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Technological Capability Development Opportunity for Africa through Infrastructure Development Projects

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Abstract: *Many African countries reside among the least developed countries in the world and face tremendous challenge to build technological capabilities. Building technological capability has been well pointed out by scholars in various fields of study as driving motor for development. Developing this capability in developed nations is driven by research and development, as it targets development and creation of new knowledge at the highest technological frontier. Low income African developing countries, on the contrary, struggle to effectively utilize lower level technological resources available at their disposal. Mega infrastructure development projects planned and being executed in African countries bring these two parties together to cooperate and achieve developmental projects. This paper explains that* *with wise coordination of stakeholders in developing African economies, such megaprojects are key opportunities to build technological capability through their experts and firms. It tries to explore this opportunity from past experience of megaprojects around the world with qualitative approach and how countries have used this opportunity to develop strong capability in specific sectors. It also spotlights some megaprojects in sub-Saharan countries (investment beyond $1Billion) to show their strong opportunity in building technological capability. With strong coordination effort and deliberate motive to build technological capability in these megaprojects, the paper concludes that significant potential exists through infrastructure development projects for African countries.*

***Keywords**: Technological Capability, Developing Nations, and Megaprojects*

1. Introduction

The notion of technological capability development is not a new concept, especially with recent dynamic growth of nations. Capability development, fueled with innovation theories, has gained substantial interest in the past (Bell, 2007; Dutrénit, 2004; Reichert, Reichert, Beltrame, Corso, & Trevisan, 2011; Shafiei, Ghofrani, & Saboohi, 2009; D. Wood & Weigel, 2011). The broadness of the term innovation as indicated by the Oslo manual (OECD/Eurostat, 2005) has interested various authors to see its driving forces. The concept of innovation is diverse from earlier understanding of tangible technological/product or process innovation to relatively recent organizational and social innovation (Lundvall, 2009; OECD/Eurostat, 2005). To reach the current developmental stage, developed nations have built innovative technological capability witnessed by their technological trajectory at the leading technological frontier, mostly through research and development (Shafiei et al., 2009). For developing nations working their way from the lowest technological frontier, technological capability development demands exploitation of innovative ways to harness various opportunities. Building technological capability similar to how developed nations have done is difficult if not impossible. Owing to these, different scholars have coined and pursued the concept of technological catch-up.

To build such capability and catch-up to minimize the gap with the technological frontier, technological capability development is vital. Low income developing countries are striving to build their infrastructure facilities spending billions of dollars. This study argues that such projects are among major means to strengthen technological capability besides the infrastructure development motive. Technological learning as a stand-alone mission, which is time consuming, dynamic and expensive (Baskaran, 2001; Kocoglu, Imamoglu, Ince, & Keskin, 2012; Shafiei et al., 2009), would be highly-priced learning. This is further magnified for low income countries that have lower human resource quality. This paper tries to illustrate how some nations and companies have used development projects to build their technological capability. It also tries to highlight current technological learning potentials for some sub-Saharan countries development projects regarded as megaprojects.

The study uses secondary data gathered from multiple sources regarding megaprojects in various corners of the world. Megaprojects that were successful in building technological capability are exemplified from developed, emerging and sub-Saharan economies in various sectors. This is followed by exploration of some large magnitude megaprojects in low income countries and opportunities presented in these projects are highlighted. Potential of these projects in some sectors which these mega projects are being/planned to be implemented illustrate possibility to build technological capability in these regions.

The paper is organized as follows. The next section recaptures the concept of technological capability and its corner stones from the literature. This is followed by discussion of nature of infrastructure development projects in low income countries and their unique characteristics. With this base in mind, how some nations and companies were able to build their technological capabilities by such projects is highlighted. At the end, opportunities that could be used in such projects are indicated. This is explained using current ongoing/planned projects in sub-Saharan African countries. Form these discussions, concluding remarks for such low income developing nations has been forwarded at the last section.

2. Development of technological capability

The term ‘technological capability’ has two cornerstone words – ‘technology’ and ‘capability’. In its plain term technology has been usually understood to mean ‘machine’ or ‘equipment’ of certain sophistication. This however has been proven to be imprecise definition by scholars (Bell, 2007). The term technology extends much beyond to mean mere ‘machine’ and runs from principles, data and understanding, design and blueprints, production facilities and methods to final use of the product in particular situation (Bell, 2007). Technology includes the soft knowledge needed to use, build and manipulate the technology with the tangible hardware part of the technology. Authors in innovation capability development in firms agree that the term capability is at the very core of the phrase technological capability. It is agreeable that capability is the ability of a firm to coordinate its resources (including labor force, facilities, financial structure, strategy on markets, competitors, alliances with other firms or with universities, and above all its internal organization) to achieve a particular objective (OECD/Eurostat, 1997; Siyanbola, 2012). This definition bases its argument in resource based view theory whereby it differentiates capability from resources – which are simple elements in an organization. The degree of coordination and integration of resources indicate the level of capability the firm has to utilize its resources.

