United Nations
Economic Commission for Africa

Advancing Technology Transfer for Sustainable Development in Africa

Revisiting Africa's Technology Transfer Landscape in the wake of COVID-19

Acknowledgement

Through its internal research and commissioned ones, United Nations Economic Commission for Africa (ECA) assessed the various mechanisms and country experience in the acquisition of foreign technologies and the commercialization of domestically developed research outputs to enhance socio-economic development. Consequently, it has commissioned studies in several African countries. The first round was published in 2010.

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Preface

The UNECA series on Technology Transfer for Africa's Development are designed to draw attention to the importance of technology transfer in economic development. The main objective of the studies in this series is to explore trends in technology transfer, the preferred modes and channels of technology transfer, the impact of technology transfer on industrial productivity and efficiency and the mechanisms and measures countries may use to facilitate technology transfer.

All countries depend on technology transfer to meet some of their national aspirations and challenges. It is difficult for many countries, including many developed countries, to specialize in all fields of technology. For many developing countries, technology transfer is the mainstay of their sustained technological, industrial and economic transformation. Many of today's developed and fast-growing countries rely on technology developed by others to grow.

Therefore, the series seek to understand the interplay between technology transfer and development. It unravels and highlights the contribution of technology transfer to innovation, entrepreneurship, investment, efficiency, productivity and export performance of African countries. Highlight research in a selected number of countries: Ethiopia, Ghana, Kenya, Morocco, Rwanda and South Africa.

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1. Introduction

Technology is deemed vital to catalyzing innovation; promoting industrial and economic growth; and effecting social changes and human development to improve lives. African countries need to make presence, acquire and absorb the technology imperative to meeting their various social-economic development imperatives as outlined in the Agenda 2063, and to actuate the catching up with developed counterparts. Given that Africa's share of the world's research and development output remains low and most African countries are marginal producers of new technologies, domestic as well as international technology acquisitions and transfers can serve as a critical means to help narrow technology gaps and accelerate technological advances in African countries.

Technology transfer is not a new phenomenon. The topic has grasped policy and research attention for almost five decades, with its importance evident in the creation of the *Journal of Technology Transfer* back in 1977 dedicated to international research on technology transfer strategies, practice and management. Amidst the large and diverse body of literature, research on technology transfer in the context of Africa remains relatively limited and the understanding is partial. Yet, it is observed that the technology transfer landscape on the African continent has undergone dynamic change and development in the past decade, driven by improvement in related policy frameworks; rapid technological changes; and the development of technology sectors and markets in African countries. More empirical research on Africa's technology transfer activities and practices are warranted to generate relevant, current and deeper knowledge for informing practice and policy discussions, and for providing recommendations for the way forward.

This Introduction Chapter will first lay down fundamental understanding of key concepts, specifically 'technology' and 'technology transfer'; and specify common technology transfer modes and mechanisms to enable clearer and synchronized interpretation of the contents by readers. The chapter then presents the aim and focus of the report, offering a more detailed picture of the background that motivates and justifies the work. The choice of empirical countries for focused national-level studies, and the data collection design are then explained. An overview of each of the national studies commenced for this research is also presented.

1.1 Defining Technology and Technology Transfer

Defining 'technology' and 'technology transfer' upfront for the report is important to: 1) establish a clear boundary and scope of the related aspects being covered (e.g. activities; models; media; channels, etc.); 2) identify and select relevant, indicative and meaningful measures and proxies to assess the extent and outcome of technology transfer; and 3) enable a comparable, consistent and comprehendible synthesis of evidence from different contexts (e.g. organizations; sectors; countries).

The concept of technology remains ambiguous and diverse despite the large body of literature on the subject. Hannay and McGinn (1980) criticised that 'failure to specify clearly what one means "technology" has resulted in persistent, mistaken, and misleading identification of technology with science, applied science, "hardware" (material artifacts), or with all the "products of technology" […]' (p.26). The lack of a clear definition is considered as a major hindrance to bridging cross-disciplinary discussions about technology transfer (Zhao and Reisman, 1992).

The Draft International Code of Conduct on the Transfer of Technology negotiated at the sixth session of the United Nations Conference defines technology as 'systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service' (UNCTAD, 1985, chapter 1, para.1.2.; see also Roffe, 1985). The definition has since been widely adopted in publications on the topic by UNCTAD[1].

While it is acknowledged that 'all technologies are embodiments of some form of human knowledge' (Parayil, 1991, p.292), interpreting technology only as a form of knowledge may be too narrow to disguise the complex content of its various components. Sharif (1987) tried to unpack the complexity of technology as a combination of four elementary forms of knowledge, tools and know-how as object-embodied (e.g. materials; machines; products); human embodied (e.g. knowledge, skills, creativity); record embodied (e.g. facts, relations, processes); and institution embodied (e.g. structures; means; interaction) (also see Technology Altas Team, 1987). Similarly, Dosi (1982) defined technology 'as a set of pieces of knowledge both directly "practical" (related to concrete problems and devices) and "theoretical" (but practically applicable though not necessarily already applied), know-how, methods, procedures, experience of success and failures, and also, of course physical devices and equipment' (pp.151-152).

Across the different conceptions, there is a common understanding that technology can be embodied in different tangible or intangible forms. Regardless of the form of embodiment, a defining characteristic of technology is its application and utilization. Herschbach (1995, p.33) explained that 'technology best finds expression through the specific application of knowledge and technique to particular technological activities'. In this regard, technology should not be seen as identical to science (even applied science) nor knowledge (also see Brooks, 1994; and de Sollar Price 1965). On the other hand, it is more commonly viewed as 'a tool' in technology transfer research (Bozeman, 2000; also see Arthur, 2007; Eveland, 1986). This view finds support in a 2020 Pew Research study, in which a majority of the 697 participating experts (covering technology innovators, developers, business and policy leaders, researchers and activists) in the US described technology as simply a tool which real effects depend upon how it is used (Vogels, Rainie and Anderson, 2020). Research on technology transfer has increasingly sought to investigate the eventual application, output and outcome of the transfer, in addition to the traditional focus on what, how, and

[1] For example, UNCTAD (2001) Transfer of Technology; UNCTAD (2014) Transfer of Technology and knowledge sharing for development;

between whom the technology is transferred[2] (Bozeman, 2000; Bozeman, Rimes and Youtie, 2015; Eveland, 1986).

The conception of technology transfer is equally problematic, due to the ambiguous definition of technology mentioned above and the cross-disciplinary nature of the field. Consequently, the term *'technology transfer'* is interpreted differently by disciplines (Zhao and Reisman, 1992) and further by the different purpose of individual research works (Bozeman, 2000). However, with the fundamental understanding of the term '*technology*' established in the above section, one can focus on how the term *'transfer'* is (*and should be*) conceived and understood in this report.

Autio and Laamanen (1995) looked at the Latin origins of the word '*transfer*', explaining that the Latin word *'trans'* means over or across the border and *'ferre'* means to carry. Therefore, 'technology transfer can be viewed as an active process, during which technology is carried across the border of two entities. These entities can be countries, companies, or even individuals, depending on the viewpoint of the observer' (p.647). The process involves a 'movement' of the technology from one entity to another via specific mechanisms and forms (Roessner, 2000; Rogers, Takegami and Yin, 2001).

Rogers et al. (2001) further remarked that such a movement (i.e. the *act* of technology transfer) is usually directed from the technology source – the owner or holder of technology (e.g. an R&D conducting organization) to a recipient, by which the technology will be used and applied. The application of the technology can be in 'the manufacture of a product, for the application of a process or for the rendering of a service' but shall not simply involve 'mere sale or lease of goods' (UNCTAD, 1985) or the transfer of a piece of hardware from one location to another (Rosenberg, 1982). To achieve the intended application of the technology, the recipient needs to have certain level of absorptive capacity[3] and make investment in the learning, adaptation, modification, and improvement of the technology to fit the local conditions (Cusumano and Elenkov, 1992; Guan et al., 2006). Thus, the cost of technology transfer covers not only the cost of transmission but also the cost of absorption (Teece, 1997). Similarly, the supplier and/or the transferer of technology needs to possess the ability to identify and activate technology transfer opportunities as well as the requisite skills such as communication, negotiation and networking skills to enable effective transfer (Lager and Hassan-Beck, 2021; Mom, Oshri and Volberda, 2012).

This report will interpret, analyze, and explain technology transfer as a planned and deliberate movement of a specific technology between two or more entities, in which the transferor and the recipient are identifiable, and their respective motives and purposes can be comprehended in most cases. This marks a clear distinction from the conception and discussion about 'technology diffusion', which involves a generic view of the adoption and uptake of a technology by a broader target population. Yet, one can expect that increased transfer of a technology is likely to promote and accelerate the diffusion of that technology in the society, resulting from the multiplied sources of the technology and its extended applications in a series of transfer.

[2] Bozeman et al. (2015) termed it as the 'Out-the-Door' approach/ lens in technology transfer literature, which key criterion to assess technology transfer is 'was technology transferred' (p.37). It does not concern about whether the receiving end has put the technology to use or the impact it creates.

[3] Cohen and Levinthal (1990) defined absorptive capacity as 'the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends…' (p.128)

1.2 Technology Transfer Modes and Mechanisms

Existing literature has recorded an array of technology transfer mechanisms, defined as 'any specific form of interaction between two or more social entities during which technology is transferred' (Autio and Laamanen, 1995, p.648; also see Winebrake, 1992). Continuous technological changes and advances have created and enabled new mechanisms for the purpose over times.

1.2.1 Technology Transfer from Public Research Organizations and Universities

Based on a case study of one of Australia's largest public R&D organizations: The Commonwealth Scientific and Industrial Research Organisation (CSIRO), Upstill and Symington (2002) differentiated technology transfer mechanisms deployed by R&D conducting organisations in three primary modes namely *non-commercial transfer, commercial transfer, and new company generation*.

- *Non-commercial transfer* often takes place without formal contractual agreements and in disembodied forms (i.e. not in the form of any artifact, device, product embodying the technology). *Non-commercial technology transfer mechanisms* may include seminars, workshops and training courses; publications and presentations; staff exchanges and secondments; and co-supervision of researchers and informal contacts.
- *Commercial transfer* is usually conducted under formal commercial agreements and contracts; thus, it involves formalised transaction with the recipient of the technology through collaborative research or contracted research projects; consulting or technical services; and licensing and sale of intellectual properties. The commercial transfer mode is usually governed by clear policy frameworks as well as codified processes and practices of both the transferor organization and the recipient entity.
- *New company generation* involves the transfer of technology to a new commercial entity, such as a start-up or a newly created joint venture. In the CSIRO case, for example, technology transfer mechanisms include spin-offs by former CSIRO staff (either using the IP directly generated by CSIRO or acquired during their careers in CSIRO) and technology transfer companies that based primarily on IP from CSIRO. In another study by Rogers et al. (2001), similar technology transfer mechanisms were also used by national R&D laboratories in New Mexico in the US, with spin-offs named as the most effective means of technology transfer from these laboratories.

The emergence of *new company generation as a technology transfer mode* signifies an increasingly common practice of public research organizations to institutionalize their IP protection and licensing, through setting up specialized intermediary units and agencies (e.g. technology transfer office; licensing office) within the organization. These specialized units and agencies help proactively protect and license the defined technologies of public research organizations to external entities, particularly private enterprises (Aridi and Cowey, 2018; Cruz-Castro and Sanz-Menéndez, 2007).

Moreover, many public research organizations take a step forward to be directly involved in the commercialization of their technologies into products, through promoting and even taking stake in spin-offs. This allows them to generate revenues from the commercialized outputs of the technology, in addition to the licensing fees and royalties from the IP.

The trends and organizational configurations concerning technology transfer in public research organizations have also been observed in the transfer of technology from universities to the industry (Li and Tan, 2020; Perkmann et al., 2013; Siegel, Veugelers and Wright, 2007; Temel et al., 2021). The university-industry technology transfer in specific has been highlighted as one of the core elements in the making of the entrepreneurial university[4] (Etzkowitz, 1983; 2013; Hsu et al, 2015; Villani, Rasmussen and Grimaldi, 2017).

1.2.2 Inter-Firm and Intra-Firm Technology Transfer

The transfer of technology between private business-oriented entities can occur between different firms (i.e. *inter-firm*) and within the same firm (i.e. *intra-firm*). The notion of 'inter-firm' and 'intra-firm' may generally be differentiated based on the ownership, control and respective hierarchical relationship of the entities concerned.

