Managing Director
	Marketing Officer
	Production Officer

Annex D: Selected ITU illustrative cases

Case 1. Hans Agriculture Machinery Ltd

Depiction: From technology transfer through importing to manufacturing of low cost farm implements

Background: Hans Agriculture Machinery Limited is a small company established in 2018 and located on Narung'ombe Street, Mnazi Mmoja, Dar es Salaam. The company specialises in supplying agricultural machinery to small-scale and medium-scale farmers. The company is owned as a joint venture between Tanzanian and Indian nationals. It has five employees working full time and also hires others occasionally as temporary workers.

Description of ITU: This enterprise does not have an R&D department because it is still in its early stages of operation. The majority of the company's machines are imported. In order to remain competitive in the existing and new markets, the company reviewed its policy in 2018 and embarked on manufacturing and importation of up-to-date agricultural machinery that requires little human effort to operate and that at the same time guarantees maximum output. Through importation, the company has learned and introduced a lot of agricultural implements and technology in Tanzania, thereby boosting farming productivity and expanding the market for both low and high income farmers. The technological upgrading that can happen in this type of business would make sure that all the inputs and machines are up to date and have little harm to the environment or farmers.

> *"When the machines reach Tanzania, we learn many things from them. First we have to know how to repair them, and you can only be able to repair the broken machines if you know how they were built. And it is in that process of learning that we acquire new skills and knowledge to produce our own products."* Hans respondent

Drivers and Impact: Increasing sales and market penetration are the main motivations for undertaking ITU. The company had to modernize agriculture machines using low cost and up-to-date technology. Market expansion was also facilitated by participation in agricultural fairs and exhibitions, as well as from creating a strong brand name in the market. Staff at the company more than doubled, going from two to five full-time employees. The success factors for Hans included the government's emphasis on improving agricultural productivity and the importance of agriculture to the Tanzanian society at large.

> *"Nowadays we sell products easily because our brand name is known, and it has helped us to reduce the cost of doing marketing and advertisement in the market."* Hans respondent

Challenges/recommendations: The challenges noted by the firm include inadequacy of workers who are conversant with modern farm equipment and the bureaucratic procedures at the port that increase the cost of doing business. Clearly, although farm implements are subsidised, the process of clearing them is too long and tedious. Nonetheless, the subsidy policy for agricultural machine imports has given the firm the ability to import high-tech equipment and made the equipment affordable to farmers. The firm recommends that the government continue fostering the role of ITU by improving the business environment.

Case 2. Meta Plant & Equipment Tanzania Ltd

Depiction: Importation agency facilitated significant technology transfer and motivation for undertaking ITU that turned into manufacturing of similar products

Background: Meta Plant & Machinery Tanzania Ltd is the only authorised dealer in Tanzania of JCB equipment from the United Kingdom. The firm also engages in the production of construction materials ranging from plumbing pipes to small machines. The firm employs 35 full-time workers. Meta Plant & Machinery Tanzania Ltd does engage in R&D, particularly in the creation of the items it sells. It undertakes marketing research in order to boost sales.

"Most of the time we learn from foreign engineers. The product made by them gives us the clue on where we can improve. If we fail to understand the working of the machines, we normally engage in training and interact with the foreign engineers to learn." Meta respondent

Description of ITU. Basically, the firm buys machines from the dealers and customises them to meet the need of local customers. In doing so, the company learns from the technology from abroad, renovates it and uses it in production of locally made construction machines and materials. The ITU process is also reflected in the production process. Before any item starts production, it is designed on the computer, a miniature created and tested as many times as are required to reach the required standards. Technology transfer takes place also through regular training, tests and trying the equipment, including learning from engineers abroad and then training other staff in return. The firm adopts a dynamic approach in its innovation needs and works to create a new product based on the market needs or challenges observed in the society. Part of the motivation for engaging in ITU is the fact that the construction industry is fast paced, which requires constant investment in ITU in order to be able to deliver what customers want.

Drivers and Impact: Two of the factors that have helped Meta to succeed in ITU are competition and interdependence in the market. As most of inventions in the industry are patented, there is a guarantee that the money invested will always bring profit as long as the product or invention is demanded in the market. As an example of impact, ITU has helped the company to expand from being just an importation agent to a firm that can produce and market its own equipment. ITU has helped Meta to establish itself in Tanzania and win the market in East Africa. Nowadays the company appears in East African real estate magazines because of the reputation of its products and the consultancy services that it offers to customers. The original plan was to sell imported products and used machines. However, ITU has helped the company to do more than this, and now it has its own products.

Challenges/recommendation: The main challenge experienced by this firm is funding shortfalls, given the high cost involved in production work from design to creation of miniature copies of the equipment to full production. Nonetheless, the government policy to waive import duties on capital equipment has been very helpful. To enable knowledge sharing and ITU among firms, the firm recommends that the government foster connectivity of such enterprises with R&D or technology institutions. The government should also continue to strengthen the business environment by enacting legislation that will make ITU processes more convenient for enterprises. It should improve enforcement of the laws in the country for safeguarding the patent rights to avert the copy and paste practices.