National technological change is driven by capabilities developed by a nation and firms in pursuit of development, competiveness and improved performance. Scholars have studies technological capability from learning, spillover and absorptive capacity viewpoints (Cohen & Levinthal, 1989, 1990), technological Learning and innovative capacities (Bell, 2007) and dynamics of knowledge (Shafiei et al., 2009). These and many more scholars have studied technological capability development from firm level up to national level. In all the perspectives pursued, technological learning lays the underlying foundation. It builds absorptive capacity, fosters R&D, creates conducive environment to utilize spilled over knowledge, builds innovative capacities and involves dynamic interaction among stakeholders.

Various definitions have been quoted by many researchers to signify importance of such capability. Some of the earlier and prominent definitions of technological capability definitions include (Lundvall, 2009; Siyanbola, 2012):

"Having resource –which are embodied in the form of skill and expertise – needed to generate and manage improvements in process and production organization, products equipment and engineering projects" (Bell & Pavitt, 1997)

"Ability to make effective use of technical knowledge to assimilate, use, adapt and change existing technologies which enables development of technology, product and process" (Kim, 1997)

"Ability to adapt or assimilate technology imported from abroad and to incorporate the additional and distinct resources needed to manage and put to productive use the newly acquired technology" (Aw & Batra, 1998)

All these and other definitions given to technological capability devote attention on firm's capacity. This capacity is embedded in skill, knowledge and expertise of human resource and how this is managed in an organization. Technology adopted, for a developing nation in particular, usually comes in the form of a tangible machine, documents and related training. The ability of local human resource to accept the machine, understand the documents and effectively absorb training provided that determines the technological capability development arena. Thus, the definition coined by Aw and Batra (1998) is highly adopted and customized towards technology adoption and capability accumulation in these developing nations.

Skill is the learned ability to carry out a task with pre-determined results which is embedded in human resources of a firm. Technological capability is asset built within human capital. This is ascertained under the Oslo manual by stating "*Skilled employees are a key asset for an innovative firm. Without skilled workers a firm cannot master new technologies, let alone innovate. Apart from researchers, it needs engineers, who can manage manufacturing operations, salespeople able to understand the technology they are selling (both to sell it and to bring back customers' suggestions), and general managers aware of technological issues." (OECD/Eurostat, 1997).*

Technological activities within an organization mandate the requirement of capabilities needed. Bell (2007) classifies these activities in three – capability for creating new knowledge, for transforming through design and engineering and using knowledge in the form of operational capabilities. This is illustrated by Bell's (2007) illustrative technological capabilities and roles shown below in Figure 1. Along this technological capability ladder, developed nations operate on creating frontier technology and knowledge while low income developing countries strive at the lower part of the ladder to effectively use the technologies at hand. The Oslo manual identifies such low level of as 'non-innovative' (OECD/Eurostat, 2005).