Inter-firm technology transfer involves obtaining existing technology from business entities *external* to the firm's control and hierarchy through trade, acquisition and collaboration. It is considered as a fast and efficient alternative to, and often complementarity of, in-house R&D. Specifically, inter-firm technology transfer is motivated and deemed more beneficial when internalization advantages are not significant; in-house R&D costs and risks are too high; internal technological capabilities are constrained; and/or the need to respond to the technological or market development is pressing (Chen, 2005; Hu, Jefferson and Jinchang, 2005; Moreira, Klueter and Tasselli, 2020). The fast-paced technological and market changes; shortened product life cycle; evolution and emergence of new players (including start-ups and emerging country firms) in the global technology market; and the receptivity of open and collaborative innovation strategies as a mainstream organizational practice instead of an exception, have all made inter-firm technology transfer a key corporate competitive strategy nowadays.

Intra-firm technology transfer has also been emphasized as strategically important to business development amidst the intensified decentralization and internationalization of R&D activities of firms in the last two decades (Belderbos, Lykogianni and Veugelers, 2008; Gassmann and von Zedtwitz, 1999; Malik, 2002; Papanastassiou, Pearce and Zanfei, 2020). Consequently, research on international business in general and international technology transfer in specific has placed greater attention on the trend and practice of technology transfer between the headquarters (or parent) of multinational enterprises (MNEs)[5] and their geographically dispersed subsidiaries and affiliates; also among subsidiaries and affiliates of MNEs in different host countries (Blomkvist, Kappen and Zander, 2019; Dunning, 1994). This stream of research extends the conventional discourse surrounding a unidirectional view of MNEs from developed countries as the vehicle bringing and transferring technology externally to local firms and internally to local subsidiaries in host locations, particularly those in developing countries (Sampath and Roffe, 2012). As a main disruption to this conventional discourse, it is increasingly recognized that developing host countries can also be sources of technology. Hence, reverse technology transfer from subsidiaries and affiliates in host countries can play an imperative role in MNEs' development of integrated global technology networks (Criscuolo, 2009; Elshout, 1995; Hsu and Iriyama, 2016).

The choice of technology transfer mechanisms for inter-firm and intra-firm transfer often involves more complex organizational considerations about internalization, co-ordination, decentralization, interdependence, and so forth. The complexity further increases in the case of international transfer

[4] UNECA has led a separate project on the entrepreneurial university in Africa. A draft of report on the first stage of the project can be accessed in: https://uneca.org/sites/default/files/Entrepreneurship_Doc.pdf

[5] Dunning (1994) defines MNEs as those firms that "control and coordinate value added activities across national boundaries"(p.67). The definition may also cover transnational corporations as referred to in UNCTAD's annual World Investment Report.

across country borders, where market and institutional contexts[6] can be significantly different. It is worth noting that a majority of international technology transfer mechanisms are intertwined with international trade and foreign direct investment strategies of firms (Kowalski, Rabaioli and Vallejo, 2017). In the face of these complexities, Radosevic (1999) categorized major technology transfer mechanisms into market, network (intermediary) and hierarchical oriented ones, as depicted in Table 1.1 below.

Table 1.1. Types and Dimensions of Firms' Technology Transfer Mechanisms

Mechanisms	Mode of Transfer		
	Market	Network (Intermediary)	[Firm] Hierarchy
Direct foreign investment (e.g. foreign subsidiaries)			X
Joint ventures			X
Co-operative alliances*		X	
Licensing	X		
Subcontracting		X	
Imports of [capital] goods	X		
Exports	X		
Transfer by people		X	
Development assistance	X	X	

Source: Radosevic (1999)

**These include production sharing agreements; management and marketing contracts; service agreements; R&D consortia and other co-operative contracts and pacts; franchising; and other technical services agreements.*

Level of resource commitment varies by these mechanisms (Tsang, 1997). Further, different mechanisms require different types of relationships in terms of length, intensity and interdependence between the entities concerned. Arms-length transactions (e.g. licensing, imports and exports) involve relatively lower interaction and interdependence between entities than longer-term collaborative and equity agreements (Lema and Lema, 2012). In this regard, the choice of technology transfer mechanism(s) present significant strategic implications about the cost, risk and uncertainty for both the transferor and the recipient of technology.

A majority of the technology transfer mechanisms identified in Table 1.1 are governed by formal rules and procedures; they either have legal-binding contracts or agreements in place. It is recognized that technology transfer by people, either internal or external to the firm, can also take place informally via different channels such as personal contacts; words-of-mouth communication; meetings and conferences (Grimpe and Hussinger, 2013). While 'informal transfer of technological information between firms is a frequent and important phenomenon' (Schrader, 1991:154), capturing and measuring informal transfer activities can be challenging and the scope difficult to define.

[6] Drawing upon Scott's three institutional pillars (1995), these differences may exist in regulatory (e.g. policies, laws, rules and regulations, technology and innovation systems, etc.), normative (e.g. value, norms and common practices), and cognitive-cultural (e.g. culture; shared understanding, etc.) dimensions of institutions that affect technology transfer approaches and activities of individuals and firms in different countries. Also see Munir (2002).

Accordingly, this report focuses mainly on technology transfer activities that take place through formal mechanisms.

1.3 About this Report

1.3.1 Research Background and Aims

With an established understanding of what technology transfer entails, this report focuses on technology transfer in Africa in general and the selected African countries for empirical studies in specific. It aims to:

- examine the status and identify trends of technology flow and transfer of African countries using various proxies;
- reveal major technology transfer practice through country examples and cases;
- articulate key lessons and implications for accelerating technology transfer as a means in support of the continent's development goals.

This study extends the work entitled *'A technological resurgence? Africa in the global flows of technology'* published as part of the UNECA series on technology transfer for Africa's development in 2010. The following decade (2011-2021) after the 2010 publication has seen a majority of African countries stepping up investment in enhancing and harnessing STI to effect national development. In 2014, the Science, Technology and Innovation Strategy for Africa 2024 (STISA-2024) - the first phrase of a ten-year strategy placing STI at the centre of Africa's 'Agenda 2063' – was adopted at the 23rd African Union Summit. It is recorded that by 2020, at least 25 African countries have national STI policy frameworks and some are in the process of revising and renewing their old frameworks (UNECA, n.d.).

Technology transfer, which is widely pronounced as a viable instrument to filling technology gaps, accelerating technology learning and upgrading, and enabling technology-based development of African countries, occupies a vital place in African countries' national STI policy frameworks and their respective industrial development plans. Morocco's Industrial Acceleration Plan (PAI) 2014-2020[7], for example, places a strong emphasis on establishing industrial ecosystems that encourage technology transfers and collaborations among key actors to enhance global competitiveness of its industries. The National Intellectual Property Policy and Strategy (NIPPS) launched by Ghana in 2016 envisions fast-track national development through promoting and facilitating commercial exploitation of intellectual properties rights and technology transfer (Duncan, 2020). The revised STI policy adopted by Ethiopia in 2012, in alignment with the country's first Growth and Transformation Plan (GTP 1) implemented in 2011, gives stronger emphasis on transfer of technology rather than local technological learning and innovation capability-building (UNCTAD, 2020). Looking up to the Bayh-Dole Act in the U.S. as a legislation cornerstone to incentivize technology transfer from publicly funded institutions, the Intellectual Property Rights from Publicly Financed Research and Development Act (Act No.51, 2008, IPR Act) of South Africa came into effect in 2010 (Brant and Sibanda, 2018; Mustapha and Ralphs, 2021). With the African Continental Free Trade Area (AfCFTA) being put in place since 2018 and trading under the agreement commenced in 2021, it is expected that the Protocol on Intellectual Property Rights - currently under negotiations - can further catalyze intra-Africa technology transfer (Nkomo, Mthombeni and Lehong, 2020). For example, the establishment of the mRNA vaccine technology transfer hub in South Africa in 2021 has highlighted the

[7] Morocco Ministry of Industry and Commerce: https://www.mcinet.gov.ma/en/content/industrial-acceleration-plan-2014-2020

need for accelerated technology transfer across African countries to combat common social and economic challenges[8].

With the regional and national governments on the continent intensifying their commitment to improving the regulatory institution in favour of technology transfer, the rapidly growing technology sectors in certain African countries have become increasingly attractive to foreign investors. *Foreign direct investment (FDI)* has been deemed an important channel for transferring technology to host countries, either through direct linkages with domestic firms or indirect knowledge spillover (Feinberg and Majumdar, 2001; Young and Lan, 1997). Accordingly, many developing countries are tactical in deploying inward FDI through different policy measures to achieve such purpose (e.g. by filtering FDI projects; including requirements for technology transfer; requiring joint venture or other equity ownership with domestic firms; offering incentives for collaboration; etc) (Kowalski, Rabaioli and Vallejo, 2017).

FDI inflows and outflows from Africa still account for a small proportion of the world's total at 5.2% and 0.16%, respectively in 2021. However, it is important to note that mergers & acquisitions (M&A), a particularly direct channel for technology transfer between business entities, have regained traction in 2021 after the significant decline during the peak of the pandemic. It was estimated that there were in total 333 M&A deals (valued at US$57.7 billion) in the first half of 2021 with the highest volume transactions in diverse sectors that cover the materials (33 deals), financials (26 deals), energy and power (24 deals), high technology (14 deals) and telecommunications (9 deals) (Baker McKenzie, 2021).

Addressing the M&A trend in Africa, Boston Consulting Group reported three key observations[9] that may offer insights into analysing the emerging technology transfer: 1) African-led acquisitions on the continent are rising; technology start-ups are attracting multiple investors; and African integration makes regional platforms plays a reality (Fihri et al., 2021). Similarly, an EY report (2021) found that the share of FDI into the service sectors in Africa is rising rapidly in the last few years. Among the 516 FDI projects recorded in 2020, almost half of them (257) were in business services, telecommunications, media and technology, and financial services. Further, 138 projects (27%) were in advanced manufacturing, automotives and renewable energy. It is also observed that global big technology companies are seeking to increase their presence on the continent despite the pandemic in the past few years (Conway, 2020; Salaudeen, 2019). For example, Google has opened its first Artificial Intelligence Lab in Accra, Ghana in 2019; Microsoft has also established two sites of Africa Development Centre in Nairobi, Kenya and Lagos, Nigeria; Facebook announced in 2020 it will open its second African office in Lagos, Nigeria. *Although many of these FDI projects in technology sectors are still geographically concentrated (e.g. in Cairo; Cape Town; Lagos; Nairobi), the growing FDI trend presents a future of diverse opportunities for increasing the extent and intensity of technology transfer within and across African countries as well as beyond the continent.*

[8] It was announced by WHO that six African countries Egypt, Kenya, Nigeria, Senegal, South Africa and Tunisia will receive the initial transfer of the technology. Source: UN website

[9] The BCG report articulates 5 observations in total, the remaining two not included in the main text are: more African-focused private equity (PE) investors are emerging; and state-owned enterprises may soon be open for private capital again.

Against this backdrop, this report presents a timely endeavour that extends the previous work and responds to the recent trends and development on the African continent, to provide current knowledge of African's technology transfer landscape.

1.3.2 Empirical Locations

Primary research was conducted in six African countries, namely **Ethiopia, Ghana, Kenya, Morocco, Rwanda, and South Africa**. These countries are from different regions of Africa, and they are at different stages of economic and technological development. The choice was deliberately made to account for the diversity of African countries, in order to capture a more inclusive view of technology transfer practice. Table 1.2 presents selected country profile data of these six countries.

Table 1.2. Selected Country Profile Data of the Six Empirical Locations

	Ethiopia	Ghana	Kenya	Morocco	Rwanda	South Africa
Region in Africa*	East	West	East	North	Central	Southern
GNI per capita, current US$ (World Bank, 2020)	890	2,340	1,840	3,020	780	6,010
Global Innovation Index Ranking** (WIPO, 2021)	126	112	85	102	77	61
2.3 Research & Development	100	93	78	71	85	43
5.2 Innovation Linkage	108	60	35	112	31	53
5.3 Knowledge Absorption	75	130	68	103	89	51
6.3 Knowledge Diffusion	109	101	45	63	123	81
Number of Patent Applications (WIPO, 2020)	60	20	424	2,688	n/a	6,688
By non-residents	54	8	35	2,438	n/a	6,146
Number of Industrial Design Application (WIPO, 2020)	n/a	1,013	223	976	52	1,708
By non-residents	n/a	89	19	273	46	738
FDI Inflow, US$ million (UNCTAD, 2021)	2,395	1,877	717	1,763	135	3,107
FDI Outflow, US$ million (UNCTAD, 2021)	n/a	542	-7	492	n/a	-1,973
Capital Goods Imports, US$ million (World Bank data)	4,268 (2018)	3,081 (2019)	3,991 (2019)	13,227 (2019)	621 (2019)	24,348 (2019)

*Based on classification in World Investment Report by UNCTAD; ** In total, 132 economies were ranked in the WIPO Global Innovation Index 2021.

