# Innovation Adaptation in Urban Light-Rail Transport

## Adapting Pricing and Infrastructural Innovations using Frugal Approach in Ethiopia and Nigeria

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## Adapting pricing and infrastructural innovations using frugal approach in Ethiopia and Nigeria

## Innovatie en aanpassing in stedelijk light-rail vervoer

## Aanpassing van beprijzing- en infrastructuurinnovaties met behulp van een sobere aanpak in Ethiopië en Nigeria

Thesis

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by

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# Dedication

I dedicate this PhD dissertation to my late father and mother, Abdulrahman Babatunde Alade and Esther Eyinade Alade; for giving me a solid and deeply rooted foundation in education. Our parent made sure we had all we needed, especially when it comes to our education. They also encouraged us to push the limits and always aim high, no matter the challenges on the way. I love you both.

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# Foreword

The pursuit of a PhD is beyond a doctoral degree. I have fortunately gained much knowledge from my promoter and co-promoter, which has helped me to attain genuine research ethics. The journey to reaching this point has been very up-hill, writing manuscripts to specific standards, especially to meet a journal's expectations and with unending delays from journals, after following the rigorous scientific writing experiences from my promoter and co-promoter. I was motivated to do this research because I have experienced some failed transport infrastructure management problems in Nigeria, such as the national rail system and national air transport system. I saw these inadequate skills from the personnel's providing operations and maintenance for these huge infrastructures, which has sometimes led to a total collapse of the rail and air transport industries in Nigeria.

In this regard, academic scholars within the technological-capability school of thought, argue that developing economies should not linger-on in a stagnant mode as receivers of technologies transferred from the global north. Rather, it is essential that these economies embark on appropriate innovation measures towards the adaptation and integration of the transferred technologies. Taking the perspective of international benchmarking, focus is given to cross-national lessons learnt, while it is frequently assumed for a genuine motive, that transplantation of policy replica of infrastructure among countries with comparable, cultural, institutional, and legal characteristics is straightforward. Even if this is correct, identifying understated institutional dissimilarities and realistic transport infrastructural policy challenges, by the receiving country are very important for the accomplishment of infrastructure transplantation. Understanding how to achieve innovation effectively is significantly essential in the period that innovation is practically a compulsory survival technique, as the statement goes "innovate or die". This means when innovating, the level of risk should be reduced using innovative and contextual approaches, or else it could be very risky, as it may lead to the end of a corporation.

Several decades of innovation management occurred in diverse periods and in completely different circumstances, demanding different forms of innovation procedures. In fact, innovation managers need to frequently focus on how to achieve their innovation process based on their precise contexts. Therefore, there is a clarion call to cities in transition to light-rail, to possess a strong political will, to strengthen the transport institutions. This will consequently provide adequately structured technological transfer components and the use of poly-contextualization methods for different cities based on their diverse contexts, for better adapted methods, processes and policies.

# Acronyms

| | |
|---|---|
| ALRD | Abuja Light-Rail Department |
| CCECC | China Civil Engineering Construction Corporation |
| CREC | China Railway Engineering Corporation |
| ERC | Ethiopian Railway Corporation |
| LAMATA | Lagos Metropolitan Area Transport Authority |
| LRT | Light-Rail Transport |
| MNC | Multi-National Corporations |
| NMT | Non-Motorized Transport |
| RPC | Rail Providing Corporations |
| RRA | Rail Receiving Authorities |
| SMG | Shenzhen Metro Group |
| TOD | Transit-Oriented Development |
| CTAs | City Transport Authorities |

# Summary of Dissertation

In recent decades, China has been collaborating and investing in Africa, via infrastructural projects, such as urban light-rail system, national rail, roads and telecommunication satellites (e.g. the Nigerian communications satellite NIGCOMSAT-1R). This research focuses on the collaborations of the urban light-rail infrastructure, between the Chinese and their African counterparts, in this case Nigeria and Ethiopia. Abundant resources do not guarantee adequate light-rail transfer and service quality from one country to another, especially when these resources are not sufficiently utilized to optimize the huge amount of the country's finances spent on the long term. Thus, sometimes these transferred infrastructures experience poor context transfer, i.e. the infrastructure transfers do not adequately consider the specific socio-economic, environmental and technological contexts of these infrastructure receiving cities. Leading to inadequate or poor infrastructure operation and maintenance at the long run, which consequently leads to a collapse of infrastructure use, despite huge investments. The collaboration between these three countries experiences a frugal approach to adapting pricing and infrastructural innovations of a light-rail, while also preserving required quality amidst frugality. This frugal approach is practiced on finance, human and time resources, because there is a significant level of resource constraint from the infrastructure receiving cities of Abuja and Lagos from Nigeria; and Addis-Ababa from Ethiopia.

In this regard, there is a need to critically and systematically investigate how frugality and frugal innovation outcomes in different parts of the world correlate to development, to effectively measure its transformational or developmental potential (Leliveld and Knorringa, 2018). A frugal viewpoint to development research is to classify under what circumstances such innovation processes are expected to contribute to more inclusive developmental results. In this sense, a critical and multidisciplinary method to frugal processes as well as an empirical approach is needed (Knorringa; Peša, et al., 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 effect of this combination on the low-income earners, i.e., the bottom of the pyramid (BoP), as an inclusive developmental outcome.

One out of three extensive innovation heuristics used in achieving frugality in service (Prabhu, G. and Gupta, 2014, McNicoll, 2013, Mukerjee, 2012) is identified as innovatively decreasing waste of time, human resources and materials to reduce cost and increase effectiveness. Little attention has been given to the study 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, et al., 2012, Zeschky; Widenmayer, et al., 2011, Prahalad, C. K., 2005, Prahalad, C. K. and Hammond, 2002) and technology (Altamirano and 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).

The aim of the first article is to know how the multi-actor interaction processes and absorptive capacity structure amongst the multi-actors deliver frugality in LRT, with effects of the changes by the new LRT on the low-income earners as the BoP and modal shift from other motorized vehicles to the LRT. Thus, implementing the LRT despite inadequate country owned financial resources, less technological and knowledge capability of LRT and limited time resource. Furthermore, the first article 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 attainment of the ninth sustainable development goals (SDG-9), stated as "building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation" as the provision of competent transportation creates employment and wealth, and fosters economic growth (UN Sustainable Development Goals, 2015).

Its theoretical framework focuses on the relationships between multi-actors' interactions, and absorptive capacity, leading to frugality in LRT and its effect on the transport affordability of the BoP and modal shifts to LRT. The research strategy is a mixed method, using a single case study. These mixed methods consist of a qualitative approach using pilot and semi-structured interviews, and a quantitative approach using the survey method. 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 process as it relates 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, formal negotiations are used to settle such expected outcomes during interactions. 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 frugal approach during the interactions was able to implement the LRT within the stipulated budget, planned time of three years and managed the human resource available through strategies of appropriate absorptive capacity from knowledge transfer. 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 leverage to use the LRT, as a cheaper, safer and more comfortable public transport, as compared to the other available public transport modes in Addis-Ababa. 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 a sound environmentally friendly electric light-rail, as a zero-carbon emission transport system.

The second article aims to know how the pricing and infrastructural innovations of a light-rail transport from a China context is transferred to the Addis-Ababa city context. This transfer is made amidst some re-modifications in order to suit the Addis-Ababa context. The article further aims to know the social, economic and environmental effects of these contextualized innovations on passengers, MNCs expected outcomes, the city environment and resident's proximity living and doing business along the LRT route. Additionally, avenues for re-modifications are identified, especially from modifications which led to negative effects. This LRT transfer requires a contextual approach, which happens through modifications to suit the Addis-Ababa city context and affect the LRT users and MNCs in the expected way, while strongly considering some contingency factors. The contextual innovation management arrangement can deliver benefits as synopsis of alternatives selections in diverse contexts and support innovation managers in their innovation-based decision-making processes.

Its theoretical framework shows a contextual approach process by MNCs on pricing and infrastructural innovations to deliver service to LRT passengers and provide MNCs with expected outcomes. Thus, depicting the relationship between pricing and infrastructural innovations and the effects of contextualized approach of the two innovations on passenger service delivery, residents along LRT corridor and the MNCs. As a methodology, the second article uses a qualitative method of a single case-study research.

The Addis-Ababa case revealed new city level contextual factors, such as fare evasion; level of travel demand; non-use of electronic device for pricing; LRT platform size; non-availability of ticket sensor barrier at platforms; use of lifts and

escalators at specific LRT stations. These newly discovered contextual factors represents new and particular challenges at hand that may influence innovation adoption (Wisdom; Chor, et al., 2014), which are different from the ones in literature. Modification of pricing and infrastructural innovation to suit the context of a city is not the end to the means of providing a sustainable LRT. However, understanding that a re-modification process is required at different phases of the LRT project is important.

Thus, it is important to create scenarios during the design phase, in order to accommodate the contextual factors that may arise during the construction and implementation phases, providing opportunities to re-modify with less negative outcomes and limited financial cost. This will further reduce the probabilities of negative outcomes, which sometimes causes some financial loss to the MNCs and negative impacts to the passengers and residents along the LRT route. The multi-actors try to strike a balance, by avoiding negative outcomes that may affect the livelihood of many city residents along the LRT route, provide safety measures for the highly populated passengers.

The third article is focused on the LRT infrastructural innovation and contextual approach based on contextual factors, by the multi-actors from Nigeria (Abuja and Lagos), Ethiopia (Addis-Ababa) and two China rail MNCs. Therefore, this article is purposed to answer the research question: What are the factors influencing the contextualization of infrastructural innovations in an urban light-rail transport, from China context to Abuja, Lagos and Addis-Ababa cities context. This article provides an academic relevance of identifying new contextual factors in rail transport sciences and relating the already known factors in literature to present events during implementation. It also provides benefits of knowing how multi-actors can implement a light-rail transport, despite challenges faced due to city level contextual factor, through poly-contextualization and re-modification. In addition, this research provides a societal relevance benefit through the provision of well-informed contextual factors to policy makers and urban transport authorities, to formulate objective policies for city's socio-economic development, sustainable LRT and satisfaction to the LRT users. The contextual method to innovation adoption is a contingency type of concept. In the sense that, contextual approach is related to contingency theory because contingency theory advocates that no ideal approach exists for all corporations, and postulates that the utmost required selection of approach variables are modified to specific factors, referred to as contingency (Ortt and van der Duin, 2008). Its conceptual framework describes the contextualized infrastructural innovations based on contextual factors, undergoing a contextual approach process by Chinese MNCs providing the light-rail (RPC) and LRT city authorities in Nigeria and Ethiopia, receiving the light-rail (RRA) as a collaboration to deliver LRT. This article uses a qualitative method of multiple case-study research, using pilot interviews and semi-structured interviews.

Abuja and Lagos cities, emerged with some contextual factors similar to both cities, which provided some lessons learnt, more in the direction of transport sciences as a benefit to the rail transport industry and their stakeholders. These factors ranged from transport sciences related, such as: Seamless integration of transport modes, Transit Oriented Development (TOD), Non-Motorized Transport (NMT) and aesthetically modern LRT for passengers' satisfaction, to other contextual factors such as inadequate energy supply. In addition, some differences were deduced as contextual factors between both cities of Abuja and Lagos. The factors found in Abuja, were more tailored towards the contextual factors found in literature, such as geographic factors, example extending bridges and constructing underpasses and overpasses due to the geographic factors of massive rock deposit and extensive swampy areas. While the contextual factors in Lagos also has some already found in literature, such as cost-effective LRT route, related to economic development and the remaining as contextual factors at-hand during implementation, related to effective operations and maintenance and safety of passengers.

The first similarity between Nigeria and Ethiopia reveals the need for a cost-effective LRT route, while minimizing expenditure in relocating third parties' facilities. The second similarity among the two countries is the need to provide seamless integration of the light-rail with other modes of transport. This was visualized in the two countries, as major LRT stations are not far from public road transport in the two countries including water transport in Nigeria. The third similarity is embedded in the two countries is the need to promote TOD and NMT. In differences between Nigeria and Ethiopia, the contextual factors were ticket shops, energy supply, TOD and NMT, modern aesthetic LRT, master plan and different Chinese Construction companies. However, bearing the differences in mind, two contextual factors at-hand were more eminent and a focus for lessons learnt. These are inadequate energy supply in Nigeria and emergency ticket shops in Ethiopia. The concern for these two contextual factors at-hand, reveals consequential effects, ranging from effects on operation and maintenance from inadequate power supply for an electric motor unit in Nigeria and for effects on fare evasion and low cost recovery in Ethiopia from the use of emergency ticket shops due to non-usability of the already provided electronic ticket machines on-board the LRT vehicles. These two contextual factors are of utmost importance to be considered and incorporated in implementing a sustainable LRT in the long run. These lessons learnt serve as a benefit to the rail transport industry and their stakeholders.

In view of the insights from this research and observations during fieldwork in both countries, it can be concluded that a more effective contextual approach to implementing a sustainable LRT depends more on the LRT receiving city authorities political will, related to political system in literature (Tsui, 2006). This political will refers to the intensity or level of commitment by the city authorities

to the adequate operation of the light-rail. In addition, it depends on the level of technology transferred, i.e., technological environment (Cheng and Huang, 2013), from the Chinese to the two countries on operations and maintenance of the LRT. These are the main key factors that foster the effective contextualization approach to LRT implementation. Furthermore, lessons learnt when LRT has been transferred from China to Africa, is the understanding of different scopes of contexts, particular to different cities, possessing different contextual approaches, based on different challenges at hand (Wisdom; Chor, et al., 2014). If these contextual factors are considered, during the contextual approach process between the LRT receiving transport city authorities, China, and other advanced rail multi-national corporations, there is a better probability of implementing the LRT in a more systematic and effective manner. This systematic approach would manage the challenges and contexts at hand in a cost and time effective manner, also managing human resources with adequate rail technology knowledge transfer for effective operations and maintenance in the long run.

The eminent contextual factors having stronger influence on contextualization of infrastructural innovations in Nigeria are electric energy supply, modernization of LRT and their stations, Transit Oriented Development (TOD) and seamless integration of the light-rail to other transport modes. Out of these four factors in Nigeria, modernization of LRT rolling stock and their stations is the strongest of all factors, as various re-modifications were made on the LRT rolling stock and LRT stations to modernize them with best practices to suit the former and present capital cities. Prominent contextual factors with more effect on contextualization of infrastructural innovations from Ethiopia are “emergency ticket shops”, seamless integration of LRT with other transport modes, and Non-Motorized Transport (NMT) especially to improve safe right of way for pedestrians accessibility to LRT, since a significant route of LRT is located in the middle of roads, sharing roads with other modes of transport. Example is public transport and private busses and cars. Out of these three factors in Ethiopia, “emergency ticket shops” stands as the strongest factor, as it was the most unexpected event, due to non-functional electric ticket machines inside the LRT, whereby there was an urgency to build ticket shops at every LRT stop, at an average of 2 minutes to every stop, causing extra expenditure for building the shops, employing ticket sellers and ticket officials inside the LRT, and leading to significant fare evasion. Common to both Nigeria and Ethiopia, the seamless integration of LRT with other transport modes stands out.

The fourth article focuses on service quality of the light-rail transport, with specific emphasis on pricing and infrastructural innovations, using frugal innovation approach. Thus, the transport corporations from China and Ethiopia are the multi-actors advancing the provision of delivered service quality as a replica of targeted

service innovation, which can be an uphill task of balancing both service qualities on a pivot stand. Thus, focusing on two gap dimensions of service quality loop.

These are delivered-perceived quality and targeted-delivered quality loops. Targeted and delivered service quality are components from the multi-actors, while the perceived service quality is a component from the passengers, thus providing a societal relevance for multi-actors, policy makers and stakeholders to measure and deliver adequate service quality to the highly populated passengers in the city. Maximizing this service quality means delivering a service quality that is equal or at least close to the targeted service quality, expected to be perceived by the passengers as satisfied with the spin-offs of pricing and infrastructural innovations provided.

Furthermore, related studies provide policy makers with clear signs of the essential quality enhancement, further research could arise from this model that studies the relationship between targeted service quality and the desires of passengers (Mahmoud and Hine, 2016). As a follow up to this push for further studies in this specific domain, therefore this article proceeds to answer the research question: To what extent does targeted and delivered service quality, using frugal approach by multi-actors, satisfy the perceived service quality from the passengers? The theoretical framework explains the relationships between passengers and multi-actors, explaining the targeted-delivered and delivered-perceived service quality gaps. In the methodology, a single case mixed method of qualitative and quantitative research approach is used.

Addis-Ababa LRT has overwhelmingly delivered good service quality to the passengers, despite the gaps, such as non-use of automated tickets, overcrowding during peak hours and fare evasion. The gaps revealed are logical because the transport corporations cannot deliver all targeted service quality, within the short term of two years. Most of the passengers are satisfied with above 70% satisfactory rate. Thus, revealing that the use of frugal innovation is a good approach, especially in pricing and infrastructural innovations, due to limited resources from Addis-Ababa city, which has led to a high satisfactory level by the users of the LRT. Understanding and practicing frugal innovation in urban public transport to achieve a significant balance between delivered service quality and its satisfaction to passengers, is an added value to literature, as a scientific significance. This justifies the fact that more can be done with less or limited resources, by providing significant service quality and not poor quality as may be presumed using a frugal approach.