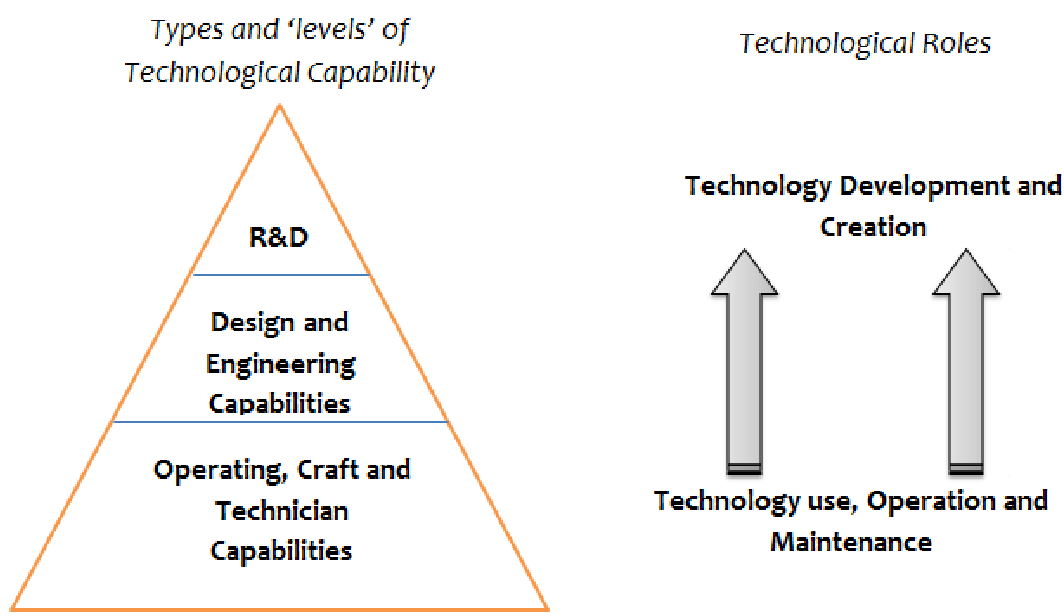

Figure 1. Technological Capabilities and Roles (Bell, 2007)

This notation of 'non innovativeness' could be argued well with the current understanding of innovation as ways of doing things differently from what used to be. However, this deviates from the objective of this paper and would not be pursued here. What is important to note is the fact that the gap in the technological ladder is too wide to rapidly minimize the gap.

Developing technological capability with all possible effort and with keen exploitation of opportunities is important for accelerated accumulation.

3. Characteristics of infrastructure development projects

Developing nations are recognized by insufficient and poor quality level of basic infrastructure requirements in various aspects including transport, energy and water (Othman, 2014; Zeybek & Kaynak, 2008). They are moreover challenged with availability of funding to ascertain implementation of many infrastructure developments. Even under such constraints, developing nations struggle to strengthen versioned developments by dedicating considerable amount of resources in these projects. Infrastructure development projects aim to construct main facilities underlining development and betterment of their people's lives.

Massive and capital intensive infrastructure development projects are usually considered as Megaprojects (Gellert & Lynch, 2003; Othman, 2014). Mega projects are defined as projects which transform landscapes rapidly, intentionally, and profoundly in very visible ways, and require coordinated applications of capital and state power (Gellert & Lynch, 2003). They also use heavy equipment and sophisticated technologies which require coordinated flows of international finance capital. Generally speaking, megaprojects are characterized by their complexity, cost over $1 billion, have significant social and political impact, are unique and have inherent high level of risk (Ansar, Ansar, Flyvbjerg, & Budzier, 2014; Flyvbjerg, 2014; Zidane, Johansen, & Ekambaram, 2013)

Mega projects' scale, complexity, number of partners and duration distinguishes them from traditional projects (van Marrewijk, 2007). Mega infrastructure projects have often training programs inherent in their plan to equip employees with state of the art and advanced technologies (Fayek, Yorke, & Cherlet, 2006). Such training programs are important to the project success by building the technological capability of the contractor – i.e. assuring competitiveness of the contractor. When it comes to megaprojects in developing nations, capability development of local human capital is neglected as the focus usually converges to social and political implications of such projects. This has undermined learning potential from projects in developing nations – yet having scarce funding for separate capability development initiatives. Even if capability development initiatives are triggered separately in these nations, practical experience becomes major challenge resulting in weak performance in actual projects and thus frustration.

Among the underpinning problems in developing nations, quality of educational system and skill gap are major ones. Othhman indicates that low standard of education and vocational training accompanied by out flow of best brains diminish capability development in these nations (Othman, 2014). He also outline challenges in developing nations under four categories – among which engineering challenges and human resource development are included. This paper argues that such challenges could be tackled by attributing technological capability development initiatives alongside these megaprojects creating spiral development. This is portrayed in the spiral learning diagram in Figure 2 below. Learning process in mega projects, as in any learning activity, is cumulative. Learning from one part of the project builds capability for the next activity and then next project and so on.

