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Frugality in multi-actor interactions and absorptive capacity of Addis-Ababa light-rail transport

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ABSTRACT

Cities in transition need strategies to do more and better using less or limited resources, i.e., to be frugal in approach, especially when implementing expensive infrastructures. Addis-Ababa city in recent years acquired the light-rail transport (LRT) from China, which entails different multi-actors interacting to achieve resource-efficient LRT in terms of cost, technical knowledge and time. Addis-Ababa re-organized their organizational structure to interact with multi-actors, in providing affordable LRT, measurable technological transfer and learning routine via structured absorptive capacity, delivering an environmentally sound electrified light-rail, as a zero-carbon emission transport system. Using mixed research methods, consisting of light-rail expert's semi-structured interviews and passenger's survey, this article aims to know how the multi-actor interaction processes and absorptive capacity structure have delivered frugality in urban rail transport. Thus, delivering the LRT, despite inadequate country-owned financial resources, less technological and knowledge capability of LRT, within a limited period of three years. Results show that frugality strongly depends on the structure of absorptive capacity and process of multi-actor interactions. In addition, tacit knowledge developed by Addis-Ababa, as an existing knowledge base is vital in harnessing the explicit knowledge provided by China. This frugally delivered light-rail consequently brought changes to the low-income passengers, including some part of the bottom of pyramid (PoB) category, and a fraction of modal shift from other motorized transport modes to the light-rail public transport.

1. Introduction

Scholars within the technological capability school of thought, argue that developing economies should not linger-on, in a stagnant mode, as recipients of technologies transferred from the global North. Rather, these economies must embark on appropriate measures towards the adaptation and integration of the transferred technologies (Bhaduri, 2016), despite complexities within the multi-actors. One out of three extensive innovation heuristics used in achieving frugality in service (McNicoll, 2013; Mukerjee, 2012; Prabhu & Gupta, 2014), is identified as innovatively decreasing waste of time, human resources and materials to reduce cost and increase effectiveness. Little consideration is provided to the knowledge of frugality and frugal innovation as a non-technological and governance network related component, as it has been conventionally viewed in the technological and hardware related domain. However, frugal processes are alive and well in the institutional infrastructures of governance networks in cities. Till-date, most focus has been given to frugality and frugal innovations from the viewpoint of management (Radjou, Prabhu, & Ahuja, 2012; Zeschky, Widenmayer, & Gassmann, 2011, pp. 38–45; Prahalad, C. K., 2010; Prahalad, C. K. and Hammond, 2002) and technology (Altamirano

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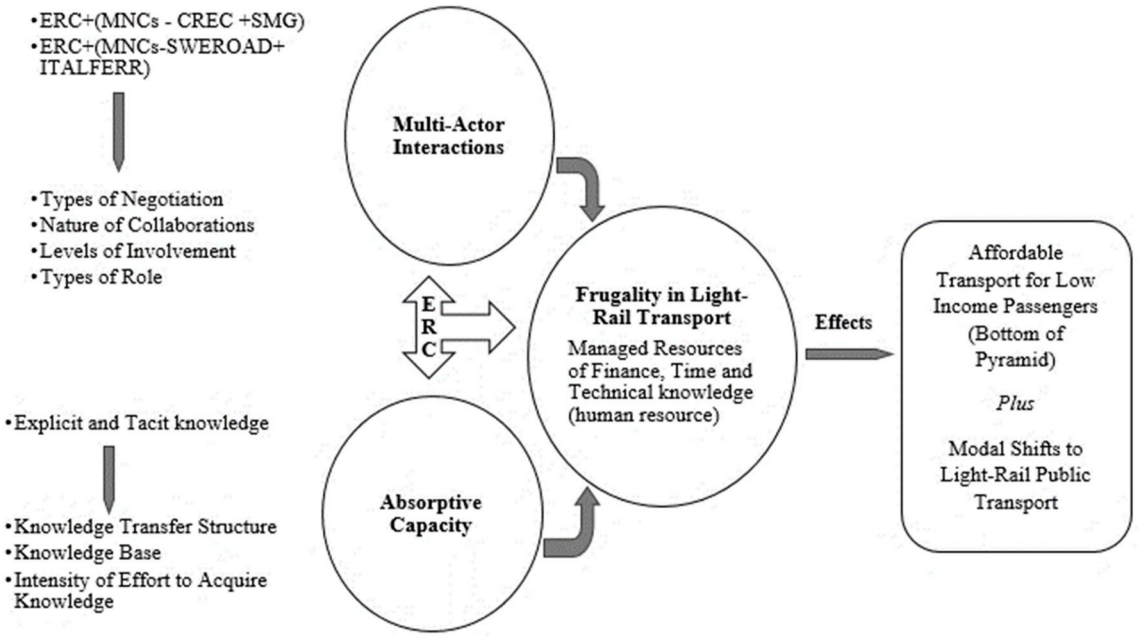

Fig. 1. Theoretical framework, showing relationships between multi-actors[1] interactions, and absorptive capacity, leading to frugality in LRT and its effect on the transport affordability of the BoP and modal shifts to LRT.

