Embedded technology transfer from an institution and culture nexus perspective: Experiences from the Mombasa-Nairobi Standard-Gauge Railway

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Abstract: Modern railway projects, characterized by “natural monopoly”, large investment, and far-reaching influences, are highly dependent on the institutional and cultural environments in China. The countries along the Belt and Road are characterized by weak institutions, unstable politics, and poor technology foundations, which are largely different from China. These factors are severe obstacles to international technology transfer. By summarizing the experiences from the Mombasa-Nairobi Standard-Gauge Railway (SGR) project, this study proposes a framework for embedded technology transfer with a technology-institution-culture nexus. The results indicate that technology localization, including technology standards, management mode, and industrial chain, should be realized in the process of technology transfer. Then, the host government ought to overhaul its institutional and policy framework to support the infrastructure projects. Moreover, the cultural conflicts between the transferor and transferee should be taken seriously. This experience could provide references for other international infrastructure technology transfers.

Keywords: technology transfer; infrastructure; localization; institution improvement; cultural integration

1 Introduction

International technology transfer is the acquisition, development, and utilization of technological knowledge by a country other than that in which this knowledge originated (Derakhshani, 1983). Technology transfers from developed countries or multinational corporations to developing countries have long been recognized as an efficient way to alleviate economic difficulties in these countries (Glass and Saggi, 1998; Alfaro *et al.*, 2003; Lin *et al.*, 2012; Newman *et al.*, 2015). Thus, it receives attention from various groups of scientists

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in the fields of economics, regional development, and geography (Alfaro *et al.*, 2003; Buckley *et al.*, 2008; Osano and Koine, 2016).

As Ito (1988) pointed out, a successful transfer could occur only if the recipient is sufficiently capable of maintaining an introduced production system. If not, this often leads to technology transfer difficulties. Therefore, reviews of critical factors associated with successful technology transfers have been highlighted in existing research (Keller and Chinta, 1990; Palich and Gomez-Mejia, 1999). Overall, the major factors often cited in previous studies mainly focused on three aspects: technology type, political and cultural environments in transferee countries, and gaps between transferor countries and transferee countries. For example, Joskow (1998) advocated that developing countries contemplate and implement restructuring and regulatory reform programs in major infrastructure sectors. Madu (1989) identified eight major factors, i.e. cultural value system, education and training, capabilities, research and development, identification and implementation of appropriate technology, stable government and political systems, managerial effectiveness, and objectives that lead to the successful transfer of technology. In addition, Steenhuis (2000) reported that the amount of technology, the accuracy of information, and the extent of organizational and environmental differences have a large impact on the efficiency of the technology transfer process in the aircraft industry.

The difficulties in the process of technology transfer often make providers hesitant to transfer technology and thus attract attention on the modes of technology transfer (Kogut and Singh, 1988; Agarwal and Ramaswami, 1992; Kirkpatrick *et al.*, 2006; Cochrane and Ward, 2012; Peck, 2012). For example, Liu and Dicken (2003) proposed the concept of “obligated embeddedness” in exploring how, under certain political-economic conditions, the investments of transnational corporations can be shaped to meet the recipient state’s objectives. Further, it is advised that measures such as strengthening regulatory priorities and political stability should be taken during the technology transfer process to alleviate the risks of weak institutions and political instability in developing countries (McCann and Ward, 2012). For instance, Song *et al.* (2018) reported that Chinese industrial parks in other countries face challenges, such as the complicated geographical environments of host countries, huge pressure from enterprise investment capital, the lack of service platforms aboard, and underdeveloped agglomeration economies. Thus, they discussed policy mobility by looking into the roles of revenue, land, and talent in developing these industrial parks.

Not surprisingly, most early studies focused on technology transfer in the manufacturing sector (Thurner and Zaichenko, 2016) due to the significant contribution of the manufacturing sector to GDP. However, infrastructure sectors such as transportation, telecommunications, energy, and power, have received relatively little attention from developed countries and multinationals even though the development of these is an essential requirement for economic growth and sustainable development (Esfahani and Teresa Ramirez, 2003; Jiao *et al.*, 2016). Three reasons might contribute to this phenomenon. First, the infrastructure sector is characterized by large investment, long investment return, large land occupation, mostly dominated by state-owned sector. These characteristics make the technology transfer in the infrastructure sector is more difficult to realize as compared to that in the manufacturing sector. Second, government regulation, the solution to “market failure” in the infrastructure sectors, brings with it the “obsolescing bargain” risk (Vernon, 1971). Third, developing

countries are often characterized by weak institutions and political instability, which increase the risks of investments in their infrastructure sector (Regalsky, 1989; Adero and Aligula, 2012). Since the mid-1980s, governments around the world have pursued policies to involve the private sector in the delivery and financing of infrastructure services (Ramamurti and Doh, 2004). In response to this trend, private capital flows for infrastructure have made great contributions to the increase in foreign investment of the service sector. At the same time, the risks, opportunities, and responses of infrastructure technology transfers in developing countries have been emphasized. For instance, Ramamurti and Doh (2004) argued that infrastructure foreign direct investment in developing countries is doubly vulnerable, faced with the risks of both foreign direct investment in infrastructure sectors and the fact that the investment is being done in developing countries. Joskow (1998) reported that many developing countries have implemented regulatory reform programs to respond to the poor performance of technology transfer in the infrastructure sector.