Therefore, to a high-level extent of above 70%, 12 out of 15 light-rail service quality delivered by multi-actors were perceived as satisfied or comfortable. Except for comfortability during peak hours, air-conditioning inside LRT and time to reach platforms. These levels in percentages, supports the multi-actors to know which of

the delivered infrastructures have met the passenger's expectations, despite delivering or not delivering a targeted service quality. Thus, serving as a societal relevance, using the passengers as a yardstick to providing service quality, consequently satisfying the multitudes, especially the low-medium income earners in the society, in the use of cheaper and comfortable LRT. The role of passengers in balancing a targeted service quality is vital because sometimes a service quality is delivered as targeted but does not meet the satisfaction of the passengers, such as the 41 LRT vehicles causing congestion inside the light-rail, from high travel demand and higher peak hours, and air-conditioning system, which almost half the passengers still need more cooling effect.

On the other hand, some pricing or infrastructural innovations in LRT delivered, do not match the targeted; however, most of the passengers are still satisfied with it. Examples are the frequency of light-rail to passengers with average 12.5 minutes headway time has 94.4% satisfaction from passengers despite use of only 41 vehicles in the city; ticket affordability with 87.7% of the 2,4,6-birr zone fare structure pricing system. Therefore, knowing the extent of satisfaction or comfortability of the passengers on different parameters of the LRT aids the knowledge of specific aspects of the LRT that may need a change or improvement.

In conclusion, this research is making a clarion call to cities in transition to LRT, for an extra-ordinary and systematic action to adapt during the LRT implementation. In this regard, cities should have a strong political-will to strengthen the transport institutions; by providing adequately structured technological transfer components and the use of poly-contextualization method; via a decentralized transport authority for different cities that are based on their diverse contexts, which will in turn enforce better adapted methods, processes and policies.

# Samenvatting Promotieonderzoek

In afgelopen decennia heeft China via infrastructuurprojecten samengewerkt en geïnvesteerd in Afrika; zoals stedelijke lightrail systemen, nationale spoorwegen, autowegen en telecommunicatiesatellieten (zoals de Nigeriaanse communicatiesatelliet NIGCOMSAT-1R). Dit onderzoek richt zich op de samenwerking tussen Chinese en Afrikaanse partners bij de stedelijke lightrail infrastructuur in de landen Nigeria en Ethiopië. Een overvloed aan middelen garandeert geen adequate lightrail overdracht en kwaliteit van service van het ene naar het andere land, vooral wanneer deze middelen niet doelmatig gebruikt worden om de enorme hoeveelheid financiële middelen van het land op de lange termijn optimaal te benutten. Deze infrastructuren ondergaan soms een slechte contextoverdracht, dat wil zeggen dat bij de infrastructuuroverdrachten onvoldoende rekening houden wordt met de specifieke sociaal-economische, ecologische en technologische context van de infrastructuur ontvangende steden. Op de lange termijn leidt dit tot onvoldoende of slechte infrastructuurwerking en -onderhoud, wat leidt tot een afname van het infrastructuurgebruik ondanks enorme investeringen. De samenwerking tussen deze drie landen heeft een sobere aanpak in het aanpassen van beprijzing- en infrastructuurinnovaties van een lightrail, terwijl tegelijkertijd de vereiste kwaliteit moet worden behouden te midden van deze soberheid. Deze sobere aanpak wordt toegepast op het gebied van financiën, personeel en tijd, omdat er een aanzienlijke beperking van middelen is vanuit de infrastructuur ontvangende steden Abuja en Lagos in Nigeria en Addis-Ababa in Ethiopië.

In dit verband is het nodig om kritisch en systematisch te onderzoeken hoe resultaten van sobere innovaties in verschillende delen van de wereld in verband staan met ontwikkeling, om het transformationele of ontwikkelingspotentieel effectief te meten (Leliveld en Knorringa, 2018). Een sober perspectief van ontwikkelingsonderzoek is het classificeren onder welke omstandigheden dergelijke innovatieprocessen naar verwachting bijdragen aan meer inclusieve ontwikkelingsresultaten. In die zin is een kritische en multidisciplinaire methode voor sobere processen en een empirische aanpak nodig (Knorringa; Peša, et al., 2016). Dit is een belangrijk aspect van dit wetenschappelijke artikel, omdat ingegaan wordt op de processen van hoe soberheid wordt bereikt door de combinatie van stakeholder dialogen in multi-actor interacties en absorptiecapaciteit. Rekening houdend met het effect van deze combinatie op de lage inkomens, de onderkant van de piramide (Bottom of the Pyramid - BoP), als een inclusief ontwikkelingsresultaat.

Eén op de drie uitgebreide innovatie heuristieken die wordt gebruikt om soberheid in de dienstverlening te bereiken (Prabhu, G. en Gupta, 2014, McNicoll, 2013, Mukerjee, 2012) wordt geïdentificeerd als het innovatief verminderen van

verspilling van tijd, personeel en materialen om de kosten te verlagen en de effectiviteit te verhogen. Er is weinig aandacht besteed aan de studie van soberheid en sobere innovatie als een niet-technologische en bestuurlijke netwerk gerelateerde component, zoals in het algemeen wordt gezien in het technische en hardware-gerelateerde domein. Sobere processen zijn echter springlevend in institutionele infrastructuren van stedelijke netwerken. Tot op heden is de meeste aandacht besteed aan soberheid en sobere innovaties vanuit het oogpunt van management (Radjou; Prabhu, et al., 2012, Zeschky; Widenmayer, et al., 2011, Prahalad, 2005, Prahalad, en Hammond, 2002) en technologie (Altamirano en Van Beers, 2018). We weten echter nog steeds weinig over hoe soberheid wordt gerealiseerd en geleverd, vooral in de praktijk bij internationale samenwerkingen. In dit artikel wordt lightrail transport (LRT) benaderd in de context van soberheid bij multinationals (MNC's).

Het doel van het eerste artikel is om te weten hoe de multi-actor interactieprocessen en absorptieve capaciteitsstructuur onder de multi-actoren soberheid opleveren in LRT, rekening houdend met de effecten van veranderingen door de nieuwe LRT op de lage inkomens zoals de BoP en modale verschuivingen van andere gemotoriseerde voertuigen naar de LRT. Met andere woorden, het implementeren van de LRT ondanks onvoldoende financiële middelen van het land, minder technologische capaciteit en kennis over de LRT en ondanks beperkte tijdsmiddelen. Verder streeft het eerste artikel ernaar om maatschappelijke relevantie te bieden voor besluitvormers en beleidsmakers, met inzicht in hoe hun multi-actor interactieprocessen met de multinationals (MNC's) kunnen worden georganiseerd en hoe hun absorptiecapaciteit kan worden gestructureerd om hun beperkte financiële middelen, tijd en menselijke vaardigheden optimaal te kunnen benutten. Deze belangrijke behoeften zijn ook gericht op het bereiken van de negende doelstelling voor duurzame ontwikkeling (SDG-9), vermeld als "het bouwen van veerkrachtige infrastructuren, het stimuleren van inclusieve en duurzame industrialisatie en het bevorderen van innovatie", aangezien het voorzien van slimme vormen van vervoer werkgelegenheid en rijkdom creëert en economische groei bevordert (UN Sustainable Development Goals, 2015).

Het theoretische kader is gericht op de relaties tussen de interacties van meerdere actoren en de absorptiecapaciteit, wat leidt tot soberheid in LRT en het effect ervan op de betaalbaarheid van het transport door de BoP en modale verschuivingen naar LRT. De onderzoeksstrategie is een gemengde methode, waarbij een single casestudy is gebruikt. Deze gemengde methode bestaat uit een kwalitatieve benadering met behulp van pilot- en semigestructureerde interviews en een kwantitatieve benadering met behulp van de enquêtemethode. De resultaten van het algemene kader tonen duidelijk aan dat soberheid in LRT sterk afhankelijk is van de structuur van de absorptiecapaciteit en het proces van multi-actor interacties, met name zoals ontworpen door het ontvangende LRT land. In dit verband is de

structuur gerelateerd aan gestructureerd absorptiecapaciteit, de geleverde kennisoverdracht, training op middellange en lange termijn, de verdeling van kennisoverdracht in 19 hoofdstromen en gediplomeerd personeel bij exploitatie en onderhoud, waar elk Chinese manager gekoppeld wordt aan Ethiopiërs op de hoofdafdelingen. Terwijl het proces betrekking heeft op de interactie van ERC als de belangrijkste actor met de andere multi-actoren, waarbij hoofdzakelijk de stakeholderdialoog en enkele formele onderhandelingen worden gebruikt voor interactie tussen de autoriteiten van Addis-Ababa en de multinationals.

De stakeholderdialogen is een belangrijke type van multi-actor interactie, volgend door de formele onderhandelingen die een positieve aanvulling bieden op de stakeholderdialogen, vooral wanneer de stakeholderdialogen zijn stilgevallen, worden formele onderhandelingen gebruikt om dergelijke verwachte resultaten tijdens interacties te regelen. De stakeholderdialogen bieden ook een soft-landing voordeel voor de formele onderhandelingen om snellere goedkeuringen te stimuleren en bureaucratie in redelijke mate te voorkomen. Door de sobere aanpak tijdens de interacties waren ze in staat om de LRT binnen de vastgestelde begroting en de geplande tijd van drie jaar te implementeren. Bovendien hebben de multi-actor interacties een tariefstructuur opgeleverd, die de BoP-passagiers meer betaalbaar vervoer biedt dan de meeste andere manieren van vervoer, waardoor deze groep meer gestimuleerd wordt om de LRT te gebruiken als een goedkoper, veiliger en comfortabeler openbaar vervoer vergeleken met de andere beschikbare openbaarvervoermiddelen in Addis-Ababa. Addis-Ababa reorganiseerde hun organisatiestructuur voor interactie met multi-actoren om betaalbare LRT aan te bieden, voor meetbare technologische overdracht en leertraject via gestructureerde absorptiecapaciteit, en het leveren van een stille elektrische lightrail als een koolstofvrije emissie transportsysteem.

Het tweede artikel richt zich op de overdracht van de beprijzing- en infrastructuurinnovaties van een lightrail-transport vanuit China naar de stadscontext van Addis-Ababa. Deze overdracht vindt plaats te midden van enkele aanpassingen om te voldoen aan de context van Addis-Ababa. Het artikel beoogt verder de sociale, economische en milieu-effecten te kennen van deze gecontextualiseerde innovaties op passagiers, verwachte resultaten van multinationals (MNC's), het stadsmilieu en de omgeving van wonen en zakendoen met bewoners langs de LRT-route. Bovendien worden wegen voor aanpassingen geïdentificeerd, met name van aanpassingen die tot negatieve effecten hebben geleid. Deze LRT-overdracht vereist een contextuele benadering, door middel van aanpassingen die passen bij de stadscontext van Addis-Ababa en die de LRT-gebruikers en multinationals op de verwachte manier beïnvloeden, waarbij sterk rekening wordt gehouden met enkele onvoorziene factoren. De contextuele regeling voor innovatiebeheer kan voordelen opleveren als synopsis van alternatieve

selecties in verschillende contexten en innovatie managers ondersteunen bij hun op innovatie gebaseerde besluitvormingsprocessen.

Het theoretische kader toont het contextuele benaderingsproces door multinationals (MNC's) op beprijzings- en infrastructuurinnovaties om service te bieden aan LRT-passagiers en biedt de verwachte resultaten aan de multinationals (MNC's). Dus, het weergeven van de relatie tussen beprijzings- en infrastructuurinnovaties en de effecten van een contextuele benadering van de twee innovaties op de levering van passagiersdiensten, bewoners langs de LRT-corridor en de multinationals (MNC's). Als methodiek gebruikt het tweede artikel een kwalitatieve methode van een single case study onderzoek.

De zaak Addis-Ababa onthulde nieuwe contextuele factoren op stadsniveau, zoals tariefontduiking, niveau van de vraag naar reizen, niet-gebruik van elektronische apparatuur voor prijzen, platformgrootte van de LRT, niet beschikbaar zijn van barrières voor ticketsensoren op platforms, gebruik van liften en roltrappen op specifieke LRT-stations. Deze nieuw ontdekte contextuele factoren vertegenwoordigen nieuwe en specifieke uitdagingen die de acceptatie van innovatie kunnen beïnvloeden (Wisdom; Chor, et al., 2014), die verschillen van die in de literatuur. Aanpassing van beprijzings- en infrastructuurinnovaties om aan de context van een stad te voldoen is niet het doel van een duurzame LRT. Het is echter belangrijk om te begrijpen dat een aanpassingsproces in verschillende fasen van het LRT-project nodig is.

Het is dus belangrijk om scenario's te creëren tijdens de ontwerpfase, om rekening te houden met de contextuele factoren die zich kunnen voordoen tijdens de bouw- en implementatiefasen, en om mogelijkheden te bieden om opnieuw het ontwerp aan te kunnen passen met minder negatieve resultaten en beperkte financiële kosten. Dit zal de probabiliteit van negatieve uitkomsten verder verminderen, wat soms enig financieel verlies veroorzaakt voor de multinationals en negatieve gevolgen voor de passagiers en bewoners langs de LRT-route. De multi-actoren proberen een evenwicht te vinden door negatieve resultaten te vermijden die het levensonderhoud van vele stadsbewoners langs de LRT-route kunnen beïnvloeden, en bieden veiligheidsmaatregelen voor de dichtbevolkte passagiers.

Het derde artikel is gericht op de LRT-infrastructuurinnovatie en contextuele benadering op basis van contextuele factoren, door de multi-actoren uit Nigeria (Abuja en Lagos), Ethiopië (Addis-Ababa) en twee Chinese railinfrastructuur multinationals. Daarom is dit artikel bedoeld om de volgende onderzoeksvraag te beantwoorden: wat zijn de factoren die de contextualisering van infrastructuurinnovaties in een stedelijk lightrail-transport beïnvloeden, van de context van China tot de context van de steden Abuja, Lagos en Addis-Ababa. Dit artikel biedt wetenschappelijke relevantie bij het identificeren van nieuwe contextuele factoren in de studie van spoorwegvervoer en het in verband brengen

van de reeds bekende factoren in de literatuur om gebeurtenissen tijdens de implementatie te presenteren. Het biedt ook de voordelen hoe multi-actoren een lightrail-transport kunnen implementeren, ondanks de uitdagingen vanwege de contextuele factor op stadsniveau, door poly-contextualisering en aanpassingen. Bovendien levert dit onderzoek een maatschappelijke relevantie op door het verstrekken van goed geïnformeerde contextuele factoren aan beleidsmakers en stedelijke vervoersautoriteiten, om objectief beleid te formuleren voor de sociaal-economische ontwikkeling van de stad, duurzame LRT en tevredenheid voor de LRT-gebruikers. De contextuele methode voor innovatie-acceptatie is een contingentie type. In de zin dat contextuele benadering gerelateerd zijn aan de contingentietheorie omdat de contingentietheorie bepleit dat er geen ideale benadering bestaat voor alle bedrijven, en veronderstelt dat de uiterste vereiste selectie van benaderingsvariabelen aangepast wordt aan specifieke factoren, aangeduid als contingentie (Ortt en van der Duin, 2008). Het conceptuele kader beschrijft de gecontextualiseerde infrastructuurinnovaties op basis van contextuele factoren en ondergaat een contextueel benaderingsproces door Chinese multinationals die de light-rail (RPC) leveren en LRT-stadsautoriteiten in Nigeria en Ethiopië, en de light-rail (RRA) ontvangen als een samenwerking om LRT te leveren. Dit artikel maakt gebruik van een kwalitatieve methode van meervoudig case-study-onderzoek, met behulp van pilot-interviews en semi-gestructureerde interviews.

De steden Abuja en Lagos kwamen naar voren met enkele contextuele factoren die vergelijkbaar zijn met beide steden, die wat lessen opleverden, meer in de richting van transportwetenschappen als een voordeel voor de spoorwegvervoersindustrie en hun belanghebbenden. Deze factoren varieerden van transportwetenschappen, zoals naadloze integratie van transportmodi, Transit Oriented Development (TOD), niet-gemotoriseerd transport (NMT) en esthetisch moderne LRT voor de tevredenheid van passagiers, tot andere contextuele factoren zoals onvoldoende energievoorziening. Bovendien werden enkele verschillen afgeleid als contextuele factoren tussen beide steden Abuja en Lagos. De factoren die in Abuja werden gevonden, waren meer toegesneden op de contextuele factoren in de literatuur, zoals geografische factoren. Voorbeelden zijn het uitbreiden van bruggen en het aanleggen van onderdoorgangen en viaducten vanwege de geografische factoren van massieve rots afzetting en uitgestrekte moerassige gebieden. Terwijl de contextuele factoren in Lagos ook al in de literatuur zijn aangetroffen, zoals kosteneffectieve LRT-route, gerelateerd aan economische ontwikkeling en de rest als contextuele factoren tijdens de implementatie, gerelateerd aan effectieve bedrijfsvoering en onderhoud en veiligheid van passagiers.

