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Technology Transfer from China to Kenya for Transport Infrastructure: The Case of International Trunk Roads

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Abstract: Literature on technology transfer to Africa is dominated by studies on agribusiness, military technology, information and communication technology, energy, climate change, health, and manufacturing, while it is scanty on others like transport infrastructure. In this article, we reviewed literature and carried out key informant interviews to collect data on technology transfer for Chinese-built roads in Kenya. Our objective was to examine the extent of technology transfer from Chinese multinational corporations to Kenyan institutions and organizations. We established that there was little technology transfer mostly because of Kenya's internal obstacles such as inadequate absorptive capacity, weak competition culture, and weak legal and institutional frameworks on technology transfer. Multinational corporations transferred technology primarily to fulfil their commercial objectives and to meet the domestic labour training requirements. The technology transferred was not sufficient to simulate innovation and technology development in Kenya. We recommend reviewing Kenya's legal and institutional frameworks on international technology transfer in order to improve the participation in and enforcement of technology transfer by government institutions.

Keywords: International technology transfer, spillovers, diffusion, international trunk roads, China, Kenya.

Introduction

After the establishment of the Forum on China-Africa Cooperation (FOCAC) in 2000, China expanded activities on technical cooperation, knowledge sharing, technical training, and education aimed at improving human resource and capacity development in Africa. It increased investments in Kenya's transport infrastructure, especially after the successful completion of the Thika Superhighway (2009-2012). However, technology transfer activities associated with roads developed by Chinese multinational corporations (MNCs) have not been adequately examined.

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The objective of this article is to explore the extent of technology transfer from China for development of transport infrastructure in Kenya, using international trunk roads as case studies. We selected these for three reasons: 1) they attracted some of the largest Chinese MNCs by capitalization; 2) they involved significant technological input; and 3) they are important to Kenya's regional and international connectivity as well as being China's strategic link to the East African hinterlands. To achieve the article's objective, we used technology transfer through Foreign Direct Investment (FDI) as a conceptual framework to answer the following questions: How was technology transferred from Chinese MNCs to Kenya? What was the nature of the technology, and to what extent was it transferred? What were the impediments to technology transfer? The article is organized in five main parts. The first reviews literature on international technology transfer relevant to Africa. The second discusses the role of FDI in technology transfer. The third discusses the research design and method. The fourth examines Chinese MNCs' technology transfer activities for international trunk roads development in Kenya. Lastly, we offer conclusions and policy recommendations.

Literature Review

The Africa Agenda 2063 has elaborately covered issues of technology development, acquisition, change, and innovation as one of the pillars of development on the continent.[1] It emphasizes research in science and access to technology as essential drivers of innovation. Africa's rate of development is dependent on its ability to acquire and use foreign technology. Europe, the United States of America, and Japan have been traditional sources of technology and development funding since the 1960's. However, Africa's failure to obtain sufficient funding and appropriate technology from these nations led to engagements with China. The continent hoped that it would significantly benefit from technology transfers and other forms of development assistance.

Some of the most recognized methods of international technology transfer are FDI, sub-contracting, franchising, licencing, joint research, technology management training, capacity-building activities, and trade in technological objects. MNCs use FDI as the primary mechanism to transfer technology and implement projects in foreign countries. Developing countries encourage FDI flow assuming it will lead to a higher rate of technology transfer, imitation, and innovation. They also assume that MNCs would directly encourage technical change and promote learning. Following the above reasoning, Africa encouraged MNC investment on the continent. However, the rate of innovation and invention is still low, suggesting a problem in international technology transfer.

Studies conducted over time evaluate, examine, and explain China's investments and their impact on the continent. A review of literature on technology transfer from China to Africa shows recurrent themes like technology transfer through industrial clustering and linkages, technical training, equipment sales, and capacity building but also attendant problems such as lack of absorptive capacity, technology and capacity gap, differences in management culture, among others.