In contrast to previous infrastructure technology transfers in developing countries, the Mombasa-Nairobi Standard-Gauge Railway project (hereinafter referred to the SGR project) was initiated by the Kenyan government in the context of China's Belt and Road Initiative. Therefore, Kenyan government takes some measures initiatively, such as overhaul its institutional and policy framework, expropriate land, propaganda railway culture, and provide preferential policies, to support the project initiatively. As a successful example of technology transfer in the infrastructure sector, the effects of the SGR project and barriers faced in the construction process attracted the attention of researchers. For instance, Wissenbach and Wang (2017) examined the impacts of Kenyan politics on the SGR construction and assessed the opportunities for local content, jobs, and skills through semi-structured questionnaires. Chege *et al.* (2019) assessed the influence of technology transfer on the performance and sustainability of the SGR in Kenya using data collected from semi-structured surveys of 165 Kenyan students in China. To the best of our knowledge, there is no study has summarized the successful experiences of the SGR project. To fill this gap, this paper summarizes the experiences from the SGR project and proposes a framework for embedded technology transfer by focusing on the institutional and cultural environments of transferee countries. It also aims to offer some insights for other international infrastructure technology transfers.

The rest of this paper is organized as follows. In the next section, we explore the difficulty of technology transfer-in the context of the dependence of technology on specific institutional and cultural environments, as well as the institutional and cultural differences between home countries and host countries. Accordingly, a framework for embedded technology transfer suitable for major infrastructure projects is proposed. Section 3 is an overview of the SGR project. Then, the local impacts of the SGR project are explored considering economic development, institutions, culture, ecology, and the environment as Section 4. In Section 5, we summarize the lessons drawn from the SGR project and offer some suggestions for host countries on technology localization, institution improvements, and cultural integration. Finally, a discussion and conclusions are presented in Section 6.

2 Theoretical framework of embedded technology transfer

In the mid-1960s, technology transfer was first mentioned in international economic theories and technology theories. It has been widely defined as the flow of tangible knowledge

(products, equipment, parts, etc.), intangible knowledge (proprietary technologies, patents, technical standards, technology licenses), and macro and micro information of countries, regions, enterprises, organizations, and individuals. The latter can be achieved through written text or “learning by doing”. Traditionally, the effectiveness of technology transfer mainly depends on the transferee, transferor and the technology itself. It can be expressed by a three-dimensional mathematical function $V = (X, Y, Z)$, wherein, X , Y and Z denote the technologies in different development states, the ability of the transferee, and the strategy of the transferor, respectively.

Conventionally, technology is universal and highly replicable, but it makes sense only from the perspective of the technology itself. In fact, technology transfer is a process of technology recognition, absorption, and spreading from the transferor to transferee. The effect of technology transfer is influenced by different factors such as the type and living environment of the technology and the differences between the transfer subjects in institutional and cultural environments. The difficulties varied from technology types. Survival and development of any general-purpose technology (related to production and manufacturing) mainly depend on the institutional and cultural environments of the transferee rather than those of the transferor. Therefore, the transfer of general-purpose technologies is easier. Large-scale infrastructure projects such as modern railway projects are characterized by “natural monopoly” and they are highly dependent on the specific institutional and cultural environments of the transferor. In case of great differences between the transferor and transferee in institutional and cultural environments, technology, institution and culture should be comprehensively considered. The difficulty of technology transfer can be roughly expressed as the result of the interaction of three factors, namely, the technology’s dependence on the institutional and cultural environment, and the institutional and cultural differences between the transferor and transferee. The greater dependence of technology on the institutional and cultural environments indicates the larger difference in the institutional and cultural environment, and the greater difficulty of technology transfer, and vice versa. As is shown in Figure 1, technology transfer of V1 is much easier than V2.