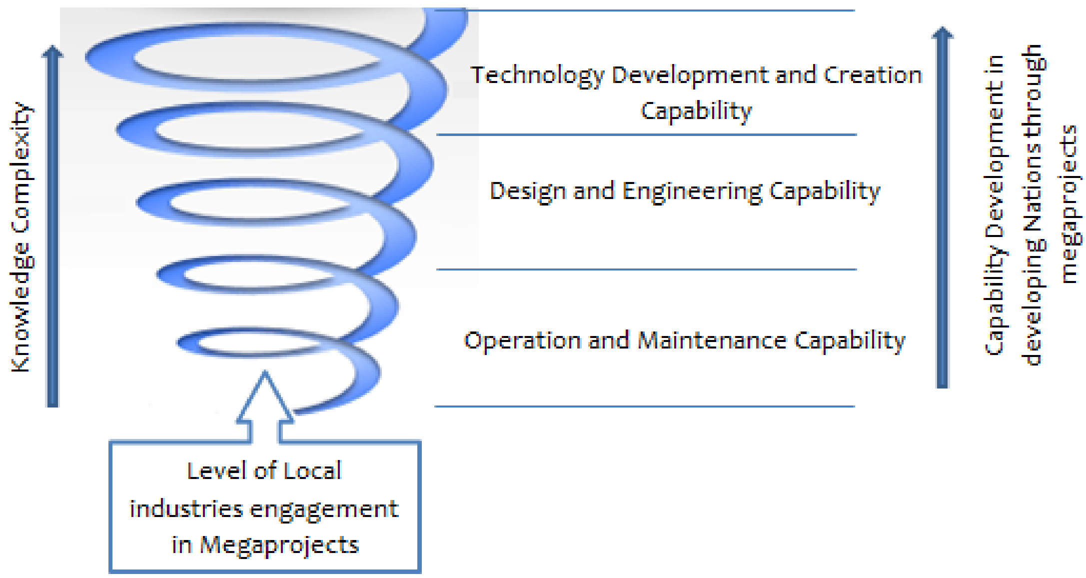

Figure 2. Technological Capability development through Megaprojects in Developing Nations

4. Learning opportunity from Mega projects in the past

In this section, we will demonstrate how different countries have used development projects to build up their technological capability in specific sector. This will be illustrated using three examples from Australia (developed nation), India (emerging economy) and Angola (Sub-Sahara country)[1]. Even though the extent of capability development varies, these examples are believed to be examples to showcase how development projects

[1] Classification based on World Bank obtained from http://data.worldbank.org/about/country-and-lending-groups - (visited on April 20, 2015)

present opportunity to develop technological capability of a nation – practically.

4.1. Australia's Snowy Mountain Hydro Electric Scheme

The Snowy Mountains Scheme initiated in 1946 (by establishment of a committee) has the distinction of being among the world's most complex, multi-purpose, multi-reservoir hydro scheme in the world (Robinson, 1997). The objective of the Snowy Mountains Scheme was to divert tributaries of Snowy, Murray Murrumbidgee rivers from south-east Australia to the west to provide water for irrigation and generate peak load electricity for the states of New South Wales and Victoria. The project which, lasted for 25 years (1949 – 1974), includes construction of 140 km of tunnels, 16 large dams, and 7 power stations (2 of which are underground) among other features with total cost of the A$820 million. To undertake this gigantic scheme, the Snowy Mountains Hydro–Electric Power Act established the Snowy Mountains Hydro–Electric Authority (SMHEA) in 1949 illustrating the long versioned commitment of the country.

For the Snowy Mountains Scheme speedy design of construction during the developmental period, an agreement was entered with contractors in the United States of America and the Commonwealth of Australia. Under this arrangement, the United States provided much valuable assistance to the SMHEA in building their technological capability. This was achieved by preparing designs and specifications for some of the civil engineering works while also providing training for the Authority's engineers under the contractors' facility in the USA. Over 100 engineers received training at the contractor Bureau Headquarters at Denver, Colorado and on large projects in the USA (Robinson, 1997). This marked technological capability development of employees of SMHEA.

At the completion of the project, the Australian Government maintained much of the diverse workforce and established the Snowy Mountains Engineering Corporation (SMEC), which is now an international engineering consultancy company. During the 1990s, SMEC was sold to staff as part of a government asset sale in 1993[2]. Currently, SMEC is registered as an engineering consultant with United Nations agencies, World Bank, Asian Development Bank and many others. It

[2] SMEC's official website http://www.smec.com/about-smec/company-history – visited April 15, 2015

has over 220 professionals, technical and administrative support staff. It has branches located in Sydney, Brisbane and Canberra and international offices in Dhaka, Gaborone, Jakarta and Kuala Lumpur with project offices in many other locations (Castles, 1991). It has become a renowned engineering design and consulting firm around the world through technological capability built in the megaproject and others afterwards. SMEC's existing presence and local knowledge has enabled the Company to secure roles in nation building infrastructure projects.