De eerste gelijkenis tussen Nigeria en Ethiopië toont de noodzaak aan van een kosteneffectieve LRT-route, terwijl de uitgaven voor het verplaatsen van faciliteiten van derden worden geminimaliseerd. De tweede overeenkomst tussen

de twee landen is de noodzaak om de lightrail naadloos te integreren met andere vervoersmiddelen. Dit werd zichtbaar in de twee landen, aangezien de grote LRT-stations niet ver verwijderd zijn van het openbare vervoer in de twee landen, inclusief watertransport in Nigeria. De derde overeenkomst is ingebed in de twee landen: de noodzaak om TOD en NMT te promoten. De verschillen in contextuele factoren tussen Nigeria en Ethiopië waren de ticketverkoop, energievoorziening, TOD en NMT, moderne esthetische LRT, masterplan en verschillende Chinese bouwbedrijven. Gelet op de verschillen waren twee contextuele factoren belangrijk als leermomenten. Dit zijn onvoldoende energievoorziening in Nigeria en nood ticketverkoop in Ethiopië. Deze twee contextuele factoren creëren opeenvolgende effecten, variërend van effecten op de beheer en onderhoud door onvoldoende stroomvoorziening voor een elektromotor unit in Nigeria en op tariefontduiking en goedkoop herstel in Ethiopië door het gebruik van nood ticketverkoop vanwege het niet kunnen gebruiken van de reeds verstrekte elektronische kaartautomaten aan boord van de LRT-voertuigen. Deze twee contextuele factoren zijn erg belangrijk om te worden overwogen en te worden opgenomen bij de implementatie van een duurzame LRT op de lange termijn. Deze opgedane ervaringen vormen een voordeel voor de spoorwegsector en hun belanghebbenden.

Gezien de inzichten uit dit onderzoek en observaties tijdens veldwerk in beide landen, kan worden geconcludeerd dat een effectievere contextuele benadering voor de implementatie van een duurzame LRT meer afhangt van de politieke bereidheid van de stadsautoriteiten in de LRT ontvangende steden, gerelateerd aan het politieke systeem in de literatuur (Tsui, 2006). Deze politieke bereidheid verwijst naar de intensiteit of mate van betrokkenheid van de stadsautoriteiten voor de adequate werking van de lightrail. Bovendien hangt het af van het niveau van de overgedragen technologie, d.w.z. de technologische omgeving (Cheng en Huang, 2013), van de Chinezen naar de twee landen met betrekking tot de werking en het onderhoud van de LRT. Dit zijn de belangrijkste sleutelfactoren die de effectieve contextuele benadering van LRT-implementatie bevorderen. Bovendien is de ervaring die is opgedaan met de overdracht van de LRT van China naar Afrika, het begrijpen van verschillende reeksen contexten, met name van verschillende steden, die verschillende contextuele benaderingen hebben, gebaseerd op verschillende uitdagingen (Wisdom; Chor, et al., 2014). Als er rekening gehouden gaat worden met deze contextuele factoren, zal tijdens het contextuele benaderingsproces tussen de stadsautoriteiten die de LRT ontvangen, China en andere geavanceerde grote spoorwegmaatschappijen, een grotere kans zijn om de LRT op een meer systematische en effectieve manier te implementeren. Deze systematische aanpak zou de specifieke uitdagingen en contexten die voorhanden zijn op een kosten- en tijdbesparende manier beheren, en ook personeel managen met adequate kennisoverdracht op het gebied van spoorwegtechnologie voor effectieve beheer en onderhoud op de lange termijn.

De uitzonderlijke contextuele factoren die een sterkere invloed hebben op de contextualisering van infrastructuurinnovaties in Nigeria zijn elektrische energievoorziening, modernisering van de LRT en hun stations, Transit Oriented Development (TOD) en naadloze integratie van de lightrail in andere transportmodi. Van deze vier factoren in Nigeria is de modernisering van het LRT-rollend materieel en hun stations de sterkste van alle factoren, aangezien verschillende aanpassingen zijn aangebracht aan het LRT-rollend materieel en de LRT-stations om ze te moderniseren met best practices die passen bij de vorige en de huidige hoofdsteden. Prominente contextuele factoren met meer effect op de contextualisering van infrastructuurinnovaties uit Ethiopië zijn "nood ticketverkoop", naadloze integratie van LRT met andere transportmodi en niet-gemotoriseerd transport (NMT), met name om het veilige gebruik voor voetgangers toegankelijker te maken voor de LRT, omdat een belangrijke LRT-route zich midden op de weg bevindt en wegen deelt met andere vervoersmiddelen. Voorbeelden zijn het openbaar vervoer en privébussen en auto's. Van deze drie factoren in Ethiopië, is "nood ticketverkoop" de sterkste factor, omdat het de meest onverwachte gebeurtenis was, vanwege het niet functioneren van elektrische kaartautomaten in de LRT, waarbij er een urgentie was om ticketverkoop balies te bouwen bij elke LRT-stop, gemiddeld 2 minuten voor elke stop, wat extra uitgaven veroorzaakt voor de bouw van de uitgiftepunten, het aannemen van ticketverkopers en ticketambtenaren in de LRT, en wat leidde tot aanzienlijke tariefontduiking. Gemeenschappelijk voor zowel Nigeria als Ethiopië, valt de naadloze integratie van LRT met andere vervoersmiddelen op.

Het vierde artikel richt zich op de kwaliteit van de dienstverlening van het lightrail-vervoer, met specifieke nadruk op beprijzings- en infrastructuurinnovaties, waarbij gebruik wordt gemaakt van sobere innovatie. De transportbedrijven uit China en Ethiopië zijn de multi-actoren die de levering van geleverde servicekwaliteit bevorderen als een replica van gerichte service-innovatie, wat een zware taak kan zijn om beide servicekwaliteiten op een pivot stand te brengen.

Dit zijn geleverde-waargenomen kwaliteit en doelgerichte-geleverde kwaliteitslussen. Gerichte en geleverde servicekwaliteit zijn componenten van de multi-actoren, terwijl de waargenomen servicekwaliteit een component is van de passagiers, waardoor een maatschappelijke relevantie wordt geboden voor multi-actoren, beleidsmakers en belanghebbenden om adequate servicekwaliteit te meten en te leveren aan de dichtbevolkte passagiers in de stad. Het maximaliseren van deze servicekwaliteit betekent het leveren van een servicekwaliteit die gelijk is aan of op zijn minst in de buurt van de beoogde servicekwaliteit, die naar verwachting door de passagiers zal worden ervaren als tevreden met de spin-offs van de aangeboden beprijzings- en infrastructuurinnovaties.

Bovendien bieden gerelateerde studies beleidsmakers duidelijke signalen van de essentiële kwaliteitsverbetering, verder onderzoek zou kunnen voortvloeien uit dit model dat de relatie bestudeert tussen de beoogde servicekwaliteit en de wensen van passagiers (Mahmoud en Hine, 2016). Als vervolg op deze drang voor verder onderzoek in dit specifieke domein, gaat dit artikel daarom verder met het beantwoorden van de onderzoeksvraag: in hoeverre voldoet gerichte en geleverde servicekwaliteit, met een sobere aanpak door multi-actoren, aan de waargenomen servicekwaliteit van de passagiers? Het theoretische kader verklaart de relaties tussen passagiers en multi-actoren en verklaart de hiaten in de doelgericht-geleverde en geleverde-waargenomen kwaliteit van de dienstverlening. In de methodologie wordt een enkele casus gemengde methode van kwalitatieve en kwantitatieve onderzoeksbenadering gebruikt.

De LRT in Addis-Ababa heeft een enorme goede kwaliteit van service geleverd aan de passagiers ondanks de hiaten, zoals het niet gebruiken van geautomatiseerde tickets, enorme drukte tijdens de spitsuren en zwartrijden. De genoemde hiaten zijn een logisch gevolg omdat de transportbedrijven niet alle beoogde servicekwaliteit binnen de korte termijn van twee jaar konden leveren. De meeste passagiers gaven aan met meer dan 70% tevreden te zijn. Aldus kan gezegd worden dat het gebruik van sobere innovatie een goede aanpak is, vooral in beprijzings- en infrastructuurinnovaties, vanwege de beperkte middelen van de stad Addis-Ababa wat heeft geleid tot een hoog bevredigend niveau door de gebruikers van de LRT. Het begrijpen en in de praktijk brengen van sobere innovatie in stedelijk openbaar vervoer om een belangrijk evenwicht te bereiken tussen de geleverde servicekwaliteit en de tevredenheid van passagiers, is een wetenschappelijke meerwaarde voor de literatuur. Dit rechtvaardigt het feit dat meer kan worden gedaan met minder of beperkte middelen door het leveren van een significante servicekwaliteit en niet van slechte kwaliteit, zoals kan worden aangenomen bij gebruik van een sobere aanpak.

Daarom werden 12 van de 15 lightrail servicekwaliteiten geleverd door multi-actoren voor een niveau van meer dan 70% als tevreden of comfortabel ervaren. Behalve voor comfort tijdens spitsuren, airconditioning in de LRT en de tijd om de platforms te bereiken. Deze percentages ondersteunen de multi-actoren om te weten welke van de geleverde infrastructuren aan de verwachtingen van de passagier hebben voldaan, ondanks het al dan niet leveren van een gerichte servicekwaliteit. Aldus dient het als een maatschappelijke relevantie en gebruikt het de passagiers als maatstaf voor het leveren van servicekwaliteit, het tevredenstellen van de menigten, met name de mensen met een laag tot gemiddeld inkomen in de samenleving, bij het gebruik van goedkopere en comfortabele LRT. De rol van passagiers bij het in balans brengen van een gerichte servicekwaliteit is van vitaal belang omdat soms een servicekwaliteit wordt geleverd als gericht, maar niet voldoet aan de tevredenheid van de passagiers, zoals de 41 LRT-voertuigen die een

opstopping veroorzaken in de lightrail, de hoge vraag naar reizen, langere spitsuren en het airconditioning systeem, waarbij bijna de helft van de passagiers meer verkoeling nodig heeft.

Aan de andere kant komen bepaalde beprijzings- of infrastructuurinnovaties in LRT geleverd niet overeen met het gerichte; hoewel de meeste passagiers er echter nog steeds tevreden over zijn. Voorbeelden zijn de frequentie van lightrail voor passagiers met een gemiddelde doorlooptijd van 12,5 minuten waar 94,4% van de passagiers tevredenheid over zijn, ondanks het gebruik van slechts 41 voertuigen in de stad en betaalbaarheid van tickets met 87,7% van het tariefsysteem van de 2,4,6-birr zone tariefstructuur. Het kennen van de mate van tevredenheid of comfort van de passagiers over verschillende parameters van de LRT helpt met de kennis van specifieke aspecten van de LRT die mogelijk gewijzigd of verbeterd moeten worden.

Tot slot geeft dit onderzoek een sterk signaal af aan steden die over willen gaan naar LRT, om tijdens de LRT implementatie een buitengewone en systematische actie op te nemen in het proces. Steden moeten in dit verband een sterke politieke bereidheid hebben om de vervoersbedrijven te versterken door voldoende gestructureerde componenten voor technologische overdracht te verstrekken en het gebruik van een poly-contextualisatie methode. Dit kan plaatsvinden via een gedecentraliseerde vervoersautoriteit voor verschillende steden die gebaseerd is op de desbetreffende diverse stedelijke contexten, waardoor betere aangepaste methoden, processen en beleid toegepast kunnen worden.

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# Chapter 1: Introduction: Innovation Adaptation in Urban Light-rail Transport

## 1.1 Introduction

Academic scholars within the technological-capability school of thought, argue that developing economies should not linger-on in a stagnant manner as receivers of technologies transferred from the global north (Fu; Pietrobelli, et al., 2011, Bhaduri, 2016). These economies must embark on appropriate innovation measures towards the adaptation and integration of the transferred technologies (Bhaduri, 2016). This also applies to international bench-marking procedures, where focus is given to cross-national lessons learnt, which have over the years increased to a large extent (De Jong and Geerlings, 2005).

De Jong and Geerlings (2005) argue that it is frequently assumed that transplantation of policy replica on infrastructures among countries with comparable, cultural, institutional, and legal characteristics is straightforward. Even if this is correct, identifying subtle institutional dissimilarities and realistic transport infrastructural policy challenges, regarding the receiving country are very important for the accomplishment of infrastructure transplantation.

At the organizational level, innovation is mostly defined as the development, which refers to the creation or use, or adoption of novel concepts or behaviours. The idea or actions may relate to a system, service, product, practice or technology. This research focuses on the service part of the Light-Rail Transport system. The developing of innovations are procedures that result in outcomes that are new to an organizational populace. The adaptation of innovations are developments that result in the integration of a process(es), practice(s), or product(s), that are new to the adapting organization (Fariborz and Marguerite, 2010).

Comprehending how to accomplish innovation effectively is extremely essential in a period when innovation is practically a compulsory survival approach, as Drucker (1999) pointed out: “innovate or die.” Which is also what Olleros (1986) and Tellis and Golder (1996) refer to, according to them when innovating, the level of risk should be reduced using innovative and contextual approach, or else it could be very risky, as it could lead to the end of a corporation.

Several decades of innovation management have occurred at different times and in completely diverse contexts, demanding for different types of innovation processes (Niosi, 1999). In fact, innovation managers often focus on how to manage their innovation processes based on their specific contexts (Ortt and van der Duin, 2008). An example is the Philips Company, a consumer and technology oriented company, which uses seven different innovation methods, each of which is applied to a precise context (Van den Elst; Tol, et al., 2006).

*Inadequate adaptations of technological and non-technological innovations in a sustainable manner are perceived as a global problem*. An example of this, in the context of technological innovation, was when the French railway operator (SNCF)

procured 2,000 new trains, which were too large for most of the stations, which in turn led to re-modifications of 1,300 platforms, costing an extra 50 million Euros (Willsher, 2014). This was partly due to an inadequate context analysis among the multi-actors on how to implement the contextualization aspect of the purchased France railways to suit the already existing platforms, which consequently wasted a huge amount of money and time despite the availability of enough human and technological resources. The new trains did not fit the context of the already existing platforms.

This sometimes happens with non-technological innovations, that are inappropriate for the city context, such as technology transfer gaps, institutional gaps, LRT support infrastructure gaps, pricing affordability gaps, passenger travel culture, congestion or population demographics and other socio-economic factors.

Light-rail is observed to be an effective instrument to bring about a synergy between high quality public transport, real estate development and urban vitality (Priemus and Konings, 2001). In recent times, there is a belief that in several key cities, if additional roads are constructed to relieve traffic congestion, it will attain nothing more than reassuring more vehicles to use them, resulting in more congestion, which is one of the main causes of bad air quality and inefficient use of energy.

In solving these challenges, some main cities are either planning or constructing mass transit railways as a backbone, complemented by light-rails and other transit modes to improve mobility and transport system connectivity. Congestion in main cities has reduced traffic flow speeds to just about a standstill (Priemus and Konings, 2001), in which unfilled public buses occupy the road space, leading to more congestion in central business districts. This is a common phenomenon of a poorly linked public transport policy. One of the useful actions which has been adapted as a solution, is the use of rail transit systems as a pillar of a public transport network. Compared with road-based public transport systems, heavy rail transit systems provide off-street, high capacity, less polluting and relatively accident-free services.

Within the last decade, the LRT has been adapted from a Chinese context with the use of Multi-National Corporations (MNC's), and the transport authorities in Addis-Ababa city context of Ethiopia, Abuja and Lagos city's context of Nigeria. Adapting this LRT from a country which is characterized by different socio-economic, environmental and technical factors (Cheng and Huang, 2013), requires innovations to enable the LRT to fit into these cities, in particular in the context of sub-Saharan Africa. These required innovations are frugal, pricing and infrastructural innovations. According to Hyard (2014) Pricing and infrastructural innovations are non-technological innovations, which need to be delivered with a frugal approach to satisfy the passengers expectations and city transport authorities targets.

*A Frugal approach* introduces something new or distinct, for the purpose of managing resources and doing more with the managed resources (Pisoni; Michelin, et al., 2017). Frugal innovation is further defined as an approach that further pursues to curtail the use of material and monetary resources in the entire value chain with the aim of reducing the cost of ownership while satisfying or even exceeding specific pre-defined criteria of adequate quality standards (Tiwari and Herstatt, 2012). A frugal innovation approach is important, especially in economies struggling with financial and technical human resource, because it innovatively manages human and material resources, decreases the wasting of time, reduces costs and increases the effectiveness of the processes (Prabhu, G. and Gupta, 2014, McNicoll, 2013, Mukerjee, 2012). In addition, because abundant resources do not necessarily guarantee a high service quality when these resources are not adequately managed to optimize the huge amount of country finance that has been spent for the long term. In this regard, limited resources requires a more frugal innovative approach, to make the amount of money spent from the limited resources productive, targeting the delivery of public transport to be inclusive of the bottom of the pyramid users (low income citizens) as well as the middle and higher income users, providing affordable and high quality public transport services.