Figure 1 Constraints of institutional and cultural differences on technology transfer

The railway construction project, featuring large investment and extensive coverage, has a far-reaching influence on the social and economic development of the transferee and is a typical transformative project. The transferee usually obtains the project fund through borrowing from the transferor, and technology transfer is often completed in the process of project construction, operation and management, so the successful technology transfer is mainly dependent on the institutional and cultural environments of the transferee country. Embedded technology transfer mentioned herein refers to the process of transformative technology flow, combination, and

evolution from the transferor to the transferee, along with the progress of the major project. In order to make the imported technology adapted to the transferee country's institutional and cultural environment, the transferee must upgrade the technology and reconstruct the institutional and cultural environment, so as to form a complex of institution, culture and technology. It can be expressed as $V = (X, Y, Z, S, C)$, where S and C represent the institution and the culture for technology transfer and development, respectively. Theoretically, the transferor needs to actively adapt to the institutional and cultural constraints of the transferee and to reconstruct the institutional and cultural environments for technology survival and development.

3 Profile of the SGR project

3.1 Project background

The SGR is one of many Chinese-built infrastructure projects in Kenya, but it is by far the most strategic and politically salient investment in Kenya against the background of the Belt and Road Initiative. For both Kenya and China, this was a new attempt at infrastructure-building. Unlike the railway built by colonizers during colonial rule, it was initiated by the Kenyan government. Its construction was necessary and urgent because of the high demand for handling goods transport over land to and from Mombasa Port. As the largest port in East Africa, Mombasa has 17 international routes and does business with 80 ports around the world. Most of the cargoes in and out of East Africa goes through this port, and there are great freight demands between the port and hinterland. In 2016, Mombasa Port handled approximately 27.4 million tons of cargo and approximately 1.09 million TEU of containers. However, the annual transport volume of the existing meter-gauge railway was below one million tons, which is less than 2.5% of Mombasa Port's throughput. With the limited capacity of the narrow-gauge railway, most cargoes had to be transported by road. When the roads were jammed due to excessive traffic, there was a delay in transporting the cargo to or from the port. The lack of a strong rail infrastructure impeded growth. Thus, a high-capacity modern railway was needed to accelerate the transport of freight between Mombasa Port and other large cities, for example, Nairobi (Figure 2).

For China, the SGR project serves as a representative infrastructure project in the Belt and Road Initiative, which is significant in exploring the mode of infrastructure construction in developing countries. The SGR connected East and Central Africa and is intended to enhance the infrastructure in Africa for international trade and investment. In addition, it provides international business opportunities for companies affected by oversupply in China's domestic market.

In 2008, the Kenyan government issued the "Kenya Vision 2030", proposing to launch the SGR as a flagship project. The construction process of the SGR is shown in Figure 3. In 2009, China Road and Bridge Corporation (hereinafter referred to as "CRBC") and Kenya Railway Corporation (hereinafter referred to as "KRC") signed the MOU (Memorandum of Understanding). In 2011, the SGR was agreed to adopt Chinese standards through amicable negotiations. In 2012, general contracts for offline and online quantities of the SGR were signed by CRBC and KRC. Kenyan President Uhuru Kenyatta and Chinese President Xi

Figure 2 Location of the SGR project in East Africa

Jinping jointly witnessed the signing of the MOU on Financing for the SGR in August 2013.

Further, Chinese Premier Li Keqiang and the leaders of East African countries concluded a financing agreement in Nairobi in May 2014. Pursuant to the agreement, China agreed to aid the construction of the SGR which will connect six East African countries. CRBC officially commenced the construction of the SGR in December 2014 according to Chinese standards. The speeds of passenger trains and freight trains were designed to be 120 km/h and 80 km/h respectively. The SGR was completed in October 2016. On May 31, 2017, the SGR was officially put into operation, and Kenyan President Uhuru Kenyatta became the first passenger. Besides, the freight service of the SGR was officially launched in January 2018.

3.2 Financing and operation mode

Investment and financing structure: The total investment of the SGR project was about 3.8 billion USD, of which 90% was funded by the Export-Import Bank of China by means of concessional loans and commercial loans, and 10% was from the Kenyan government. The debt to the Export-Import Bank of China could be repaid by export concessions and self-operated loans. Since most of the initial investment funds were offered by the Chinese government in the forms of concessional loans and commercial loans, the SGR did not put huge pressure on Kenya's finances.