1.3.3 Data Collection and Research Instruments

This report presents findings from ***survey data*** and/ or ***case studies of practical experiences*** of technology transfer in the six African countries. Data collection and reporting in each of the six countries were coordinated and overseen by a local expert consultant, who was also responsible for identifying the respondents for the survey and the national case studies for analysis and discussion. Specific sampling and data collection procedures of each country can be found in the respective section of the country report.

Survey was conducted to collect primary data using two standardized questionnaires developed and provided by UNECA respectively on:

- Public research organizations, including universities; and
- Domestic firms in the country

The questionnaires were originally designed in English and have two main sections as follows:

Section A records the background information of the responding organization/ firm, including its R&D inputs in terms of number of employees and budget. Specifically, the survey on firms includes questions about their foreign business (e.g. exporting and overseas operation) and the survey on public research organizations records the sources of their R&D funding.

Section B records the technology transfer strategy and activities of the responding organization/ firm. Five main proxies of technology transfer activities are used as follows:

- Technology Collaborative Partnership
- Technology Licensing
- Business, Professional and Technical Services, including technological consultation and contract research
- Capital Goods Purchase and Sales, locally and from/to abroad
- Use of Open-Source Technologies

Section B also includes questions to capture the geographical spread of the technology transfer activities and changes in a 3-year period. Motivations and challenges to undertaking technology transfer, including availability and access to government incentives in the country are also recorded.

The two questionnaires are included as Appendix 1A (Research Institutions) and Appendix 1B (Firms).

Descriptive case studies were conducted and prepared by the expert consultant in each of the 6 countries. The aim of these case studies is to showcase distinctive and focused technology transfer approach and experiences in practice. The cases also seek to provide insights into how differences in the national institutional environment, including development strategies and policy frameworks may shape technology transfer activities and practices of domestic organizations and firms. Accordingly, these national case studies may offer more 'contextuality' of the technology transfer strategies, approaches and practices observed, and account for country specific technological progress, institutional contexts and other path-dependent factors in the explanation and outcome assessment (Sampath and Roffe, 2012).

The local expert consultants were asked to make the choice of the cases based on their rich local knowledge and linkages. Eventually, the cases selected and presented in the six countries ranged from those focus on a micro view of a specific research institution or business-oriented entity (as seen in Upstill and Symington, 2002), to a macro view about an industry of the country (as seen in UNCTAD, 2022).

1.4 Overview of Country Reports

1.4.1 Ethiopia Report

The Ethiopian report starts with an overview of the country's science, technology and innovation landscape to highlight the role of technology transfer strategies in the overall national development strategies and STI policy framework.

The report presents and discusses findings of both *descriptive case studies* that were constructed using secondary data, and *statistical results of the primary survey* conducted on research organisations (specifically universities) and firms. *The case studies* analyze the development of the Ethiopian Airlines; the Ethiopian Space Science and Technology Institute (ESSTI); the Ethiopian Education and Research Network (EthERNet); the Leather Industry; the Metal Industry; and Ethiopian Biotechnology Institute (EBTI), respectively with reference to technology transfer activities and partnerships.

Survey results on 27 research organizations, covering public research institutes and a range of universities present a mix picture and status of the technology transfer practice. The majority (26 out of 27) indicated they had technology transfer strategy and a dedicated unit/ team for technology transfer activities in place and, 21 (78%) said their technology transfer budget has increased from 2018. Close to 80% of the responding organizations also reported an increase in both technology acquisition and technology provision activities between 2018-2020, comparing to the previous 3-year period (2015-2017). Yet, relatively fewer (52%) reported an increase in technology transfer with private sector entities, comparing with reported increase in technology transfer with other entities (i.e. public sector; other research institutes; higher education institutes). The technology-link between the largely publicly funded research institute and the private sector needs to be further strengthened. Overall, research organizations were motivated to undertake technology transfer activities to advance human and institutional capabilities; explore new applications; elevate social and political image and status; make societal development impact; and cultivate strategic partnerships. But they were significantly constrained by the lack of required resources, skills and information as well as clear strategy and guidelines to direct and govern related activities.

Survey results on 32 firms show that only slightly more than half (56%) of firms had technology transfer strategy, although 70% suggested they would monitor and evaluate technology transfer activities. All of them reported an increase in budget for technology collaborative partnerships from 2018, and the majority also reported an increase in technology acquisition activities (84%) and technology provision activities (75%) between 2018-2020, comparing to the previous 3-year period 2015-2017. The increase was reported in both intrafirm and inter-firm technology transfer activities. Overall, the responding firms are motivated to advance human and institutional capabilities; earn revenue from the firm's technology, cultivate strategic partnerships, elevate social and political image and status; and to explore new applications with technology transfer. Yet, they faced similar challenges to research organisations, in terms of lacking specific skills, resources and information. Moreover, many firms admitted that technology transfer activities are not their priority, which explains why many do not have technology transfer strategy in place.

It is interesting to note that while 66% (18 out of 27) of the responding research organizations reported they did not aware of any government incentives for technology transfer activities and 2 organizations indicated there were none, 16 out of 32 firms (50%) of the firms sampled said government incentives were present. To this end, the author highlights unstable and rapidly changing research and technology organizations' institutional arrangement, and the lack of moderate funding mechanisms and incentives for researchers as two key challenges to promote and accelerate technology transfer activities in the country. The need for enhanced and aligned information flow between policy formulation and implementation, and improved coordination and collaborative among different public and private stakeholders is stressed.

1.4.2 Ghana Report

The Ghana report provides an overview of the country's regulation frameworks that are related and influential to technology transfer activities and procedures. It also reports a summary of the survey findings based on a sample of private firms from a mix of sectors (agriculture, financial, tourism, education, and ICT), size, and stage of development.

Despite having a clear regulatory framework in place, the survey results show the extent of technology transfer among the firms sampled in Ghana to be low, with less than one-fourth (23%) indicated they were involved in any technology transfer activity and had respective strategies and guidelines in place. Further, no firm reported to have a budget designated for technology transfer partnerships; and there was no patent application indicated. Overall, one can conclude that the sampled firms' commercial technology transfer activities within and outside the country are negligible. Accordingly, the author stresses the crucial need for sensitization and resource mobilization to promote and facilitate technology transfer partnerships.

1.4.3 Kenya Report

The Kenya report starts with a broad overview of technology transfer practice, and some challenges and opportunities of technology transfer in the African context in general. It then reports the findings of the technology transfer activities primary based on a survey on research institutions (20 respondents, including universities).

The majority of the research institutions sampled reported to have a strategic plan, policy, or guidelines pertaining to technology transfer (70%); also dedicated teams that handle TT issues including licensing, industry liaison, and knowledge exchange (75%). These institutions were motivated to undertake technology transfer to safeguarding intellectual properties; advancing human and institutional capabilities, becoming global technology leaders; and earning revenue from the technologies and cultivating strategic partnerships.

While licensing and intellectual property rights ownership were reported to be the most commonly used mechanisms for technology transfer, licensing-in is more common than licensing-out with only 1 institution indicated that it had licensed out technology to other entities. This is despite the report by different institutions that they own patents, with 1 institution indicated it has 50 new patent applications in 2020. The gap between the ownership of patents and licensing out to other entities, particularly private sector firms may be an indication of these patents being under-exploited and/or their value for commercial applications not being recognized. With regard to the low licensing-out activities, respondents highlighted difficulties in identifying and accessing technology transfer partners and the lack of readily or enough developed technology to be transferred; and lack of information on technology needs and clear strategy as major challenges to accelerate technology transfer activities. It was observed that research institutions, including universities in Kenya are still primarily funded by donors (43%) and the government (38%). The donor-driven R&D funding may lead to predominating technology transfer activities with donor partners but not with the private sector. The researcher suggests that the inherent weak linkages between industry and academia present a major hinderance of research institutions in the country to play a more central role in the technology transfer process and to offer industry relevant and applicable solutions. These are areas that require attention and improvement, for which the report offers some recommendations.

1.4.4 Morocco Report

The Morocco report illustrates the country's current position in intellectual properties generation based on patent data. It outlines the roles and technology transfer activities of key actors: universities, research centres, incubators, firms, and other institutions in the civil society that constitute the innovation eco-system; and discusses the institutional arrangement and governance in place to support, facilitate and promote their technology transfer. Specific sectoral case studies are presented. The report articulates ten key challenges to accelerate technology transfer in the country; and it offers some recommendations for the way forward.

Morocco's recent 15-year development model published in 2021 has set out clear commitment and plan of the government to make it a nation of opportunity, entrepreneurship, and innovation through human capital development, digital infrastructure, and enhancing R&D in new technologies such as AI. The impressive two-fold increase in the number of non-resident/ foreign patent applications in the country between 2015-2019 suggests Morocco has a well-established position for international technology transfer through FDI and other forms of international collaboration. Local universities, research centres and incubators show various degree of involvement in international technology transfer partnerships and success in the generation of intellectual properties. The country's various indigenous industrial sectors, from the traditional agriculture industry to more strategic ones such as automotive, defence and new energies industries are all benefited from international technology transfer - often led by foreign multinational's subsidiaries and joint ventures between foreign and local companies – to accelerate industrialisation and capacity building.

Yet, the author also highlights challenges to sustaining and accelerating technology transfer activities, including the lack of incentives to undertake R&D particularly by local companies; difficulty to enhance commercialisation successful rate and scale-up of businesses; brain drain of talent; and imbalanced support to as well as unaligned focuses among different actors (e.g. universities and firms) in the innovation eco-system at both the national and the local level. It is suggested that monitoring and evaluation of technology transfer activities and outcomes are lacking, making it difficult to underline status, identify bottlenecks and respective areas for improvement, and to share experiences.

1.4.5 South Africa Report

The South Africa report starts with an overview of the development of the National R&D strategy and other institutional frameworks with reference to promoting technology transfer in the country; and presents previous findings concerning technology transfer based on earlier surveys.

Case studies of two small-and medium-sized companies offer illustrative example regarding how and with whom technology transfer took place, and the opportunities and challenges encountered by the practitioners. These are supplemented by insights obtained from a focus group meeting, which underlined key issues about possible improvements and development to accelerate technology transfer among different actors (businesses, universities, and research councils), in terms of technology transfer mandates, eco-system, and information availability. Specifically, it is reported that South Africa's National System of Innovation (NSI) still has a number of disparities, and there is a declining uptake of research and development (R&D) in the private sector in general, and SMEs in particular, largely affected by the lack of funding, incentives and other resources to support commercialisation. The problem of over-reliance on research-push rather than market-pull R&D and innovations was also pinpointed as an issue.

Further insights into the status of technology transfer in research organisations (including universities) and firms are drawn from the primary survey. A particularly important finding is that despite the present of positive technology transfer mandates, the impact on generating corresponding technology transfer outputs and outcomes is apparently not effective. Some reasons may be due to the underdeveloped funding system, particularly when funding sources of technology transfer remains largely limited and depended on government funding programmes.

The next chapter analyzes and discusses the global technology flow and transfer of African countries based on secondary data of various proxies and indicators.

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2. Africa in the Global Flow of Technology

2.1. The Options and Issues to Consider in Tracking Technology Transfer

Access to key technologies could lead to improvement in quality of production, generation of new knowledge, improvement in living standards, productivity and efficiency of firms, and diversification and competitiveness of exports, among other benefits (Zhou and Youssef, 2012). In part, the producers of basic products such as baby diapers, shirts and shoes; and everyday items such as toothbrushes, mobile phones, drugs and vaccines as well as providers of key services that include water, electricity and transport, all depend on technologies developed and sold by others. By and large, technology transfer affects every aspect of life and the more advanced a nation gets the more technology it needs to remain competitive and grow.

As shown in figure 2.1a and 2.1b, the fast economic growth of China is mirrored in the rapid pace at which it acquired technology as measured in terms of payments for intellectual property, from US$1.3 billion in 2000 to US$13 billion in 2010 and about $47 billion in 2021. This is not surprising given the rapid growth of its high-tech manufacturing (e.g. automobiles, computers, mobile phones and pharmaceuticals) and high value added services (e.g. eCommerce, Fintech, cloud computing, advanced energy technologies etc), all of which depend on some technologies developed elsewhere. As China becomes a major production hub, its imports of technology have reached the level of the United States. Other major technology importers include United States, Japan and Germany.