Casadella and Liu's study notes that Chinese private investments in Africa created industrial clustering effect in some countries. They mention Huajian, a shoe manufacturing firm that installed a production plant near Addis Ababa in Ethiopia. This attracted other firms to the

location, leading to setting up operations that resulted in a 300% growth of FDI in the region.[2] On the same issue in Nigeria, Chen states that there were limited Chinese MNC linkages to local firms, thus preventing industrial cluster development that would catalyze the growth of local manufacturing sector and supply chains. He argues that the few linkages that developed contributed to transfer of skills and knowledge through intra-firm training. He also notes that there were cases of technology exchanges between firms, though they relied on imported parts because of lack of an industrial ecosystem for spare parts supply.[3]

King shows that China's activities in capacity building continued growing since the inception of FOCAC. FOCAC promoted vocational training and capacity building in several Africa counties including Djibouti, Egypt, Morocco, Nigeria, Kenya, and Ethiopia through such programs as the Luban Workshops. This was in line with the FOCAC Action Plan of 2021 on promotion of technology transfer.[4] Casadella and Liu add that since 2000, Chinese state-owned MNCs engaged in technical training and capacity building in several countries in Sub-Saharan Africa.[5] However, they assert that there is no reliable data on the impact of their activities on technological learning in the region. They observe that there was no data collection activity in Senegal to ascertain direct technology purchases through patents, technological licencing, or copyright. Nonetheless, they observe that Chinese MNCs shared expertise and technology with local firms to improve productivity of Senegalese groundnuts for export to China.[6] Generally, technical cooperation between Chinese MNCs and local firms did not lead to significant benefits to the local population. The MNCs were concerned with making profits even at the expense of meaningful benefits by locals. The same was the case with a Chinese firm (China-Africa Cotton) in Zambia where it trained a local workforce. Tang observes that they trained locals only to the extent to which the training was useful to maximization of profits.[7] His study indicates that the firm would rather invest in hard technology to improve productivity as opposed to training local laborers. For example, it invested in advanced seed technology instead of training workers on other production techniques that would have equally improved productivity.

According to Park and Tang, Chinese MNCs hired and trained local employees in Africa, cooperated with local firms, and demonstrated advanced technologies. However, the effectiveness and viability of knowledge transfers was not the same in all countries and economic sectors.[8] Their study covers telecommunications, agricultural, and manufacturing sectors in Zambia, Tanzania, Nigeria, Malawi, Madagascar, and Kenya. They observe that training of local personnel was the most widespread practice of Chinese firms. They also note that there were similarities in technology transfer practices between state-owned and private Chinese enterprises.

Rataj avers that Huawei deliberately engaged in technology transfer activities such as human capacity development to enhance capacity in Africa.[9] Huawei operates in more than fifty African counties and has a research and development center plus several training facilities. Park and Tang, nevertheless, state that there were few cases across the continent of classroom training in local and overseas learning centers. Huawei has training centers in Kenya, Nigeria, Egypt, Tunisia, South Africa, Angola, Morrocco, and the Democratic Republic of Congo.[10] The Chinese MNC created a pool of workforce in sales, construction, and technical areas to implement and operate its projects.[11] But Park and Tang note that knowledge was not

transferred from Huawei's ecosystem to local industries, partly due to internal factors in host counties, and because of Huawei's deliberate market-seeking strategy.

Similarly, the demonstration centers of Hunan Agri were a means of commercialization and outward expansion of the Chinese MNC's business in host countries.[12] However, while analyzing the technology transfer activities of Huawei's training centers discussed by Park and Tang, Tugendhat claims that the Chinese firm had indeed transferred skills and knowledge to Kenyans—some of whom started successful e-commerce businesses such as 'Kilimall,' while other former employees applied their skills and knowledge in such ventures as the Government of Kenya's innovative flagship project Konza Technopolis.[13] The problem and importance of capacity building in Africa has also been discussed by other authors such as Li, Ibonye, and Hu et al. who argue that Chinese experts and firms such as Huawei were involved in training Africans to build capacity in management and organizational skills in various sectors such as agriculture, manufacturing, clean energy, radio and television, handcrafts, and culture and sports.[14]

Casadella and Liu indicate that technology transfer failure in most African countries is a result of lack of innovation capabilities. They opine that Sub-Saharah Africa had a weak technological base and as a result, it was incapable of technological learning from imported technology. They found that most firms were below the levels of best international technological practices. Technical assistance by foreign actors in the region had not promoted technological learning. Instead, it had led to deterioration in technology development.[15] Iroegbu et al. as well discuss capacity of technology receiving countries, market dynamics, and government policies as major factors preventing technology transfer.[16]