Construction and operation of SGR: Many participants such as the Kenyan government, KRC (the owner), Advisory Consortium, and CRBC, cooperated to construct and operate the SGR project (Figure 4). Specifically, the Kenyan government is responsible for issuing regulations and laws on railway construction and operation as well as for land acquisition. KRC, as the project owner, was responsible for railway construction, operation and maintenance on behalf of the Kenyan government. The Advisory Consortium is composed of the China Railway Design Group and a Kenyan company. They are responsible for procuring equipment and supervising the project. In the early stage, CRBC regarded the SGR as an EPC project only and was responsible for the survey, design, procurement, construction, and trial operation. However, CRBC acquires the Australian railway operation and management company John Holland Corporation to obtain operating qualifications because the operator

of Kenya did not have the railway operation capability. Since each country has its own railway construction and operation technologies, and thus John Holland Corporation's railway operation technology and management experience are not suitable for the SGR. In this context, CRBC had to set up a railway operation team composed of Chinese personnel and adopting Chinese technical standards. Afterward, CRBC agreed to assume operational

Figure 3 Timeline of the SGR project

Figure 4 Construction and operation mode of the SGR project

responsibilities in a certain period under the “5+5” operation mode. This means, in the first five years, CRBC is responsible for railway operation and training of Kenyan technicians. Five years later, CRBC will hand over its operating power and responsibilities to Kenya, completing the technology transfer.

3.3 Growth of passenger and freight volumes of SGR

The SGR shortens the time of land transport between Mombasa and Nairobi from more than 10 h to 4 h, enhancing the linkage between them. Since the operation of the SGR project started, the passenger and freight volumes have experienced rapid growth (Figure 5). As of July 31st, 2020, the SGR had been operating for 1,157 days and carried approximately 4.3 million passengers, including 344,000 passengers transported in 2020.

Note that the number of passengers shrinks sharply in March 2020 was related to the COVID-19 pandemic (Zhang *et al.*, 2020). In addition, the SGR suspended its passenger services from April 7 to July 23, 2020 due to the COVID-19 pandemic. Regarding freight, it carried nearly 6 million tons of cargo in 2019, which is 70% more than in 2018. Since June 2019, four passenger trains with an average attendance rate of 90% and an average of 14 of freight trains run every day. The SGR project not only addressed the urgent transport needs and significantly reduced transport costs but also contributed to the rapid growth of passenger demand.

Figure 5 Growth of passengers and freight volume of the SGR project

4 Impacts of SGR on Kenya

As a regional railway connecting Mombasa and Nairobi, the SGR is conducive to improving Kenya's traffic conditions, reducing its logistics transportation costs, facilitating its employment and economic development, and increasing its political and economic influence in East Africa. To investigate the impacts of the SGR project, we visited Kenya and Djibouti during May 16 to May 20, 2019. Several managers and a group of employees of the SGR were interviewed regarding the problems, difficulties, experiences and lessons during the construction and operation of the SGR and how to overcome them. Further, we visited the Nairobi inland container port, Mombasa seaport, and a few industrial parks, towns, villages

along the railway and discussed how the railway influenced their accessibility, economic development, income, and lifestyle with residents.

4.1 Socio-economic development

The SGR project enhanced the infrastructure connectivity and regional connectivity. The SGR shortens the travel time for passengers from Mombasa to Nairobi from the original over 10 h to 4 h, and the transport time for freight is shortened to less than 8 h. In the future, the SGR will be extended and connect the other five members of the East African Community including Uganda and Tanzania, which is mentioned in the *Uganda Vision 2040*, *Rwanda Vision 2020*, and *South Sudan's Post-war Reconstruction Plan*. By then, the SGR will further facilitate the import and export of goods in East Africa and boost the economic development and integration in East Africa. The SGR has improved the efficiency of passenger travel and freight transport in Kenya and promoted its industrial production. In addition, the SGR as an important part of the East African Community's railway network as planned will improve the efficiency of railway transport in the East African Community, including that of freight transport.

The SGR project promoted local economic and industrial development. First, the SGR construction contributed to the localization of the industrial chain of Kenya. At that time, Kenya's building materials, construction techniques, and workforce levels were not in line with China's railway construction standards. Given this, CRBC assisted some local steel and cement companies to upgrade and transform their products and production lines. CRBC also established a material procurement platform to make rational use of local materials, such as steel, cement, oil, and initiating explosive devices. All these measures contributed to the localization of the industrial chain, reduced construction costs, and promoted local employment, thus achieving a win-win situation. Second, with the operation of SGR, Kenya has improved the efficiency of transport between Mombasa and Nairobi, reduced logistics costs by about 40%, greatly reduced the transport costs, and increased its imports and exports. According to relevant statistics, the SGR has promoted long-distance land transport in Kenya and contributed to its economic growth by 1.5% (Kacungira *et al.*, 2017). In addition, an economic corridor including several industrial parks and modern towns were planned along the SGR to further accelerate the process of industrialization and urbanization. With the release of transport capacity, the role of the SGR as an engine driving Kenya's economic and social development will be further enhanced.