Frugality in Light-Rail Transport is achieved through the structuring of interaction processes by multi-actors at every stage with an absorptive capacity, within components of knowledge and technology transference. Thus, when acquiring the LRT technology transfer, the structure of its absorptive capacity, using tacit knowledge by the LRTs receiving actors is vital, to maximize the provided explicit knowledge from the MNC providing the LRT (Ernst and Kim, 2002). 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. This means the structure of the absorptive capacity ensures the realization of frugality within the LRT by the multi-actors, who are very keen as to how best to minimize operational costs of the LRT in the long run, using local personnel as the human resource, within a limited budget or loan and limited time.

*Pricing innovation* is a pricing system innovation, structured by a transport related organization to deliver transport services to passengers, which can be categorized into ticket, pricing, parking pricing, fare structure, and taxes (Hyard, 2014).

*Infrastructure innovation* is defined as supporting infrastructures provided as components required to aid passenger service use of a public transport, such as park and ride, pedestrian accessibility infrastructure, public transport measures (priority, increased frequency) and information provision to passengers (Hyard, 2014), thereby increasing the level of usage of the LRT public transport.

The first aim of this study is to unravel in what ways the multi-actor interactions and absorptive capacity processes deliver frugality in Light-Rail Transport. The

second aim is to examine the categories and processes of how light-rail infrastructure is transferred from one city context to another, amidst multi-actor complexities and limited resources. The third aim is to assess the effects of these city context light-rail infrastructure adaptation on the passengers, MNCs and transport city authorities. The fourth aim is to assess the targeted and delivered service qualities by the multi-actors, as compared to the perceived service qualities by the LRT passengers.

## 1.2 Innovation Adaptation as a Scientific Importance

There is a much smaller amount of published studies regarding non-technological innovations compared with technological innovations, as more attention is given to technological innovations, particularly in sustainable transport (Turton, 2006, Hillman and Sanden, 2008, Steenhof and McInnis, 2008). Although a remarkable amount of empirical research has been done, a lot remains to be known about the conditions for and consequences of innovation (Kimberly and Evanisko, 1981). It is therefore also important to delve into this field and discover how non-technological innovations are contextualized, to suit a city's context, especially regarding cities in-transition to LRT. Very little literature has been published regarding case studies about observing differences across continents.

The *significance* of this study is further visualized as a multiple case study research, which has been made up of empirical examples to comprehend how innovation adaptation currently is and what changes could be made to enhance it in practice. Furthermore, it has a *scientific relevance* of fostering non-technological innovations, which are key components to make a technological innovation, such as how to make the rolling stock of a LRT function appropriately with better service delivery, operation strategies and market value, which consequently promotes the use of public transport.

Adapting the LRT using pricing and infrastructural innovations with a frugal approach needs to consider every city's particular contexts; leading to poly-contextualization to incorporate various scopes of a city context within the implementation process (Von Glinow; Shapiro, et al., 2004).

An adequate knowledge on the latest innovations needs to be broadly understood to improve innovation. New solutions and innovations need scientific capability and knowledge, so that they are able to deal with complex developmental issues in service delivery (Fariborz and Marguerite, 2010). In other comparable fields, managers and administrators in innovation adaptation also use multifaceted and varied methods to deal with challenges and offer suitable solutions in decision making (Fariborz and Marguerite, 2010).

As the newness of innovation generates a sense of uncertainty for the facilitators and users, managers' with a scientific understanding of innovation adaptation have

a greater capability to achieve introducing the new innovation using innovative methods to reduce the uncertainty, as they are more capable of facilitating the adoption of innovation (Rogers, 1995). Scientific knowledge on innovation adaptation also encourages and determines the rate of adaptation to new concepts, which play a significant role in detecting the need for creating a favourable environment and innovation, and for its implementation (Damanpour and Schneider, 2006).

An intentional adopter (manager) who is competent and motivated with specific skills, goals, values, and other similar knowledge to use specific innovations, is in turn more likely to adopt the new innovation(s) (Greenhalgh; Robert, et al., 2004). If the innovation satisfies a recognized requirement by the proposed adopter of the invention, then the adopter will be more likely to adopt it.

Our dynamic world is categorized by significant technological, economic and social changes, which are all encompassing and innovation enables the progression of adaptation to several variations (Talukder, 2014). Keeping a fast pace with dynamic innovation adoption requires consistent research into innovation adoption methodology. This is important as it plays a role in enhancing and sustaining high performance of organizations, fostering the economy, building competitiveness, improving standards and efficiency, and generating better quality (Talukder, 2014).

It is important to contribute to the knowledge and the broader theoretical understanding of the dynamics and new trends of innovation adoption, both in the developed and developing countries. Refining innovation adoption can be seen as a system of multifaceted quality development intervention (Wisdom; Chor, et al., 2014). The capability and capacity of applying adaptive procedures from adopted innovations in a way to guarantee its sustainability and delivery of service to the light-rail users is very vital to the research and development sector in the current dynamic world. It is assumed that the managers' knowledge about innovation adaptation in service delivery of the LRT will positively influence better innovations that are required to be adopted.

## 1.3 Innovation Adaptation for Service as a Societal Relevance

*Societal relevance* is associated with better affordability for the public through better pricing innovation, market competition, more passenger use options and a rise in the usage of public transport to reduce the level of privately owned cars, thereby reducing greenhouse gas emissions, which can transcend into transport policy for climate change by decision-makers in the transport sector.

The society requires a framework that can protect and promote its interests with bearable trade-offs. Thus, by bearing this in mind, better processes of ensuring the onset of sustainability goals throughout the design stage to the implementation stage is very important in ensuring that the societal values are not reduced or changed as

a trade-off to other values, such as economic gains at the detriment of the societal values.

This research also wishes to provide the decision-makers with adoptable processes, strategies and policy instruments which can provide quality services in the urban transport system. Furthermore, it intends to provide researchers and practitioners alike with an in-depth understanding about how service innovations can be categorized; how the multi-actors interact amongst themselves to optimize resources and motives; how, by using different policy instruments they will be capable of protecting and nurturing the adopted innovations; understand sustainability trade-offs and how to avoid trading off vital sustainability issues - especially the values necessary to provide a quality service for the commuters as a public good; and finally the science and art of contextualizing modified innovations to make the most of its particular socio-economic context of specific countries.

In addition, as a deliverable, this research will provide systematic strategies that are able to better implement during the stakeholder interaction processes, before the innovations are finally adopted. Thus, understanding each other's trade-offs and using real practical scenarios within the already implemented sectorial interactions among the multiple actors, such as the government ministries in the transport domain, foreign partners, the private sector, research institutions and the public. The complexity of making choices on how a sustainable innovation can provide a better quality of service will also be simplified with a reliable methodology that is practicable for the stakeholders. This will further enhance the choice of policy instruments to be made, with less negative effects coupled with more expected positive effects with bearable trade-offs.

Furthermore, it provides researchers and practitioners alike with an in-depth understanding on how the multi-actors interact amongst themselves to optimize resources and motives; it explains the use of different strategies that are capable of protecting and nurturing the adopted innovations; it helps understand sustainability trade-offs and how to avoid trading off vital sustainability issues as a public good; it shows viable practices of contextualizing adapted innovations to maximize their use in the distinct socio-economic and technological circumstance in specific settings of the cities in the research.

## 1.4 Main Theoretical Focus of Dissertation from Theoretical Contributions

The main theoretical focus deals with the adaptation of innovation as a non-technological innovation amidst frugality. This buttress the cornerstone of this research, providing specific insights to the conceptual interlinks and basis of relationships. After the general introduction and theoretical contributions of chapter one, the remaining parts of chapters two, three, four and five focus on specific

theoretical concepts, which approaches the subject differently from general theoretical contributions.

Chapter two departs from the theoretical contributions of frugality and frugal innovation, innovation adaptation (knowledge required to use innovation), complex multi-actor interaction processes, and sustainable urban light-rail transport. Thus, chapter two specifically focuses on the theories of polycentric knowledge creation and frugal innovation that Leliveld and Knorringa (2018) mentioned in the theory of frugality in decision-making theory, which Gigerenzer (2008) and Gigerenzer and Todd (1999) also referred to in absorptive capacity and how it was achieved in the absorptive capacity and multi-actor interaction processes. In addition are the theories of Bottom of Pyramid (BoP) and transport modal shift.

Chapter three proceeds from the theoretical contributions of categories from non-technological innovations for sustainable transport, innovation adaptation, and sustainable urban light-rail transport which includes: compatibility, complexity, reinvention, triability, and risk. Chapter three specifically focuses on pricing and infrastructural innovations out of the three non-technological innovations, contextualization theory from the contextual processes based on Wisdom; Chor, et al. (2014), Cheng and Huang (2013) and Tsui (2006) by multi-actors that van Buuren and Edelenbos (2002) also refer to and the contingency theory mentioned by Ortt and van der Duin (2008) which is related to contextual processes.

Chapter four advances from the theoretical contributions of categories of non-technological innovations for sustainable transport, and sustainable urban light-rail transport that Yigitcanlar and Dur (2010) mention, innovation adaptation, which includes compatibility, triability, relative advantage, reinvention, risk and complexity. Chapter four concentrates on infrastructural innovations out of the three non-technological innovations, contextualization theory from the contextual processes by multi-actors and innovation adaptation of infrastructure.

Chapter five sets out from the theoretical contributions of frugality and frugal innovation, innovation adaptation which includes: compatibility, triability, and complexity sustainable urban Light-Rail Transport, innovative directions in implementing sustainable transport, and categories of non-technological innovations for sustainable transport. Then, it further concentrates on targeted and delivered service quality from the multi-actors and perceived service quality from the passengers, level of satisfaction on transport mode, and frugality in light-rail transport.

## 1.5 Theoretical Contributions

The dynamic and multifaceted setting of service delivery for a sustainable urban Light-Rail Transport in diverse and uncertain technological and socio-economic circumstances of cities needs a systematic and empirical approach (Turton, 2006,

Hillman and Sanden, 2008, Steenhof and McInnis, 2008). Lessons from the relationship amongst innovation adoption and innovation characteristics at the level of organization are still few (Fariborz and Marguerite, 2010). Fariborz and Marguerite (2010) emphasized its complexity as its construct is considered from various viewpoints at diverse stages of study by various researchers from various academic disciplines.

The service aspect of public rail transportation needs to be well developed and in the trend of continuous innovation and its adoption to sustain the dynamic framework of service provision for a sustainable light-rail transport system. The neglect or redundancy of better service provision through recent effective innovation adoptions is to a reasonable extent the cause of failure in public transport services worldwide. The culture regarding constant interest and implementation of better innovation adoption in the service provision of public transport contributes to what makes public transport successful.

There is a rising concept of grassroots innovation, which has been activated by users or communities, virtually or physically, in search of solutions to a societal or personal problem. This has countless possibilities as new sources of sustainable transport innovations, but has received little attention until present and relatively limited research has been directed towards innovations in services (Aa and Elfring, 2002). The focus is that innovations appear to be much less technologically oriented and a significant number are social or organizational in nature. Such innovations are typically unsystematic efforts of individuals within organizations. Thus, the innovation procedure is more informal in-service delivery than in the manufacturing processes. Innovations in service organizations also tends to be more driven, amid other factors, by the consumers and the market.

As the process of innovation is complex, it requires a specific definition, as what is innovation in one aspect may not be innovation in another. However, the definition that is required for this research takes into consideration the dimensions of this research and is within a framework capable of measuring innovation objectively.

Despite the similarity of individual-level adoption, it is suggested that people within organizations may struggle in identifying, assessing, or choosing suitable innovations to solve specific challenges at a public level. Their decision to adopt new innovations is usually complex due to factors such as culture, values, and hierarchy that are not necessary experienced in individual problem solving (Aarons; Hurlburt, et al., 2011).

The process of adapting innovations to Light-Rail Transport entails that multi-actors need to collaborate in a complex setting because they are all from different technological and socio-economic contexts. They need to combine forces in order to harmonize their ideas and strategies to achieve the execution of the light-rail, that

is acceptable to all parties, within a restricted period and with the use of the available financial and human resources. Understanding the main theoretical concepts of the innovation is critical for adequate adoption of ideas, serving as managerial benefits to experts, stakeholders and policy makers for the public good.

This research intends to relay its findings to the service delivery part of the light-rail transport system. Organizations generate innovation for a particular use or for use in other organizations. The creation of an innovation is a process that provides an outcome that is new to an organizational populace. The adoption of an innovation is a procedure that results in the integration of a process, practice or product that is new to the adopting organization.

Concept development is important for sustainable innovation, it is also essential for the advancement of supportive frameworks, methodologies, and tools that integrate stakeholder contributions into the collaborative innovation development. Sociological and policy frameworks, and corporate social responsibility are also considered to be vital aspects. Apart from the typical diffusion of innovation and knowledge-based collaborative efforts, institutional, stakeholder and ecological modernization theories also describe collaborative contributions to sustainability in innovation. Institutional innovation in sustainability comprises of learning prevention and adaptive management, which is managed by diverse stakeholders (van de Kerkhof and Wieczorek, 2005; Johnson, Hays et al. 2004, Foxon, Reed et al. 2009).

### 1.5.1 Contribution 1: Innovation

An innovation, by Rogers' (1995) theory is defined as a procedure, system, thing or an idea that is perceived to be new by a person or organization that is adopting it. Although, the innovation does not have to be new to the entity that is adopting and applying it (Lundblad, 2003). The innovation adoption method has two key phases, which are the initiation and implementation phases (Fariborz and Marguerite, 2010).

Fariborz and Marguerite (2010) argue that the two stages have usually been distinguished by the choice to adopt, the initiation and implementation stages reveal respectively, the pre- and post-adoption decision processes within the innovation adoption procedure. It is assumed that organizations innovate with the purpose of improving or at least with the intention of sustaining their state of effectiveness or productivity. Fariborz and Marguerite (2010) also point out that an innovation has not totally been adopted when it is initially introduced but it is considered as an innovation only when it has been truly put into practice and fully used by the adopting organization. The anticipated aims of innovating and advancing services is unable to be accomplished if it is not fully executed.

Addis-Ababa, Lagos and Abuja cities are all new in the process of adapting the innovations of the light-rail from China. These innovation adoptions are into diverse environmental and socio-economic conditions in each of the respective cities, which is a complex process. Adapting innovations from one country into another over the years has been a challenge in the trend of continuous innovation and its adoption. The neglect or redundancy of better service provision through recent effective innovation adoptions is to a large extent responsible for the failure of public transport services globally. The effective innovation adoption process has however acknowledged little attention to date (Ross; Mitchell, et al., 2012).

The capability and capacity of using adaptive approaches from adopted innovation in a way that will assure its delivery of quality service to the light-rail users is vital. This is because it plays a role in: enhancing and sustaining the high performance of organizations; nurturing the economy; creating better quality of service; improving standards and efficiency; and building competitiveness (Talukder, 2014). This study integrates related variables into a framework capable of fostering the adoption of innovation in a sustainable style, into an articulative process such as:

- Non-technological innovations
- Pricing innovations
- Infrastructural innovations
- Frugality in light-rail
- Multi-actor processes
- Quality of services
- Contextual processes
- Bottom of Pyramid (BoP)
- Modal shifts
- Perceived service quality
- Targeted service quality
- Delivered service quality

*Thus, innovation as a theoretical contribution provides the foundational understanding of different categories of innovation (Rogers, 1995). It identifies the innovations that are specifically related to transport services and frugality, which have been further developed and are related to the Light-Rail Transport systems.*

### 1.5.2 Contribution 2: Frugal Innovation and Frugality

Frugal innovation is defined as one of the innovation heuristics that is used in achieving frugality in services (Prabhu and Gupta, 2014, McNicoll, 2013, Mukerjee, 2012). It is identified as innovatively decreasing the wasting of time, human resources and materials to reduce cost and increase effectiveness. Frugal innovation is defined as a service, product or solution that develops in spite of human, financial, technological and other resource constraints, especially for a final

outcome that is less costly than competitive options, if existing and which meets the requirements of those customers who otherwise stay un-served (Simula; Hossain, et al., 2015).

Frugal innovation is likewise a new and flexible way of thinking, which provides insights for the corporations to be conscious of the limitations of resources, and develop in a sustainable and consistent manner (Bencsik; Renáta, et al., 2016).

Frugal innovation is considered an excellent approach to innovation in emerging markets like Africa, India, Brazil and China. It can also be applied in developed markets where there is a necessity for affordable quality (Radjou and Prabhu, 2013).

Frugal innovation is constantly being applied by more western corporations, due to the significance of cost-conscious operations. Affordable cost does not depict low-priced technology as there is often a high demand for the newest knowledge and technologies. This means that the innovation processes need to be not only frugally organized, but also receptive and flexible.