Figure 2.1a: Trade in intellectual property (*Imports in* US$ billions)

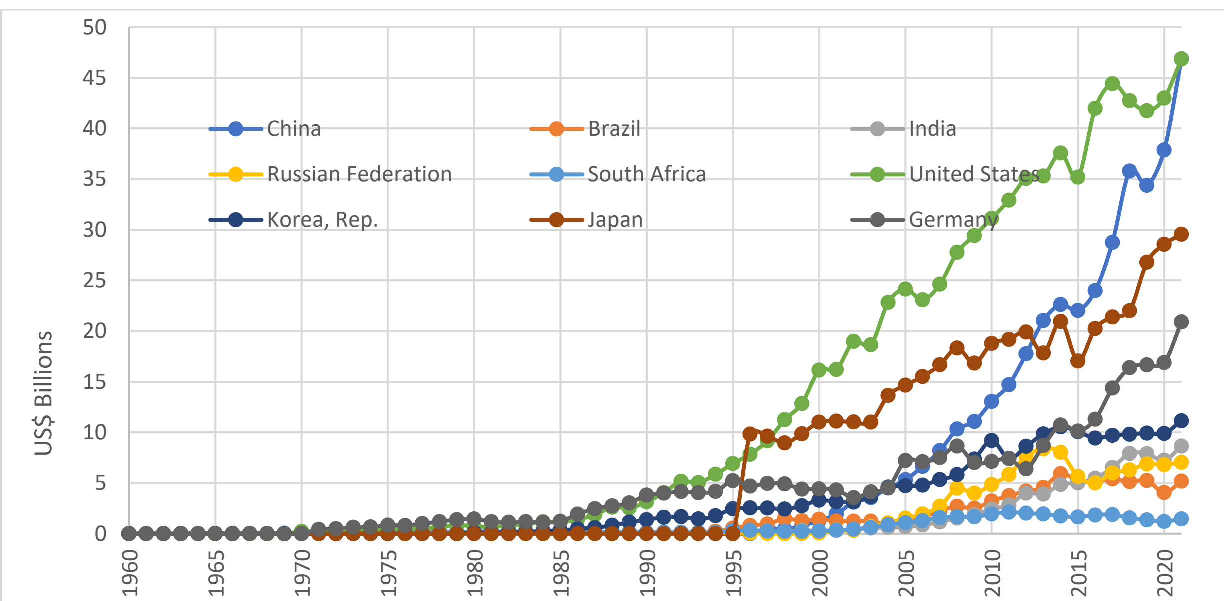
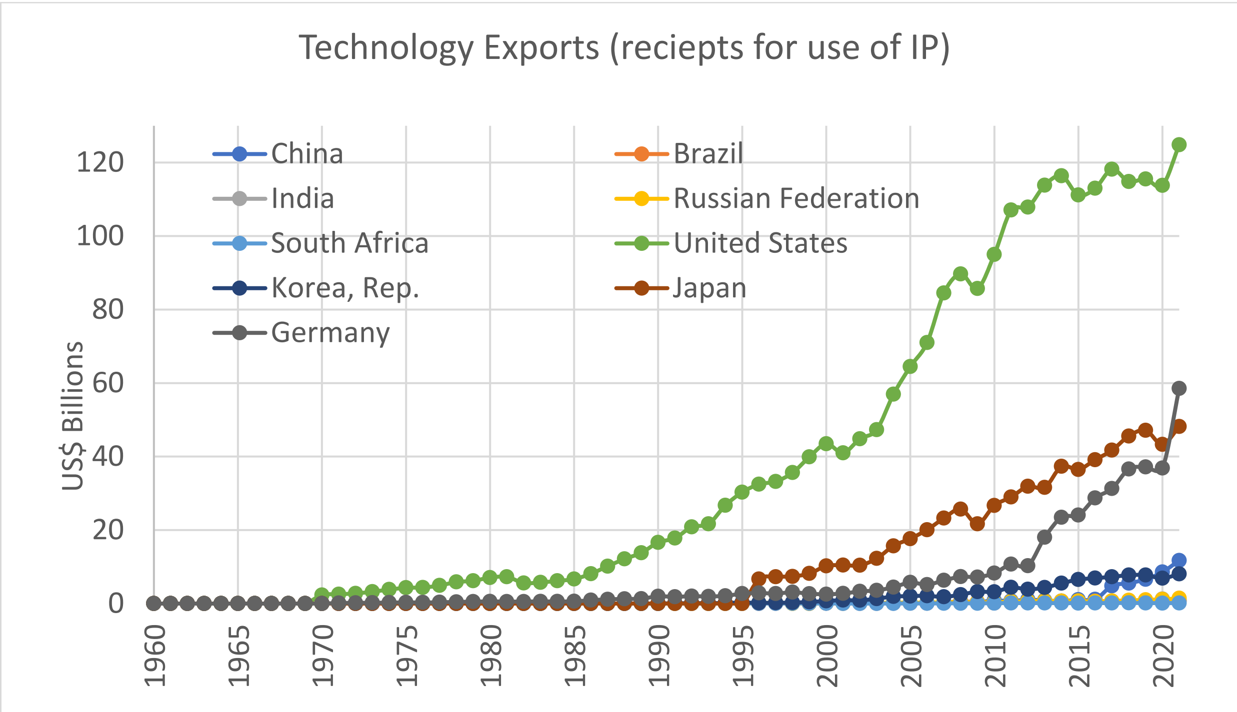


Figure 2.1b: Trade in intellectual property (*Exports in US$ billions*)



Source: World Development Indicators database (accessed August 2022).

However, before technology can be transferred it must be developed. The gap between technology importers and technology exporters remains high. Using the same countries, China's payments for intellectual property was equal to that of the United States in 2021 (Figure 2.1a) but its receipts in 2021 were only US$11.7 billion compared to the US$124.8 billion earned by the United States or the US$58.5 billion by Germany and US$48.2 billion by Japan (Figure 2.1b). Taken together, Germany, Japan and the United States were net technology exporters while all the BRICS[10] countries and Korea are net technology importers. Put differently, most technologies in the world are still owned by a few countries (largely developed countries) that possess well developed and functional research and development system in both the public and private sectors (UNECA, 2010).

The COVID-19 pandemic has demonstrated some of the issues associated with technology transfer with respect to access to vaccines. There are at least 367 COVID-19 vaccine candidates[11] as of 29 July 2022 with 169 in clinical trials of which only eleven (two being the same but made by different manufacturers) were authorized for emergency use by WHO. These eleven vaccines are largely from countries and regions with experienced pharmaceutical research and manufacturing industries and entities such as China, India, the United Kingdom, Germany and the United States[12]. This enables alliances to be formed between research institutions and big pharmaceutical companies (e.g., Oxford University and AstraZeneca), and between large pharmaceutical companies (e.g., Johnson & Johnson and Merck) that have significant experience in

[10] BRICS countries refer to Brazil, Russia, India, China and South Africa

[11] See https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines

[12]See https://covid19.trackvaccines.org/agency/who/

R&D and manufacturing vaccines. The same has been observed in India and China where alliances among domestic as well as foreign research institutes and firms have been established.

Other countries and regions that needed to produce more COVID-19 vaccines had to seek ways of acquiring the technology for the preapproved vaccines. South Africa, for example, acquired the technology to produce the Johnson & Johnson COVID-19 vaccine[13]. As a result, South Africa became the fourth major supplier of COVID-19 vaccine to Africa as of May 2022, just behind the United States (supplied about half) out of the total 971 million doses, followed by the European Union and China.[14] Other deals have been reached between South Africa's Biovac Institute and Pfizer (United States); Morocco and China's SinoPharm; Senegal/Rwanda and BioNtech (Germany – build a plant), and Kenya and Moderna (United States – Moderna seeks to invest US$500 million in a plant in Kenya)[15] [16]. In this regard, countries are seeking different means of technology transfer – ranging from licensing and partnerships or alliances and to foreign direct investment (FDI) – that meet their domestic realities. Put differently, licensing of IP is useful to countries that already have a decent pharmaceutical manufacturing base for vaccines while attracting foreign vaccine manufacturer may be preferred for countries that have limited vaccine manufacturing capacity.

Irrespective of the chosen route for technology acquisition, intellectual property rights will be a key component. In the case of COVID-19 vaccines, IP became a major subject in the World Tarde Organization (WTO) with several countries led by South Africa and India calling for a patent waiver to enable countries to manufacture the life-saving vaccines for their population, given the global shortage and limited resources of developing countries to compete for the same doses with rich countries. The Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement of the WTO allows governments to issue compulsory licensing and government use of a patent without the authorization of its owner under certain conditions; but this has been difficult and complex to apply.

The COVID-19 vaccines are based on four technology platforms that encompass a range of intellectual property rights (e.g. patents, trademarks, trade secrets and trade names, etc). Most of the patent families covering COVID-19 vaccines are owned by firms, followed by universities and public institutions as shown in table 2.1. Patent families (i.e. patent application claiming the same or similar technical content) are important as they highlight areas of research and experimental development interest. This is highlighted by the patent applications filed by various developers of messenger ribonucleic acid (mRNA) on similar targets (e.g. the spike protein), and targeting system (e.g., lipid nanoparticles used in all mRNAs vaccines) among others (Storz, 2022).

Table 2.1. Patent families involved in 10 COVID-19 vaccines

		Patent owner			
Technology platform	**Vaccine (maker)**	**Private**	**Public**	**University**	**Not-for Profit**

[13] See https://www.dw.com/en/africas-covid-19-vaccine-production-line-in-jeopardy/a-61756730
[14] See https://www.wto.org/spanish/tratop_s/covid19_s/vaccine_trade_tracker_s.htm
[15] See https://african.business/2022/02/agribusiness-manufacturing/morocco-starts-construction-of-562m-covid19-vaccine-plant/
[16] See https://www.reuters.com/business/healthcare-pharmaceuticals/moderna-build-mrna-vaccine-manufacturing-facility-kenya-2022-03-07/

mRNA	Moderna	15		2	
	BioNTech	11		3	1
	CureVac	11			
Viral vector	Johnson & Johnson	19		2	2
	Sputnik		6		
	AstraZeneca			2	
Protein subunit	Novavax	5			
Inactivated	Sinovac	2	1		
	Bharat	1		1	
	Sinopharm	1			

Source: Chiang and Wu (2022)

The case of COVID-19 vaccines puts a spotlight on three aspects of technology transfer: 1) countries with well-established R&D systems can easily bring a product to market through various partnerships and alliances with top research and manufacturing entities; 2) teams with good knowledge of the subject matter seek ways to protect future outcomes of research based on prior knowledge of the field which may be unclear in developing countries[17] and; 3) technology transfer may range from provision of information and knowhow to equity investment abroad.

Assuming all the above issues are considered, it becomes easy to appreciate that technology is neither free nor easy to access, acquire, adapt and upgrade. For instance, the Government of Zambia, private firms, donors and the community at large worked together to acquire new technologies, train personnel in the public and private sectors, and design new standards and policies for the fortification of sugar with vitamin A. By 1998, Zambia had become the first country in Africa and the second in the world (after Guatemala) to fortify sugar with vitamin A commercially (Besa, 2001). In this case, the process of acquiring the technology included knowledge transfer through visits to Guatemala, and discussions and presentations by partners with interest in fortification of sugar while the actual technology was designed and developed by the National Institute for Scientific and Industrial Research (NISIR) in collaboration with Zambia Sugar. As fortification increased the cost of the final product, new policies and standards were designed to protect both the consumer (with a minimum guarantee of vitamin A per kilogram of sugar) and the firm from suppliers of cheaper unfortified sugar (Fiedler et al., 2013). Competitors responded by fortifying their sugar to re-enter the market.

The above example indicates that technology transfer often has cost implications for firms (e.g., plants may be shut down to incorporate new technology, technical experts may be hired, new lines of work may

[17] Most of team with prior research knowledge of corona virus vaccines research experience commenced work and patent applications immediately after it became clear the outbreak in China was caused by a corona virus and its genomic blueprint was published. Some patent application were filed within weeks and were based on combinations of knowledge of the expected outcome (i.e. in present tense).

be introduced, etc), and for consumers (e.g. prices may go up). It may also induce changes in the market and affect more players than just the immediate user of the technology. As some of the costs may be reported as research and development expenditure, and as training of workers and consultancy services. However, the full cost of technology transfer is unlikely to be known because some of the common proxies (e.g., payment for intellectual property) rely on the actual cost of the technology and not the associated costs.

Payment for technology transfers does not necessary always reflect actual transfer of technology. In some cases, technology transfer payments may be legalizing a process or product already in place or providing the rights of use. For instance, a firm may already be producing a generic version of aspirin but may have to pay if it must label the product in question as 'Aspirin', which is a registered trademark. Similarly, most of the patent and copyright infringements, lawsuits and countersuits (e.g. close to 50 cases between Apple and Samsung over patent and copyright infringements in various jurisdictions[18]) are rarely the result of firms actually transferring or acquiring the concerned technology *per se* but rather the use of knowledge and designs that may be protected by intellectual property rights.