Case 3. Watercom Ltd

Depiction: The drive for market penetration necessitated significant ITU initiatives including initiating a unique bottle design and quality improvements that led to increased volume

Background: Watercom Ltd is a firm owned by a Yemeni national that specializes in the production of bottled mineral drinking water with Afya as its brand. It was founded in 2004 and is located in Kigamboni, Dar es Salaam. It employs approximately 100 full-time workers.

Description of ITU: Watercom does not have an R&D department, but R&D operations are supervised by the laboratory and marketing departments, which are in charge of the quality of every single product made. The majority of the machines in the firm are automated, with a few others being semi-automated. As one of its marketing penetration strategies, the company introduced innovations in three areas that are crucial for product development, namely quality improvement, volume increase and better design. In this case, the company bettered the quality of its water by improving its pH level for fresh water and it also bottled a bigger volume of water in a bottle whose design had been improved. This way it gave customers more quality fresh water for the same price as the competitors. Before undertaking the three improvements, the company did preliminary market research to understand what was lacking and what was available in the packaged water market.

Drivers and impact: ITU has helped Watercom to penetrate the market and maintain its market share since its establishment, along helping the company to secure a new market in each production year and thereby increase its sales. However, ITU has also led to more intense competition in the industry. One challenge the company has faced is that other firms quickly copied the improvements it made, affecting the benefits from its sale increase. Watercom recommends that the government do more to protect innovative ideas that businesses or people introduce by making sure that the laws that guide ITU are adhered to. Those who copy the ideas of others should be punished severely.

Challenges/recommendations: The main challenge for the firm is how to monetize its investments in innovation and technology. There are a lot of competitors in the packaged water market and the market is almost saturated. Copying of technology or innovation is also very easy, because there are no patents available in that area. In such an environment, the pressing challenge is how to recoup the investment in ITU. In addition, since Watercom supplies products similar to its competitors, it is always difficult to manage its labour turnover because of the high mobility of labour in the sector.

> *"You can train people today and tomorrow you find them working with your competitor."* Watercom respondent

Case 4. Imara Technology Company Ltd

Depiction: The linkage with Innovation Accelerator, Twende Hub, led to the successful development of a multi-crop threshing machine that contributed to the significant increase in sales and exports and the dramatic growth in productivity of smallholder famers in particular.

Background: Imara Technology Company Ltd (Imara Tech) is a limited liability company incorporated in 2015. It is located in Arusha city, within the SIDO area dealing with the manufacturing of mechanised agricultural equipment from local materials. Imara Tech's major project is the multi-crop threshing machine that separates the common staple crops such as maize, beans, sorghum, pigeon peas and sunflower up to 75 times faster than manual threshing. This technology reduces grain and seed damage, improves the end product quality and enables smallholder farmers to generate more income by selling their produce at higher prices. Despite being a small firm, it has managed to expand its market in some other countries such as Rwanda and Zambia. Imara Tech has 15 employees, out of whom four are female.

Description of ITU: Imara Tech received support from Twende Hub social innovation accelerator, an innovation hub that is involved in R&D. Its ITU process involves a number of steps including creating the idea, followed by the design, the prototype and then the model, which is then tested and the feedback analysed by expert engineers. In the case of the threshing machine, the trial and error testing included strong customer feedback. Notably, most of the firm's machines are manual with an average age of less than five years. Imara Tech's R&D department currently has two engineers who are responsible for work on the designs of the machines and conducting tests. The firm does not have any patent for its innovation. The production process involves mainly assembly of the machine's parts as the company designs the components of the machine and outsources their manufacturing to other firms. In ensuring that farmers get the benefits that come with the equipment, Imara Tech offers a range of services to support customers and their businesses, including training on the product to ensure its smooth usage. They also offer a warranty for the equipment for the payback duration. Looking forward, under the R&D department, Imara Tech has been working on the project to develop four new solar-powered productive-use agricultural appliances that is, a grain mill, an oil press, and a peanut and cashew sheller.

Drivers and impact: The motive for ITU stems from the firm's ambition to increase its market share and boost the technology to improve the quality of its products. Clearly, an important factor for success has been the support from the Accelerator Innovation Hub. The firm also works with agents to supply the machines to clients. The agents have been very helpful in bringing the feedback and reviews from the customers, which have helped Imara Tech to improve its products.

The ITU initiative led to significant improvement in the quality of the products and also enhanced the firm's competitiveness. The firm has since then exported equipment to Rwanda and Zambia and has also been able to increase its sales significantly. The machine can save around 90 hours of labour per two acres of farmland. In addition to reducing threshing time, the MCT machine produces grain uncontaminated by rocks and dirt, and reduces post-harvest losses by a range of 5% to 2%. One MCT machine can be used by around 50 smallholder farmers. Through such innovation, Imara Tech estimates that it has been able to generate 177 agribusiness jobs in the rural area, enabled 8,850 smallholder farmers to access mechanised threshing services and saved a total of 888,500 hours. Since its establishment, Imara Tech has been able to sell 244 MCTs with a production capacity of 20 MCT per week and expanded its workshop space to twice its old size.