Frugal innovation do not only provide development opportunities for the developing markets, but can be applied to western economies that are struggling with budget reductions and recession (Santander, 2013). Western corporations that have been able to integrate frugal innovations into their organizational culture and structure have had the trend of positively accelerating their markets (Radjou, 2014; Radjou, Prabhu, et al. 2012; Schumpeter, 2012).

The core of frugal innovation is to develop a new, flexible and open manner of thinking, to expose creativity and knowledge, that can construct distinctive and cost-effective solutions. A frugal approach is closely connected to the functioning logic of knowledge management structures, as innovation and knowledge facilitate the provision of unique and at times leading-edge results, in both cases producing the correct organizational values as a prerequisite (Bencsik; Renáta, et al., 2016).

In a dynamic business environment for adaptability and a continuing level of city competitiveness to work, advancement and operation of knowledge management systems must be exceedingly developed. It is a significant factor, as a knowledge-based economy that is inclusive of frugal innovation has an influence on how multi-actors should interact and how knowledge is transferred in a frugal manner (Bencsik; Renáta, et al., 2016).

Corporations in the 21st century should be concerned about the development and re-use of knowledge, bearing in mind the costly acquisition of knowledge from other MNCs. It should also be utilized within a stipulated time period and limited budgeted finances. Otherwise the knowledge will not be adequately acquired and reproduced (less absorptive capacity), which in turn may vanish within a small time frame, leading to more costly re-investments in knowledge transfer and further

unnecessary and costly hiring of consultants to fill the gap in a new round of multi-actor interactions.

Knowledge management via absorptive capacity using frugal innovation by multi-actors are two inseparable factors that may determine the success of a corporation (Bencsik; Renáta, et al., 2016). Hence, to acquire and uphold human resources with unique skills, an endless growth of these skills as a human resource, which are able to sustain their concepts and innovation to current levels are important mandates for the multi-actors to build into the core of their interactions, as knowledge is an asset of a corporation to achieve a competitive advantage. Thus, it is important to identify the intellectual capital (knowledge) of a corporation, its enhancement, creation, evaluation and utilization, protection, application and sharing of knowledge (Davenport and Prusak, 1998)

Furthermore, researchers such as Lim et al. (2013) have stressed the important role of building innovation competences and Bencsik et al. (2016) mention the relevance of management of knowledge transfer. Bhaduri (2016) mentions the need to modify the procedures and organizational structure of innovative actions. This outlook, is also shared by Fransen and Helmsing (2016) and Hyard (2012) regarding the will of discourses on suitable technology, technological capability and absorptive capacities to enhance the influence of global value-chains on the non-technological and technological innovations adapted by cities, using equipped indigenous experts and government departments, and reducing negative trade-offs such as language barriers, technological gaps, and inadequate knowledge transfer for a more sustainable transport system, which is, according to Fu et al. (2011) and Ernst and Kim (2002), achievable with equivalent indigenous LRT innovations, pro-activeness and by optimizing the absorptive capacity by the innovation receiving corporation or city using tacit knowledge to harness the provided explicit knowledge by the providing MNCs.

Scholars, such as Bhaduri (2016) argue that within the technological capability school of thought, developing economies should not linger in a stagnant mode as receivers of technologies provided from the global North. Rather, it is essential that these economies embark on appropriate measures towards the adaptation and integration of the transferred technologies. Even with steady developments in production, manufacturing, and employment, renewed investments will also be required in the least developed nations to develop required infrastructure that will guarantee the expansion of industry's portion of GDP in those nations by 2030 (UN Sustainable Development Goals, 2015).

The frugal innovation concepts derived from this research will add knowledge to the existing theories, which are resilient approaches in the frugal innovation context of transport governance, which are capable of nurturing and developing the public transport sector as a whole, especially in cities in transition, to achieve the

Sustainable Development Goal (SDG) nine of the United Nations SDG, UN (2015). In the authors case study of LRT in Addis-Ababa, the ERC strongly demonstrated an existing knowledge base and expertise, most of the knowledge was tacit knowledge, and the intensity of commitment, self-developed capability and effort (Cohen and Lavinthal, 1990). This was achieved using the four approaches mentioned above, which is referred to as absorptive capacity, fulfilling the pre-requisite for effective and productive knowledge transfer, as local capability formation.

*Hence, frugal innovation and frugality as a theoretical contribution provides the integration of these concepts as innovation heuristics which are used in achieving frugality in service* (Prabhu and Gupta, 2014, McNicoll, 2013, Mukerjee, 2012). *These heuristics further deliver the core of frugality in LRT, identified as innovatively decreasing the waste of time, human resources and materials to reduce costs and increase effectiveness*.

### 1.5.3 Contribution 3: Innovation Adaptation

According to De Jong and Geerlings (2005) dissimilarity in political and administrative procedures or cultural differences can critically hinder the adaptation of infrastructural related innovations. They also pointed out that in general, if the country does not vary significantly from the country, they are adapting the technology from, when importing infrastructural strategies, it normally works out like expected. If there are differences in terms of cultural and structural conditions, or economic and geographic circumstances this will also not significantly have a large impact, the receiving country will constructively find solutions to solve the differences.

Although the barriers should not be underestimated, if a receiving country is very similar to the country where the new infrastructure is from, sometimes it does not work due to hidden institutional disparities. Importing new technology can also fail to provide the outcomes that are expected. For example, it is believed that The Netherlands and Denmark have some key attributes in common, in the domain of transport infrastructure policies, institutional settings and citizens perception and government policies. Such as differences in their infrastructural technologies, innovation and strategy types, geographic and economic models. The Dutch-Denmark comparison and documentation of exchange alternatives provides a springboard to perform comparable assessments with other countries (De Jong and Geerlings, 2005).

When introducing new service innovation, it is anticipated by all parties concerned that there will be a smooth integration of user values while adapting the new innovations. According to Rogers (2003) and Ozaki (2009) there are five sequential stages that have been identified in innovation adaptation, namely:

(1) The use of social networks to increase knowledge of an innovation
(2) The development of a positive attitude towards the new innovation
(3) The choice of rejecting or adopting the new innovation
(4) Implementing the innovation that has been adapted
(5) Approval of the implementation decisions

Preceding an innovation adaptation decision process, there are a variety of ways that potential clients are informed about what will happen, depending on the country. This happens via various communication channels like social networks. As many people as possible need to be correctly informed as well as opinion leaders. The vital issues at this phase are the potential adopters' perceptions of the features of the innovation (Rogers, Everett, 2003).

It is further argued that the perceived characteristics of an innovation are key to the degree of acceptance of the users to the new innovation. The rate of accepting of a new innovation is dependent on five attributes: compatibility with what is already in use, what the relative advantage is to the potential client, whether it is possible to try out the new innovation - trialability, what it looks like, and how complex is it to use, in which the first two attributes according to Ozaki (2009) are the most significant of the five.

*Therefore in understanding innovation adaptation, the related characteristics to innovation needs to be incorporated for a more holistic understanding of how innovations are adapted in different circumstances and conceptual knowledge* (Greenhalgh; Robert, et al., 2004).

There are nine attributes which are as follows:

## Relative Advantage

What the relative advantage is of an innovation is regarded as the extent to which an innovation is perceived (Horbach, 2005). Innovations with clear and definite advantages in either effectiveness or cost-effectiveness are more effortlessly adopted and applied (Greenhalgh; Robert, et al., 2004). They are adopted over preceding ideas, products, programs or existing practices (Wisdom; Chor, et al., 2014). If a prospective user can see no relative advantage of the innovation, they usually will not deliberate on it further; thus, the relative advantage is a pre-requisite for adoption (Rogers, 1995). However, Greenhalgh et al. (2004) further explain that a relative advantage on its own does not necessarily assure that the innovation will be widely adopted. They also emphasized that evidence-based innovations experience an extensive phase of negotiation between prospective adopters, in which their implications are deliberated, challenged and restructured. These deliberations, they also argued, can decrease or increase the innovation's seemingly relative advantage.

### Compatibility

The compatibility of a new innovation with present practices are mostly assessed through pre-adoption (Wisdom; Chor, et al., 2014). Compatibility is also visualized as the extent to which an innovation is dependable compared with past experiences, the needs of the potential adopters, and existing values (Horbach, 2005). These ideas are also supported by the adaptability to fit organizational requirements and compatibility with practice standards which are positively associated with adoption. Thus, innovations need to be well-matched with the intended adopters' perceived needs or ways of working. Values and norms are also contributing factors in order to successfully adopt an innovation (Greenhalgh; Robert, et al., 2004).

### Complexity

The extent to which an innovation is viewed as challenging to comprehend and implement can be termed as complexity (Horbach, 2005). Innovations that are more observed by important actors as easily used are more simply adopted (Greenhalgh; Robert, et al., 2004). Greenhalgh et al. (2004) explained that observed complexity can be reduced by real-world involvement and demonstrations. It is also argued by them, that if the innovation can be scaled down into more manageable components and adopted incrementally, it will be more simply adopted. They also mention that by reducing the number and degree of such response barriers improves the chances of a successful adoption.

### Triability

The degree to which an innovation can be tested contributes to pre-adoption and adoption (Wisdom; Chor, et al., 2014). Wisdom et al. (2014) established that by conducting a partial trial, or by using a continuous ease of use and implementation processes, then the pertinent innovation impacts are positively connected with the pre-adoption stage. Innovations that provide the intended users with an opportunity to test out the innovation on a limited basis are adopted, accepted and adapted more effortlessly (Greenhalgh; Robert, et al., 2004). The extent to which an innovation can be tried on a limited basis is also perceived as triability (Horbach, 2005).

### Observability

Innovations with more visible benefits to potential adopters are more easily accepted. This can be done through initiatives to make the advantages of an innovation more evident, for example via demonstrations, this will increase the probability of their adaptation (Greenhalgh; Robert, et al., 2004). Horbach (2005), explains observability as the extent to which the outcomes of an innovation are noticeable to others, so that it is possible to visualize the difference in the expected impact.

## Reinvention

Greenhalgh et al. (2004) define reinvention as when likely adopters adapt, modify or refine an innovation to fit their needs, it will be adopted without difficulty. They further explained that reinvention is particularly significant to those innovations that rise suddenly as good concepts in practice and diffuse through decentralized, horizontal and informal social networks.

## Fuzzy Boundaries

According to Greenhalgh et al. (2004) complex innovations in service organizations can be theorized as possessing a "hard core," which is the irreducible rudiments of the innovation itself. The "soft periphery," is the organizational structures and systems that are required for the complete application of innovation. The adaptiveness of the soft periphery is an important feature of the innovation. The hard core combined with the soft periphery make fuzzy boundaries.

## Risk

According to Wisdom et al. (2004) risk is perceived uncertainty. Greenhalgh et al. (2004) further define risk as: If the innovation possesses a high level of uncertainty of result that the individual identifies as personally risky, it is less expected to be adopted. The more the equilibrium between the benefits and the risks which is the organizational power-base, the more likely the innovation will be assimilated and thus more likely to be used.

## Knowledge Required to Use Innovation

According to Greenhalgh et al. (2004), knowledge is compulsory for the classification and transfer from one context to another in the use of easy innovation adoption. Sahin (2006) adds that the innovation-decision procedure begins with the knowledge phase, where an individual study about the reality of innovation and pursues information about the innovation. Rogers (2003) adds that during this stage, the individual tries to determine what the innovation is and how and why it functions.

As explained by Rogers (2003), these questions form three sorts of knowledge, namely: how-to-knowledge, principle-knowledge and awareness-knowledge.

*Awareness*-knowledge signifies the knowledge of the innovation's presence, which can encourage the individual to learn more about the innovation and finally adopt it (Sahin, 2006).

*How-to*-knowledge as explained by Sahin (2006) is characterized by information regarding how to use an innovation appropriately. Rogers (2003) observed that this knowledge is an indispensable variable in the innovation-decision procedure. Therefore, to increase the adoption possibility of an innovation, an individual

should have a high enough level of how-to-knowledge about the innovation. This knowledge is more important for relative multifaceted innovations.

*Principle*-knowledge, explained by Sahin (2006), comprises of the operative principles describing how and why an innovation function. He further points out that it is important to note that an innovation can be adopted without this knowledge, but if the innovation is inappropriately used it may cause its discontinuance.

*Thus, innovation adaptation as a theoretical contribution, firstly offers the understanding of innovation adaptation in different socio-economic, political and technological contexts* (De Jong and Geerlings, 2005). *Secondly, it provides five sequential stages in innovation adaptation (Rogers, Everett, 2003). Thirdly, if gives a framework on the related attributes of how innovations are adapted in different circumstances and it provides conceptual knowledge* (Greenhalgh; Robert, et al., 2004).

### 1.5.4 Contribution 4: Innovative Directions in Implementing Sustainable Transport

In recent times, many cities are following sustainable approaches in seclusion or as part of wider sustainability approaches. The amount of actions varies tremendously and are too diverse to document. Sustainability is often combined with other planned policy objectives in numerous ways, with effects on reasons that range from the continuation of business-as-usual to actual alterations in urban systems.

There are four innovative guidelines in the real-world application of sustainable transport policy, namely: *New Mobility, City Logistics, Liveability and Intelligent Systems Management,* (Goldman and Gorham, 2006). These four groups of innovation guidelines arose from studying innovative applications that are already in use. The four methods share a variety of shared elements that are very important to their effective implementation. Each of the four methods have diverse systems in which they are assessed. This is done from the perspective of what the collaboration is between transportation and other social and economic systems, or by adopting a more complete assessment of the transportation system itself.

*New Mobility* deals with how individuals strategize their daily routines. It tries to comprehend the impact and the complete range of economic and psychological features that determine what choices an individual makes regarding his/her choice in the use of transport, which includes mode of transport choices and vehicle ownership choices.

*City Logistics* deals with the movement of goods, which not only confronts the challenge of promoting collaboration among competitors, it tries to promote new business models for more sustainable urban delivery arrangements.

*Intelligent System Management* deals with trying to find a solution in the relationship between infrastructure and the public institutions that operates it. It pursues the restructuring of government policies regarding managing public infrastructure. It sees it as an asset whose worth is maximized when evaluated, enforced, and effectively managed.

*Liveability* deals with how the society interrelates with its transportation systems. It advocates a greater combination of transportation planning combined with societal requirements and it also takes into consideration what transport is necessary for recreational use, social interaction and accessibility for the poor, the elderly and the children.

Therefore, *innovative directions in implementing sustainable transport provides theoretical footings as four innovative pathways in the real-world application of sustainable transport policy* (Goldman and Gorham, 2006). *This further provides the conceptual link from liveability as one of the directions to LRT accessibility for all branches of society including the poor, the elderly, children or bottom of pyramid (PoB) users.*

### 1.5.5 Contribution 5: Sustainable Urban Light Rail Transport

The Transportation Research Board formally defined the Light-Rail Transport as:

> *"A metropolitan electric railway system characterized by its ability to operate single cars or short trains along exclusive rights-of-way at ground level, on aerial structures, in subways, or occasionally, in streets and to board and discharge passengers at track or car floor level"*

As the Light-Rail Transport (LRT) runs directly through a city, when planning a LRT, various elements need to be taken into consideration, to make the LRT compatible with the city itself, like freeways, streets, railroads, rights-of-way, underground or aerial structures, pedestrian malls, drained canals etc. These characteristics differentiate it from other rail modes. Due to its design flexibility, LRT is less expensive to build and operate than other fixed-guide way modes.

According to Priemus and Konings (2001), the Dutch Ministry of Transport, Public Works and Water Management describes light rail as a rail related public transport idea which is connected to trip measurements of between 10-40 Km amid a central city and its direct area of impact, or it is entirely focused on an urban area. The vehicles also need to provide enough pick-up and set-down points, they need to have fast acceleration and short stopping times, they should have an adequate top speed and they need to be flexible so that they are also capable of moving on already built infrastructure like the rails of already existing trains, metros and express tram networks. LRT is further characterized by a one-man operation and the relatively

light weight of the carriages which in turn leads to minimizing operational costs and it should have a simpler rail maintenance system compared to that of a train.

Even though this is a broad definition of LRT, it mainly covers two components, namely: the interoperability of the light rail system and the geographical scale of the light rail network, in terms of using diverse categories of tracks, i.e. combination of tram infrastructure and heavy trains.

If one considers the Dutch topography and scale level for light rail transport systems in The Netherlands, there are journeys of up to 40 Km. The length of the journeys may seem very long in comparison with other countries, but it is in line with the diverse policy goals that have been adopted for the light rail in The Netherlands. Light-Rail Transportation in The Netherlands and other countries does not aim to have an exclusive urban regional transport structure. In urban regions, the development of public transport instead of car use is a key aim. (Priemus and Konings, 2001).

Selective advancement of light-rail at an agglomerate level can attain an improved quality of public service and a higher cost recovery level of the urban regional public transport. In addition, it can be assumed that the LRT will have a significant spatial influence within the urban area.