& Van Beers, 2018). However, we still know little about how frugality is realized and delivered especially in the practice of international collaboration. In this article, light-rail transport (LRT) is approached in the context of frugality amongst Multi-National Corporations (MNCs). (see Fig. 1)

There is a requirement to critically and systematically examine how frugality and frugal innovation outcomes in diverse areas of the world correlate to growth, to effectively measure its transformational or developmental potential (Leliveld & Knorringa, 2018). MNCs are progressively occupying cities in-transition and informal economies with frugal innovations, while local authorities, social entrepreneurs and Non-Governmental Organizations (NGOs) gradually endeavor to bring the local and frugal innovation practices to balance (Leliveld & Knorringa, 2018). A frugal viewpoint to development research is to classify in which circumstances these innovation procedures are expected to impact a more inclusive developing results, such as including benefits to the low-income passengers, i.e., bottom of pyramid (BoP). In this sense, an objective and multidisciplinary method to frugal processes and an empirical method is needed (Knorringa, Peša, Leliveld, & Van Beers, 2016). *This need serves as one of the scientific importance of this article, as it delves into the processes of how frugality is achieved through the combination of stakeholder dialogues in multi-actor interactions and tacit knowledge in absorptive capacity. In addition, considering the effects of this combination on the BoP, as an inclusive developmental outcome and modal shift to light-rail public transport.*

The aim of this case study, therefore, is to know how the multi-actor interaction processes and absorptive capacity structure amongst the multi-actors have delivered frugality in LRT, with effects of the changes by the new LRT on the BoP and modal shift from other motorized vehicles to LRT. Thus, implementing the LRT despite inadequate country owned financial resources, less technological and knowledge capability of LRT and limited time resource. Furthermore, the study aims to provide societal relevance for decision and policy makers, with the understanding of how to organize their multi-actor interaction processes with the MNCs and how to structure their absorptive capacity, to make optimum usage of their limited financial, time and human skill resources. These important needs are also geared towards the achievement of the ninth sustainable development goals (SDG-9), stated as “building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation”. Thus, effectual transportation services produce employment and prosperity and foster economic growth (UN Sustainable Development Goals, 2015).

The present-day dialogue on frugality in decision theory attempts to draw a conceptual roadmap to aid us fathom frugality in the context of decision making (Gigerenzer, 2008; Gigerenzer & Todd, 1999), has been interpreted in (Bhaduri, 2016). This dialogue fosters the need to analyze both the person taking the decision and the environment in which the decision is been taken, in order to comprehend frugality. Frugality needs to therefore, emphasize not only what is achieved, but likewise and possibly more importantly how it is achieved. In the context of this article, frugality is defined as the process of adaptation, adoption, invention, transformation and appropriation, not just of products but likewise of systems, not simply technological and scientific systems and products, also including all organizational, institutional, political and social dimensions (Leliveld & Knorringa, 2018). Similarly, this article also

[1] Ethiopian Railway Corporation (ERC), Multi-National Corporations (MNC's), China Railway Engineering Corporation (CREC), Shenzhen Metro Group (SMG) Swedish National Road Consulting (SWEROAD), Italian State Railways Group Engineering Firm (ITALFERR).

focuses on the institutional and organizational aspect of frugality, which is visualized in the multi-actor governance network and absorptive capacity, within the transport institution of Addis-Ababa light-rail.

Section one is the introduction. Section two depicts the theoretical framework which describes the relationships between frugality, multi-actor interactions, absorptive capacity, modal shift and BoP; section three focuses on the methodology describing the mixed method from a qualitative and quantitative approach; section four entails the empirical results and discussion based on multi-actor interaction processes and absorptive capacity leading to frugality, and effects of light-rail on BoP and levels of modal shift; section five is the conclusion.

2. Theoretical framework

Absorptive capacity concept is derived from three model theories. First is the theory of frugality in decision-making, see (Bhaduri, 2016), to understand and highlight the role of tacit knowledge and learning strategies, and the theory of frugality as a particular type of heuristic based decision-making process derived from knowledge on the setting or context gained from learning, experience, and intuition (Bhaduri, Sinha, & Knorringa, 2018). This frugality in decision making describes a framework, which highlights three main characteristics of frugality in decision theory (Bhaduri, Sinha, & Knorringa, 2018), specifically as: A search process by means of simple classified stages and intuitive thinking, rather than explicitly-defined instruction-based choices; Proactive steps to adapt to the environmental challenges via demonstrated capacity for imitation and learning; Focus on concrete performance, feasibility and effectiveness rather than scientific or logical validation. These processes foster the advantage of decision making in a specific context rather than pre-determined or rigid arrangements. Thus, serving as a benefit in the real environment for constructive use as knowledge interaction in the context of decision-making procedures. Second is the theory of process in local capability formation in explicit and tacit knowledge transfer (Ernst & Kim, 2002*, pp. 1417–1429)*, between network flagships, i.e. MNCs or LRT innovation supplier and local suppliers, i.e. local knowledge receiver or innovation receiving city or institution. Third is the theory of absorptive capacity for new knowledge as part of system antecedents for innovation (Greenhalgh, Robert, Macfarlane, Bate, & Kyriakidou, 2004). The absorptive capacity concept was used because there is a need to understand how ERC fosters the management for the acquisition of knowledge transfer from the Chinese Consortium (CS). This is because knowledge transfer is one of the key performance indicators (KPI), which makes it important to focus on, as it enables the context of frugal approach. This frugal approach is in managing the three major and related resources namely; limited budget, limited time and technical knowledge transfer for human resources to deliver the LRT.