It may be important to remember that the direction on payment for technology, also the size of the payment may not necessarily reflect the direction of the flow of technology nor the quantity of technology transferred. The flow may reflect the interest of a party in a technology exporting country to subcontract another in a technology importing country to produce and market its products abroad. In this case, the partner in the technology importing country may acquire technology and get paid for the service delivered, and the technology exporter will get the proceeds from sales of its products. Thus, payment and technology may flow in the same direction. In addition, the size of payments may be determined by the size of the market, revenues to be made, level of technical assistance required, bargaining power of the parties involved, level of investment in the venture and relationships, among others.

That said, there are several proxies that can be used to assess technology transfer overtime. In this work, we use a few key proxies: ***imports of capital goods; payments for use of intellectual property; imports of business and technology services (in terms of ICT-related services); FDI; and trends in intellectual property rights (non-resident patents)*** *to highlight the trend of technology transfer in Africa, with a special focus on the six empirical countries of this report, or wherever data is available. Such as assessment is important as technology imports from technology exporting countries are key to building a sound and competitive domestic scientific, technological and industrial base, and to initiating the process of catching up.*

[18] As recorded in Albasoos and Musallami, 2020.

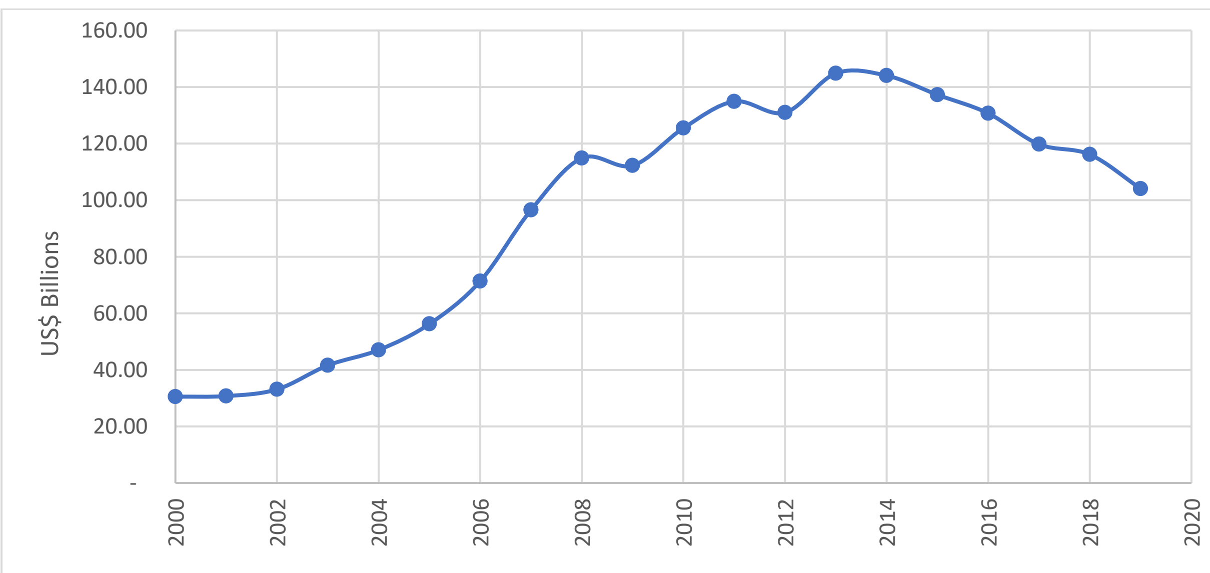
2.2. Tracking Technology Transfer in Africa

2.2.1. Imports of Capital Goods

Capital good, as defined by UNCTAD, are "manufacturing goods such as machinery that are intended to be used in the production of other goods"[19]. In simple terms, capital goods are fixed assets used in the production of other goods and services; thus, are not bought for their own consumption. Examples are a harvester, earth moving equipment, or computerized supermarket tills that are used in efficient harvesting of crops, clearing the ground for roads and mines, and offering a faster service to shoppers, respectively. Countries that are growing fast are likely to register an increase in imports of capital goods.

For instance, research suggests that imports of capital goods have contributed greatly to economic growth in China (Herrerias and Orts, 2013) and, in the United States of America, accounted for 20–30 per cent of growth in output per hour between 1967 and 2008 (Cavallo and Landry, 2010). A research based on firm-level data from four manufacturing industries – wood & furniture, food & bakery, metal & machinery, and textiles & garment in Ghana, Kenya and Tanzania shows that increase in capital goods imports has a significant positive effect on productivity (Nyantakyi and Munemo, 2016). Similarly, capital goods imports drove most of the growth of the information and communications technology sector in Africa. Often referred to as "knowledge in machines", capital goods embody the research and development effort and knowledge of others and thus, serve as a useful proxy for knowledge flows.[20]

Figure 2.2. Capital goods imports in Africa (US$ billion)



Source: WITS Database

In this regard, capital goods imports by Africa grew from some US$31 billion in 2000 to US$145 billion in 2014, before dropping to US$107 billion in 2019 (Figure 2.2). Sub-Saharan Africa witnessed the largest fall in imports of capital goods, from US$101 billion in 2013 to US$83 billion in 2018, while those for North Africa were relatively stable, varying between US$42 billion and US$47 billion. Countries that were

[19] https://unctad.org/webflyer/key-trends-international-merchandise-trade

[20] ECA analysis based on UN Comtrade database, rad economic categories (BEC) group 4. Data for BEC 41 are limited to a few countries only.

growing fast witnessed the fastest growth in imports of capital goods. For example, capital goods imports by Ethiopia grew from US$363 million in 2000 to US$6.6 billion in 2015 and US$4.8 billion in 2018. Besides Morocco, capital goods imports by all the empirical countries in this report are lower than the levels seen between 2014 and 2016.

All the six countries covered in this report registered a rapid growth in capital goods imports since 2000 (see Figure 2.3a and 2.3b). Ethiopia and Rwanda registered the fastest growth between 2000 and 2019 – about 1,200% and 1,100% in value – of imports of capital goods followed by Ghana at 375% and Morocco at 355% over the same period. However, between 2010 and 2019, all countries have registered slower growth: Rwanda's imports of capital good grew by 100%, followed by Ethiopia at 76% and Morocco at 58% in the last decade. In terms of value, South Africa remains the top importer of capital goods, followed by Morocco, Ethiopia and Ghana.

Figure 2.3a: Capital goods imports of South Africa and Morocco (US$ billion)

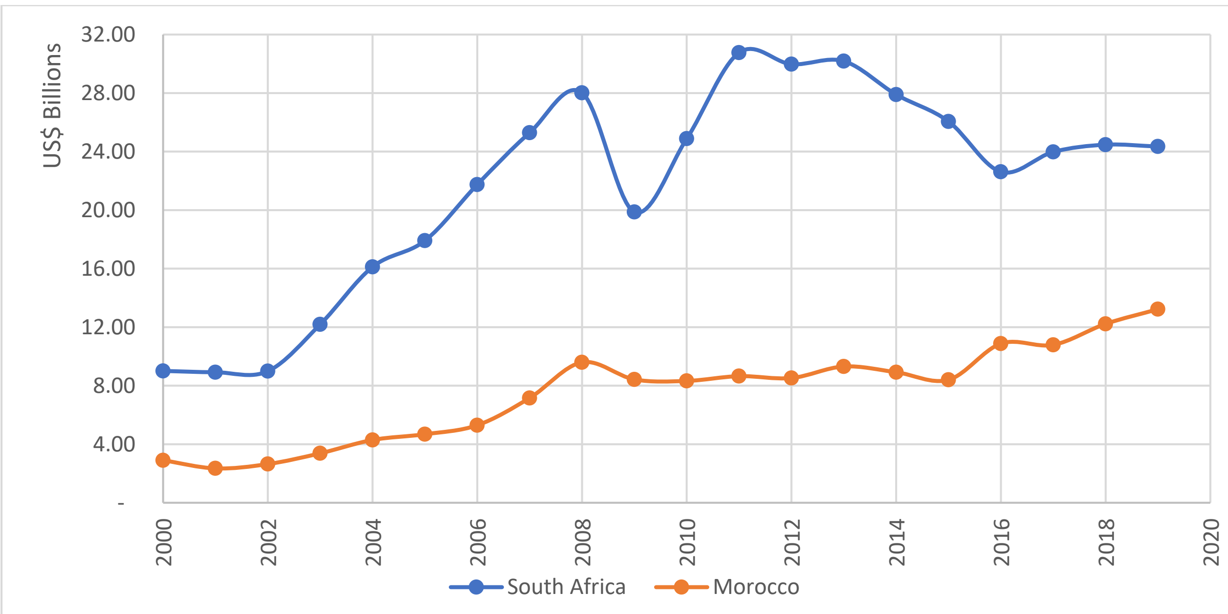
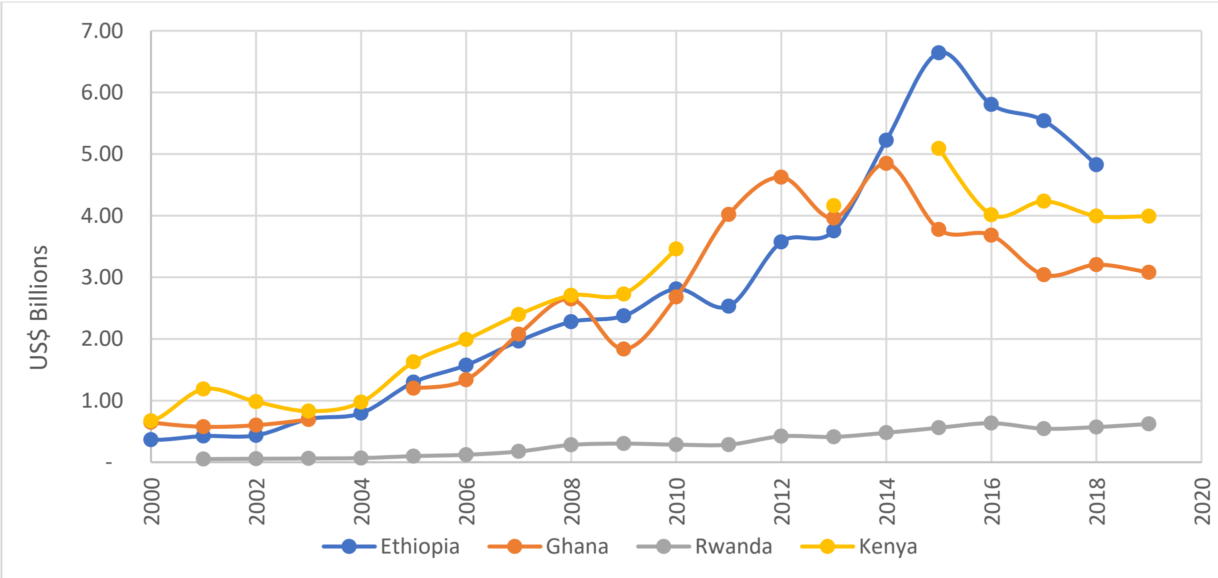


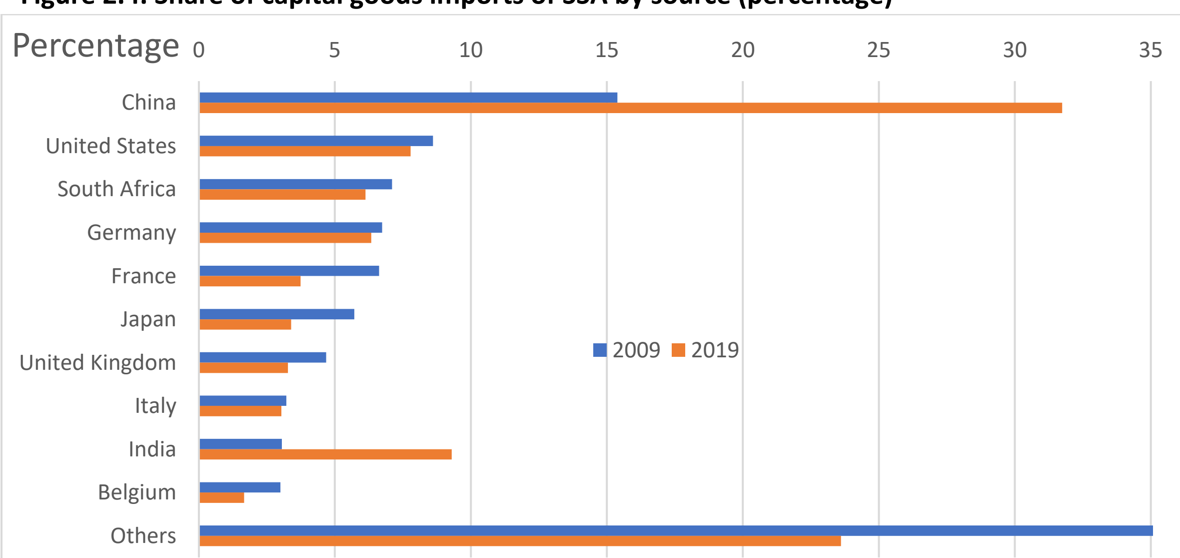
Figure 2.3b. Capital goods imports by Ethiopia, Ghana, Kenya and Rwanda (US$ billion)



Source: WITS Database

In terms of source of capital goods, there are notable changes and differences (Figure 2.4). For instance, China accounted for 15% of the capital goods import by Africa in 2009 and has since increased to about 35% by 2019. India's share of SSA's imports of capital goods has risen from about 3% to about 9% between 2009 and 2019. South Africa is the only major exporter of capital goods to SSA, but its share has declined from about 7.1% to 6.1% over the same period. Among the top sources of capital goods for SSA, large declines were recorded by France, Japan, Belgium and the United Kingdom. The growth of imports of capital goods from China and India may be linked to increased investment and contracts in Africa undertaken by the two countries (Khana and Arora, 2017).