Stimulating employment and solving unemployment problems. The SGR project provided many job opportunities for local people and improved their skills. As shown in the Human Development Reports in 2013 (UNDP, 2013), Kenya's unemployment rate was as high as 39.1%, of which the youth unemployment rate was 53%, ranking top in East Africa. According to the 2016 Corporate Social Responsibility Report on the SGR Project, Kenyan employees accounted for 94% of the total employees engaged in the construction and operation of the SGR, and the SGR project directly created more than 46,000 jobs for local residents. It also generated over 10,000 jobs indirectly by increasing the demand for production in some industries, such as steel, power, wood, cement, and glassmaking. Moreover, the technology skills of local workers were improved by providing them with on-the-job training.

4.2 Communities and cultures

The SGR project intensified various land disputes caused by a decades-old incomplete system of land ownership registration in Kenya, which focused the attention of the Kenyan government on this issue. Land issues have been politically sensitive in Kenya for decades. Land ownership has traditionally been subject to nepotism, corruption, and manipulation by elites in a neo-patrimonial political culture. For example, the issue of land compensation backed by political power posed significant obstacles to railway construction in Mombasa County. The successful construction of the SGR provides some insight into facing land disputes for other infrastructure projects.

Besides, the SGR project focused on the issue of competitive and transparent bidding mechanisms in Kenya. As the Public Procurement Act of Kenya pointed out, awards without competitive bidding for government-to-government agreements is allowed and the non-competitive procedure minimizes costs. In the early stages of the project, the absence of competitive and transparent bidding induced concern about fraud, as well as doubts among the local people about the overall high cost and corruption problems. To respond to these problems, the World Bank's Africa Transport Unit proposed several alternative plans for the SGR project to choose from. This is the embodiment of how foreign direct investment can lead to a better competition mechanism.

Further, the SGR project brought railway and industrial culture into Kenya. Railways are an important component of transportation systems and have been playing a key role in efficient economic and social communication in many countries since the 19th century (Wang *et al.*, 2009). However, a modern railway culture was absent in Kenya, which impeded its economic growth. The SGR project brought modern railway culture into Kenya and helped local people to realize its convenience. Since the operation of the SGR, railway transport was welcomed by increasing number of people and has become their first choice of travel. In addition, the SGR project promoted the integration of industrial culture and traditional agriculture culture in Kenya. Previously, agricultural culture and nomadic culture were dominant in Kenya, which had some conflicts with industrial culture, such as work time regulations. The SGR project helped Kenya to explore the ways to integrate industrial culture into their traditional culture and to promote the process of industrialization.

4.3 Ecology and the environment

The ecological and environmental impact of the SGR project has also been a topic in debates and related research indicated that local people attached great importance to environmental protection and wildlife conservation. Wildlife corridors were built under the railway so that the SGR project would not disturb the migration routes of elephants, giraffes, and other wildlife. Vegetation might be destroyed in the process of construction. The subgrade occupies the land permanently, whereas other occupancies, such as the areas occupied by construction materials storage, could be repaired after the construction. To quantify the impact of the SGR project on the local ecology and environment, changes in vegetation coverage in 2013 (before the SGR construction) and in 2017 (after the SGR completion) were compared. Landsat-8 remote sensing images were used to analyze the vegetation coverage changes in the 5-km buffer zone along the SGR.

The proportions of areas with different vegetation coverages are shown in Table 1. From 2013 to 2017, the area with the vegetation coverage of greater than 0.4 increased from 4,090.26 km² to 4,126.43 km², with the proportion rising from 86.2% to 87.4%. This indicates that the natural environment in the 5-km buffer zone is basically sound, with generally high vegetation coverage. The overall vegetation coverage value after the commencement of the SGR construction in 2017 was higher than that before the completion in 2013.

Table 1 Areas and proportions of vegetation coverage in the 5-km buffer zone along the SGR before and after construction

Year	Vegetation coverage	0–0.2	0.2–0.4	0.4–0.6	0.6–0.8	0.8–1
2013	Area (km ²)	188.99	451.59	984.24	1239.48	1866.54
	Proportion (%)	4.00	9.54	20.55	26.20	39.45
2017	Area (km ²)	43.08	552.34	2062.18	1710.84	353.41
	Proportion (%)	0.91	11.70	43.67	36.23	7.48

Inevitably, the SGR project will occupy certain ecological resources and cause certain ecological losses during construction. To quantify the ecological resources occupied and direct and indirect ecological losses from the construction of the SGR, Google Earth images (spatial resolution of 0.5 m) and Landsat remote sensing images (spatial resolution of 30 m) are used to demonstrate the distribution of ecological resources in the 5-km buffer zone along the SGR in 2013 and 2017. Before the SGR project, there were 2230.69 km² and 1822.21 km² of forest and cropland cross-distributed along the SGR (Table 2), accounting for 47.17% and 38.54% of the total area of the buffer zone, respectively. In contrast, forest covered an area of 118.45 km², accounting for only 2.50% of the total area of the buffer zone. After the SGR project completed, the areas of grass and cropland as main ecological resources changed to 2,775.22 km² and 1,439.39 km² (Table 2), accounting for 58.68% and 30.44% of the total area in the buffer zone, respectively. Meanwhile, grass increased by 228.44 km² (nearly one time) than that before the SGR project.