The multi-actor interactions concept emanated from two model theories. The theory of inter-organizational norm-setting and networks in outer context in the implementation of innovations in health service delivery organization (Greenhalgh et al., 2004), and theory of sustainable collaboration (Fadeeva, 2005). The multi-actor interaction concept was used because of the interactions of Ethiopian Railway Corporation (ERC) with four other multinational corporations, to understand the patterns of their multi-actor collaborations as a governance network.

The frugality concept originates from the theories of frugality and frugal innovation for resource management, such as finance, time and technical knowledge (human resource), to do more or better with less or limited available resources (Leliveld & Knorringa, 2018; Pisoni, Michelin, & Martignoni, 2017; Bhaduri, 2016; Knorringa et al., 2016; Prabhu & Gupta, 2014; McNicoll, 2013; Mukerjee, 2012; Tiwari & Herstatt, 2012, pp. 245–274).

The BoP concept is deduced from two theories. First is the theory of business opportunities at the BoP, as a market base method to alleviate poverty (Hammond, Kramer, Katz, Tran, & Walker, 2007). Second is the theory of eliminating poverty by MNCs earning revenues at the BoP, generating shared values (Prahalad & Hammond, 2002). The base or BoP, denotes to the four billion persons in developing economies, a high significant part of the world's inhabitants (Hammond, et al., 2007). The yearly per capita income of these four billion people is less than $1,500 per year (London & Hart, 2004; Prahalad, C. K. and Hart, 2002), as $1,500 is measured as the least to withstand a basic life (List, 2017). Multi-national corporations make significant efforts to include the poor BoP and lower-middle class persons with reduced or relatively affordable versions of provided products and services (Leliveld & Knorringa, 2018). This BoP group forms a mega portion of most populations worldwide, were the MNC's can locate their wealth by providing services targeting them (Prahalad, C. K. and Hall, 2002).

The modal shift concept is coined from the travel behavior theory, which in transport planning is traditionally divided into four parts in a model acknowledged as the four step model (Ortuzar & Willumsen, 2006). This deals with the behavior of humans regarding travelling decisions. This article is concerned with the third part of the model, which is the modal choice. This describes the transport mode in a given trip, therefore relating the modal choice as a measure for modal shift, because it is when passengers change their mode of transport to another mode that it reflects the modal shift based on different factors, such as affordability, comfort, safety, reliability, etc.

2.1. Relationship between multi-actor interactions, absorptive capacity and frugality in light-rail transport

Prominent multinational firms and multi-actors in recent times use billions of dollars to develop innovations that are more affordable and measurable with significant environmental impact (Radjou & Prabhu, 2013). Frugality needs business to reassess and substitute existing strategies, organizational learning routines, innovation processes, partnerships, research methods, business objectives and finances (Nakata & Weidner, 2012).

Multi-actor interactions in MNCs are structured in a way that seeks to minimize the cost (Greenhalgh et al., 2004) of construction and maintenance of a huge infrastructure investment like the LRT. In this regard, a new LRT requires a frugal approach (Leliveld &

Knorringa, 2018; Bhaduri, 2016; Knorringa et al., 2016; Pisoni, Michelin, & Martignoni, 2017; Prabhu & Gupta, 2014), to be used by the multi-actors of the concerned MNCs, during their various stages of interactions in the design, construction and operation phases. To achieve this required frugality in light-rail, the multi-actors therefore structure their interaction processes at every stage with absorptive capacity, in the component of knowledge and technology transfer, which is regarded as one of its key performance indicator (KPI) and a benchmark for assessing the progress amongst multi-actor interactions during various implementation processes. Thus, when acquiring the LRT technology transfer, the structure of its absorptive capacity, using tacit knowledge by the LRT receiving actor is vital, to maximize the provided explicit knowledge (Ernst & Kim, 2002*, pp. 1417–1429)* from the MNC's providing the LRT. This determines the rate at which it can be acquired within a limited time and the depth of how much of the technology and knowledge has been transferred. In other words, the structure of the absorptive capacity ensures the realization of frugality in LRT by the multi-actors, who are very keen about how best to minimize cost of operating the LRT in the long run, using local personnel's as the human resource, within limited budget or loan and limited time. As a well transferred knowledge on LRT technology will guarantee the benefit of less cost in maintaining the LRT rolling stock in the long run, using local skilled engineers, paid in local currency. Regularly, the number of expatriates and days spent by same expatriates will be paid in foreign currency rate from the foreign MNC, costing more than the locals. This benefit guides against negative trade-offs, such as overshooting stipulated budget or loans received and long-term use of foreign personnel's from MNCs.