Figure 2.4. Share of capital goods imports of SSA by source (percentage)



Source: WITS Database

In terms of the countries of focus (Table 2.2), Ghana has more diversified sources of imports of capital goods with its top six countries accounting for only 58.7% and the rest of the world accounting for 41.3%. It is followed by South Africa, who's top six import sources account for 64.1%. The highest concentration is observed in the case of Ethiopia where two countries - China and United States - accounted for 62.6% followed by Rwanda (top countries account for 52.9%) of the total imports of capital goods. There are also differences among the top six countries: France and Spain being the top import partners for Morocco; China and the United States are the top two partners for Ethiopia and South Africa; China and India are the top two for Kenya and Rwanda; and China and the United Kingdom are the top two for Ghana. The level of sophistication and knowledge content of 'machines' may vary by the level of development of the exporting country.

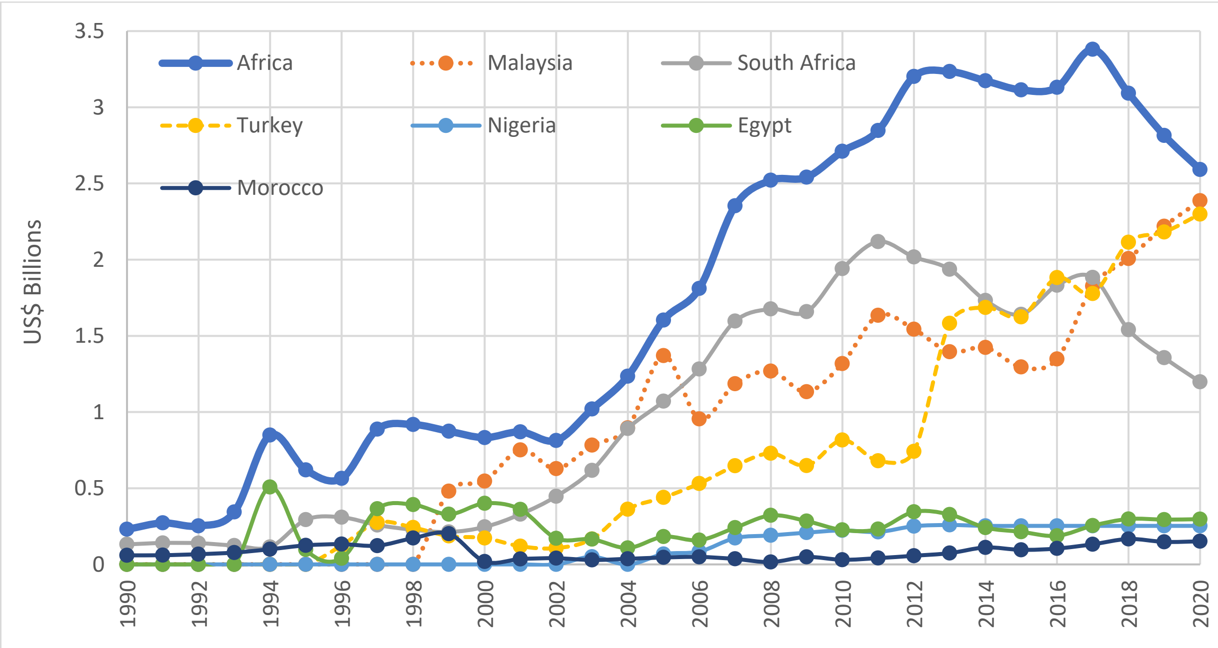
Table 2.2: Top six sources of capital goods imports of the empirical countries (percentage of the total capital goods imports to the country from other countries)*

South Africa		Morocco		Ethiopia	
China	31.7	France	20.4	China	38.4
United States	10.8	Spain	16.4	United States	24.2
Germany	10.4	China	15.0	Japan	5.6
Japan	4.2	United States	7.3	United Kingdom	5.0
Italy	3.6	Italy	6.2	Germany	4.0
India	3.4	Germany	5.8	Italy	3.9
Rest of the world	35.9	Rest of the world	28.9	Rest of the world	18.9
Ghana		**Rwanda**		**Kenya**	
China	21.8	China	37.4	China	39.4
United Kingdom	10.4	India	15.5	India	10.2
United States	8.2	Germany	8.0	Japan	7.4
Belgium	7.5	United Arab Emirates	5.2	United States	6.4
India	5.9	Turkey	2.8	Netherlands	5.2
South Africa	5.0	United States	2.7	Germany	5.1
Rest of the world	41.3	Rest of the world	28.4	Rest of the world	26.2

Source: WITS database *(*2019 figures for all countries, except Ethiopia of which 2018 figures are used)*

2.2.2. Payments for Use of Intellectual Property

Figure 2.5. Charges for Intellectual Property (Payments)



Source: World development Indicators Database

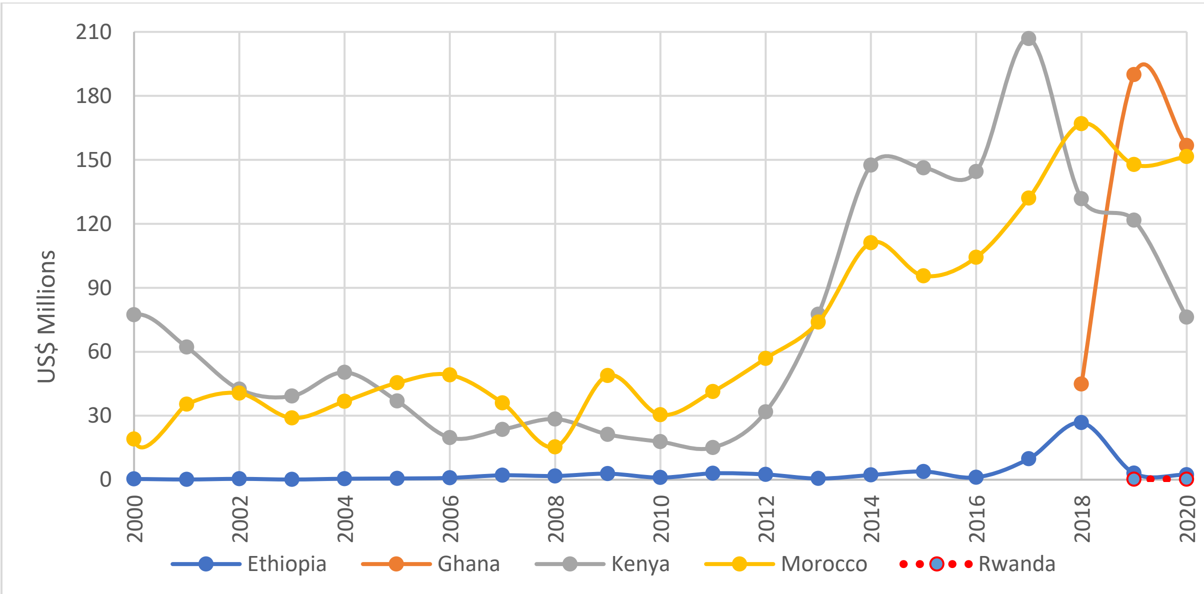
To access and use the intellectual property of others, one may be required to pay royalties and licensing fees. As such, technology transfer can be tracked through payments of royalties and licensing fees for the use of intellectual property owned by others as noted earlier. Despite data deficiencies, the latest data suggest that payments for intellectual property by Africa to the rest of the world rose from US$832 million in 2000 to US$2.7 billion in 2010 and US$3.4 billion in 2017,[21] before falling to US$2.6 billion in 2020 (Figure 2.5).

South Africa accounts for about half of Africa's payments for IP to the rest of the world. It is more likely explained by the large presence of affiliates of multinational firms and knowledge intensive domestic firms that need current knowledge to stay competitive. In comparison to global peers such as Turkey and Malaysia whose payments for IP have risen rapidly in the last 4 years, payments for IP by African countries such as Egypt, Morocco and Nigeria remain very small and that by South Africa has even experienced sharp decline since 2018.

The African share of the world payments for intellectual property was about 1 per cent between 2007 and 2011 and has since declined to about 0.8 per cent by 2017 and 0.6 percent by 2019. Its payments are more highly concentrated in a few countries than imports of capital goods. The small share of the world's total of royalties and licensing fees held by Africa and their concentration in only a handful of countries suggest that most African countries have few firms – or few firms of sufficient substance – that would need to use new knowledge (UNECA, 2010).

[21] Based on latest and more complete data as of 2019 in the World Development Indicators database.

Figure 2.6: Payments for intellectual property (Balance of Payments)



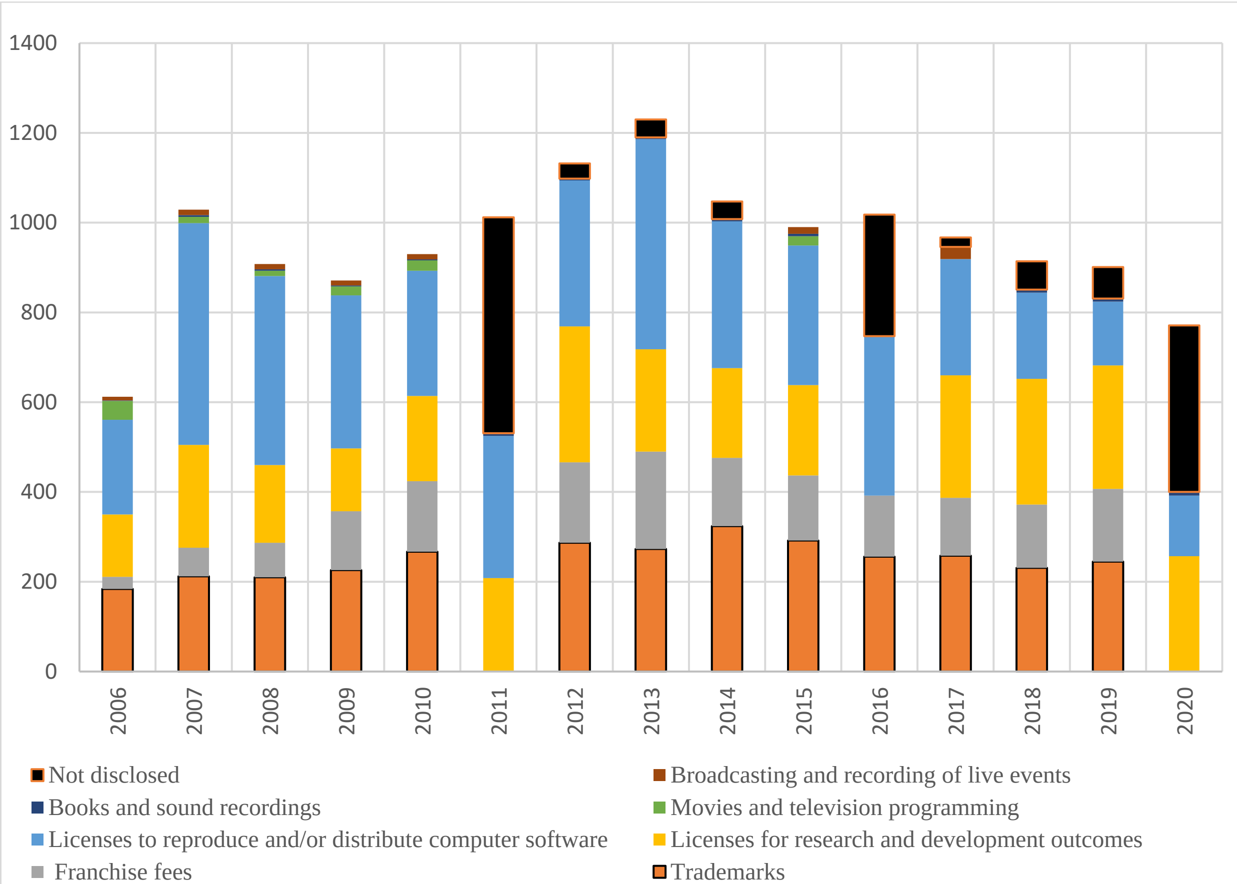
Source: World development Indicators Database

In terms of the countries of focus (Figure 2.6), Morocco has registered a steady rise in its payments for intellectual property, with the annual average increased from about US$36 million between 2000 and 2009 to about US$155 million between 2018 and 2020. Kenya's payments for IP, however, were relatively volatile, deteriorating from about US$77 million in 2000 to US$17 million in 2011 and then rising steeply to reach US$210 million in 2017 but steadily declining to US$76 million by 2020. Such swing may reflect changes in licensing fees charged by some of the larger firms (e.g., Safaricom's payments to Vodafone for the license fee for the M-Pesa platform dropped 40 per cent after 2017)[22]; and the general decline in economic performance, which may have an impact on the need for acquiring licenses. Rwanda and Ghana have limited data points (two to three years) to provide any clear direction or trend.