Challenges/recommendations: The main challenges faced by Imara Tech are the high costs involved in continual improvement of designs to get the best machine, where funding support from Twende Innovation significantly has boosted the resources, and the low level of skills among the employees. Imara Tech recommends the establishment of a platform that brings together the government and firms to discuss issues on ITU, provision of assistance on export markets and reduction of the taxes imposed on firms, especially the young firms.

Case 5. Anjari Soda Factory Limited

Depiction: The desire to increase efficiency and productivity in production pushed investment in modern and automated technology in a soft drink industry.

Background: Anjari Soda Factory Limited is a well-established soft drinks and syrups manufacturing firm incorporated in 1960 and located in Gofu industrial area in Tanga city council. It produces mineral drinking water, soda and syrups and is owned by Indian investors. Among other things, the firm's vision is to promote the manufacturing process through technological advancement and environmentally compliant operations. Thus, ITU is among the critical features of the production process to support its competitiveness. Over 80% of the firm's machines are automatic and aged on average 10 years.

Drivers and impact: One of the key strategies for enhancing ITU is provision of frequent in-service training to ensure employees comply with the standard operating procedures and to enhance productivity. Another mechanism used to support ITU is to engage in frequent interactions with other firms that operate in the same field. The firm reported that innovations made by the firm led to a significant improvement in the production process, including increasing efficiency in production and productivity.

Challenges/recommendations: The main challenges experienced by the firm include the unstable power supply that has caused the damage of several machinery and products during power outage and limits production capacity. Other challenges include inadequate funding for ITU activities and the high import duty charged on the imported machines. Although the firm's management appeared to be aware of the existing institutional and policy frameworks that support ITU in Tanzania, they noted the key challenge to be the lack of implementation of such policies. They recommended that the government put in place sound infrastructure for supporting ITU, including reliable power supply, and reduce the import duty on machinery to facilitate affordable access to technology.

Case 6. BAFREDO Electronics Limited

Depiction: Leveraging the University Innovation Centre and entrepreneurship to promote ITU in electronics industry (design and fabrication of electronic circuits and systems)

Background: BAFREDO Electronics Limited was incorporated in 2015 and is located on Sam Nujoma Road, university junction in Dar es Salaam. With a total of 10 employees, two of whom are female, the company deals with a range of activities in the field of electronics, including producing and selling electronic appliances in and outside the country. BAFREDO Electronics it is also known as the Centre of Innovation and Entrepreneurship since it provides room for the best engineering students from the University of Dar es Salaam to work within its Innovation Centre as interns and helps them with innovation of different tools and applications. The revenue obtained is shared, with 30% going to the company and 70% to innovator. The company's flagship products include long-range transmitter receiver modules (LoRA) and SIM 800C GSM communication module for transmission or reception of data and information over the GSM network.

Description of ITU: The main innovation took place following the joint venture between a local entrepreneur who had gone to China for his PhD and a Chinese investor. They started with importing raw materials but gradually invested in machines and experts to train their staff on how to make electronic appliances, mainly motivated by knowledge on the existing opportunity and the challenge of the low supply of electronic appliances in the market. ITU for the company is driven by the firm's desire to boost productivity, reduce costs of production and improve quality and efficiency in the production process. The company leverages the opportunity to provide internships to engineering students from the University of Dar es Salaam. The production, technology and innovation process revolves around a combination of three factors: machinery, raw materials and experts. Production is also supported by a number of testing and monitoring processes through sales records and customer feedback. BAFREDO Electronics practices technology transfer through training, especially after procuring a new machine. The company hires experts from the supplier side (China) who bring and install new machinery and teach staff on how its operated. Also, the students who work as interns receive practical knowledge from the company.

Drivers and impact: The ITU exercise led to improvements in the quality of products and increased volume of sales due to increases in customers. For instance, according to the company's respondent, the production volume increased by 35% and the number of products increased, the latest being SIM 800C communication module.Furthermore, provision of services improved, for instance now the company does design and fabricate electronics circuits and systems. Overall, the high level of professionalism underlies the success of the company. According to the company respondent, ITU contributed to the improvement of production by 35%, and has increased quality, efficiency and number of customers. So far, BAFREDO Electronics has achieved 30% of the expected achievements from ITU activities.

Challenges/recommendations: The company noted several challenges, notably the bureaucracy in the process of certification of their products and the inadequate financial support, which hinders huge investment in ITU and realisation of the company plans to construct a big electronics factory in Tanzania. The company recommends that the government promote ITU by supporting ITU training and creating or facilitating partnerships between the government and manufacturing industries

Case 7. Baobab Energy Systems Tanzania Ltd

Depiction: Strong clientele and partnership with foreign, globally reputable company facilitated ITU in the supply and production of electricity meters.