3. Methodology

3.1. Research strategy

The research strategy is a mixed method, using a single case study. These mixed methods are the qualitative approach using pilot and semi-structured interviews, and the quantitative approach using the survey method. The qualitative approach, provides instruments for researchers to study complex phenomena within their contexts (Baxter & Jack, 2008), which can inform professional practice and serves as evidence-based decision making in policy settings. In this research, it is a specific case of Addis-Ababa city LRT, with specific context of how the variables are related to one another, during multi-actor interactions between the MNCs from China, Italy, Sweden and ERC of Addis-Ababa city context. Case studies provides a more robust understanding of the social characteristics of adoption of innovation (Lawrence & Tar, 2013), in infrastructure provision and outcome of events (Radcliff, 2013, pp. 163–180). In addition, for public transport institutional analysis, variables are better analysed qualitatively, which needs in-depth methodologies (Altmann & Engberg, 2016), such as semi-structured interviews, providing deeper and more comprehensive data (Groves et al., 2009), considering specific context of study and actors actions and interactions are taken into consideration (Santander, 2013). The pilot provided a credible and sound research approach and interview protocol (Willis, 2004), in which the pilot confirmed if variables to be measured actually exists in the study area, because the area of research is relatively new in the study area.

The pilot and semi-structured interviews have a total of twenty-two respondents, five for pilot in-depth interviews in 2015, six for semi-structured interviews in 2015 and eleven for semi-structured interviews in 2017. The analysis from the qualitative analysis are descriptive statistics and coding of responses from the LRT experts to form reliable trends and validate responses based on the number of occurrences, thereby categorizing various levels of data to deduce categories and patterns, using the atlas-TI software.

The quantitative approach entails the use of survey questionnaire for a total of 254 passengers. These 254 respondents comprise of passengers along the North-South (N–S) line and East-West (E-W) line. The sampling method used is the purposive sampling selected because it is based on characteristics of the population of LRT passengers along the two available N–S and E-W lines in operation and the objective of the study. The analysis from the quantitative approach is descriptive statistics of related indicators, using the statistical package for social sciences (SPSS) software.

4. Empirical results and discussion

4.1. Frugality in light-rail transport

Frugality in light-rail is characterized by how limited resources are managed and optimized to achieve more expected outcomes during production of goods or provision of services to its target audience (Pisoni, Michelin, & Martignoni, 2017). This is because the type of resources varies according to several factors, while its indicators are categorized as limited stipulated time used during the LRT implementation, level of budgeted finance and level of technical know-how.

The processes of how frugality in light-rail was achieved are as follows:

4.1.1. Frugality in time resource

Frugality was achieved in time as a resource in the following phases of time periods in the light-rail project:

(a) Design Phase Period: This is characterized by ERC's timely interaction with city level authorities, such as Addis-Ababa road authority, city water and electricity companies, city telecommunication provider, etc., to incorporate their activities and assets with the needs of the LRT. In addition, and very importantly, resolving the third-party issues arising from the private and public owned assets along the LRT routes.
(b) Construction Phase Period: Multi-actors' interaction between ERC and other MNC's – CREC, SMG, SWEROAD and ITALFERR, was facilitated by ERC using the stakeholder dialogue method, having some of the steering committee members involved at every

main construction phase interaction. This ensures that most contract proposals of different phases were approved as quickly as possible and few rejected, not exceeding any of the stipulated periods of construction, as they this committee, which includes top government officials are aware of every development, to avoid bureaucracy on timely approvals, from the city and federal government.

(c) Operation Phase Period: The structured absorptive capacity, aided a timely technology transfer of knowledge, which ensured that only Ethiopians were driving the LRT after six months of starting the operation. In addition, major parts of operation and maintenance were handled by the Ethiopians between two-three years after operation. This saved Addis-Ababa city via ERC, significant amount of money, which would have been used to pay the Chinese in foreign currency, costing more as extra expenses, if the locals were not technically empowered within the right period of LRT implementation.

4.1.2. Frugality in technical knowledge (human resource)

In acquiring light-rail technology transferred from China, ERC used tacit knowledge as a form of absorptive capacity to structure its knowledge transfer to acquire the Chinese explicit knowledge. Frugality was achieved in human resource, as extra cost was avoided in extending the five years concession to the Chinese, via appropriate knowledge gap-filling by the Ethiopians, whom have received technical trainings few years before, during and after the operation of the LRT. In addition, significant component of training on future routes of LRT in Addis-Ababa will be done by the Ethiopians, saving cost of hiring fresh hands from abroad and reduced cost on salaries during the implementation of the proposed expansion of the LRT routes in Addis-Ababa, as significant percentage of expenditures goes to payment of drivers and other personnel working within the operation and maintenance departments.

4.1.3. Frugality in finance

Using the limited available finance, borrowed as loan from China, Addis-Ababa city controlled the use of this resource through efficient use, consequently from both frugality in human resource and time. Frugality in these two ensured that frugality is achieved in finance, because it aided expenditure in a more prudent manner, avoiding request of more loans, which may be required if time of completion is delayed and inflation sets in, affecting Addis-Ababa's counterpart funding and costs for components of the rolling stock. Thus, saving costs in the present and future implementation of LRT in Addis-Ababa. As mentioned by a top director, “We did not have any reason to spend more than we budgeted for, because all components of the LRT was done within time, avoiding any form of significant inflation of foreign currency for our counterpart funding and 50% of our workers have presently taken over the LRT operations and maintenance, paid in our local currency”.