It is perhaps important to note that intellectual property rights cover a range of industrial rights (e.g. patents, utility models, trademarks) and copyrights. Accordingly, royalty and licencing fee payments cover different IP rights. While a breakdown by each IP category is not available at the global level, the United States Bureau of Economic Analysis (BEA) provides detailed breakdown for countries whose firms' total payments to the United States based firms exceed $500,000. Most importantly, the US accounts for about a third of Africa's payments for IP and thus may provide some indications. As can be observed from figure 2.7, most of the payments for intellectual property are related to reproduction and distribution of software; trademarks; and use of research and development outcomes.

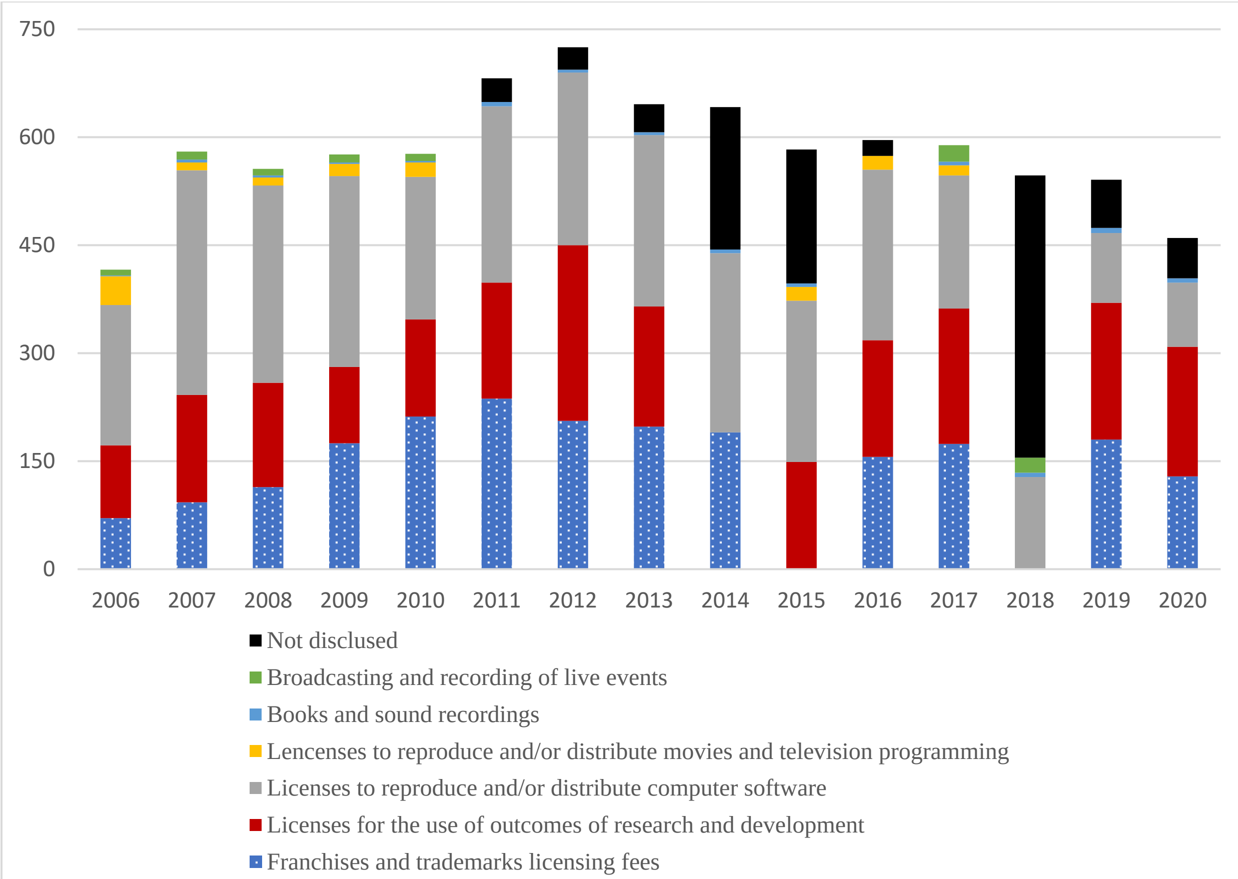
[22] Data from online source: https://www.businessdailyafrica.com/bd/corporate/companies/m-pesa-licence-fee-to-vodafone-drops-40pc-on-reduced-royalties-2214518

Figure 2.7: Africa's payment for IP to the US by service (US$ million)



Source: US Bureau of Economic Analysis database

Figure 2.8: South Africa's payments by categories of intellectual property (US$ million)



Source: US Bureau of Economic Analysis database

There are national differences in terms of the proportion of payments for the different categories of intellectual property. Focusing on the case of South Africa (Figure 2.8), the main IP exports by the US to South Africa are related to distribution and/or reproduction of software followed by franchises and trademarks, and use of outcomes of R&D. In a way, South Africa's payments for IP to the United States is relatively higher for knowledge intensive products such as software and R&D outputs. On the other hand, payments by Morocco for IP to the US are dominated by franchises and trademarks (69-90%), followed by use of R&D outcomes with software reproduction and distribution making being small (about 4%) as shown in table 2.3 below.

Table 2.3: Morocco – Import of IP services from the USA (US$ million)

	2010	2013	2016	2019
Charges for the use of intellectual property	**13**	**109**	**68**	**105**
Franchises and trademarks licensing fees	9	98	(D)	(D)
Trademarks	***6***	***(D)***	***25***	***(D)***
Franchise fees	3	(D)	(D)	(D)

Licenses for the use of outcomes of research and development	*1*	*8*	*(D)*	*(D)*
Licenses to reproduce and/or distribute computer software	3	3	2	5

Source: US Bureau of Economic Analysis database

The differences between national payments for intellectual property, such as that of Morocco and South Africa, may be related to the presence of affiliates of multinational firms in different sectors, and/or the presence of technologically sophisticated enterprises that need the IP of others to remain competitive. As shown in table 2.4, over two-third of all payments for IP are between affiliated firms (i.e. multinational firms and their subsidiaries outside the United States and Africa). Over 95% of such transactions are between the US parent and affiliated firms in Africa, and only 5% are between parent firms in Africa and their affiliates in the United States.

Table 2.4. Payments for IP by affiliation

	2006	**2010**	**2014**	**2018**	**2020**
Africa ($ millions)	613	931	1047	914	771
Unaffiliated (%)	27.9	27.8	26.2	31.4	38.1
Affiliated (%)	71.9	72.2	73.8	68.5	61.9
US parent firm to foreign affiliate (%)	99.1	94.6	98.6	96.6	93.5
US affiliate to Africa parent (%)	0.9	5.4	1.4	3.5	6.5

Source: US Bureau of Economic Analysis database

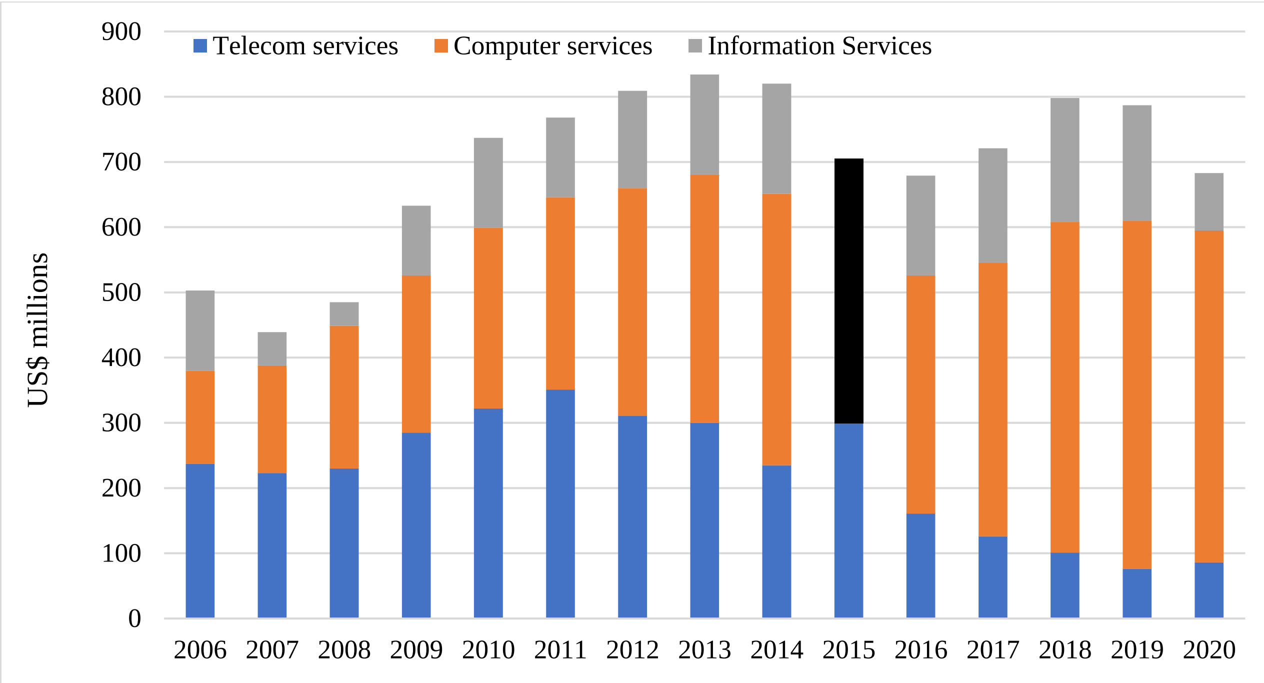
2.2.3. Imports of Business and Technology Services (ICT-related)

While licensing of IP has slowed down especially in 2020, the direct import of ICT related services from the US to Africa has gone up in some areas (Figure 2.9a). Specifically, the imports of computer services climbed from about US$143 million in 2006 to US$534 million in 2019 and US$509 million in 2020. On the other hand, imports of telecommunication services from the US have declined from a high of about US$351 million in 2011 to US$76 million in 2019 and US$86 million in 2020. The decline may be linked to the increased shift by African telecommunication service providers from the US vendors towards Chinese vendors rather than a reduction in overall demand for such services. One report suggests that about 50% of the 3G networks and 70% of the 4G networks in Africa were built by Huawei from China and a total of US$7.2 billion in technology investment and contracts was made by Chinese entities (Agbebi, 2022; Hrubi, 2021). Using the same data source, China's imports of computer services to Africa rose from US$70 million to US$1,403 million between 2006 and 2020 (about 20 times).