Table 2 Area and proportion of ecological resources in the 5-km buffer zone along the SGR before (2013) and after construction (2017)

Year	Type	Forest	Grass	Cropland	Other
2013	Area (km ²)	118.45	2230.69	1822.21	57.32
	Proportion (%)	2.50	47.17	38.54	11.79
2017	Area (km ²)	346.89	2775.22	1439.39	167.87
	Proportion (%)	7.33	58.68	30.44	3.55

5 Embedded technology transfer in the SGR project

Modern Chinese railway technology is highly dependent on the country's political and cultural background, which is totally different from that of Kenya. Due to the large difference between China and Kenya regarding technology foundations, political systems, and cultural environments, great efforts have been made to overcome the obstacles in the process of technology transfer. Eventually, the project succeeded by embedding the technology into the

context of Kenya, which provides some insight for other major international infrastructure technology transfers in the context of the Belt and Road Initiative. Subsequently, we illustrate the process of technology transfers by focusing on technology localization, institution improvements, and cultural integration.

5.1 Technology localization

In the SGR project, technology localization is mainly reflected in three aspects: technique standards, localized management mode, and industrial chain. China is one of the countries with the most advanced technologies in railway construction and operation, particularly in high-speed railways. The faster speed and higher technical level of the railway will cause an exponential increase in costs of railway construction, operation and maintenance. Despite this, governors prefer to use "high standards" to construct modern railway due to their education background in western countries. At the preliminary design stage of the SGR, Kenya initiated hot debates on technical standards and specifications (electrified railway or diesel railway? double-track railway or single-track railway? passenger-dedicated line or mixed traffic line?) CRBC made a lot of studies in the early stage, including the pre-feasibility study, first feasibility study (designed speed of 160 km/h, double track), and second feasibility study (designed speed of 120 km/h, single track). According to the social and economic development status in Kenya, the results of site survey, inspection, negotiation, detailed investigation, analysis and research, Kenya finally proposed to adopt the technical standards of "standard gauge, single track, design speed of 120 km/h, diesel locomotive, and mixed traffic railroad". The electrification and double-track conditions were reserved. Sticking to the principle of stimulating local social and economic development, CRBC built many bridges and culverts under the premise of remaining unchanged the intended investment and ensuring no highway-railroad grade crossings, which greatly reduces such accidents as wild-life's collision with trains, and helps to ensure the safe and high-speed operation of the SGR. So far, the SGR has been operating for more than two years. Operating conditions prove that the technical standards designed for the SGR are appropriate and suited to local social and economic development. In addition, it leaves room for railway upgrading and transformation.

A localized management mode was adopted for the SGR. "Localization" is an important management mode in which enterprises operate international projects in accordance with international norms, and laws and regulations of host countries. Localization is mainly embodied in such aspects as operation, regulations, labor, welfare, and salary. Localized management of the SGR has been realized throughout the process of construction and operation. First, most of the basic service and team management positions have been localized by the SGR operator. The localization rate of crew reached 98%. Second, according to the requirements of localized technology transfer, some rules, and regulations such as *Employee Skills Promotion Management Measures* and *Employee Education Training Management Measures* were introduced to meet the job promotion demands of local employees. Accordingly, the SGR operator actively organized the pre-employment training, on-the-job training, off-job training, and ability enhancement training, accumulatively promoting more than 120 grassroots Kenyan managers and 48 senior managers. Third, the localization of labor is one of the most important parts of management localization. Many factors need to be taken into

account, including the host country's requirement for the proportion of local employees, as well as culture integration, corporate social responsibility, technology transfer, etc. In addition, the SGR project created a total of 46,000 jobs, 41,800 of which were for Kenyans. The ratio between Kenyan employees and Chinese employees was as high as 15:1. Fourth, the localization of salary has been realized. The SGR operator adopted the personnel management mode in line with local employment practices, unified the wage standards and pay social insurances for all employees in accordance with relevant regulations, providing career development paths for them.

In addition, the industrial chain of the railway also realized localization. During the construction of the project, CRBC assisted some local companies to upgrade their production lines to meet the standards of railway construction. It also established a material procurement platform to make use of local materials, such as steel, cement, and oil, which is crucial for realizing the localization of the industrial chain and promoting the development of related industries.