Furthermore, differences in levels of economic and technological development between China and Africa significantly contribute to capacity gap. Casadella and Liu find that technology spillover was negatively affected by the technology gap between local firms and MNCs.[17] Tang's study has similar findings. He observes that the China-Africa Cotton company and China's Ministry of Commerce training programs exposed Zambians to advanced technology, knowledge, and skills in China, but Zambians did not have the capital required to realize such technology locally, thus making the technology inappropriate.[18] Elu and Price affirm that China did not transfer technology for productivity improvement in Sub-Saharan Africa. They note that Chinese FDI was not suitable and accessible to the region because of the continent's weak absorptive capacity.[19] The FDI received contained significant portions of intangible assets such as human and organizational capital that was inappropriate and inaccessible to local firms, and therefore not useful for growth in productivity.

Park and Tang's study reveals that while Chinese businesses created jobs and transferred some skills, they did not transfer significant knowledge and technology, and as such had limited impact on structural transformation on the continent. They point out factors such as capacity gap, poor absorptive capacity, weak financial capabilities, weak innovation policies, poor physical infrastructure, and management culture of local firms. These often hindered knowledge and skills transfer from Chinese firms to the local workforce. Chinese training types and activities, and their rationale also played a significant role in lack of technology transfer.[20] Iroegbu et al. establish that there were remarkable differences in management cultures between Chinese MNCs and local firms. For instance, they note that Chinese MNCs were more

aggressive in developing and using technology as opposed their African counterparts—this posed a challenged when it came to transferring such skills.[21] Furthermore, some Chinese firms in Zambia, Tanzania, Nigeria, Malawi, Madagascar, and Kenya did not transfer knowledge and skills to local workforce because they were unable to retain workers they trained.[22] As a result, they engaged in informal, short-lived, and practical skills transfer activities. But Chen's study in Nigeria shows that even though training workers involved high "sunk cost of forfeited products as workers made mistakes and learnt from them," Chinese furniture makers preferred retaining them to avoid incurring such costs repeatedly.[23] As such, they incentivized workers to stay.

Technology Transfer by Multinational Corporations: A Conceptual Framework

MNCs are a vital source of technology for increasing competitiveness and productivity of firms in the developing countries (DCs). Organizations in DCs depend on technology developed by MNCs to run their daily activities. MNCs' FDI, licencing agreements, import of capital goods, training of personnel in technologically advanced countries, turnkey projects and contracts, and technical consultations all facilitate technology transfer.[24] MNCs are preferred by countries as a source of technology since they provide an environment for continuous interaction and learning between technology transferors and transferees, thus enabling transfer of tacit knowledge and other components of technology. Additionally, corporate taxes on MNCs provide revenue for investment in domestic sectors such transport infrastructure, agriculture, health, and education.[25]

However, the nature of the impact of FDI, whether negative or positive, depends on host country's internal structures, organizational efficiency, and level of development.[26] For FDI to be effective, the receiving country should have adequate absorptive capacity, well developed human capital, domestic capacity to compete foreign investors, and abundancy of capacity that cannot be filled up by domestic organizations alone.[27] According to Brenner, the less developed a country is the less it benefits from FDI activities such as knowledge spillovers and diffusion.[28] MNCs competition with local firms often leads to loss of employment, especially when local firms cannot fairly compete. Additionally, positive capital flows in host economy change to negative if MNCs use relatively cheap labor and materials to produce goods priced highly. Tax breaks on MNCs to attract foreign investment and MNCs' profit repatriation lead to reduction of government revenue, thus affecting the amount of funds available for reinvestment in the domestic economy. This slows overall physical, social, and economic development, and impedes provision of quality life. Sometimes, FDI source countries use investments to acquire political and economic control over host countries.[29]