Background: Baobab Energy Systems Tanzania Ltd is a partnership venture between the Singaporean company EDMI Ltd and the Tanzania firm Comfix & Engineering Ltd. The firm, located along Goba Road in Dar es Salaam, was incorporated in 2018 and has a total of 22 employees, 80% of whom are female. The company designs, develops and manufactures innovative and technologically advanced energy meters and metering systems for the global utility industry, with an emphasis on Tanzanian and African markets. The firm is among the first local manufacturers of energy meters, which were previously imported. It created a meter-reading system for its client TANESCO, to monitor the use of electricity among users. Baobab Energy Systems Tanzania Ltd has rights to this system but it is used by TANESCO. It is among TANESCO's main suppliers.

Description of ITU: The turning point for ITU improvement was the existence of experienced and knowledgeable innovation and technology engineers and the partnership with EDMI Ltd, based in Singapore, which is one of the five big reputable smart meter companies in the world. All the machines in the company are fully automated, with an average age of four years. As a result of focusing on innovative and technologically advanced systems, Baobab Energy Systems Tanzania Ltd has been awarded various certifications that include ISO9001, ISO27001, ISO14001, ISO17025 etc. It collaborates with EDMI Ltd to produce and assemble electricity meters to supply to TANESCO. EDMI Ltd supplies machines and technology to Baobab Energy Systems Tanzania Ltd that are used to design, develop and manufacture innovative and technologically advanced energy meters and metering systems in Tanzania. The process of ITU begins with an existing opportunity such as a demand for electricity meters and a problem such as an inadequate supply of electricity meters in the country, to which Baobab Energy Systems Tanzania Ltd offers a solution. The company has TANESCO as the only client, so its monitoring and evaluation depends on feedback from TANESCO. The main motivation for conducting ITU is to improve production to up to 1,000,000 electricity meters per year. So far, the company is producing 500,000 meters per year against TANESCO's demand of 4,000,000 meters.

The company also plans to increase the quality of its products to for its client's satisfaction and to improve efficiency for timely delivery of products.

Drivers and impact: The success of Baobab Energy Systems Tanzania Ltd emanates mainly from its experience in the industry and the good relationship with its main customer, TANESCO. In addition, the global reputation of its partner, EDMI Ltd, which is also the main supplier of its technology, has contributed significantly to the ITU activities and investment. Through ITU, Baobab Energy Systems Tanzania Ltd has managed to increase its productivity, efficiency and sales revenue. Production of electricity meters increased from 300,000 per year before the ITU to 500,000. The government also has provided major support to Baobab by banning importation of electricity meters in 2018 and assuring the firm of a market for the meters it produces.

Challenges/recommendations: The company's main challenges are disruptions in the global supply chains due to the COVID-19 pandemic and the Russia-Ukraine war. These have raised shipping costs for Baobab Energy Systems Tanzania Ltd by 66.6% because it imports some of its raw materials from Russia. Another key challenge is the inadequate finance, as the firm depends on its own funds.

Case 8. Silafrica Tanzania Limited

Depiction: Massive investments in technology to respond to market needs coupled with good leadership to support company multi-product diversification thrive.

Background: Silafrica Tanzania Limited was established in 2007 and is located on Nyerere road in Dar es Salaam. It has 396 employees with 17% of them as female. The company is involved in manufacturing and selling plastic products, including the familiar water storage SIM tanks.

Description of ITU: Silafrica Tanzania Limited is among the most experienced plastic companies in Tanzania, and it is one of the branches Silafrica Limited, which has branches around the world. As part of Silafrica Limited, Silafrica Tanzania has a good pool of experienced engineers in plastics production as well as the latest machines, numbering 55, in their production chamber. All the machines are fully automated and average three years in age. All Silafrica Limited branches use the same level of technology in the production of plastic items. The company invests heavily in ITU and provides machines, experts and technology to branches.

The company has a specialised unit called Innovaxis for developing and promoting innovation using the available experts. It allocates 50% of its total investment to machinery and the rest is shared between human resources (20%) and raw materials (30%). As a result of the ITU initiative and led by marketing intelligence through Innovaxis – the firm's ITU department – the company introduced multi-product operations introducing new products such as crate pallets, bottle-shaped kiosks, umbrella kiosks, tent kiosks, cooler boxes, cool wagon/wave, penguin floor merchandisers, plastic chairs, woodplast furniture sets etc. One particularly interesting innovation is a tank that is smaller but taller than previous versions but carries the same volume of water.

Drivers and impact: The innovation initiative was a result of customer profile research by the marketing department. The success of Silafrica Tanzania Ltd is largely explained by the good working culture, i.e. through the Silafrica way that equips staff with the skills to work properly and ensures team work, involving everyone from the top leadership to common workers. The company also provides good services to its workers, including recognition of the best workers e.g. during the get-together party every year and the monthly best performer awards. As a result of the ITU initiatives, the firm increased its market share, increasing the level of productivity, sales turnover and profits. In particular, Silafrica Tanzania Ltd increased its productivity from 18 tons per day to 21 tons per day; and equipment efficiency rose by 75%. In the future, the company plans to increase production to 30 tons per day and equipment efficiency to 88% to support quality improvement. Realisation of these plans requires huge investment in machinery.