According to missions abroad done by the Dutch Ministry of Transport, the high quality and success of the Light-Rail Transport in some German and French cities was due the fact that they all had sustainable long-term policy visions that were well organized (Priemus and Konings, 2001).

In order to achieve a financially feasible heavy rail transit development system, the system developers need to make the most of catchment areas for the commuters and need to take into careful consideration the position of the interchange stations. They also need to coordinate various transport modes and the need to use medium or light volume feeders.

The effective utilization of innovative transit systems as a means of feeder to the backbone system is likely in many circumstances to improve the connectivity of the heavy rail systems to aid the residents and make the best use of the railway service. Furthermore, it will aid and improve the failing environmental conditions owing to vehicular emissions. In current surveys, rail transit can deliver substantial energy preservation and emission reduction advantages, which consumes approximately one fifth of energy per passenger per kilometre, which is much less than automobile travel, due to its high efficiency and load aspects. International contrasts show that per capita energy consumption drops with increased transit usage, especially the use of rail public transport (Alade, 2013).

Sustainable development as explained in the Brundtland commission is:

> *"The development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Jeon and Amekudzi, 2005).

Transportation system sustainability can be defined with respect to the effects of the system on the social well-being, environment and economy, which is measured by system efficiency and effectiveness (Jeon and Amekudzi, 2005).

In the transportation sector, some specific resources are of concern when referring to the concept of sustainability. The transportation industry uses various exhaustive resources, such as human resources, ecological habitats, energy, limited availability of time and atmospheric carbon loading capacity, to name a few. However, solutions that lessen the exhaustion of one of these may aggravate depletion of another. In addition, transportation choices are often made depending on greater policy goals such as: socioeconomic and geographic transfers of wealth, economic growth, the nature and intensity of land use and employment creation (Alade, 2013).

During more than a century of development, rail transport has proved itself to be an effective and efficient means of taking large numbers of passengers directly into and around the heart of a city, connecting communities and supporting businesses (Barrella, 2012).

Urban transport in the European Union (EU) accounts for 80% of congestion costs, 15% of all greenhouse gas emissions, 20,000 road fatalities annually and upwards of 100,000 premature deaths each year from air pollution (May; Page, et al., 2008). There is thus ample evidence that European urban transport policies are currently far from sustainable. In many cities urban rail transportation projects, like the light rail, metro and tram systems, have over the years demonstrated that they are an optimal solution in providing sustainable mobility for the increasing urban population. The heavy rail, light rail, metro and tram services also provides other benefits such as better comfort, medium-high carrying capacity, faster, more regular services and a safer alternative to using a car (Alade, 2013).

Heavy rail transport systems are very large projects that requires a very high amount of investment, especially for the construction of infrastructure and maintenance costs. Apart from the economic benefits, the social and environmental improvement benefits are also derived from heavy rail transport system projects (Cascajo, 2004).

Investing in transportation infrastructure does have continuous effects on the transportation systems and their economic, social and environmental sustainability (Barrella, 2012). A recent survey of tram schemes in France similarly notes that the French Internal Transport Law (LOTI) requires cities that implement major urban transport infrastructure schemes using public funds to evaluate the projects using criteria that are able to "*verify the socio-economic efficiency of the investment*."

These evaluations are in essence, "*before and after*" studies of the projects from a socio-economic point of view (Gleave, 2005).

There is presently a widespread acceptance of a sustainable urban development concept, which seeks to find a precise method to evaluate, using quantity comparative sustainability stages of current and future developments, which have become important issues. Indicators are derived from values and in turn create values. Therefore, the strong and unique advantage of an indicator based comparative urban sustainability assessment model is the quantifiable ability of the comparative sustainability levels. At a local perspective, sustainability indicators reflect large-scale environmental and economic aspects and local social issues which are relevant to urban sustainability. There is however a growing concern to be able to balance environmental, economic and social dimensions of sustainability (Yigitcanlar and Dur, 2010).

A much-awaited Light Rail Transport system is expected to provide the city with social, economic and environmental benefits that also need to be assessed or measured using specified indicators that are related to ascertain their level of benefit to sustainable development. The scope and contents of local indicators differ from one large infrastructural investment to another. Nevertheless, the main intention of a sustainability assessment is to include the most prominent local indicators in the assessment model. An assessment model with a comprehensive inclusion of key issues provides findings that will be very beneficial to an inclusive decision making arena to support development of policies and effective measures for a more sustainability urban future (Yigitcanlar and Dur, 2010).

A sustainability model is characterized by the following three main aspects, namely: environmental, economic and social. It is not completely adequate just to gain the knowledge about the importance of indicators to achieve a sustainability transportation system. A framework in the form of instruments is needed to determine if the transportation system is progressing towards sustainability. Therefore, a set of indicators is required to assess the progress in the development of a sustainability urban transportation system, which may also serve for other purposes, such as benchmarking, evaluating effectiveness of policies and measures, a comparison of two cities and monitoring the trends of progress towards sustainability development (Quaium, 2012).

The last two decades have witnessed a considerable change in the delivery of infrastructural services worldwide, especially in developing countries. The World Bank and other donors who have contributed to developing such infrastructure have been disappointed with the sustainability of their investments in state-owned infrastructure services. They found that their investments were not having a long-term impact of the quality and extent of utilities and transport services that were desired according to standards (Kenny, 2007).

*Sustainable urban LRT aims to provide a sound foundation within the conceptualization of the LRT's impacts on the economy, environment, and social well-being. It is required to be evaluated through assessing the systems efficiency and effectiveness* (Jeon and Amekudzi, 2005).

*These are used in article one on BoP as social well-being and frugality which are related to the economy and modal shifts as an effect on the environment through the reduction in carbon emissions*.

### 1.5.6 Contribution 6: Categories of Non-Technological Innovations for Sustainable Transport

Non-technological innovation is defined as:

> "*The introduction of new organisational techniques or the incorporation of new marketing procedures*" (Schmidt and Rammer, 2008)

This includes important variations in product promotion or pricing, product design or packaging, and product placement. Non-technological innovation is an important component of an organizations' innovation actions that together augment and complement technological innovation. Non-technological innovation also refers to accomplishment with respect to product and process innovation in terms of sales with market originalities and cost drops from new procedures (Schmidt and Rammer, 2008).

According to Hyard (2012), non-technological innovations can be characterized for sustainable transport into three main groups, namely: *pricing, infrastructure and regulation*. This research focuses on the *pricing and infrastructure innovation* aspects of light-rail public transport, because it is more evident in the LRT adoption by the Ethiopian Railway Corporation (ERC) in Addis-Ababa city LRT from China; while only the infrastructural innovation is visible at the moment in the Abuja and Lagos LRT, because the two cities are yet to start operations.

The study of non-technological innovations has been minimally written about compared to technological innovations, as over the years, more attention has been given to technological innovations. In the technological forecasting and social change literature, several articles emphasise the role of technological innovation within a transport's broad spectrum (Moore and Pomrehn, 1971, Sahal, 1980, Sviden, 1988), and particularly in sustainable transport (Turton, 2006, Hillman and Sanden, 2008, Steenhof and McInnis, 2008). As a result of this, very few papers emphasize the prospect of using non-technological innovations with an outlook to sustainable transport (Tuominen and Ahlqvst, 2010). In this regard, we can refer to the efforts done by other authors, such as kemp and Rotmas (2004), who emphasize the role of institutional innovations which assist in generating social backing to support the creation of additional ecological modes of transport. The foundation for

non-technological innovation for sustainable transport, shows the transport industry as not only a manufacturing industry but also a service industry (Hyard, 2012).

Transportation of goods and people do not only deal with engineering structures and communication networks, it also deals with specific processes, thus making it a material and immaterial activity. This is argued to be a productive action, not regarding wealth, but of meeting human requirements, this is a 20th century concept and characterizes how transport is regarded as a service (Colson, 1907).

Categories of non-technological Innovation are classified under the following 3 main groups (Hyard, 2012)

1. Pricing
2. Regulation
3. Infrastructure

*Pricing* innovation category can be further subdivided into the following:

- Ticket
- Pricing
- Parking pricing
- Fare structure
- Taxes

*Regulation* innovation category can be further subdivided into the following:

- Activity time
- Tele-working
- Information to users
- Parking management

*Infrastructural* Innovation category can also be subdivided into the following:

- Park and ride
- Pedestrian
- Public transport measures (priority, increased frequency)
- Accessibility (to rail stop without using another mode of transport)

*Therefore, as a theoretical contribution, categories of non-technological innovations for sustainable transport provides the vital categories. This research has focused on two out of the three categories, namely: pricing and infrastructural innovations. This research further has used the obtainable sub-categories of these two types of innovation as a guide to focus its methodology and analysis, as seen in chapters 2, 3 and 4.*

### 1.5.7 Contribution 7: Complex Multi Actor Interaction Processes: A Garbage Can Decision Making Process in Innovation Adaptation

According to Styhre et al. (2010) multi-actor processes are related to garbage can decision making, which refers to the fact that innovation processes are a sequence of actions that easily transform into each another, but in reality the innovations are categorized by uncertainty, risk levels, politics, trade-offs and time pressure, which consequently deviates from the rationalist model.

This represents a variety of non-linear elements such as: which decisions of adoptions should be made in garbage can decision making, and how to operate under genuine uncertainty. Innovation processes are in most circumstances hypothesized as a sequence of events ending with some new product, process or service. These types of linear models are frequently prominent at openings and landmarks, where new choices must be made. These innovation processes are frequently portrayed within innovation management text books as quite smooth events, in real life situations, each new adopted innovation frequently occurs with strong deliberation and many arguments (Styhre; Wikmalm, et al., 2010).

It is argued that customary knowledge invention methods or processes can no longer meet the new demands of a complex network society in order to be used in a transition towards a sustainable society (Van Buuren and Edelenbos, 2002). Thus, adopting sustainable innovation is vital for service provision, where quality matters. The systematic involvement of stakeholders is the process whereby stakeholders systematically collaborate in ensuring that innovations for transport system service are implemented in a sustainable manner which has been agreed upon by all with minimum trade-offs amongst them. The quadruple "helix model of innovation" mentioned by Arnkil et al. (2010) regarding the feedback mechanism, is of great importance, it proposes that innovation requires knowledge creation which occurs via multi-actor networks.

*Therefore, complex multi-actor interaction processes, as a theoretical contribution provides the understanding of interaction processes of multi-actors. Taking into consideration processes such as garbage can decision making, complex network society and the quadruple helix model of innovation through multi-actor networks.*

## 1.6 Articles and related theoretical Contributions and focus

In the table below, the four articles are shown with their related theoretical contributions, focus and main contributions. The article column shows the title and its sub-title. The theoretical contributions column explains the umbrella theories which leads to specific theoretical focus. In this regard, the main contributions as its importance to the theoretical contributions and focus have also been illustrated.

**Table 1: Articles and related theoretical contributions and focus**

| SN | Article | Theoretical Contributions | Theoretical Focus | Main Contributions |
|---|---|---|---|---|
| 1 | Frugality in multi-actor interactions and absorptive capacity of Addis-Ababa Light-Rail Transport | 1. Frugality and Frugal innovation<br>2. Innovation adaptation (Knowledge required to use innovation)<br>3. Complex multi-actor interaction processes<br>4. Sustainable urban light-rail transport<br>5. Innovative directions in implementing sustainable transport | 1. Polycentric knowledge creation and frugal innovation<br>2. The theory of frugality in decision-making theory<br>3. Absorptive capacity and multi-actor interaction processes<br>4. Bottom of Pyramid (BoP) and transport modal shift<br>5. Liveability as a societal need, in accessibility to LRT by the poor.<br>6. Context-specific knowledge interaction | Provides the specific the conceptual categories that are specifically related to frugal innovation and frugality in transport service, which are further developed and related to light-rail transport system, considering its heuristics as innovatively decreasing the wastage of time, human resources and materials to reduce cost amongst multi-actors interactions, and effects on BoP and modal shift. In addition, it provides how a context-specific knowledge interaction can foster frugality in LRT. |
| 2 | Sustainable Approach to Innovation Adoption in Light-rail Transport | 1. Categories of non-technological innovations for sustainable transport<br>2. Sustainable urban light-rail transport<br>3. Innovation adaptation (compatibility, complexity, reinvention, triability, and risk) | 1. Pricing and infrastructural innovations from non-technological innovations<br>2. Contextualization theory from the contextual processes by multi-actors and contingency theory which is related to contextual processes<br>3. Sustainability factors | Firstly, it contributes to the understanding of innovation adaptation in different social, economic and environmental sustainability factors peculiar to Addis-Ababa during the implementation and operation of the LRT. Secondly, it provides a framework on the related attributes of how innovations are adapted in different circumstances and conceptual knowledge. In addition, it contributes to the vital categories of pricing and infrastructural innovations. |

| | | | | |
|---|---|---|---|---|
| 3 | Adapting Urban Light-Rail Transport to the African Context: A Process Conducted by Transport Authorities and Chinese Rail Corporations in Addis-Ababa, Abuja, and Lagos | 1. Categories of non-technological innovations for sustainable transport<br>2. Sustainable urban light-rail transport<br>3. Innovation adaptation (Relative advantage, compatibility, complexity, triability, reinvention, and risk)<br>4. Sustainable urban light-rail transport | 1. Infrastructural innovations from non-technological innovations<br>2. Contextualization theory from the contextual processes by multi-actors and innovation adaptation<br>3. Poly-contextualization | Provides poly-contextualization as a concept describing different types of contextualization based on different socio-economic and technological city contexts. In addition, it offers a new niche to literature on factors responsible for contextualization of pricing and infrastructural innovations. |
| 4 | Delivering Targeted Service Quality to Light-rail Transport Passengers | 1. Frugality and frugal innovation<br>2. Innovation adaptation (compatibility, triability, and complexity)<br>3. Sustainable urban light-rail transport<br>4. Innovative directions in implementing sustainable transport<br>5. Categories of non-technological innovations for sustainable transport | 1. Targeted and delivered service quality from multi-actors<br>2. Perceived service quality from the passengers<br>3. Level of satisfaction on transport mode<br>4. Frugality in light-rail transport | Delivers in-depth correlation of three main terminologies, as targeted, delivered and perceived service delivery. Furthermore, it provides the metrics of measurement for its empirical analysis from the operationalization of these three terminologies. |

## 1.7 Research Questions

The first aim of this research is to unravel how multi-actor interactions and absorptive capacity processes deliver frugality in light-rail transport. The second aim of this research is to examine the categories and processes of how light-rail infrastructure is transferred from one city context to another, amidst multi-actor complexities and limited resources. The third aim is to assess the effects of these city context light-rail infrastructure adaptations on the passengers, MNCs and transport city authorities. The fourth aim of the research is to provide useful directions using contextual factors in the contextualization of an urban Light-Rail Transport system, amongst MNCs providing the LRT and city transport authorities receiving the Light-Rail Transport. Thus, providing pathways to achieving a properly adapted Light-Rail Transport system which can be adapted to any city's technological, environmental and socio-economic context.

This research focuses on the adapted LRT in the 3 cities from China, using the overall research question:

*How can pricing and infrastructural innovations be adapted to Urban Light-Rail Transport using a frugal approach?*

To answer this overall research question, four sub-research questions were formulated including the reasons as to why the questions were chosen. Sub-question three has three sub-questions, this is due to its contextual factors and combination of pricing and infrastructural innovations. These four sub-questions are as follows:

The first sub-question was formulated because the multi-acting stakeholders possess specific governance structures and interaction processes, which are used to combine multi-actor interactions and absorptive capacity to achieve frugality in light-rail transport. The first sub-question also seeks to know what the effects are of the frugally provided light-rail on modal-shift and the low-income passengers (bottom of pyramid).

1. How do multi-actor interactions and absorptive capacity processes deliver frugality in Addis-Ababa Light-Rail Transport and what are the effects of the light-rail transport on modal-shift and the low-income earners (bottom of the pyramid users of the transport)?

The second sub-question tries to assess how the pricing and infrastructural innovations of the Light-Rail Transport have been transferred by the Chinese consortium and how they have been received by Ethiopia's ERC. In addition, the sub-question seeks to understand the types of effects that these two innovation types have on the passengers, MNCs, the city environment and resident's proximity and business activities along the LRT route. Furthermore, the sub question is important

to depict the type of modifications that have occurred and why they have occurred during the contextualization of these innovations in Addis-Ababa?

2a. How does pricing and infrastructural innovations of a Light-Rail Transport from China contextualized to the Addis-Ababa city context?

2b. What are the social, economic and environmental effects of these contextualized innovations on passengers, MNCs expected outcomes, the city environment, and resident's proximity and business activities along the LRT routes in Addis-Ababa?

2c. Why do the effects of the contextualized innovations on the passengers, MNCs, the city and residents lead to re-modifications in Addis-Ababa?

The third sub-question was necessary to categorize each specific factor responsible for the contextualization of infrastructural innovations from the Chinese context to the three research cities. This is important because the three cities have different technological and socio-economic contexts as light-rail receiving cities, which are different from the light-rail provider.