FDI and Technology Spillovers

Within the context of international technology transfer, technology spillovers refer to the indirect technological benefits to a technology-receiving country arising from research and development (R&D) activities of another country without the cost of R&D being shared between the countries. Technology spillovers occur through several ways. First, the entrance of an MNC can lead to increased competition in the host country leading to improved

productivity. It can encourage efficiency in previously inefficient firms and make them invest in personnel and acquire advanced technology. Second, MNCs can train their personnel and replicate the same in domestic firms. Third, MNCs have intangible assets such as managerial and entrepreneurship skills that cannot be sold but which become available to host countries through labor turnover. Fourth, technology spillovers occur when local production facilities, consultancy services, suppliers, and others quickly upgrade to meet higher standards of quality control, specifications, reliability, and operating methods of MNCs.[30] For substantial technology spillovers to occur, the knowledge flowing through various firms and institutions by way of production linkages and cooperation in R&D should be undistorted.[31] Additionally, the host country should gather information and document processes of technology transfer, train the domestic labor force on new production methods, and engage in reverse engineering activities.[32] Developing countries can also purchase 'whole technology'—that is, acquire a complete physical technological setup, together with related technical documents, and at times, personnel. Though not legal or encouraged, industrial espionage and forced technology transfer can be effective methods of acquiring foreign technology.

FDI and Technology Diffusion

Technology diffusion is the movement of technology from one geographical region to another, or from one use to another. According to Liu and others, diffusion is a process of knowledge exchange.[33] Stoneman and Battisti argue that when new technology appears, it "initiates a process by which the number of users of the technology increases absolutely and/or over time and space."[34] Methods of improving diffusion include technical training, conducting awareness campaigns, and organizing conferences, workshops, seminars, demonstration, and exhibitions. In circumstances where the receiving country has inadequate absorptive capacity, the transfer of knowledge and know-how through technical courses, hands-on training, and observation play a crucial role in enhancing diffusion. Training equips learners with skills to manage, maintain, adapt, and monitor new technology. As opposed to technical courses taken in a classroom setting, hands-on training has the advantage of being results oriented. It facilitates the development of best practices. It is dynamic, situated, and practice oriented. Hands-on training arises from, and is embedded in, work circumstances and can focus on an individual, a group, or a firm.

In addition, industrial clustering and networking are major determinants of the rate of domestic technology diffusion.[35] For instance, geographic clustering and linking of firms eases knowledge flows. In roads development this might involve those engaged in engineering consulting, construction, transportation, topographical surveying, quantity surveying, construction material processing and manufacturing, marketing, plant and machinery repairs, and other related services. Industrial networking achieves technology diffusion amongst different industries, especially in situations where smaller organizations do not possess resources for internal R&D. Subcontracting, where MNCs engage local firms to do some of the works, is an additional and efficient channel for technology diffusion, especially for management and production knowledge and skills. It enables smaller firms to access advanced technology and, in the process, reduce the technology gap.[36]

Research Design and Methodology

In undertaking this study, we used a qualitative research design which involved collecting primary data from targeted key informants in the industry. A key informant interview (KII) guide was developed as a tool to collect data from the identified informants. The instrument had perception as well as objective questions whose responses informed the article's questions. We collected data from twenty-three informants that included three CEOs of state agencies, two quality control managers, and eight highway engineers working on various projects, some with experience with more than three Chinese MNCs. In addition, we had in-depth discussions with two legal experts on international law to provide insights on international technology transfer contracts. Given the specialized nature of the sector and its relatively small size in terms of the number of actors, most informants were conversant with the subject matter.

We selected key informants on the basis of their knowledge, skills and experience in technology transfer issues in road construction. In some cases, a snowball method was employed—an informant was asked to identify someone that they knew in the field, then the researcher approached them independently in order to maintain objectivity and anonymity of informants. Interviews lasted between thirty minutes and two hours depending on the information that an informant was giving and their availability. Data collection occurred between September 2022 and February 2023. The KII guide covered transfer of knowledge and skills on technical specifications and standards; managerial issues and entrepreneurship; purchase of whole technology packages; establishment of production linkages; and legal and institutional frameworks involved in technology transfer. Other areas covered in the instrument included factors affecting technology transfer such as differences in norms, culture, and knowledge base; and the complexity of the knowledge and skills possessed by MNCs.

While a researcher conducted the interview, two research assistants took notes. A few informants agreed and gave consent to record interviews. Where this method was used the research assistants helped in transcribing the interviews. Qualitative data was thematically analyzed to develop a narrative on technology transfer activities.