Challenges/recommendations: The main challenge identified by the company was the lack of adequate ITU experts in Tanzania. The company recommends that the government provide tax exemption on the imported machines and technology to boost the country's level of technology.

Case 9. 21st Century Textiles Limited

Depiction: Coupled with the financial ability of the private investor, the ITU facilitated diversification of the products of a once state-owned enterprise into a vibrant textile firm with increased productivity, sales and profit

Background: 21st Century Textiles Limited is a company established in 1978 and located on Dodoma Road in Dar es Salaam. It has a about 2,550 employees out of whom 40% are female. The company converts textiles into fabric and makes garments. It is one of the largest textile industries in Tanzania with the highest efficiency level of 91%, more than 60 installed machines and many textile experts.

All the machines are semi-automatic but relatively old, with an average age of 50 years. The history shows that the company was owned by the government from 1978 until its privatization in 1990. After taking it over, Mohamed Enterprises Ltd, a private investor, made significant investments in the factory, especially in installing machines.

Description of ITU: The firm has a specific unit within the production department that deals with innovation and technology in textile production. Regular ITU at 21st Century Textiles involves investment in machine upgrading, and the last time that occurred was in 2017. The machines bought included automated sewing machines, processing machines and knitting machines. The process of ITU begins in the ITU unit with the production department working with the marketing department to assess the needs of the market and the requirements to fulfil those needs. This is followed by the formulation of innovative ideas to fully meet the needs and a plan on how to bring such ideas into reality. After implementing the plan, i.e. creating innovative products or upgrading the machines, the company monitors and evaluates the progress against such performance indicators as productivity increase, reduction in production costs and efficiency improvement.

Drivers and impact: The main motive for the ITU investment was the need for diversification of the products, particularly to enable the factory to manufacture knit fabric to produce such items as t-shirts, vests, underwear etc. In addition, the company had adequate financial resources for procuring the needed machinery and technology and made a business decision to expand the investment in ITU. The investment has increased textile production from 16 million metres to 60 million metres per annum. Productivity per person rose from 1,000 pcs per person to 4,000 pcs per person, in addition to the improved product quality. According to the company respondent, 100% of the expected impact has been achieved. Clearly, ITU facilitated the diversification of the products and increased productivity, sales and profit for the company.

Challenges/recommendations: The challenges identified by the company included the lack of skilled ITU experts in the textile industry. The company recommends that the government be committed to implementing the established policies and strategies for promoting skills and ITU. Furthermore, the it should reduce or remove all unnecessary taxes and duties that hinder ITU.

Case 10. Twiga Cement PLC

Depiction: To remain competitive in the market, the company combined investment in distribution (chain supply) and quality, which bolstered sales and profit performance.

Case 11. Laylow Limited

Depiction: Interactions with other garment-making SMEs facilitated acquisition of modern and automated machinery that contributed to increased efficiency, productivity and sales.

Background: Laylow Limited is a small garment-making firm located in Dar es Salaam and established in September 2014. It is owned by a male youth and employs 11 workers.

Description of ITU: Although Laylow does not have a formal process for conducting ITU, in 2019 it bought additional button sewing machines and an embroidery machine to improve the quality and speed of button and pattern sewing. Owing to the lack of finance, the firm bought used machines at a low price, and paid for them by instalments. Knowledge acquisition occurred through training and interactions with other small firms, including on recommendations on the machines to buy and help on how to operate them, and market connection. Laylow also used training to increase knowledge and skills of its employees. External trainers come from the company's friends working in other garment-making firms who provide the service for very low fees that are close to nothing.

Drivers and impact: Although no evaluations have been conducted to objectively assess the impacts of acquiring the machines, the company noted that they can easily observe such impacts, including in the improvement in the quality of the finished garments and in the 57% reduction in the time taken to fill customers' orders, which went from 21 to 9 days. The training provided to machine operators has helped uplift their skills. The newly acquired machines have achieved 60% of their expected impact.

Challenges/recommendations: The company has experienced several challenges that have limited its ITU, including the inability to carry out formal R&D activities owing to the low level of education among its employees, and the low availability of quality locally produced fabric, which has forced the firm to import fabric at high prices, which ultimately drags down the firm's competitiveness. The firm recommends that the government (i) help small firms acquire loans at affordable costs to buy new machines rather than used ones; (ii) address the challenge of low availability of locally produced quality fabric in order to increase firms' competitiveness; (iii) collaborate with the private sector to ensure that ITU-related policies are implemented effectively; (iv) promote linkages between academia and the private sector to help the private sector to effectively leverage knowledge transfer.

Background: Twiga Cement PLC, also known as Tanzania Portland Cement PLC, is the largest cement producing enterprise in the country and was established in 1966. It is part of the Heidelberg Cement Group, which holds 69.25% of the shares, with the Government of Tanzania holding the rest. The shares are actively traded on the Dar es Salaam Stock Exchange.