A breakdown of computer services (Figure 2.9b) suggests strong growth in imports of computer software, from US$28 million in 2006 to US$282 million in 2020, and in cloud computing and data storage device services, from about US$3 million to US$55 million over the same period. However, imports of the rest of computer services grew from US$82 in 2006 to a peak at US$228 million in 2018 and then declined in

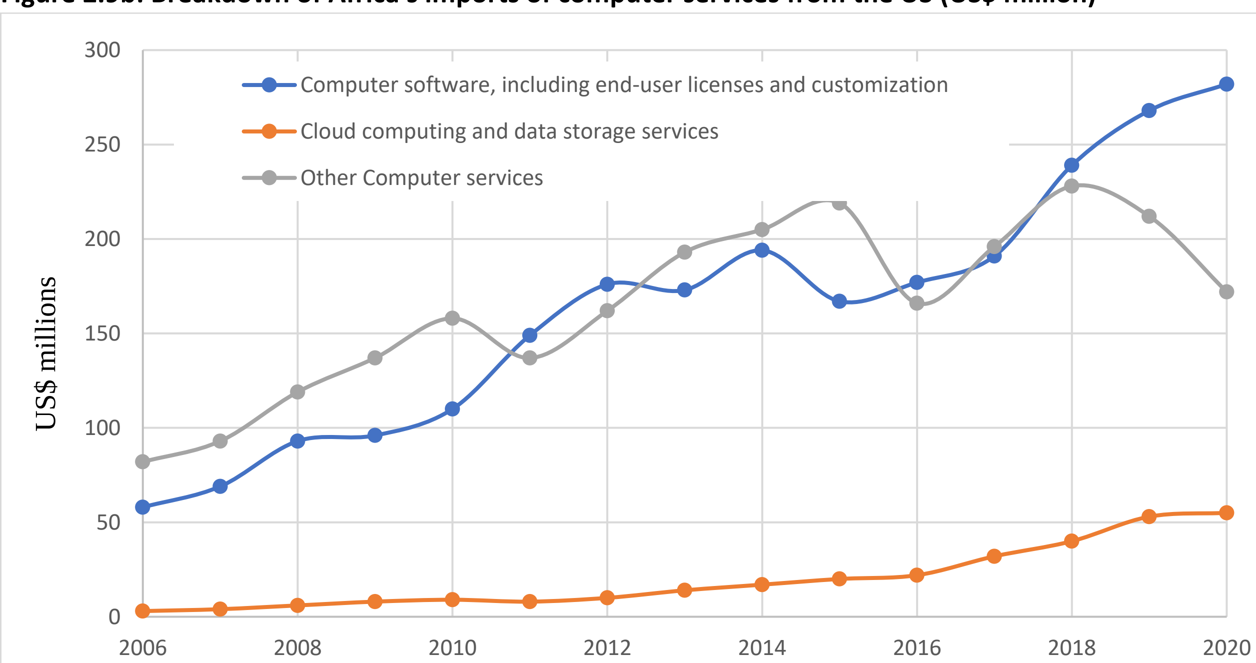
2019 and 2020 to US$172 million. Africa's share of imports of computer services from the US remains low at only 1.2%.

Figure 2.9a: Imports of telecommunications, computer, and information services from the US (US$ million)



**The black bar in 2015 indicates data that are not disclosed by categories.*

Figure 2.9b: Breakdown of Africa's imports of computer services from the US (US$ million)



Source: US Bureau of Economic Analysis database

2.2.4. Foreign Direct Investment and Technology transfer

While not all foreign direct investment (FDI) is likely to involve direct transfer of technology to the recipient country, there is little doubt that FDI plays a pivotal role in the transfer of knowledge that may be related to international practices, norms and expectations. Specifically, FDI brings in products/services, know-how, new management and marketing expertise, and technologies that may be new or advanced compared to the existing ones. The rapid growth of the information and communication technology (ICT) in Africa since 2000 would not have happened without private investment that has continuously upgraded the networks by bringing in capital, expertise and technologies (Corrigan, 2020; Ofori and Asongu, 2021). Some of the top firms such as Airtel, Safaricom, Vodafone and Tigo have investment partners that help bring in new technologies from other countries or are foreign invested firms altogether.

Technology transfer through FDI may take place in the form of acquisition of projects and facilities abroad with the desired technologies. For example, South African multinational pharmaceutical company Aspen's interest in Merck's (MSD) manufacturing facilities in Netherlands and Iowa, the United States that produce active pharmaceutical ingredients (API) to meet its international expansion plans. A main aim is to access skills and knowledge resources in the major technologically advanced location.

Even in non-technology intensive sectors such as entertainment, hospitality and agriculture, foreign-invested firms may introduce new methods and practices that lift the entire sector. For instance, the rapid expansion of South African retailers (e.g. Shoprite in 13 African countries), food chains (e.g. Hungry Lions with restaurants in 7 countries in Africa), and real estate investment in shopping malls across Africa has transformed the design of shopping centres, created thousands of jobs, advanced the environment and culture, enhanced security and standards of basic goods and services across countries (Adanlawo and Vezi-Magigaba, 2021).

Table 2.5: FDI Inflows to Africa and target countries (US$ million)

	2000	2005	2010	2015	2018	2019	2020
Africa	10,381.8	29,260.3	47,243.0	57,902.3	45,374.2	47,142.7	39,785.2
Ethiopia	134.6	265.1	288.3	2,626.5	3,310.3	2,548.8	2,395.4
Ghana	114.9	145.0	2,527.4	3,192.3	2,989.0	3,879.0	1,877.0
Kenya	110.9	21.2	1,882.1	1,463.7	1,139.4	1,098.4	716.8
Morocco	422.0	1,654.0	1,573.9	3,254.8	3,558.9	1,720.0	1,763.1
Rwanda	8.1	8.0	250.5	379.8	381.9	353.8	134.8
South Africa	887.3	6,646.9	3,635.6	1,729.4	5,449.6	5,125.0	3,106.5

Source: UNCTAD Handbook of Statistics database (accessed 31 July 2022).

Foreign Direct Investment (FDI) in Africa has grown from about US$10 billion in 2000 to about $58 billion in 2015 and $40 billion in 2020 (see table 5). Countries such as Ethiopia, Ghana and Morocco have seen their inflows of FDI grow by more than 20 times between 2000 and 2018. The impact of COVID-19 on FDI was more pronounced for Rwanda and Morocco (declined by about half from the 2018 level). All the empirical countries registered a decline between 2018 or 2019 and 2020.

That said, there are four major types of FDI: 1) resource-seeking FDI (e.g. access to land, mineral deposits, forestry resources, etc); 2) market-seeking FDI (e.g. banks, food retailers, airlines, hotels etc comes to serve and grow the domestic market); and 3) efficiency-seeking FDI (e.g. cheaper skilled labour, low-cost manufacturing services etc); 4) strategic assets seeking FDI (e.g. advanced technology and advanced R&D centres; specific know-how and capability). Most of the FDI in Africa is either seeking to exploit natural resources or to grow a market; thus, transfers only the knowledge it needs to extract the resource or compete in a given African country market (Anwar, Iwasaki and Dornberger, 2022). Countries such as Morocco and South Africa have attracted a good number of efficiency-seeking FDI in sectors such as automobiles and aeronautics, whose products are exported to developed countries. Such FDI is likely to bring some of the latest technology for the production and delivery of products that can compete globally beyond the domestic market.

For instance, top manufacturers of vehicles in South Africa are thought to have invested about US$659 million (ZAR 9,23 billion) in 2020 and US$628 million (ZAR 8,8 billion) in 2021[23](about a fifth of the FDI inflows recorded in 2020 by UNCTAD). While not all the investment is related to technology acquisition, the drive towards developing new models, manufacturing platforms and electric vehicles in South Africa may have induced technological learning and acquisition (e.g. as capital goods, designs and intellectual property).

2.2.5. Trends in Intellectual Property Rights (Non-resident Patents)

Intellectual property rights are not technologies in themselves and the extent to which they may serve as proxies for technology transfer vary widely. For instance, the Agreement on TRIPS addresses various intellectual property rights that include:

- Copyrights and related rights (Section 1)
- Trademarks (Section 2)
- Geographical indications (Section 3)
- Industrial designs (Section 4)
- Patents (Section 5)
- Layout-designs (Section 6)
- Protection of undisclosed information (Section 7).

For a detailed discussion of the definitions and scope of protection offered in the Agreement for the various categories of intellectual property rights, see Part II of the Agreement as amended in 2005 (WTO, n.d.).

[23]Data from Baker McKenzie (2022) at:https://insightplus.bakermckenzie.com/bm/industrials-manufacturing-transportation/south-africa-developments-in-the-automotive-industry-creating-optimism-for-manufacturing-sector

For the purposes of this report, patent applications are regarded as technical documents that carry the new and emerging inventions of industrial value and constitute an important source of new knowledge and insights into emerging technological trends (WIPO Secretariat, n.d.). The underlining assumption is that an increase in non-resident patent applications to a given jurisdiction may be indicative of the interest of inventors to enter the market or at least the perception by inventors that their competitors are likely to enter the market or increasing technological capacity of the country to exploit the invention. Willoughby (2020) observed that "exploitation by national residents of foreign markets for the commercialization of endogenous technology through the sophisticated use of the intellectual property systems of foreign countries is an important factor for national economic development" (p.844, abstract). Therefore, non-resident patents are seen as key in technology flows between nations (Bransetter, Fisman and Foley, 2006; Hu et al., 2016) and are commonly used as a proxy for technology transfer.

Table 2.6: Non-resident patent applications in selected Africa countries

	2005	2010	2015	2016	2017	2018	2019	2020
Ethiopia	4	--	32	26	39	49	--	54
Ghana	--	--	--	17	11	39	--	8
Kenya	59	120	56	59	43	42	41	35
Morocco	520	882	797	1066	2026	2350	2531	2438
Rwanda	--	--	1	3	2	1	--	--
South Africa	6001	5562	6608	6506	6816	6258	6347	6146
Africa	8758	9504	11275	11439	13076	13336	12923	12381

Source: World Development Indicators

The number of non-resident patent applications registered for Africa has grown rapidly in the recent years. For instance, non-resident patent applications dropped from about 8500 in 1980/81 to about 4500 in 2000, but the number has since risen to about 13,336 in 2018 and 12,923 in 2020, representing about 2.7-fold increase between 2000 and 2021. This is higher than the world average of 1.9-fold increase in the same period. However, Africa's share of the global non-resident patent applications remains low at 1.3 percent, which is way below Africa's global share of researchers (about 2%), trade (3%) and GDP (2.8%).

Among the empirical countries in this report, Morocco registered a four-fold growth in non-resident applications between 2005 and 2021 as shown in table 2.6. The growth may have been driven by increased investment in automotive, aeronautics and pharmaceuticals, among others. Meanwhile, South Africa accounts for about half of all the non-resident patent applications to Africa but the number of non-resident patent applications received by South Africa has not grown since 1990s, averaging about 6000 a year. In comparison to other members of the BRICS countries, South Africa gets the least number of such applications. For instance, between 2000 and 2021, Russia registered about 53% growth (to reach around 12,000); those to Brazil grew by 46% (reaching about 19,058), applications to India grew by 431% (to hit 33,630), and to China by 485% (about 152,000) over the same period.

As shown in table 2.6, non-resident patents applications to Kenya have declined while Rwanda, Ghana and Ethiopia seem to attract very few non-resident patent applications. It is possible that the IP offices and patent systems in these countries are not reporting or processing applications quick enough to be registered; the market is not sufficiently sophisticated to demand new knowledge hence patent applications and/or; most of the domestic inventors are not a threat to trigger such application. It is rather surprising considering that most African countries were among those that witnessed rapid economic growth in the last three decades, sprouting of innovation hubs across the continent, and increased investment.

2.3. Concluding Remarks

Technology transfer plays an important role in narrowing the gap in economic, social and environmental advancement between rich and poorer countries. Irrespective of the proxy for technology transfer used, it is observed that countries that are growing fast and uplifting the living standards of millions of their people (e.g. China, India and Turkey) also have registered rapid inflow of technology.

Data show that imports of technology to Africa rose rapidly in years when economies were growing rapidly – largely between 2002 and 2014 – then plateaued and declined in the last three years. The COVID-19 pandemic, despite having driven ICT uptake, has negatively impacted technology inflows in 2020 and 2021 even for acquisition of licenses to reproduce and distribute computer software. Africa was not alone. It would seem entities that reproduce and distribute software either have less business or are diversifying their sources of such software, resulting in the decline in payments to the United States globally. It may also be due to the increase in the use of open source and cloud-based services, which may have reduced the need for reproduction and distribution of computer software. This observation may be backed by the increase in payments for cloud-based services.

The empirical countries in this report seem to perform better in imports of capital goods and attracting foreign direct investment. This is not entirely surprising given the huge investment that flowed into infrastructure development, especially in construction and extractive industries between 2000 and 2014. These sectors' demand for capital goods are likely to have driven the trade in capital goods imports. That may also explain why capital goods imports rose for most of the countries irrespective of their levels of development. The decline in the last few years may also be linked to reduced investment and subdued economic performance of most countries.

The proliferation of innovations was expected to drive innovation in digital and in turn, should drive technology transfer needed to accelerate Africa's digital revolution. Africa needs to seed more innovation and growth-driven firms that can compete with other major players in the market for technologies. Countries can negotiate with key technology holders to co-invest, form joint-ventures and/or other modes of collaboration.

Other recent deals to manufacture cars and mobile phones in Ghana, Kenya and Rwanda; pharmaceutical products in Kenya and Morocco; and textiles in Ethiopia, as well as setup digital platforms in South Africa (e.g. by Amazon Web Services, Huawei and Google) may start to fuel technology flows to Africa. It is also necessary to support small- and medium-sized firms in technology, manufacturing and value-added services to acquire the technology.

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