Technology Transfer for Chinese-built International Trunk Roads in Kenya

The use of foreign technology is key to the improvement of transport infrastructure in Kenya, including planning, designing, erecting, repairing, maintaining, altering, and demolishing existing roads and other infrastructures. Since 2010, the development of major roads in Kenya increasingly relies on technology supplied by Chinese MNCs. China Road and Bridge Corporation (CRBC) developed the Nairobi Southern Bypass and the Nairobi Expressway in addition to the Standard Gauge Railway and ports at Mombasa and Lamu. Other Chinese MNCs such as the China State Construction Engineering Corporation (CSCEC) developed the Webuye-Kitale-Endebess-Suam Road while the Power Construction Corporation of China's subsidiary, Sinohydro Corporation, developed the Thika Superhighway.

In 2022 alone, Chinese MNCs build about 85% (by value) of international trunk roads and approximately 50% of rural and urban roads in Kenya. Local companies' share of rural and urban roads was 26%, with only 6% of international trunk roads.[37] The international trunk roads developed by Chinese MNCs include Isebania-Endebess-Suam that involved six Chinese MNCs

for a total contract value of more than Kshs. 47.8 billion (~US$ 388.6 million). Another road connecting the capital to the Kenya-Ethiopia border town of Moyale involved six Chinese MNCs for a total contract value of more than Kshs. 86.9 billion (~US$ 706.5 million). Sections of the road running from Nairobi to the Uganda-Kenya border town of Malaba, plus their interchanges and bypasses, were also developed by these MNCs. At the end of 2021, Kenya had about 5,400 kilometers of paved international trunk roads, up from 2,890 and 2,920 kilometers in 2000 and 2011, respectively.[38]

Technology Spillovers from Chinese MNCs to Kenyan Organizations

Theoretically, competition between MNCs and local firms is known to foster technology spillovers. However, informants indicated that the competition created by the entry of Chinese MNCs in the road construction sector in Kenya did not lead to productivity improvement of local firms. Local firms did not invest in personnel training and acquisition of advanced technology. The amount of financial, physical, and knowledge resources at the disposal of the MNCs, and lack of adequate resources by local firms to invest in upgrading technology and improving the quality of personnel, made it impossible for them to favorably compete through self-improvement. Instead, nearly all were disqualified during the procurement process of high value road contracts for reasons such as technical and financial inability to undertake the works.[39]

Notwithstanding, local highway engineers in the projects noted that Chinese MNCs trained local personnel on hands-on skills and sponsored theoretical learning in both local and foreign institutions of learning. Upon project completion, the trainees sought employment in local firms, (potentially) leading to knowledge and skill spillovers. When asked, most of the local engineers employed as project managers and supervisors by the Kenya National Highways Authority (KNHA) admitted that they were trained in advanced management and hands-on technics through training-by-doing and other ways such as conferences, seminars and in learning institutions locally and abroad. This provided an opportunity for managerial knowledge and skills transfer to local organisations and institutions. However, one engineer, who was involved in three projects done by three different MNCS, did not think that the training they received was unique or useful. He said that "the training was useless. I learnt nothing new."[40]

Chinese MNCs used materials, tools, machinery, and equipment whose standards and specifications were higher than what local firms employed. Moreover, informants averred that the MNCs technical personnel possessed advanced skills and knowledge in certain areas such project scheduling, general planning, and management of the implementation processes as compared to their Kenyan counterparts. But despite awareness that MNCs possessed advanced technologies, there was no evidence to demonstrate that local production firms in the sector upgraded their facilities or products to meet higher standards of production inputs required by the MNCs. Informants however stated that there were exceptions: local producers of cement and steel upgraded their products to the meet higher standards requirements of the MNCs. Nevertheless, informants noted that the upgrading was not because they did not previously possess the capabilities to produce such materials. Rather, prior to installation of some of the infrastructural projects such as bridges along the Nairobi Expressway, there had been no

demand for such quality of cement and steel. Notably, the general failure of most local firms to upgrade was a result of lack of human and financial resources. Additionally, MNC production facilities had controlled access. Only authorized personnel were allowed to enter the facilities. In fact, interviewing local labor force for this article had to occur at the gate house, or other places not near production plants. This restricted direct learning from the machinery and production processes.