3. What are the factors influencing the contextualization of the infrastructural innovations from the Chinese context to Abuja, Lagos and Addis-Ababa cities context?

The folk of the respective cities are at the centre of every sustainable development, like implementing Light-Rail Transport, which is expected to be sustainable if the passengers, representing the people, are adequately considered during the design of the Light-Rail Transport system. In this regard, it is pertinent to quantify the extent of the targeted and delivered service qualities from the multi-actors, using a frugal approach, and whether they satisfy the perceived service quality from the highly populated passengers. This leads to the fourth sub-research question.

4. To what extent does the targeted and delivered service qualities, using the frugal approach by multi-actors satisfy the perceived service quality from passengers in Addis-Ababa?

**Table 2: Overview of Dissertation**

| SN | Chapter | Research Question | Method | Status |
|---|---|---|---|---|
| 1 | Introduction | - | - | - |
| 2 | Frugality in multi-actor interactions and absorptive capacity of Addis-Ababa Light-Rail Transport | RQ 1 | Mixed method on a single case study | Article published in volume, in the Elsevier Journal of Urban Management on 15th November 2019.<br>https://doi.org/10.1016/j.jum.2019.11.003 |

| | | | | |
|---|---|---|---|---|
| 3 | Sustainable Approach to Innovation Adoption in Light-rail Transport | RQ 2 | Mixed method on a single case study | Article published in volume, in the Journal of Sustainability, section sustainable transportation, on 10th February 2020. https://doi.org/10.3390/su12031262 |
| 4 | Adapting Urban Light-Rail Transport to the African Context: A Process Conducted by Transport Authorities and Chinese Rail Corporations in Addis-Ababa, Abuja, and Lagos | RQ 3 | Multiple and comparative case study | Article published in volume on the 3rd of December 2019 at the Journal of Urban Science. https://doi.org/10.3390/urbansci3040109 |
| 5 | Delivering Targeted Service Quality to Light-rail Transport Passengers | RQ 4 | Mixed method on a single case study | Under review in the International Journal of Sustainable Transportation (Tailor and Francis). Submitted 31st December 2019. |
| 6 | Conclusion | RQ's 1, 2, 3, 4 | Multiple and comparative case study | Parts of conclusion submitted in a book chapter, titled: Lessons Learned for Urban Management and Governance. Second submission on 2nd January 2020, after first review in the last quarter of 2019. |

## 1.8 Overview and Outline of Dissertation

To answer the overall research question, sub-question one is to know how the multi-actors' interactions and absorptive capacity processes deliver frugality in Light-Rail Transport. The focus here is on the interaction processes and structure of implementing the absorptive capacity. This question contributes to the existing literature regarding the non-technological aspects of frugality, embedded in the transport governance of multi-actor interactions and the frugal innovation domain, it also emphasizes the importance of its non-technological aspect, complementing the accustomed technological angle of frugal innovations.

In addition, the theory of frugality in finance, human and time resource management during multi-actor interactions is useful to show how other emerging economies harness their financial resources to implement large infrastructural projects like roads, water ways and national rails etc. The theory of absorptive capacity in the context of multi-actor interaction of a Light-Rail Transport systems is a benefit to studying different structures of knowledge transfer in different cities in transition, to understand how effective they are and what the reasons are behind

each structure. In order to understand how some structures can be harnessed to better suit their socio-economic conditions.

Sub-question two dwells on the contextualization of both pricing and infrastructural innovations, by the two main parties from the Chinese consortium as the MNC and ERC from Addis-Ababa. This further venture to understand the various types of effects that it had on the passengers, MNCs and resident's proximity in daily movement, compared to the past before the LRT along the corridors. In addition, this question seeks to know the specific reasons why the contextualized innovations lead to some form of re-modifications. This sub-question, with regard to the contextual approach in literature is fragmented, which necessitates this research, as a context-based method typically produces the best outcomes (Miller and Blais, 1993, Nessim; Ayers, et al., 1995).

Thus, the useful added value to research, under the domains of urban public transport and transportation science, are the newly established city level contextual factors, such as fare evasion; level of travel demand; non-use of electronic devices for pricing; LRT platform size; Non-availability of ticket sensor barrier on the platforms; and the use of lifts and escalators at specific LRT stations. These new contextual factors arose because the research dealt with the specific context of an urban light-rail public transport in the specific East-African city of Addis-Ababa, regarding the adaptation of LRT from the Chinese consortium by the ERC of Ethiopia. Thus, investigating the scientific relevance of fostering non-technological innovations, that are the key components to make a technological innovation, such as the rolling stock of an electrified LRT to function appropriately with better service delivery, operation strategies and market value, that consequently promotes the use of public transport. The societal relevance is associated with better affordability and accessibility for the public through the better managerial practice of pricing systems, market competition, more passenger use options and an increase in the use of public transport by the public to reduce the level of privately owned cars, thereby reducing greenhouse gas emissions, which can transcend into transport policy for climate change by decision-makers in the transport sector.

Sub-question three considers a multiple case study of three cities, to understand and categorize the factors influencing the contextualization of infrastructural innovations from a Chinese context to the African cities of Abuja, Lagos and Addis-Ababa cities context. This question provides benefits to academic literature by filling in some literature gaps. This is especially in the area of infrastructural innovation adaptation in transport sciences, with specific contextual factors that have emerged overtime and in specific countries that have shaped the implementation processes of Light-Rail Transport, and results also shows the reasons why a context is the way it currently is in the three cities of two countries (Tsui, 2006). Furthermore, results support the concept of poly-contextualization

that was proposed by von Glinow et al.(2004), which described the scopes of a context for a valid understanding of contextual factors within it and that contextual factors depends on a particular challenge at hand (Wisdom; Chor, et al., 2014).

This adds a practical application for the LRT industry which is a societal impact, as it provides justified information and analysis for decision and policy makers in the transport sector. Furthermore, it provides meaningful data about contexts in different types of cities with socio-economic conditions, for appropriate decision making, for a cost and energy efficient LRT, which is good quality and user friendly to the passengers. As it is envisaged that the socio-economic and environmental conditions in Abuja, Lagos and Addis-Ababa cities as LRT receiving cities are different from China as the LRT producing country, even though they are both from the global south. This contextual process is necessary because it also shows how capable the Rail Providing Corporations (RPC) from China are in terms of contextualizing a LRT to any city's contexts, which are sometimes complex and require technical capacities from both parties.

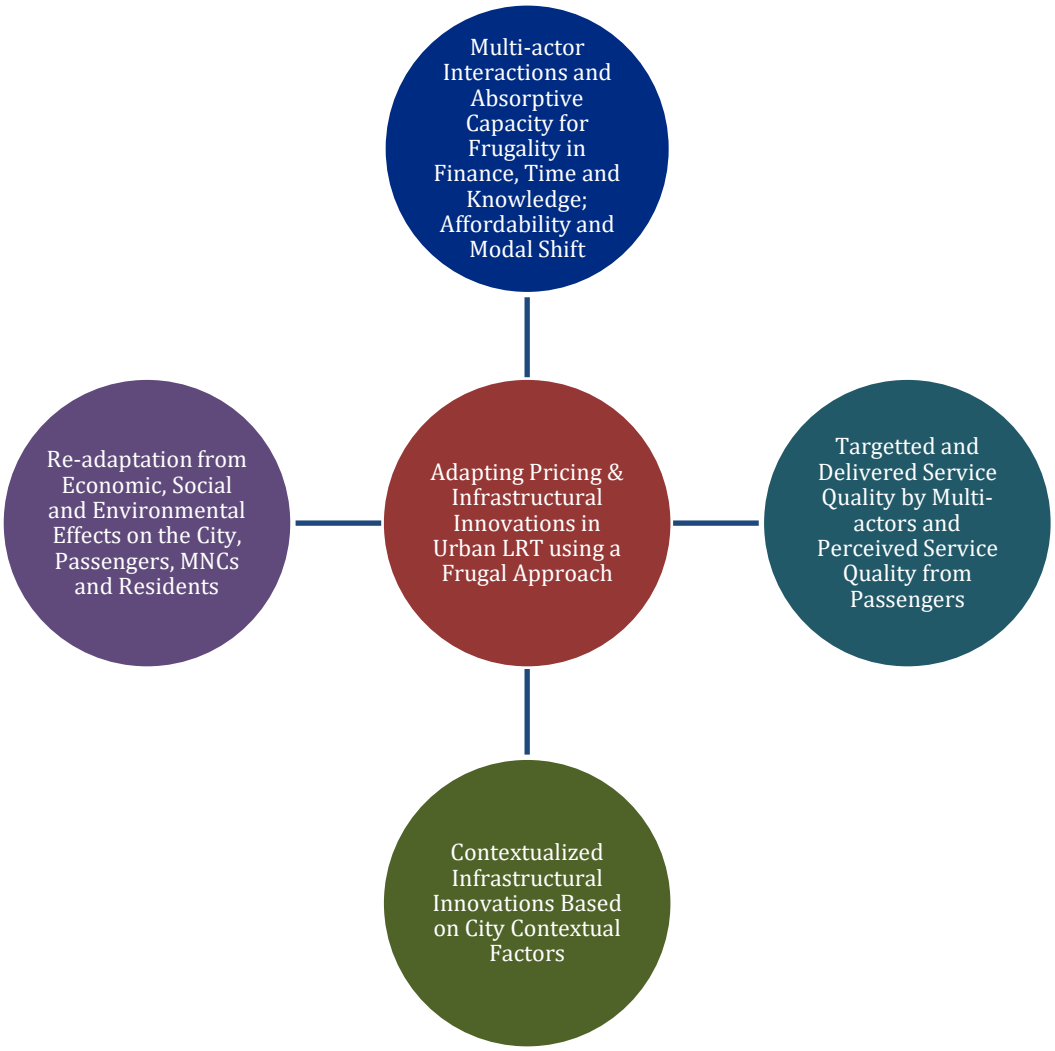
Sub-question four seeks for a possible pivot balance between the multi-actors and passengers on the operation and use of the light-rail respectively. Thus, quantifying with empirical results, the extent to which the targeted and delivered service qualities', using frugal approach by multi-actors satisfy the perceived service quality from passengers. As it is assumed sometimes that the frugal approach to delivering an infrastructure may result in low quality or poor operational delivery for the passengers. Therefore, necessitating the question on seeking a balanced supply and demand of the LRT and level of satisfaction respectively on the different components of the LRT. Understanding and practicing frugality in urban light-rail transport to achieve a significant balance between delivered service quality and its satisfaction to passengers is a benefit to existing literature, as it has a scientific significance. This justifies the fact that more can be done with less or limited resources, which can provide significant service quality and not poor quality as may be presumed using a frugal approach.

The structure of this research is further divided across chapters. Chapter one is the introduction, research questions, literature review and methodology related to qualitative and quantitative research strategy. Chapter two to five comprises of articles one to four, also representing each sub-research question, their specific literature reviews, conceptual frameworks, empirical analysis and conclusions. Chapter six provides a conclusion for the whole research.

### 1.8.1 Theoretical Framework of Dissertation

The theoretical framework in Figure 1, represents the conceptual model of the whole dissertation. This framework shows the explicit links or relationships between the research questions, the chapters and the core concepts used.

**Figure 1: Theoretical Framework of Pricing and Infrastructure Innovations Adapted to the Urban LRT using a Frugal Approach**




The theoretical framework in Figure 1 shows how the pricing and infrastructural innovations are adapted to the urban light-rail transport, using a frugal approach. Thus, the concept in the middle represents the overall research question: How can pricing and infrastructural innovations be adapted to urban light-rail transport using a frugal approach.

The connection to this overall research question from the top, shows the first sub-research question, of how the pricing and infrastructural innovations can be adapted in the urban LRT, using a frugal approach. This is by means of multi-actor interactions and absorptive capacity, to achieve frugality in finance, time and knowledge, with effects on transport affordability and modal shift from other motorized transport to the LRT.

The link to the overall research question from the left, is the second sub-research question two, of how the pricing and infrastructural innovations can be adapted in the urban LRT, using a frugal approach. This is through the re-adaptation of the LRT, considering the economic, social and environmental effects of the implemented LRT on the city, passengers, MNCs and residents' proximity and business activities along the LRT route.

The relationship between the overall research question and the third sub-research question from the bottom, reveals how infrastructural innovations are contextualized using different cities contextual factors, to provide adapted infrastructural innovations in the urban LRT, using a frugal approach.

The link between the overall research question and the fourth sub-research question, from the right, depicts the need to measure the targeted service quality, provided by the multi-actors, through the perceived service quality of the passengers on the delivered service quality by the multi-actors; in order to further adapt the pricing and infrastructural innovations in urban LRT, using a frugal approach.

### 1.8.2 Abstract of Four Articles

The first article aimed to understand how the multi-actor interaction processes and absorptive capacity structure delivered frugality in urban rail transport. It showed how the Ethiopian Railway Corporation in Addis-Ababa interacts with the Chinese consortium to achieve resource efficient Light Rail Transport (LRT) in terms of cost, technical know-how and time. Results have shown that frugality strongly depends on the structure of absorptive capacity and the process of multi-actor interactions. This has consequently helped the low-income passengers, also known as the Bottom of Pyramid (PoB) passengers and it also changed a fraction of modal shift from other motorized transport modes to light-rail public transport. This article aimed to provide societal relevance for decision and policy makers, enabling them to understand how to organize multi-actor interaction processes with Multi-National Corporations (MNCs); and how to structure absorptive capacity in order to make optimum use of limited financial, time and human skill resources.

The second article aimed firstly to know how the pricing and infrastructural innovations of LRT from a Chinese context was transferred to the Addis-Ababa context. Secondly, what were the social, economic and environmental effects of these contextualized innovations on passenger service delivery, MNCs expected

outcomes, city environment, what effects it had on the resident's proximity and business activities along the LRT routes. Thirdly, why did the effects of these contextualized innovations on passengers, MNCs, and residents lead to re-modifications? The results showed that the economic factors accounted for 12 out of 14 sustainability factors; while 2 out of 14 revealed the social and environmental factors. In addition, new city level contextual factors were revealed, representing specific challenges that may influence innovation adoption; such as fare evasion, level of travel demand, non-use of electronic pricing devices, LRT platform sizes, and the non-availability of platform sensor barriers. The societal relevance of a contextual approach was actualized through the formulation of good contingency factors, to ease the translation from theory to practice in transport governance. Furthermore, it served as a decision support system to innovation adoption, for a sustainable approach to LRT planning.

The third article analysed the similarities and differences in contextual factors between Abuja and Lagos in Nigeria and between Ethiopia and Nigeria. The important contextual factors with stronger influence on contextualization of infrastructural innovations in Nigeria were electric energy supply and the modernization of LRT with other transport modes. Prominent contextual factors with more effect on contextualization of infrastructural innovation from Ethiopia were emergency ticket shops, seamless integration of the LRT with other transport modes, and Non-Motorized Transport (NMT).

Common to both Nigeria and Ethiopia, was the seamless integration of the LRT with other transport modes. This provided the understanding of how multi-actors can implement a LRT, despite challenges faced due to city level contextual factors, through poly-contextualization and re-modification. In addition, it provided a societal relevance benefit through the provision of well-informed contextual factors to policy makers and urban transport authorities, to formulate objective policies for the city's socio-economic development, sustainable LRT and satisfaction of the LRT users.

The fourth article focused on the two gap dimensions of a service quality loop for light-rail transport, with specific emphasis on pricing and infrastructural innovations, using a frugal innovation approach. These are targeted and delivered service quality from the multi-actors and perceived service quality from the passengers. This provided societal relevance for policy makers to be able to measure and deliver adequate service quality to the large number of passengers, despite gaps, such as non-use of automated tickets, overcrowding during peak hours and fare evasion.

A mixed research method was used. Light-rail experts were interviewed using a pilot and semi-structured interview for a qualitative method; and a quantitative method was used in the form of a passenger's survey. The mixed research method

for a single case study was used in Addis-Ababa and multiple case studies in Addis-Ababa, Abuja and Lagos.

## 1.9 Research methods and data collection

The methodology used in this research was a mixed method of qualitative and quantitative approaches, in a multiple case study research. This provides instruments for researchers to study complex phenomena within their contexts (Baxter and Jack, 2008), which can inform professional practices and serves as evidence-based decision making in policy settings. This affords researchers the opportunities to describe and explore an occurrence in context, using various data sources. It also permits the researcher to explore entities or organizations, by complex relationships, interventions, programs and communities (Yin, 2003). Furthermore, it supports the deconstruction and subsequent reconstruction of various phenomena. This approach is useful for research to develop theory, develop interventions and evaluate programs, due to its flexibility and thoroughness.

Using multiple case studies enables one to deliver effective avenues for recognizing and collecting data (Gibbert; Ruigrok, et al., 2008). Furthermore, the importance of this multiple case study comparing Addis-Ababa, Lagos and Abuja is that it will provide knowledge concepts serving as learning pathways for the three cities and other cities in LRT transition, to learn from one another, as a concept of learning by doing and doing by learning during the different phases of the LRT, thereby co-creating knowledge. The case studies also provided a more robust understanding of the social characteristics of adoption of innovation (Lawrence and Tar, 2013).