5.2 Institutional improvement

The construction and operation of railway lines such as Kenya's SGR are highly dependent on an institutional environment such as that in China, which is characterized by semi-militarized management, strict rules and regulations, and effective legal constraints. However, Kenya has weak institutions and unstable policies, which cannot meet the institutional environment needs of the SGR project. To ensure the smooth construction and safe operation of railways, KRC and the Kenyan government made some rules, laws and regulations on railway construction, operation, safety supervision and emergency response. In addition, the Kenyan government attaches great importance to the SGR project because it is not only the flagship project in *Kenya Vision 2030* but also the biggest project since its independence in 1963. Thus, the Kenyan government actively made relevant laws and regulations to support the project. For example, the Kenyan government formulated the *Railway Development Fund Law* to support the SGR project through the special railway construction fund as China does. Meanwhile, the Kenyan government unveiled some laws and regulations such as the *Regulation on the Railway Transport Safety*, *Regulation on the Administration of Railway Safety* and other relevant laws and regulations.

After the SGR project started providing commercial freight services in January 2018, the Kenyan government introduced a series of preferential policies to increase its freight volume and ensure the supply of cargoes. First, the volume of meter-gauge freight was required to reduce. Second, the volume of standard-gauge freight was improved through the signing of the Mombasa Port and Railway Freight Guarantee Agreement and cooperation contracts with international logistics companies. Third, Nairobi as an inland container port (dry port) was expanded and improved to support the SGR project. It required the freight from places farther inland than Nairobi to clear customs and settlement in this inland port before being transported on the SGR to Mombasa Port. Fourth, railway transport rates were reduced, and loading and unloading charges for return cargo were exempted for the SGR. The above-mentioned policies and measures enhanced the market competitiveness of the SGR and rapidly increased the freight volume, thereby ensuring its successful operation.

The SGR project was an important achievement during President Kenyatta's administra-

tion, which helped to formulate policies and regulations related to the project. President Kenyatta visited the SGR project quarterly to inspect its progress, and he convened on-site cabinet meetings to discuss the issues of land acquisition, demolition, and work visas, which largely promoted the project's process. In addition, President Kenyatta's re-election is also a vital factor to ensure the stability of the political and institutional environments related to the railway projects.

5.3 Cultural integration

Cultural conflicts with local communities were also taken into account seriously in the SGR project. First, there are conflicts between modern industrial culture, local farming, and nomadic culture. Kenya is still in an agricultural society with a small number of nomads remaining and they are skeptical of industrial development. Kenyan people have a relatively high awareness of freedom and are less willing to follow schedules determined by companies. However, the railway operation department applies semi-military management to ensure the safe operation of railway, and it also has a strict system to guarantee the efficient and punctual operation of trains. In view of the large differences between Chinese railway culture and local culture in Kenya, the operation and management technologies in China could not be directly copied to Kenya. To help local people to accept railway culture, CRBC established mechanisms such as corporate culture, corporate management regulations, employee training, and a "Learning by Doing" mode to enable local people and employees to understand the technical objectives and standards of Chinese railway operations. These activities were significant for the successful construction and operation of the SGR project.

Second, the conception and values of the Kenyans were affected by the British, which are different from those of China. The great gaps between the cultural concepts in Kenya and China reduced the faith of Kenyans in "Chinese technology", "Chinese standards", and "Chinese enterprise", which contributed to potential cultural conflicts and risk in the SGR project. The frequent strikes led by the Central Organization of Trade Unions are due to problems with issues such as salaries, benefits, and work hours. If CRBC could not address the conflicts induced in the process of construction and operation, they would lead to strikes and disturb the normal social order and railway operating environment. Therefore, CRBC strengthened the promotion of railway culture by means of media and engaged with local communities. Various experience activities, such as organizing students in primary school to experience the SGR, were conducted to make local people understand and experience modern railway culture and industrial development. Moreover, CRBC has issued corporate social responsibility reports in the past several years and has organized more than 220 local social welfare activities, such as donation and funding, water resource sharing, water conservancy facilities assistance, free medical treatment for people in the countryside, road repair, and wildlife protection. These activities benefited the people of Kenya with practical actions, thus creating a harmonious social environment for railway operations.

Third, the Kenyan government and people attach great importance to environmental protection. Kenya has established a relatively complete legal framework, including Kenya Constitution, Kenya Environmental Management Act, Wild Fauna and Flora Act, Forest Act, Water Resources Act, and several bilateral and multilateral environmental agreements. In this context, it has very strict environmental protection standards for investment projects.

Since the railway cuts through the Tsavo National Park, the environment and wildlife protection problems were serious. Before construction, CRBC actively engaged in relevant work with local and international environmental agencies, for example, China-Africa Joint Research Center and United Nations Environment Program, to assess the environmental impact of the project comprehensively. To minimize the impact on the environment, CRBC purchased transportation equipment with the lowest environmental impact and strictly controlled the discharge of exhaust gas, waste oil, and wastewater. For protecting wildlife, “Measures for environmental protection and wildlife protection” and “Emergency Plan for Collision Avoidance of Large Wild Animals” were introduced by CRBC. To ensure the free migration of wildlife, 14 large wildlife channels, 61 bridges, and 600 culverts were built across and underneath the railway. In addition, electric fences and B-type fences were built to prevent wild animals from going onto the railway track.