Most informants noted that Chinese MNCs had advanced quality control measures, specifications, reliability, and operating methods for producing construction materials and components. While their methods and procedures were advanced, employing cutting-edge equipment and technical knowledge, local firms in the sector used outdated processes and technology to produce equivalent products, thus taking more time and limiting resources at their disposal. A local project resident engineer observed that in many cases, the specifications in tender procurement documents produced by government institutions still recommend use of outdated processes of technology transfer.[41] Informants noted further that the receiver of the technology, a government agency, was concerned solely about the final product and, as such, paid little attention to processes and technologies used.

Technology Diffusion from Chinese MNCs to Kenyan Organizations

Chinese MNCs imported machinery, tools, and equipment for use in road construction. In addition, they imported specialized and technical labor who in turn trained local personnel on production methods and techniques. They also sponsored technical training of local workers in learning institutions both in Kenya and China. A key informant working on one of the roads noted that it is the policy of the Kenyan government that every road project undertaken by a foreign entity must train interns and recent college graduates.[42] As a result, hundreds of interns were trained and allowed to seek employment in numerous other industries. It was however difficult to know the total number of trainees, and to establish effectiveness of the training. Nonetheless, informal discussions with local contractors and other actors in construction industry indicated that they found the trainees slightly more competent than those not trained by MNCs.

Interview data corroborated findings in our literature review that hands-on training is preferred and emphasized by Chinese MNCs. MNCs consider it effective in passing over skills required to perform tasks aimed at project delivery. An informant from a government agency stated that construction of a single road segment could train over 200 interns in hands-on skills.[43] However, the nature of the skills and knowledge transferred during the training has been questioned. For instance, MNCs China Wu Yi, Sinohydro, and Sheng Li Engineering completed the first major international trunk road (Thika Superhighway) in 2012. But Sanghi and Johnson contend that only basic skills and knowledge in safety and hygiene were transferred to local workforce during the implementation of the project.[44] Generally, hands-on training programs provided a feedback mechanism between academia and industry, creating an opportunity for students and the teaching staff in learning institutions to evaluate the knowledge and skills in practice against theoretical knowledge and skills imparted in classroom settings.

In addition to hands-on training, China Road and Bridge Corporation (CRBC) established a Technology Transfer Competence Training Facility in Voi in 2015 where more than 300 students received training in various technical fields such as equipment operation, construction engineering, and laboratory skills. The same MNC sponsored more than 100 students to study various technical subjects in China.[45] By 2018, Chinese MNCs had trained more than 60,000 Kenyans in all sectors (since 2015).[46] However, highway engineers interviewed argued that the training received was similar to what local institutions offer.

Apart from training, other mechanisms used to transfer knowledge and skills include workshops, seminars, conferences, demonstrations, and exhibitions. However, there was no research output documenting the activities, and no follow-up studies on their effectiveness in technology transfer. Industrial networking and clustering of firms has been used in developed and emerging countries to foster technology diffusion. But they have not been purposefully applied to improve technology diffusion from Chinese MNCs to Kenyan organizations. Firms involved in construction of roads located depending on their needs and linkages between or among them that would encourage technology diffusion remained weak.

Technology Transfer Challenges

The knowledge and skills gap between Chinese MNCs and local organizations/institutions in Kenya is wide in certain areas such as technology transfer processes, theoretical tools, and practical considerations leading to asymmetric information. This impedes technology transfers in three ways. First a transferor may have concerns about the possibility of technology imitation with a consequent reduction in transferor's competitive advantage.[47] Second, when the transferor has more information about the transfer than the transferee, the transferor might not know how to correctly transfer knowledge, and the transferee might not correctly know the value of the transferor knowledge. In the former, the transferor might not be familiar with the context and capabilities of the transferee while in the latter, the transferee, having little or no information concerning the technology, disregards the knowledge and attempts to transfer, leading to project implementation by MNCs without exchange of knowledge. A third scenario where neither the transferor nor the transferee has complete knowledge about the transfer often leads to MNCs employing local personnel without requisite technical know-how and importing technical experts having no local business knowledge.[48] The second and third scenarios each occurred in projects we studied. To resolve them, MNCs re-trained Kenyan personnel who possessed some technical knowledge and expertise. They were in turn expected to train others since it was cheaper than importing experts from China.[49] The MNCs also relied on the re-trained local workforce to act as intermediaries between them and various local social, cultural, and economic contexts. They also made efforts to reduce the asymmetry through mechanisms further discussed below.