4.2. Multi-actor interactions

Multi-actor interactions defined in this context as the Multi-stakeholder group collaboration. These collaborations vary broadly for its type of interactions and nature of collaboration, in terms of their size, goals, membership and actions (Fadeeva, 2005). *The multi-actor interactions use mainly the stakeholder dialogues and sometimes formal negotiations*, which fosters frugality, despite differences in interaction methods, culture and methods of implementing infrastructural projects. Thus, ensuring less cost increment as a result of certain tradeoffs between the MNCs and city authority organizations, such as asset resettlement claims along LRT routes, electrical and communication utility transfers by the utility companies, city government building demolitions to allow for LRT route space, right of way issues with other road vehicles, crossing distance allowed for pedestrians between LRT stops due to safety barricades along the LRT routes, etc. For example, as mentioned by one of the Ethiopian LRT experts – “We the ERC, facilitate stake-holder dialogues with related city authorities on behalf of Ethiopian government and Chinese consortium, as a form of informal dialogue”.

4.2.1. Nature of collaborations and types of negotiations

This is defined as formal negotiations, voluntary agreements, stakeholder dialogue, multi-partner projects and information sharing, reasoned argumentation to foster mutual understanding, which in turn requires trust and transparency in the use of terms (Sarkis, Cordeiro, Alfonso, & Brust, 2010).

The ERC uses mainly the stakeholder dialogues and government intervenes with formal negotiations when the Addis-Ababa city administration is facing challenges with other stakeholders. For example, as mentioned by an ERC expert using the stakeholder dialogues, “We don't need to go back and forth, the federal government representatives in the steering committee are already aware of the technical and non-technical decisions the ERC is proposing, so we have their support for approval and funding by the government, which becomes easier and moves faster”. This provides better understanding by avoiding a top-down communication, through the engagement of related top government officials' positions from the bottom, i.e. *bottom-up approach*. In a way that decisions are informally and substantially taken and understood at the bottom, before it proceeds to the top for formal negotiations and final approval. Thus, revealing a smoother process, saving time and fostering faster LRT implementation. 70% of the 17 respondents during the second and third round semi-structured interviews from ERC supported the claim that their dialogues with other multi-actors are more of stakeholder dialogue than formal negotiations.

In order to minimize risk and cost during the operations, the Chinese consortium will saddle any cost responsibility from a component failure or revenue shortage from a component during construction (building) or operation.

4.2.2. Levels of involvement and type of roles

Levels of involvement is categorized as very active, active, slightly active or passive: The Addis-Ababa city administration, ERC and Chinese consortium are the very active multi-actors, because the LRT is implemented inside the Addis-Ababa city, thereby

playing the role of interacting with her city multi-actors, such as the utility companies. While, the ERC also performs the role of an intermediary between the city multi-actors and the Chinese consortium, as the Chinese consortium is a client of ERC and needs ERC to facilitate several issues, such as right of way, security matters, demolitions and resettlements, utility relocations, etc. The federal government mainly plays an active role, by financing the LRT counterpart funding and seeking for loans from EXIM bank as a guarantor for the country. The government also plays the role of providing rules for checks and balances, especially from the Chinese consortium, such as fare regulation to avoid over charging the LRT commuters, quality control of rolling stock provided and adherence to her key performance indicators, such as knowledge transfer. Other multi-actors playing active roles are the consultants hired by the ERC, such as the Italferr, MNC from Italy and SweRoad, a MNC from Sweden. Thus, no actor was in the range of slightly active or passive.

4.3. Absorptive capacity

The ERC has less maintenance capacity to maintain the LRT infrastructure, due to the sophistication or complexity of the LRT system. Therefore, there is a strong presence of knowledge transfer as one of the KPI's in the contract agreement between the ERC, CREC and Shenzhen metro. Thus, the transfer of knowledge varies, depending on how the LRT receiving organization organizes her tacit knowledge to assimilate and effectively use the explicit knowledge, using various capacity building structure. These are present in its indicators, such as knowledge transfer structure, initial knowledge base, type of effort to acquire knowledge, knowledge transfer ratio plans, type of knowledge transfer streams and types of approach to knowledge transfer.

This knowledge transfer takes place mostly between the ERC directors/mid-low experts and the Chinese consortium experts. The technical knowledge shared by the Chinese consortium represents explicit knowledge codified in formal, systematic language, i.e. encoded knowledge, in various forms of documented manuals of operation, instruction and concepts organized in digital formats provided to ERC. The information sharing is also based on tacit knowledge, practiced by ERC, the LRT receiving organization. Example of tacit knowledge in Addis-Ababa, as mentioned by one of the officials, “I have to reject some of the proposals from the Chinese consortium, on the basis that I need more explanation, in order to understand in-depth, the reasons behind the proposal and acquire the knowledge behind the technical proposal, on why the Chinese designed or plan to implement some aspects of the LRT”. This will enable the Chinese to re-explain the methods in more detail and in a simpler manner, easier for the Ethiopian counterpart to comprehend. Another example is the replacement of the LRT driving from the Chinese by the Ethiopians, just in six months after the start of operation, as a result of continuous observation, face to face apprentice training, imitation and practice.

A structural framework to acquire the knowledge was setup with different strategies, namely:

4.3.1. Knowledge transfer ratio plan

First year – Ethiopians (ET) -30%: Chinese (CH.) 70%: This depicts that with the first one year, the knowledge transferred from the Chinese to the Ethiopians will be at ratio ET -30% and CH – 70%.