Description of ITU. Twiga Cement is equipped with sophisticated laboratory equipment and experienced personnel. Owing to its commitment to produce high quality cement to comply with national and international standards for consumer satisfaction, the company has invested in modern machinery and equipment. With five brand products, Twiga Cement considers one of the key factors in its success as its regular investment in distributor loyalty, which has ensured that its cement is available in every corner of the country. Its strategy for conquering the market has included combining distribution (chain supply) and quality to yield the maximum impact, as evidenced by the performance in sales and profit. Investment in ITU has included an increase in the number of machinery to meet the increasing demand. Product quality is controlled stringently by harnessing the function of an in-house, well-equipped, modern laboratory. The laboratory has a modern X-ray machine for analysis of geological materials, various semi-processed products and cement. The control of the process in each step of production ensures that the company meets the required quality and production specifications.

Impact and drivers: Owing to the fierce market competition in the Tanzania cement industry, the company has leveraged innovation and technology as a strategy to sustain its growth. As part of the strategy, it invested over US$ 3.2 million to rehabilitate cement mill No. 2, which, in addition to investments made in the previous years, increased cement production capacity by 66% from 1.2 Mta in the then past 10 years to 2 Mta in 2021. Data on the company's performance show that pre-tax profit rose by 25% from TZS 85.87 billion (US$ 37 million) in 2019 to TZS 107.42 billion (US$ 46.3 million) in 2020, as the sales turnover increased by 13% and 6% during the respective years.

Challenges/recommendations: The main challenges noted by this company include (i) concerns on environmental pollution owing to the vast emission of dust, gases, noise, and pollutants from the kiln stacks; (ii) high compliance costs associated with the multiple and frequent inspections by regulators; and (iii) high competition from the many cement producers in Tanzania. The company recommends that the government work with the private sector in addressing such challenges as environmental pollution rather than taking unilateral decisions to shut down plants over their lack of pollution-handling technology, since it takes time and a huge amount of money to acquire technology that is favourable to the environment.

Case 12. Apex Resources Limited

Depiction: Combining machine and skills acquisition through trainings

Background: Apex Resources Limited is a Das & Co. subsidiary located in Chunya district of Mbeya region, and was formed to process undervalued gold in Tanzania. The company's model includes utilising advanced technology to extract economic yields of gold from high-concentrated ore and tailings inventory at reduced prices. Once Apex Resources processes smelted gold from its production in Tanzania it sells it to refineries in Dubai through its licensed affiliate Das Brothers Trading DMCC.

Description of ITU: Although Apex Resources does not have an R&D department, it has a point person who deals with issues of machinery technology and provides advice on the machines to buy etc. Once funding has been allocated, the machines are procured and training undertaken for the operators before they use the machines. The company conducts regular machine improvements including repair and buying of new machines. The aim is to eliminate interruptions during production, increase the productivity and quality of smelted gold, and reduce environmental pollution. The new machines bought are usually imported and sometimes a foreign expert is required to support their installation and to provide training to operators on how to use them.

Drivers and impact: The company's objectives in carrying out ITU included increasing output, quality and productivity and reducing waste emitted into the environment. One key success factor has been the availability of internal funding to buy the machines and hire foreign experts. In addition, the company has a point person for machine technology who provides advice on the new machines needed for the company's needs and where to get them. Based on evaluations done, the new machines have helped reduce interruptions during gold processing and have hence increased productivity, improved the quality of smelted gold and reduced environmental pollution.

Challenges/recommendations: The challenges faced by firm in its ITU activities include machine costs and difficulties in processing work permits for foreign experts. Training is used to uplift the overall skill profile of employees and covers areas relating to technical and managerial aspects. The firm recommends that the government to (i) reduce import duties on imported machines and costs of processing work permits for foreign experts in order to help reduce the overall costs of adding new machines; (ii) improve the reliability of power supply to reduce production interruption and machine damage; and (iii) promote linkages between educational institutions and manufacturing firms to support learning.

Case 13. Tanzania Tooku Garments Company Ltd

Depiction: Massive investment in modern industrial production technology bolstered quality and productivity, which have significantly helped to sustain competitiveness in the export market.

Background: Tanzania Tooku Garments Company Ltd is a garment producing enterprise for the United States African Growth and Opportunity Act (AGOA) market specializing in jeans and operating under the Export Processing Zone scheme. The company started operations in late 2012 with 250 employees in one building and producing 35,000 pieces of jeans monthly. Currently it has six factories employing 3,200 employees. It produces only for the export market, particularly for the US, Canada and European countries.

Description of ITU: Tanzania Tooku Garments does not have an R&D department but does have a point person who oversees issues of ITU. The key objective of ITU was to enable the company stay competitive in the export market. Following the ITU initiative, Tanzania Tooku Garments made major improvements to the production process by mainly installing automatic pocket setter machines and an automatic hanger system to improve the movement of unfinished garments among operators during production, shifting from the traditional process. The technology acquisition involved installation of new machines by foreign expatriates who also provided the required training to the operators. Technology transfer happens mainly through training and interactions with clients. The company faces competition from producers in Kenya, Ethiopia, Lesotho and Cambodia. Foreign customers want a supplier who is reliable in terms of technology, quality and time used to produce garments.