Coordinated national capability development of expertise who are involved in the project with the external contractor enabled the nation to have strong technological capability. Besides the coordination for capability development, the nation has also recognized not to dissolve the expertise after completion of the project. Rather, it kept such combination of skilled workers to form a national corporation that would lead engineering infrastructure projects as a consultant. The corporation (currently known as SMEC Holdings Limited) operates in various countries as internationally renowned consultant. Even though the first objective of this project was to provide irrigation waters and generate electricity, with keen desire to build technological capability, the government has achieved to have an outstanding corporation along the way. This exemplifies the argument that developing nations could utilize infrastructure development projects to build technological capability. This situation has taken Australia further up the technology trajectory to manipulate the knowledge base in dam construction in various situations throughout SMEC's experience afterwards.

4.2. India satellite technological capability development

Another particular example illustrative to technological capability development through development programs is India's experience in satellite technology capability development. The satellite program is part of the space program, which started in 1962 with a vision to build and launch geostationary communication satellites, weather and remote sensing satellites. The program initiated at the formative stage (1971 – 1985) where dependence on foreign companies was prominent followed by the accumulative phase (1986 afterwards) characterized by significant contribution of the indigenous knowledge (Baskaran, 2001; Bommakanti, 2009). Baskaran assessed how imported technology of satellite has been used alongside with local knowledge (foreign and local technological inputs) to build national technological skill learning between early 1970s and 1990s (Baskaran, 2001). Technology accumulation followed a step-by-step procedure with construction of various satellites. India has built more than 70 Satellites[3] since initiation of the program implementation with significant initial support from various countries and more and more local companies' involvement afterwards in the accumulative phase. Advanced satellites built afterwards needed complex and advanced technologies which made India dependent on foreign countries(Baskaran, 2001). It then strategically started manufacturing some components locally which later on were also exported to various countries like US and Europe.

Capability development of local firms to produce and supply the sector was among major strategies followed by the Indian Space Research Organization (ISRO). This was supplemented by fostering local firms in both public and private sectors and establishing linkages with other R&D and academic

[3] Official Web-site of Indian Space Research Organization: http://www.isro.gov.in/spacecraft – (visited April 20, 2015). The satellites are categorized under communication, earth observatory, scientific, navigation, experimental, small and student Satellites.

institutions. Baskaran (2001) indicated the collaboration of local stakeholders as:

> "*The wider technology diffusion through creation of strong links between ISRO, other R&D performing organizations and firms appears to have helped India to accumulate a high level of capacities in space technology*" Page 119

ISRO collaborated mainly with three categories of stakeholders - with academic and other R&D institutions, Space centers and the industry (Baskaran, 2001; p. 120). This illustrates triple helix integration for developing the satellite technology along with strong encouragement of local industries. The technological capability development path followed in this program focuses on technological learning as demonstrated in formative (initial) phase which lay foundation for further accumulating advanced and complex technologies. This is slightly different from the previous Australian Snowy Mountain Scheme in that the program objective included dedicated learning phase in the formative phase – which requires significant time and funding by itself. However, the success achieved by India verifies worthiness of such progression. From lower satellite technology capability prior to 1972 (Bommakanti, 2009), India has been able to climb the technological ladder further up to have solid capability sufficient to supply/export some technologies abroad (Baskaran, 2001). The country has demonstrated that it has possessed the requisite technical proficiency for Research and Development (R&D) of complex satellite systems (Bommakanti, 2009). This example thus also illustrates how developing nations can expand to achieve extended vision to reach the higher end of technological ladder.

4.3. Angola's Kizomba deep-water project

The Kizomba deep-water project, is an oil drilling project owned and operated by Esso Exploration Angola (ExxonMobil), situated off the coast of northern Angola. Esso Exploration Angola started construction on the Kizomba A development in 2001. It utilizes the Hungo and Chocalho oil fields, in the so-called Block 15 concession off the Angolan coast. The project first began producing oil in August 2004 at a rate of more than 130,000 barrels per day. ExxonMobil initiated Kizomba B in 2003 situated 8Km east of Kizomba A. The project was initiated by the principle 'Design One, Build Multiple' strategy to reduce cost and accelerate startup but did not preclude innovation in design and project management. The design for Kizomba B essentially duplicates Kizomba A, therefore reducing costs and cycle time. The third phase, Kizomba C was started producing oil in 2009 in three fields – Mondo, Saxi and Batuque[4].

Incremental innovation in design engineering and project management for new production facilities has been achieved by these Angola's Kizomba offshore oil industry projects. Lessons learned from Kizomba A have been priceless asset in Kizomba B execution along with continuity of personnel and transferring of key members of the completion and commissioning teams to next project (Bell, 2007; Pennwell, 2006). These efforts have resulted in ahead of schedule accomplishment of the project with certain anticipated cost reduction. According to Offshore technology.com, nearly $1.5bn was spent on local goods and services for Kizomba C, including contracts for in-country fabrication, logistics support, training and development of Angolan personnel. Suppliers of components of various parts were recruited from local industries. Components produced include subsea manifolds,

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[4] http://www.offshore-technology.com/projects/kizomba/ - (visited on April 18, 2015)

helidecks, laydown modules, umbilicals, anchor piles and specialized turret components, which were successfully fabricated in Angola. ExxonMobil has also acknowledged that this fabrication of the turret components was the first of its kind in Angola.