Second year – ET -40%: CH -60%: This ratio means by the second year, there should be an improvement from 30% to 40% increment, while the Chinese counterparts are also releasing responsibilities to the Ethiopians more than the first one year from 70% to 60%.

Third year ET -60%: CH -40%: The third year shows that slightly more than half of 100% as 60% knowledge is now transferred to the Ethiopians.

Fourth – Fifth year – ET -100%: By the 4th-5th year, it is expected that the knowledge transfer from the Chinese should have completed the whole 100% to the Ethiopians.

The progress from October 2015 of this was actualized as the knowledge transfer in 2017 was 296 personnel as Ethiopians and 117 Chinese left and technical know-how improved after one year with good inputs. Example in 2017, 100% Ethiopian LRT drivers are already driving the LRT, 100% of the operations control center is managed by the ERC locals, 100% of the finance, human resource and security departments were managed by the ERC locals. While some components of the operations and maintenance department are still building more capacity, aiming to reach the 100% by the 5th year.

4.3.2. Medium- and long-term training

Trainings in China, Ethiopia and other parts of the world, with a planned learning curve for all LRT processes and phases. Approximately 600 ERC staff were sent for training to prepare for construction and operation, a fraction where sent to China, parts of Europe and some trained locally and on the job during the construction and operation phase. However, 70% out of this 600 ERC staff were trained outside before the commencement of the LRT project and the Chinese at times only need to fill in the gap where the ERC staff trainee falls short, i.e., the local staff already has some level of training before the Chinese counterpart arrives. Example, out of this 600 Ethiopian personnel, 20 people were trained in China on signaling component. While some of the technicians and engineers that needs retraining were retrained in the short term.

4.3.3. Nineteen (19) mainstreams and certifiable positions in operation and maintenance

The knowledge transfer was divided into different components of trainings, which is embedded in all stages with specific number of trainees. Such as: control centre, information dispatcher, power dispatcher, operation dispatcher, this is from the operation aspect. There are also maintenance aspect, such as sub-signalling, communication, rolling stock, construction of the infrastructure, human resources department, security department commercial centre, transport centre, driving department, operation control centre, etc.

4.3.4. Pairing of every Chinese manager by Ethiopians in the main departments

An example here is when a Chinese manager in the procurement, finance, operations and maintenance departments also have an Ethiopian manager working side by side as the local manager. In this way, the Ethiopians can learn on the job quickly, by working alongside the Chinese to see what is been done daily, ask questions and get clarity of understanding and purpose.

4.4. Reasons why multi-actor interactions and absorptive capacity contributes to frugality in light-rail transport

The main practice of stakeholder dialogues over occasional formal negotiations by multi-actors and use of absorptive capacity contributes to frugality in light-rail transport. This is because, the theory of frugality in decision-making theory (Gigerenzer, 2008; Gigerenzer & Todd, 1999), with regards to the absorptive capacity concept shows that ERC used classified stages to develop the technology transfer into different training classes, ratio-plan stages and learning strategies. In addition, proactive steps of imitation and learning were used to adapt to peculiar context challenges in Addis-Ababa via demonstrated capacity to adapt. In addition, there is a focus by ERC on concrete performance, feasibility and effectiveness rather than scientific or logical validation, achieved through structured learning, imitation and tacit knowledge for actual performance, such as taking-over specific operation and maintenance activities within stipulated time. In the same viewpoint, frugality in light-rail did not only highlight what was achieved in technology transfer from China to Addis-Ababa, but more importantly how it was achieved in the absorptive capacity and multi-actor interaction processes (Gigerenzer, 2008). Furthermore, it gives local authorities a competitive advantage because ERC regularly own tacit knowledge of the peculiar local conditions, needs and local desires (Leliveld & Knorringa, 2018). This is realized from the use of tacit knowledge by LRT receiving corporation – ERC in Addis-Ababa city, of unique and peculiar local contexts. An approach by MNCs included in designing, constructing, marketing or operating frugal innovations is consequently to involve entrepreneurs and local innovators in business networks and polycentric innovation, to benefit from this valuable knowledge (Leliveld & Knorringa, 2018).

4.5. How context-specific knowledge interaction fosters frugality

The ERC understood the importance of their long-term goals to manage and operate the LRT. Thus, the need to fathom in their experience about the context of their needs or ability to detect in detail the smallest of complications (Bhaduri, Sinha, & Knorringa, 2018) that may arise if interaction processes between the ERC and MNCs are inadequate for expected knowledge transfer via structured absorptive capacity. Therefore, it is pertinent to show that the context-specific knowledge interaction processes between the multi-actors was a symbiotic relationship with decision-making processes, which are sensitive to the local skills, decision process initiatives and context-specific knowledge (Bhaduri, Sinha, & Knorringa, 2018), from ERC of Addis-Ababa. This consequently fosters or promotes opportunities for adaptation and testing, built on context-specific knowledge. Therefore, context-specific knowledge interaction processes promotes frugality because the local skills and knowledge from ERC provides benefit to the MNCs and all multi-actors, to better understand the context situation at hand, which only ERC possess, thereby harnessing the knowledge interaction and transfer within a reasonable time, with the required number of personnel and within the allocated and limited finance. Examples of these skills and decision-making process of absorptive capacity for adequate knowledge transfer by ERC with the cooperation of the MNCs are: Pairing of Chinese managers with Ethiopians in main departments, structuring certifiable positions in operations and maintenance, knowledge transfer ratio plans and other tacit inclined skills embedded in personal intuitive reasoning of the ERC personnel.