Drivers and impact: Some of the key factors that led to successful ITU include the fact that the company obtained financing internally and that it is operating under the EPZ scheme, which enabled it to obtain customs duty exemption on imported machines. Following the installation of the new machines, the firm was able to increase its productivity output of pieces of garments per hour from 1,800 to 2,300, that is 28%. Furthermore, Tanzania Tooku Garments improved the quality of the finished garment and increased the efficiency of operation, worker skills and garment quality. The impacts represent 80% of the company plans and expectations for the ITU undertaken.

Challenges/recommendations: The challenges experienced by firm in promoting ITU include the high cost of processing work permits for foreign expatriates which is about US$ 3,500 to US$ 4,000 per person for two years, and the low level of skills among local workers that affects their ability to acquaint themselves with new machines or technology. The firm recommends that the government improve the training provided by TVET institutions so as to produce more skilled machine operators. The SEZ/EPZ scheme has been effective in attracting foreign direct investment, which brings in new technologies and knowledge that can be transferred to domestic producers. However, there is little if any linkage between SEZ investors and the local economy.

Case 14. Malebu Company Ltd

Depiction: Operating in the cluster facilitated learning from other firms in the cluster.

Background: Owned by a local investor, Malebu Company Ltd is a microenterprise operating in Tanzania and engaged in manufacturing residential and commercial wood products including household furniture, doors, windows and custom wood products. The company is located in Keko cluster, Dar es Salaam and employs four full-time employees all of whom are male**.**

Description of ITU: Although Malebu Company is yet to engage in any technology upgrading initiative, it has been producing a variety of new design furniture, including beds, shoe racks, cupboards, sofa sets etc., to keep up with customer and market demands. The firm's technology upgrading and innovation acquisition occur through learning from and observing other firms operating in the cluster. However, as the firm's respondent noted, that there were some furniture designs that Malebu Company could not produce mainly because the machines required to produce them were not available in the cluster and the materials needed for production were very expensive. Nonetheless, operating in the Keko cluster has greatly helped the company, since knowledge is shared through cooperation among the firms.

Drivers and impact: The company revealed that shifting to new furniture designs has helped it to continue receiving customers, which is a sign that the company remains competitive in the market.

Challenges/recommendations: The main challenge is the stiff competition, since the firms in the cluster produce same designs. Firms that come up with new designs are quickly imitated by the others.

Case 15. OpenSanit Company Limited

Depiction: The strong push to remain competitive and sustain sales required harnessing the available opportunity to supply the emerging market needs for protective gear, alternative packaging materials to replace the banned plastic bags and face masks, which necessitated carrying out ITU. Interaction with other firms and conducting R&D and training were essentials in ITU.

Background: OpenSanit Company Limited is a locally owned, medium size firm located along Nelson Mandela Road in Dar es Salaam. It has a total number of 150 employees of whom about 18% are female. It was established in 1998 and is engaged in manufacturing uniforms, tents and tarpaulins and supplying safety gear such as personal protective equipment etc.

Description of ITU: Most of machines in the company are semi-automated and a few others are manual. The main ITU initiative was carried out in the zeal of the company to leverage opportunities arising from the need to address certain challenges facing the country. In particular, the government ban on plastic carrier bags in a move to address plastic pollution in the country led to a shortage of alternative carrier bags. OpenSanit decided to engage in the production of paper bags in a bid to supply the increasing demand and increase its sales. Although the bags were already being produced everywhere around the world, this firm was producing them for the first time. This venture was facilitated by the good interdepartmental coordination among the strategic planning and marketing departments, which together formulated a good business plan. The firm entered into a partnership with CRDB Bank for access to funding through affordable bank overdraft facilities. The company learned more through training and interactions with other firms than through R&D, which for them happens relatively infrequently. The knowledge obtained from such avenues covered areas such new production techniques, new products, markets and suppliers, and improved managerial practices. The decision to produce and supply paper bags required OpenSanit to bring in new machines and provide training to workers on how to operate them.

Drivers and impact: The company's motivation was the goal to increase sales and productivity by penetrating new markets and producing new products. One key factor in the success has been internal management approaches where the strategic planning unit works hand in hand with the marketing unit to identify and harness opportunities by supporting the management to invest in the required machinery. In addition, the company carries out monitoring and evaluation to assess the results. The success of the paper bag business was a result of having reliable off-takers who bought the initial supply of the paper bags and the good interactions with other firms in conducting R&D and training. The production of paper bags helped to increase the company's sales by 8%, while the company's improvement of machines and training of workers helped to improve the overall company productivity.

Challenges/recommendations: OpenSanit has encountered several challenges that limit its ITU activities, including the lack of adequate skills for conducting R&D. The firm recommends that the government improve the business environment to support acquisition of new technology or increase investment in innovation. According to the company, the government policies and institutions are not very effective in promoting ITU in the Tanzania industrial sector. Although OpenSanit is a member of the industry association, the Tanzania Chamber of Commerce, Industry and Agriculture, the only benefit from that is in marketing of their final product and not on the promotion of ITU.