This example project clearly illustrates a sub-Saharan Africa country building its capability with existence of projects to utilize its resources. The extent to which these local firms which produced the first of its kind production in relation to offshore oil industry need to be further investigated in depth. However, the evidences presented earlier indicate technological capability development of local firms by taking part in the projects. human capital capability development has been realized practically within these projects when Kizomba B was finalized five months ahead and well under budget (Pennwell, 2006).

These examples could be taken as evidence to support the potential of development projects in different sectors to build technological capability. This, however, is challenged by poor execution of mega projects in general. Weak performance in building technological capability by linking local industries to participate in mega projects could be exemplified with Mozambique's Mozal Aluminum Smelter project (Castel-Branco & Goldin, 2003; C. H. Wood, 2011). This aluminum smelter project has benefited Mozambique in some regard while being criticized for many other drawbacks – among which no technological capability development initiative is one. Utilization of scrap from the smelter would be a simple and yet significant capability development issue. Castel and Goldin (2003) illustrated this in their report by indicating that 200 tons of dross with a value of $34,000 per month was being exported to South Africa. With appropriate linkage and support from the project, such scrap could have been used to recycle and supply the local demand with simple technologies to produce affordable consumable household utensils for the nation while creating entrepreneurial opportunities. Other similar projects exist in many nations as result of megaprojects' mega risk. Uncertainty, risk and diminished output (as compared to the anticipated) are characteristics of all megaprojects (Ansar et al., 2014; Flyvbjerg, 2014). However, this is magnified for low income developing nations – they cannot risk too much.

Developing nations, especially, low income sub-Saharan countries need to strategically utilize the limited resources they have. Mega development projects are one untapped opportunities to build local technological capability. This paper argues that there exists huge opportunity to be exploited in these nations. As illustrated in the previous example projects around the world, concrete aim to build possible capability alongside the project execution is mandatory. How to build these capabilities may differ from sector to sector and from nation to nation. Absorptive capacity of nations determines extent of learning in these projects while its complexity varies from sector to sector and from project to project. With the technological capability difference between developed nations from which technologies are imported in these projects and that of low income developing nations, there is huge learning opportunity –but needs wise strategy to tap. To highlight this opportunity, the following section presents some of the mega projects being undertaken in sub-Saharan African countries and their diversification.

5. Opportunities in African Development projects

Africa has recently become destination for many emerging and developed economies for its natural resources. This fact presents opportunity that can build technological capability of African countries – if utilized wisely. According to PwC, it is estimated that infrastructure development for sub-Saharan African countries would reach US$180 billion per annum by 2025 (PwC, 2014). Projects that are currently underway vary in size, scope, cost, sector and complexity. These projects vary from roads connecting multiple countries, to hydroelectric dams, to modern ports and advanced technology and financial cities including telecommunications. Accomplishment of all these projects with internal capacity is impractical and with the current status, unattainable mandating external assistance.

Conducting research and development activities need capital as well as the capability to do so. The absorptive capacity to learn to greatest extent possible is also minimal in developing nations hindered by many factors (Doranova, Costa, & Duysters, 2011). This capacity to absorb is, of course, vital in developing nations. Waiting for programs focused on only such capability development is wrong. No matter how small, the available capability needs to be considered as base and capitalized using megaprojects – among others.

Most infrastructure development projects in Africa are constructed by foreign companies mainly from China, India and European contractors. Involvement of China in these projects is dominant and much more extended. According to Stratfor Global Intelligence, China has proposed or committed about $101 billion to commercial projects in Africa since 2010, some of which are under negotiation while others are currently under way[5]. This is further illustrated in Figure 2. Technological sophistication and project implementation experience become critical assets used by such foreign companies. The table below shows some megaprojects being undertaken in sub-Saharan countries. This list is not exhaustive and is merely indicative of magnitude and potential of megaprojects being performed. If all list of megaprojects performed is gathered, the opportunity becomes even more prevalent.