4.6. Effects of fare affordability and pricing by zone distance on bottom of pyramid (BoP)

The new LRT was able to cater for the transport needs of the people, including some part of BoP through the provision of affordable ticket fare price and structure. This fare structure provided by the multi-actors for the passengers is a zoning system of 2, 4 and 6-Ethiopian ETB[2] per NS or EW line trip, for short, intermediate and long/end-to-end zone distance passengers respectively. *The multi-actors used the competition based method* (Kozlak, 2007; Rokicki, 2014), where the price is determined and reduced on the basis of price analysis of competing services, such as competing private bus and taxi operators, and public bus operators. This was used as a benefit because it supports the provision of more affordable transport fare to the BoP (Pansera & Owen, 2015, pp. 300–311), as compared to other main public transport modes, for the low-income earners to easily migrate to the LRT, which is lower in price than its competitors. Out of 254 total passengers as respondents, 66.7% of the passengers perceived this ticket fare as affordable (just OK), 21% perceive it as very affordable; while 9.7% perceive it as expensive (not affordable). This brings the total percentage perceived by the passengers as affordable ticket pricing in general to 87.7%, *thus fulfilling the target for the low-income passengers, which includes some part of BoP, to increase accessibility and foster inclusion*.

Hence, it can be argued that the BoP population in Addis-Ababa is assumed to be higher than the 9.7%, which perceived the ticket fare as expensive. Since almost 50% lives below poverty line, i.e., less than 500 ETB per household per month, and near 23% are in total poverty, i.e., less than 300 ETB per household per month (Abreha, 2007). Therefore, it is further argued that the LRT is still in the process of reaching a significant population of this BoP category. Nevertheless, the LRT has begun a journey towards affordable transport, to be inclusive of the BoP, as the ERC plans to regulate the price in a manner that would reflect inclusion for a part of the BoP, which may however not cover all the BoP passengers.

[2] (ETB) Ethiopian Birr - Ethiopian national currency, with an equivalence present rate of 29 ETB to 1 USD (dollar).

Based on the occupation type of the 254 passengers surveyed, 62% of these passengers shows they belong to the bottom of the pyramid as low income earners, earning between less than 300 to 550 ETB. The most popular ones are petty traders, street hawkers, shoe repairer, roadside traders, and the unemployed. In addition, 85% of these 254 passengers do not use private car as one of their modes of transport, as deduced from their modal combinations. While the remaining 38% of passenger's occupation status depicts, they belong mostly to the middle-income earners and few passengers belong to the upper income earners. As most of the upper class are still more comfortable with their private cars and are not yet willing to change modes. Most popular middle-class categories are university lecturers, telecommunication shop owners, bank workers, private business owners, civil servants and other government workers. The positive consequence here is that, the more affordable LRT has made some fraction of BoP passengers to change their modal choice of transport from other public transport modes to light-rail. This is because the LRT fare rates are slightly more affordable than the white and blue minibus taxis, alliance bus and higer midi-buses, which has a price range from 2.5 ETB for 2.5–7 km, 4.5–5.5 ETB for 8–15 km, and 7 ETB for 15–25 km. The LRT to a significant extent is more affordable than the salon taxis, which costs at least triple the price of the LRT, depending on the distance covered, and is usually patronized by the mid and high-income earners. On the other hand, the LRT is slightly less affordable than the Anbessa city buses which is predominantly used by the BoP's, with cost ranging from 1 ETB for 6–12.4 km, 1.75 ETB for 9–13 km, 2 ETB for 13–15 km and 10 ETB for 47–50 km. In this regard, a fraction of BoP's using the other modes of transport, especially those with close proximity to the LRT platforms, have a better choice of shifting to the LRT, which has better safety, reliability, comfort, and cheaper fare except the Anbessa city bus. This modal shift is proven by the high peak-hour rate patronage of LRT per day in Addis-Ababa. The LRT has also provided relieve as reduction in the use of taxis and other bus types by the middle- and high-income passengers.

4.7. Effects of new light-rail as a modal shift from other motorized modes to LRT

In addition, another important change to the city from the new LRT is the *modal shift from other modes of motorized transport to public LRT*. To depict the extent of modal shift, the estimate for other transport modes capacity shows: 487 Anbessa city buses with passenger capacity of 30 sitting and 70 standing, 10,000 white and blue minibus taxis with passenger capacity of 12 sitting, alliance bus with passenger capacity for 40 sitting and 60 standing, 460 higer midi-buses sitting 22–27 passengers, 366 additional vehicles and 6500 salon taxis sitting 4 passengers (Fenta, 2014). The Anbessa city bus is also characterized by 730,500 passengers per day with 100 passengers per trip, through 93 routes, average total of 6352 daily trips, with the shortest route as 6.8 km, longest route as 47.2 km and total route length of 1207 km (Abreha, 2007).