Interview data indicated that Chinese MNCs had advanced design knowledge and specifications plus cutting-edge institutional, management, administrative, hands-on skills, and knowledge. Informants stated that the MNCs relied on standardization of components, iteration, and creativity as planning and production techniques in which individuals specialized in producing specific components. This led to higher quality and efficiency. An in-depth discussion with a local highway engineer revealed that the personnel imported by MNCs had

knowledge on fundamental design concepts that was at par with that of Kenyans of equal training.[50] Nevertheless, despite the parity in both theoretical and practical knowledge and skills, and despite cooperation with local institutions and organizations, technology transfer was limited. Local organizations had not learnt and developed institutional, administrative, management, and technical skills and capabilities available in Chinese MNCs. Institutional capabilities proved more difficult to transfer. Ordinarily, these require more than well-trained individuals to be effective agents of change—they need to be accompanied by technical expertise and scientific knowledge to be embedded in local institutions and organizations. There was limited deliberate effort by MNCs to train local workforce beyond what was required for project implementation. MNCs imported technical personnel who were not embedded in local institutions and organizations.

As a result, stagnation continued in technological development of the road construction sector. The limited technology spillovers and diffusion from Chinese MNCs to local organizations had not facilitated innovation and technological development. Generally, impediments to construction technology development in Africa and other developing nations include the conservatism of construction workers and firms, the fragmented nature of the sector, and its reliance on laborers who acquired skills on the job without formal training.[51] Concerning conservatism, Kenyan firms had not paid adequate attention to Chinese MNCs methods and techniques of implementing projects. They were found neither technology-driven nor technology-following—rather, they were technology-indifferent. They persistently used traditional methods and processes despite awareness of cutting-edge knowledge and skills.

Several methods attempted to transfer technology but with minimal success. Some methods such as publications and exhibitions were not guided and structured in a manner to serve as effective avenues of technology transfer. Conferences, seminars, workshops, and other forums on technology transfer that occurred did not specify the knowledge and skills to be transferred and the processes to be involved. They instead generalized technology transfers, omitting key details concerning the nature of the knowledge/skills, and how, why, or when they could take place. Crucially, there was no technology transfer documentation and post-project implementation evaluation, thus preventing future technology spillovers and diffusion to local institutions and the labor force. It is difficult to access embodied technology in a finished road without detailed and systematic documentation of the entire technology transfer process.

Concerning the training of interns, local project managers (mostly local civil engineers) indicated that the government had no monitoring and enforcing mechanisms to guarantee desired technology transfer objectives. Furthermore, they stated that there were no rules and guidelines enumerating the kind of knowledge and skills, and how they ought to be transferred. As a result, trainees were exposed to new knowledge and skills—but not to procedural knowledge—without assistance in interpretation or explanation for them to make a connection between theoretical learning in classrooms and the industrial practice. In addition, informants emphasized that there was a disconnect between the academia and industry in the sector. The practical training program did not receive sufficient input and guidance from learning institutions. Informants, some of whom were interns on road construction projects while learning at universities, strongly argued that university teaching staff who supervised the interns did not add value to the training program.

Moreover, our data showed that Chinese MNCs could not effectively transfer skills and knowledge to the local industry due to low absorptive capacity and lack of appropriate local institutional frameworks to guide the process of technology transfer. For example, National Construction Authority (NCA) regulations stipulate that foreign organizations undertaking construction activities in Kenya must enter a joint venture with a local company, or subcontract at least 30% of the work to local firms, and transfer skills not available locally. The regulations further state that joint ventures between local and foreign contractors must seek the approval of the authority before employing foreign technical or skilled workers.[52] However, joint ventures, which are effective in technology transfer, were not used for project implementation. Instead, turnkey contracts were adopted, allowing MNCs to carry out all necessary work from planning, design, installation, and handover of complete project to the government. Moreover, an informant observed that NCA did not have a clear framework concerning the type of knowledge/skills or quality/quantity to be transferred and it had no framework to monitor, evaluate and enforce technology transfer in the road construction sector.[53] Contract documents for road construction do not specify explicitly technologies and mechanisms of transfer, resulting in limited transfers—especially of knowledge/skills—in areas such as management and production processes, among others.