Table 1. Some megaprojects being undertaken /planned in sub-Saharan countries

Country	***Mega-Project***	***Cost (billion)***	***Sector***

[5] https://www.stratfor.com/sample/image/chinese-investments-africa

Kenya	Kenya's Lamu Port-South Sudan-Ethiopia Transit Corridor (LAPSSET)	25.0	Transportation facilities including (including port, refinery, pipeline, railway and highway)
Mozambique	Mozambique Ports and Railways	4.4	Railway
Nigeria	Lagos Metro Blue Line	1.2	Railway
Congo	Great Inga Dam first Phase (Inga 3)	12.0	Hydropower
Kenya	Mombasa - Kampala - Kigali railway project	13.5	Railway
Kenya	Konza City (African Silicon Savannah)	9.2	Technology and Financial
Ethiopia	Ethio-Djibouti railway	1.2	Railway
Ethiopia	The Grand Ethiopian Renaissance Dam	4.7	Hydropower
Tanzania	Bagamoyo Port	10.0	Port

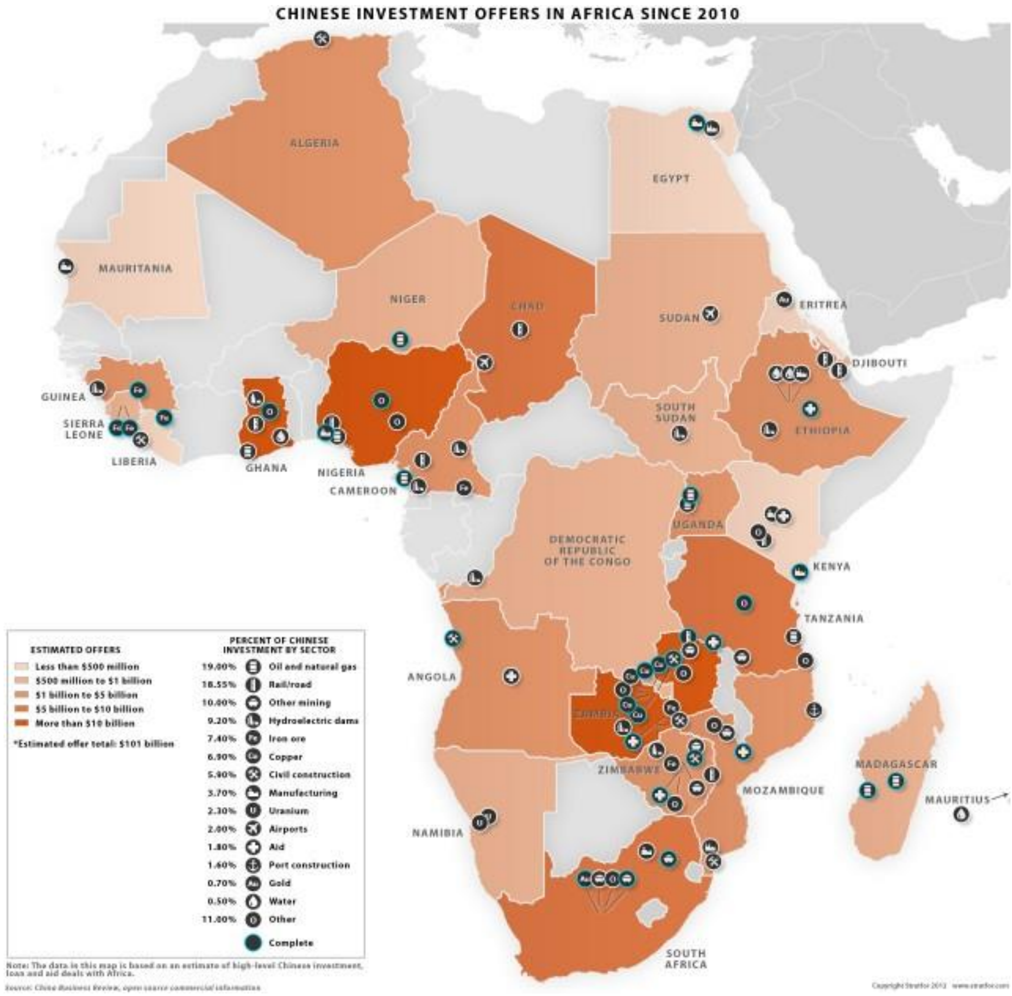

Figure 3. Chinese investment offers in Africa since 2010 (Source: Stratfor Global Intelligence)

These projects and many more not captured in this table have potential to create technological capability in the nations they are being pursued. Railway construction and hydroelectric power generations have higher portion from the listed megaprojects. Advanced technologies involved in such projects may not be developed in short time or would not be strategic to develop from scratch. As illustrated in the Indian satellite technological capability development, advanced technologies could be sourced elsewhere whereas majority components to be used in the future are possible to manufacture locally.