The LRT network is designed to carry 15,000 passengers per hour per direction (PPHPD) and 115000–153,000 passengers per day (PP/PD). Comparing these 153,000 passengers of the LRT to the closest mass public transport like the Anbessa city buses, which carries 730,500 passengers per day, is for now only 21% (153,405) of the passengers from Anbessa city buses. This justifies the plan by the ERC to purchase more LRT vehicles and open more routes, to accommodate the high travel demand. Presently, as a top director in the operations department affirmed, “We hardly have off-peak periods, the people of Addis-Ababa embraced the LRT more than we expected, and it is most of the day peak periods, as the LRT is most of the time full to its total capacity”. *This gradual modal shift will consequently reduce congestion on the roads and reduce the level of CO2 emissions*, as the 275,500 Addis Ababa vehicles are releasing between 25,000 and 32,000 tons of hydrocarbons and 49,000 to 58,000 tons of carbon monoxide to the city's air annually, which is two to six times higher than World Health Organization standards (Benjaminson, Shankute, Torgerson, Gebre, & Gallavan, 2012).

5. Conclusion

Multi-actor interactions and absorptive capacity delivers frugality in LRT

Results of the overall framework vividly shows that frugality in LRT strongly depends on the structure of absorptive capacity and process of multi-actor interactions, especially as designed by the LRT receiving country. In this regard, the structure is related to structured absorptive capacity, provided knowledge transfer ratio plan, medium- and long-term training, knowledge transfer division into 19 mainstreams and certifiable positions in operation and maintenance, pairing of every Chinese manager by Ethiopians in the main departments. While the process as it relates to how ERC as the main actor interacts with other multi-actors, using mainly the stakeholder dialogue and some formal negotiations to interact between the Addis-Ababa city authorities and MNCs. The stakeholder dialogues lead as a main type of multi-actor interaction, while the formal negotiation follows and provides the benefit of complimenting the stakeholder dialogues, especially when the stakeholder dialogues have reached a standstill. The stakeholder dialogues also provide a soft-landing benefit for the formal negotiations to stimulate faster approvals and avoid bureaucracy to a reasonable extent. The combination of these absorptive capacity structure and multi-actor interaction processes, amongst ERC, MNCs and Addis-Ababa city authorities, to a large extent have delivered frugality in light-rail transport during the implementation, despite inadequate country owned financial resources, less technological and knowledge capability of LRT and limited period of time resource of three years. Thereby addressing the research question, that to a large extent the use of mainly structured absorptive capacity and stakeholder dialogue processes during multi-actor interactions, have delivered frugality on finance, human and time resources of the Addis-Ababa light-rail transport. In addition, the multi-actor interactions produced a fare structure, which provides more affordable transport fare to the BoP passengers than most of the other modes of transport, providing them an inclusive advantage to use the LRT, as a cheaper, safer and more comfortable public transport. Addis-Ababa re-organized their organizational structure to interact with multi-actors, in providing affordable LRT, measurable technological transfer and learning routine via structured absorptive capacity, delivering an environmentally sound electrified light-rail, as a zero-carbon emission transport system.

In addition, it is pertinent to state that adequate attention was paid to local context situations at hand through ERC, the local institution with creditable cooperation from the MNCs. This focus on local context provided benefits to frugality, because it provided a platform for the MNCs to incorporate the complexities, as endogenized in the decision-making process of the real city environment (Bhaduri, Sinha, & Knorringa, 2018) by ERC. Another benefit is the provision of opportunities for adaptation and testing based on context-specific knowledge or skills, which encourages frugality. This is because the purpose of frugality will be lost if a policy or defined process operates along strictly fixed rules from MNCs alone, as a transfer to the ERC and Addis-Ababa city. This would complicate the context challenges at hand, because the MNCs need to understand and incorporate the LRT implementation plans using local and context specific knowledge from the ERC, leading to better frugality in financial expenditure and knowledge transfer between both parties.

Little is known about how diverse kinds of governance affect frugal processes, and what may be effective governance frameworks to follow, to affect the development and diffusion in frugality and frugal innovations (Hillman, Nilsson, Rickne, & Magnusson, 2011). Therefore, the theory of frugality in finance, human and time resource management during multi-actor interactions, will be beneficial to how other emerging economies harness their limited resources to implement large infrastructural projects like roads, water ways and national rails etc. This has opened further dimensions to frugality within the transport governance domain. The theory of Absorptive capacity in the context of multi-actor interaction of LRT system, will be useful in understanding different structures of knowledge transfer in different cities in transition to infrastructure adaptation and transfer. This will provide the understanding on how effective they are and reasons behind each structure, to see how some structures can be harnessed to better suit their socio-economic and institutional contexts.

The policy makers can make use of vertical equity service (Geurs & Ritsema van Eck, 2001), to target economic equity of the poor (BoP) and non-poor. This is to foster the inclusion of less mobile people or economically disadvantaged group for improved mobility. Such as incorporating special fare structure as a subsidy for BoP passengers and students to reduce financial exclusion. The policy or decision makers in LRT receiving cities can also use the benefit of context specific knowledge to structure and strengthen their infrastructural transfer plans when receiving similar and costly infrastructural expenditures to foster frugality.

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