Case 16. Hill Packaging Limited

Depiction: Unique bottle design to provide palm fit and winsome experiences in addition to natural water taste and strong branding enabled the firm to conquer the market

Background: Hill Packaging Limited is a Tanzanian-owned company that specialises in the manufacture of bottled water. It was established in 2007 and is headquartered in Mapinga, Bagamoyo in the coast region. Currently it employs 200 full-time employees.

Description of ITU: Hill Packaging Limited does not have an R&D department, but R&D operations are overseen by the laboratory and marketing departments, which are responsible for the quality of every product manufactured. The bulk of the firm's machines are fully automated, with a few others that are semi-automated. The degree of automation is around 75%. To stay competitive in the market, Hill Packaging Limited changed the design of its water bottle to provide better palm fit and winsome experience, and undertook strong branding and improvement in water filtration and processing to ensure a great taste. They branded their delivery vehicles to advertise their business and create a brand loyalty. This door-to-door delivery of water is a part of a very aggressive marketing strategy. They also use an agent for water delivery.

Drivers and impact: Generally, Hill Packaging Limited's product innovation is driven by the need to remain competitive in a saturated market. More critically, the company had the required financing to cover the costs of the ITU. The design of the bottle has afforded the company an opportunity to penetrate new markets and sustain their market position. The firm observes high hygienic conditions in water processing to ensure the quality and natural taste of their water. As a result, and far from what they expected, as a company official noted, they have surpassed their production and sales milestones. The number of full-time employees rose from 150 to 200 (a 33% increase) after the ITU initiative. The firm employs two methods for knowledge transfer: market research and training. Market research opens doors to new manufacturing processes, goods and markets. Employee training increases productivity.

Challenges/recommendations: The firm identified as a main challenge the protection of its innovation, given the existing copy and paste malpractices in the market. Such practices limit the returns on ITU. Another challenge is the frequent inspection by regulators, which interferes with the production schedule. Regulators make visits to the plant almost every other month to inspect the same thing, and sometimes do require the machines to be turned off during inspection.

“Literally no one wants to waste money for something that can be easily copied.” Hill Water respondent

The firm recommends consolidating all the inspection visits into one to reduce their duplications and multiplicity that make compliance costly. Also, the government should strive to lower the cost of production by improving the business environment for firms to compete in the regional and continental markets.

“The way the market has responded has given us the energy to continue, that is despite all the challenges. ITU is the way out if you want to win the market.” Hill Water respondent

Case 17. Tanga Cement PLC

Depiction: Investment in superior technology, high quality and operational efficiency buttressed the company’s plan to remain innovative and competitive in the market by introducing a new product that would cater for multiple customer needs.

Background: Tanga Cement PLC is the prime supplier of cement to various construction and housing projects in Tanzania and in the East African region. The formerly state-owned enterprise established in 1980 was divested and has changed its ownership structure several times. Currently 68.3% of the shares are owned by AfriSam Mauritius and 31.7% of the shares by Tanzania public institutions and individuals. The company’s flagship brand, Simba Cement, enjoys healthy brand equity with the highest customer recall due to its consistent high quality.

Description of ITU: The company invests in R&D activities spanning production, distribution, marketing and sales areas. It recruits professional and qualified personnel from different nationalities to support its strategy to improve its business operations. The larger part of the production process now uses automated operations. Also, the company offers technical support to customers, for example in the selection of proper aggregates materials for concrete mix design, cement storage facilities and handling and stacking of cement bags (Lumliko, 2017). The company’s main innovation is its new Mkombozi all-purpose 32.5N cement launched in 2016 that meets requirements for various construction activities. The product was part of the company’s strategy to serve the expanding market demand with innovative and high quality products. Notably, production of the Simba brand involved a careful process by a team of dedicated professionals to

Impact and drivers: The aim of the ITU investment was to expand the market by offering a range of product varieties to fit the increasing domestic demand. Following the innovation, and despite the challenges posed in the market, ITU has helped Tanga Cement PLC to expand its production capacity and cater for multiple needs of cement customers. The goal is to continue to be innovative and competitive in the market. The company plans show that the investment in ITU will help increase clinker capacity from 0.5 Mta to 1.25 Mta. In addition, the innovation is expected to reduce the import bill and improve operational efficiency. For instance, the company invested in a system that will ensure smooth production operation even when there is a power interruption.

Challenges/recommendations: The company noted three main challenges: the frequent power cuts, the depreciation of the currency that makes payment of loans more expensive, and the stiff competition in the market, especially Dangote Cement. These challenges increase the cost of production and affect the firm's competitiveness. For instance, the company reported a drop in revenue of 20% in 2016 as a result of new competition. The poor quality of domestic clinker forces the company to import a more expensive type, increasing the cost of production. The firm recommends that the government ensure that cement companies have a reliable source of power supply and there is stability in foreign exchange to reduce losses for domestic companies. The management noted that Vision 2025 has been a guidepost for Tanga Cement in forecasting the cement demand and planning production capacities.

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