For instance, production of hydroelectric power generating Francis turbine, Pelton wheels, or Kaplan water turbines takes time, needs huge investment and demands time tested experience due to its advanced facility requirements. Striving to produce such components in low technological capability nations, for example Ethiopia for its Grand Ethiopian Renaissance Dam (GERD) project, would be difficult target to achieve. Many other parts of hydropower generating plant could however be locally produced and further developed with appropriate coordination of efforts. Such coordination needs to be initiated by the governments in these nations as observed in the practical examples presented in the previous examples. Nevertheless, private sector needs to play the central role in owning the technology being used. The success behind India satellite technology capability development is the committed involvement of the private sector with Indian space research organization in components design and production. This is again observed in Angola's Kizomba projects. Local expertise design and improvement of parts as they proceed from the initial project to the others accompanied with local industries adaptation to the technology to accommodate design changes has created opportunity to build capabilities.

These future projects have similar opportunity of capability development in their respective sectors. Democratic Republic of Congo's Hydropower Great Inga project is expected to be the world's largest hydropower dam in the world – superseding Three Gorges Dam in China. Having such magnificent icon without the technological capability to maintain it in operation and build future dams in the region would be unwise. Such huge investment presents opportunity to learn and build technological capability in the nation. Of course this, as in any learning opportunity, demands certain investment in human capital development. But this cost is insignificant when compared to trying to build technological capability without presence of such projects. Facilities established to perform the project activities, design expertise employed by international contractors and external linkages could be used as vital assets to build local technological capability.

Such coordination demands commitment of the government from the get-go of the project inception. International contractors may refrain from such knowledge transfer issues with concerns surrounding intellectual property rights (IPRs). This needs to be well understood and acknowledged as such as IPR underlines competitiveness issues. But with proper agreement to transfer most of non-IPR technological capabilities could be pursued.

Failure of many technology transfers underline in transfer of technology hardware without tacit knowledge and ability to use the technology effectively – absence of operational technological capability in the technology frontier ladder. Infrastructure development projects are performed by experts from international companies with limited participation of locals' expert wise (high number but low skill local participation). Involvement of local expertise in skill demanding activities paves way for tacit knowledge transfer. Furthermore, participation of local experts in design and engineering activities builds their capability to manipulate the technology and move further up the ladder. Once such capabilities are developed and well-practiced in the future projects with less and less involvement of foreign companies, the country can build a knowledge hub to undertake such projects in the region. If the nations indicated at the beginning of this section, with some of their mega projects in their boundary build technological capability, future hydropower projects, railway development, highway road and port constructions technological capability could flourish in African countries.

Building technological capability in developing nations has been clearly articulated in literature. Building this technological capability has distinctive nature in developed and developing nations. Firms and organizations in the developed nations conduct advanced research and development to realize advanced technologies in the technological frontier of their respective sectors. Developing nations on the other hand struggle to cope with technologies developed elsewhere in earlier times and face quite difficult challenge. This further increases the gap between developed and developing nations. Low income developing nations thus need to harness all opportunities possible. Mega infrastructure development projects have been proved to be vital in this paper to build technological capability in low income developing nations.

It has been presented in this paper that building capability using megaprojects as key vehicle to be successful and well achievable. Examples presented here in developed, emerging as well as low income developing nations illustrated this possibility. It, however, needs deliberate attention and commitment to engage local expertise and industries with an aim to build their capability. The learning from megaprojects needs to follow the spiral, cumulative and ever increasing trend shown in this paper. Engagement of local expertise and industries could start from the lowest level, operational capability, where they are engaged in providing simple components for such mega projects. This could be followed by co-design of parts and co-engineering of various activities in the projects. Such cooperation creates practical learning opportunity whereby tacit technological capabilities could be developed.

This paper has also indicated the projects underway in sub-Saharan countries and the opportunity they present to build knowledge hub in the region. The initial target of these projects is usually political or social issues driven by development agenda. It is the argument of this paper that these projects also present an opportunity in the country they are being undertaken. Hydropower, railway, oil extraction and port construction projects are underway with significant investment from different sources in these capital scarce nations. With wise utilization of these opportunities, mega infrastructure development projects become invaluable to build technological capability in developing nations. Studying technological capability of local expertise and industries accompanied by enabling contractual agreement with international contractors paves way to capability development in megaprojects. This motive needs to be driven by developing nation governments as key owners and clients of international companies who build these mega projects.

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