5.4 Technology-institution-culture nexus in the SGR project

Considering the big difference between China and Kenya regarding technology foundation, institution, and culture, we present a technology-institution-culture nexus in embedded technology transfer in the SGR project (Figure 6). Specifically, China has advanced technology and good ability to construct, operate, and maintain infrastructure. In addition, the effective regulations, good social orders, and few land disputes in home countries provide a stable political environment for operating the railway. In the long-term industrialization and technology upgrade process, people in home country have already adopted and integrated into industrialized culture. However, host countries are often disadvantaged in technology and do not have the ability to operate and maintain the SGR independently (Ramamurtia and Doh, 2004). Regarding political environments, the political corruption phenomenon in host country is serious and the legal framework is incomplete (Chege *et al.*, 2019). Private land ownership also increases the difficulty of land acquisition for infrastructure construction.

Figure 6 Framework of embedded technology transfer in the SGR project regarding institution, culture, and technology

Besides, the host country is still in the stage of agricultural culture or tribal culture, which, in some respects, conflicts with modern industrial culture. Moreover, people in host country have resistance to the SGR project because they believe that it would damage the environment and ecology.

To realize successful technology transfer in major infrastructure projects, the technology should be localized regarding technology standards, management modes, and industrial supply chains to serve demands in the local markets. Then, host countries ought to overhaul their institutional and policy frameworks. For instance, some laws and policies, such as regulations on railway transport safety, and regulations on the administration of railway safety, should be issued to guarantee a complete legal framework. Last, industrialization and railway culture should be introduced to local people to let them realize and accept the convenience brought by industry and railways.

6 Conclusions and discussion

Major overseas infrastructure projects play an important role in promoting the high-quality development of the BRI. Liu *et al.* (2020) classified the BRI projects into four categories (transformative projects, supporting projects, general projects, and cooperative park projects) according to the “destructiveness” and “regional embeddedness” of the projects/technologies, to identify their institutional and cultural sensitivity. In China, the construction and operation of modern railway projects as typical transformative projects are deeply rooted in China’s institutional and cultural environments. In contrast, the countries along the Belt and Road need great institutional improvement and differ greatly from China in culture, usually lacking the capacity for railway construction and operation. Chinese contractors face great challenges in the construction of modern railways up to Chinese standards in African countries. The SGR project is a relatively successful model of Chinese railways “going global”. Based on the field research, we summarized the successful experience of overseas railway projects, including the synthesized output of technology, institution and culture, establishment and improvement of relevant laws and regulations, cultural adaptation, the introduction of advanced technical standards and management mode, and localized management of industrial chain. Accordingly, this study proposed a framework for embedded technology transfer regarding technology localization, regulation construction, and cultural integration. Such experience is conducive to the successful construction and operation of China’s overseas railway projects.

According to our findings, the success of overseas “embedded technology” transfer hinges on the dependence of the technology on the institutional and cultural environments, the institutional and cultural differences between the transferor and transferee, and the corresponding efforts of Chinese contractor and the host country. If the factors of technology, institution and culture are not fully taken into account, it is usually hard to successfully operate railway projects. For example, the Tanzania-Zambia Railway built by China in the 1970s, and the Addis Ababa-Djibouti Railway both are under unfavorable operation, mainly because the institutional and cultural differences were not considered, and technical standards were not well designed according to actual conditions and needs.

Therefore, some recommendations can be provided for both China and host countries. For Chinese companies, they should modify their technology based on the technology founda-

tions, institutions, and cultural background in the host countries. Second, Chinese companies should understand and respect the political background of the host countries. It is crucial to cope with potential issues, such as land expropriation compensation, tensions in labor relations, strikes, and cultural conflicts. Third, closely engaging with local communities might be an efficient way of promoting cultural integration. For example, Chinese companies could organize some experience activities and social welfare activities to make local people realize the convenience brought by the railway or other infrastructure. Fourth, Chinese companies should increase transparency in projects, particularly to local media, to avoid criticism from local people.

For host countries, they should rigorously assess long-term fiscal and economic impacts. In the early phases of the project, the government should improve its communication with local communities to convey the rationale of the project and reach agreements on potential issues in advance. It might be an efficient way to avoid construction disruptions and relieve undue pressure on Chinese companies. To create a suitable environment for the project and ensure it is carried out, it is recommended that policymakers publish some regulations by combining the background in the local and institutional environment needed by the project.

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