Technology transfer has not been emphasized by KNHA—it is simply not key to its strategy. To illustrate, the KNHA strategic plan for 2018–2023 mentions technology transfer only twice, and the whole document mentions technology ten times. It notes that the technology transfer performance indicator is the "percentage of the value of aggregated contract sums expended on locally sourced inputs including local contractors, local subcontractors, local suppliers, local service providers and local materials."[54] The strategy did not have a budget for technology transfer activities and did not specify any activity in the first place. Its mission statement reads: "to develop and manage quality and adequate national trunk roads through innovation and optimal utilization of resources for sustainable development" but its practices in road implementation do not reflect these aspirations.[55] There is lack of innovativeness on the part of Kenyan teams involved.

Apart from KNHA, which actively participates in roads implementation projects, other institutions and agencies mandated with R&D, technology acquisition and transfer, regulation, and enforcement of government policy in the sector were passive participants in technology transfer matters. These include the National Construction Authority, the Technical and Vocational Education and Training Authority, National Industrial Training Authority, and the Public Procurement Regulatory Authority. These institutions should form a primary network of agencies to ensure that technology transfer from Chinese MNCs is effective. Fragmentation in research and development activities among statutory bodies, and low priority on roads technology research weakens the country's ability to develop internal technological capabilities and capacity. China collaborates with Technical and Vocational Education and Training institutions in Kenya, but there is a lack readily available data concerning the trainees to ascertain whether the partnership improved technology transfer in the roads development sector.

Lastly, informants noted that international networking in the sector is weak. Networking actors in the infrastructure sector at country-to-country and industry-to-industry levels is

important since it enables MNCs to effectively transfer technology to local industries, especially in areas of wide technology gaps. In addition, technology transfer is more effective when international networking is complemented by local industrial networking incorporating institutions of higher learning, public research institutions, government agencies, private research organizations, and related entities. For technology spillovers to succeed, the Kenyan government and Chinese MNCs should facilitate diffusion of knowledge among local organizations. This should be carried out through material and component production linkages and cooperation in technology R&D.

Conclusion and Policy Recommendations

We reviewed literature and carried out key informant interviews and in-depth discussions to collect primary data on the extent of technology transfer from Chinese MNCs to Kenya. The findings are summarized as follows: First, technology transfer occurred geographically, that is, it moved from China to Kenya. However, technology transfers from Chinese MNCs to local organizations and institutions was limited by several factors, most of which were internal, including: lack of absorptive capacity in local industries, lack of appropriate institutional frameworks to guide technology spillovers and diffusion, disconnect between industrial practice and research institutions, and lack of resources by local firms to upgrade technologically. Second, MNCs transferred technology primarily to fulfil their commercial objectives and fulfil domestic legal requirements for training local workforce. The limited transfers were not sufficient to stimulate innovation and development of local technological capabilities.

The findings of this paper have multiple implications for technology transfer policy. First, existing policies on international technology transfer should be reviewed to guide and enforce networking between government agencies/institutions, construction industry players, and private research bodies. They should be reviewed to facilitate active regulation, monitoring, evaluation, and enforcement of technology transfer activities. Second, contract agreements between government agencies and foreign governments or MNCs should contain specific technologies, quantities, and qualities to be transferred, and preferred mechanisms and channels of transfer. Third, the government should acquire 'whole technology' packages in critical areas such as materials, equipment, tools, and machinery design and production. This should involve buying of not only the material objects and associated techniques, but the design elements carrying media such as formulas, books, manuals, blueprints, specifications, technical magazines. They should be accompanied by scientific and technical expertise necessary to create local capacity for adaptation of the technologies, innovation, and creation of new ones. In short, technology transfer and capacity building for the sector should be government-driven.

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