Diaries and thoughts are recognized in qualitative research as rich and multi-layered sources of data, providing participants with the opportunity to acquire their recollections of events and the associated emotions in the relatively instant outcome of those events (Radcliff, 2013). Although structured reflection questions may have an obstructive effect on the variety of concerns discussed by participants, it can provide more substantive data grounded in the common background of the participants (Grinnell, 2003).Thus, this multiple case study approach allows for in-depth study of variables and relationships between variables, considering the specific context of the cases. Using case studies provides a more robust understanding of the social characteristics of adoption of innovation in infrastructure provision (Lawrence and Tar, 2013). This approach to research is applied to real-life settings, which also focus on studies with small units and large variables (Davenport and Prusak, 1998, Topp, 1999, Fennell and Warnecke, 1988). According to Altmann and Engberg (2016), in public transport institutional analysis, variables are better analysed qualitatively, which needs in-depth methodologies, such as semi-structured interviews which provide deeper and more comprehensive data, depending on the specific context of study. It makes the data that is collected more comprehensive, because it is obtained by collection of

respondents' opinions, using various sources and concepts related to actors, their related groups, and their interactions are taken into consideration (Santander, 2013).

The various contextual approaches in contextualizing and re-modifying the infrastructural innovations to fit the characteristics of the three cities are key elements of this research. It was assumed that China has replicated some of their innovations in service provision from China to the Abuja, Lagos and Addis-Ababa cases, since they are the custodians of the constructions in these cities and partly the sponsor of the Light Rail Transport system in Abuja and Addis-Ababa cities. These cities received the rolling stock, technological and non-technological innovations from their provider - China. These were compelling reasons to choose the three cities for this study. The research methodology classified principles about the design, collection, processing and analysis (Groves; Fowler Jr, et al., 2009).

This research employed the use of mixed research strategies both qualitative and quantitative. The qualitative strategy used a semi-structured interview method for the multi-actors, and the quantitative method used a survey research method for the passengers. Three out of the four sub-research questions focused on Addis-Ababa city as, at the time of research, the LRT was in operation. Thus, it had up to three years operational experience (2015-2017), enriched with the full cycle data regarding the design, construction and operation.

The third sub-question focuses on a comparison of the three cities. It focuses specifically on the design and construction phases, as Lagos and Abuja at the time of research did not have operational data. Thus, to compare all three cities it was decided to use comparable LRT construction phase characteristics which were similar to all three cities.

This research used for the first three case studies described below, a qualitative approach. The fourth case study used a quantitative approach.

1. Pre-Test: Pilot interviews using open ended questions in Addis-Ababa and Abuja.
2. Semi-structured interviews: Semi-structured questions in Addis-Ababa, Abuja and Lagos.
3. Focus group discussion of light-rail users in Addis-Ababa.
4. Questionnaire survey of the light-rail users in Addis-Ababa.

**Table 3: Interviews, Focus group and Survey**

| Cities | Addis-Ababa | Abuja | Lagos |
|---|---|---|---|
| Pilot Interviews (2015) | 5 | 3 | - |
| 1st Round semi-structured interviews (2017) | 6 | 5 | - |
| 2nd round semi-structured interviews (2017 and 2018) | 11 | 9 | 11 |
| Total | 22 | 17 | 11 |
| Focus group discussion | 6 | | |
| Survey for LRT passengers | 254 | | |

Table 3 above shows a summary of sample sizes in the three cities for interviews, focus group discussions and surveys of LRT passengers.

### 1.9.1 Pilot Interviews as a Pre-Test

Pretesting entails a sequence of actions planned to appraise a survey tool's capability to gather the needed data, the abilities of the chosen mode of data gathering, and the overall sufficiency of the field processes (Willis, 2005). Willis (2004) defined a pre-test as the assemblage of all those methods and actions that permit researchers to assess survey questions and survey processes before data collection commences. In this regard, a pilot study refers to pretesting measures that utilize all the processes and materials involved in data gathering, not considering how trivial of a scale before the real data collection starts. Pilot studies are also denoted to as a dress rehearsal or field trials in the research methods literature and they have a precise aims which includes approximating response rates from a specific recruitment procedure to labelling the best possible design characteristic, for example the incentive amount through research (Groves; Fowler Jr, et al., 2009).

The goal of a pre-test is to guarantee that the types of instruments that will be used in the main test sufficiently communicate the anticipated research questions, values, reported facts and behaviours, are able to quantify the proposed attitudes and that the data collection will be conducted according to stated study protocols in every country and language (Willis, 2005).

The rationale here is to make the best use of the several pretesting methods that have been selected in advance, what matters needs to be addressed. Whether, the survey wants to assess all field processes, or only the survey instruments or portions

of it, or compare the similarity of the survey instruments using various modes of data collection.

Pretesting in a local context is essential, making it possible to evaluate the tests performance in the mode of obtaining the information and the order of the questions with the target populace. It is important understanding the specific types of vocabulary that the respondents are using to qualify the terms in the innovation concepts being measured, to ensure that the researcher and respondents are speaking the same research vocabulary. Addis-Ababa and Abuja are considered the capital cities of Ethiopia and Nigeria respectively, and they were also the cities where the pre-testing was conducted.

The pilot interview entailed general questions, which focused on prior knowledge and understanding of the subject matter. These pilot interview questions targeted experts who were knowledgeable enough regarding how the cities have adapted to the innovations. These questions were primarily introductory and general in form to ascertain the use of the innovations in each context.

There were three pilot interviews conducted in Abuja and five done in Addis Ababa, as explained these were also in order to ascertain the understanding of the experts on the adapted innovations.

In Addis-Ababa the five respondents comprised of 3 Ethiopians, one manager, one assistant director in service delivery and 2 Chinese consortium members, who were the main directors of the Chinese consortium for Ethiopia.

While in Abuja, two of the respondents were Nigerians who headed the main Abuja light rail department, the main director and his assistant and one Chinese from the Chinese consortium, who was the manager in charge of the CCECC.

As pointed out, the interviews gave insights into understanding what the experts understood about innovation adaptation in the Light-Rail Transport system. Consequently, establishing categories of concepts from data, which in turn formed a basis for specific semi-structured questions.

### Interviews in Addis-Ababa

Using semi-structured questions for 22 respondents, which comprised of 5 respondents from the pilot test, 6 respondents who took part in the first round in October 2015, and 11 respondents who took part in the second round of interviews in June 2017. The second round of interviews were necessary in order to collect data from the operational phase to be able to compare the responses over time. As there was a difference of almost two years between the first and the second round of interviews which gave the experts' about 24 months of experience with the operation of the LRT, that would provide more comprehensive data on how the infrastructures, pricing systems, operation and maintenance systems had been or changed within two years.

### Interviews in Abuja

Abuja had a pre-test of 3 respondents, 5 respondents during the first round of interviews and 9 respondents during the second round, making a total of 17 interviews. Fewer experts were interviewed in Nigeria compared to Addis-Ababa, as Addis-Ababa had more experts on ground, as they had already started the operations and consequently at that stage needed more experts who were trained prior to the start of the LRT system. Although Abuja and Lagos also has some experts trained prior to the construction of the LRT, as the operational phase was still pending at the time of the second round of interviews in both of these two cities, they had less experts who were trained on the job during the implementation and operation phases compared to Addis-Ababa.

## 1.9.2 Semi-Structured Interviews

Semi-structured interviews were implemented in all three cities. In Abuja data was collected regarding design and construction during the LRT implementation phase. In Addis-Ababa data was collected regarding the design, construction and operational phases. Semi-structured questions were chosen in order to serve as a reminder and avenue to re-explain earlier discussed innovation adaptation concepts that had previously been discussed during the pilot interviews, which in turn opened up more concepts to be included in the research, such as questions on absorptive capacity, resource management, key performance indicators, pricing and infrastructure, operations and maintenance.

This helped avoid or reduce the non-response errors for specific questions that the respondents were unable to remember, if a self-administered questionnaire was used (Groves; Fowler Jr, et al., 2009). It will also reduce measurement errors, reducing the rate at which certain questions are answered inadequately by a well-informed respondent. The semi-structured questions also provided the opportunity of retrieving answers from respondents as originally understood by them, giving them more room to provide more answers that may be useful to the researcher, that were able to be categorized and coded at a later date (Groves; Fowler Jr, et al., 2009).

Lagos was initially not part of the research design, but it was included later as Abuja's LRT was not ready for operation over the period of research, and it was not possible to compare a city with operational data (Addis-Ababa) and one without (Abuja). Therefore, Lagos was included at a later stage, in 2017, in order to be able to compare cities comparable to one another, that were both in the same phase of design and construction and not yet in operation, such as Abuja and Lagos. It was only possible to compare Addis-Ababa city with Abuja and Lagos in the design and construction phases. This systematic comparison was able to provide concepts which led to theories and served as learning pathways for the three cities to learn

from one another as a concept of learning by doing and doing by learning during the different phases of the LRT.

### 1.9.3 Sampling Method for Interviews

The sampling method used was a *purposive sampling method.* It was selected because it was based on the characteristics of the population (LRT experts) and the objectives of the study. This specific selection was made in order to acquire up-to date data and reasonable information from the multi-actors based on their respective daily experiences and direct involvement with the LRT on a more frequent basis, with adequate expertise qualifications as mid and high-ranking experts. This enabled the respondents to relate their experiences on ground with their expertise as engineers and managers. Thus, concepts qualifying these interactions and processes were drawn from the data that was acquired during the pilot test and semi-structured interviews.

### 1.9.4 Population Coverage for Interviews

When referring to the population, the researcher refers to the population of experts and general population that were surveyed, which included the Nigerians, Ethiopians and Chinese LRT experts. the Abuja and Lagos LRT experts working with Abuja Light-Rail Department (ALRD) and Lagos Metropolitan Area Transport Authority (LAMATA) respectively, Ethiopians that included Addis-Ababa LRT experts working with the Ethiopian Railway Corporation (ERC). The Chinese LRT experts working with China Civil Engineering Construction Corporation (CCECC) in Nigeria and China Railway Engineering Corporation (CREC) / Shenzhen Metro in Addis-Ababa.

The coverage method that was used in collecting the social context of the survey respondents, was developed to estimate the respondent's network size, or degree. Thus respondents are asked how many people they know in a list of specific relationship types, for example co-workers in the field of LRT in their city and their role and responsibilities in the LRT project, and these responses were then summed to yield an approximate number (McCormick and Zheng, 2015).

### 1.9.5 Sample Size for Interviews

As already mentioned, the sample size in the pilot and semi-structured interview phases in Abuja city had a pre-test of 3 respondents, 5 respondents during the first round of interviews and 9 respondents during the second round, making a total of 17 interviews. The second round of semi-structured interviews in Abuja took place in 2017. This allowed for a reasonable period to gather data based on the design and construction phases, especially as some of the data collected concerned modifications. The interviewees consisted of 5 new respondents and 4 formerly interviewed respondents. The formerly interviewed respondents provided an

opportunity to gain more insights into the latest developments in the design and construction phases that had taken place within two years, while the new respondents provided insights based more on the present situation and sometimes they were able to reflect back on the two former years. These 9 respondents in Abuja comprised of 2 Chinese engineers, 3 Nigerian senior engineers, 1 Nigerian senior director, and 3 mid-level Nigerian engineers, who were all in the LRT department.

The sample size for the semi-structured interviews in Lagos city comprised of 11 respondents who were LRT experts, that included 9 Nigerians (6 engineers and 3 directors) and 2 Chinese experts. The Chinese LRT experts had constant managerial roles as engineers and spoke English well during the interviews.

Unfortunately there were few members of the Chinese population in Largos that were able to respond to the questions as most of the remaining Chinese workers were technicians who were only able to respond to questions based on their specific duties and not on the aspects related to the contextual approach that was used during the LRT implementation phases. All selected respondents were selected because they had a daily routine during the design and implementation phases, which was useful to compare events during these two phases.

The sample size in Addis-Ababa in the two-step approach of pilot interviews and semi-structured interviews was 22 respondents. 5 respondents took place in the pilot interviews in 2015, 6 during the semi-structured interviews in 2015 and 11 during the second round of semi-structured interviews in 2017. The research initially targeted double the executed sample size but was constrained due to the limited number of Ethiopian and Chinese LRT experts that were available to provide the specific and required feedback. As one of the LRT top expert mentioned:

> *"It has been commented by fellow workers that we are limited on the knowledge know-how, and lots of things are yet to be known".*

Abuja and Lagos cities had experts that were trained prior to the construction of the LRT. However, because the operation phase was still pending at the time of the interviews in these two cities, there were less experts that were trained on the job during the implementation and operational phases compared to Addis-Ababa, which had a total of 22 respondents. There was also a longer history of being between 2-3 years in operation, which led to an increased number of LRT technical personnel that covered the three phases.

The pilot interviews were carried out as mentioned due to the pre-test goals, which were to ensure that the versions of the survey instruments were eventually adequately able to communicate the anticipated research questions, measure the intended attitudes, values, reported facts and behaviours, and that the collections of data were able to be conducted according to specified study protocols in every case study (Willis, 2005).

The pilot interviews also provided a credible and sound research approach and interview protocol, in which the pilot survey confirmed whether the variables that were measured existed in the study area, as the area of research is relatively new in the study area. This made it possible to streamline the related semi-structured questions from the pilot survey into more specific semi-structured questions during the first and second round interviews. Thus, it was possible to estimate response rates under a recruitment procedure to identify the best possible design characteristic through experimentation, for adequate and suitable onward design of the second phase of semi-structured interviews.

The pre-testing was also crucial in this research because there was a need to first confirm whether the specific types of vocabulary that was used by the LRT experts in Abuja and Lagos was understood by the researcher. This also qualified the terms of the multi-actor interactions, absorptive capacity and frugal innovation concepts that were also being measured. The pilot interview entailed in-depth questions, which focused on the knowledge and understanding of the subject matter, especially targeting experts who are knowledgeable enough on how the cities were able to adapt the LRT innovations.

The first and second round of semi-structured interviews were implemented for data acquisition on design and construction of the LRT. The second round of semi-structured interviews was also chosen to serve as a reminder and avenue to re-explain earlier discussed concepts during the pilot and first round interviews, which in turn highlighted more details regarding the required concepts of study. Such as questions on what caused some of the context modifications during implementation and after the implementation phase.

The second round of semi-structured interviews was also able to avoid and reduce the number of non-response errors for specific questions that the respondents were unable to remember. This also reduced the measurement error; it reduced the rate at which certain questions are answered inadequately by a well-informed respondent. The in-depth semi-structured questions also provided the opportunity of getting answers from respondents as originally understood by them, giving them more room to provide more answers that may be useful to the researcher, that were able to be later categorized and coded (Groves; Fowler Jr, et al., 2009).

### 1.9.6 Data Coding for Semi-Structured Interviews

The data that was gathered was coded using the Atlas-TI software, which facilitated being able to categorize the various levels of data and generate a robust data set capable of deducing categories from the data within the design and operation phases of the LRT in the three cities. The units of analysis made it possible to study the processes and actions involving many individuals (Khan, 2014).

The cases studied in this research are completely in line with this, as it studied actions and processes between multi-actors from Abuja and Lagos cities in Nigeria, and their Chinese counterparts. Thus, concepts qualifying these interactions and processes were drawn from data acquired during the pilot test and in-depth semi-structured interviews. This highlights Africa-China interaction processes along the line of LRT infrastructure innovation implementation, which required contextualization and re-modification processes.

### 1.9.7 Focus Group Interviews that were Undertaken Before the Survey

According to Anderson (1990) a focus group interview is a qualitative technique for data collection, comprising of persons with specific features who focus discussions on a given subject. Denscombe (2007) points out that such a focus group comprises of a small group of people, typically between six and nine in number, who are brought together by a researcher, to explore perceptions, ideas, attitudes and feelings about a subject. A focus group interview offers the possibility for a moderately homogeneous group to respond to the questions asked by the researcher. Morgan (1997) also notes that focus groups can be used in three different ways namely:

(a) As a **self-contained technique**: The respondents become the main source of data acquisition. The main argument is that a focus group, opposed to individual interview, exposes the respondent's practices and perspectives, which may not be accessed otherwise.

(b) As a **supplementary source of information**: The focus group is used to create survey questionnaires, to develop an intervention or program or to authenticate the discoveries of a quantitative study. This research followed this method, as it had a focus group of 8 people who used the LRT. Which was comprised of students, government workers and independent entrepreneurs which were subgroups, comprised of the focus group that was used as supplementary information to generate survey questionnaires for the 254 LRT users.

(c) As a **focus group** which is used in multi-methods research: This was used successfully for example to collect data regarding the participant's reflections and in-depth interviews. This is also referred to as triangulation, which is using a research method to confirm the findings of another research approach. To a reasonable extent, this research also used this focus group to confirm some answers in the questionnaires administered in Addis-Ababa.

## 1.9.8 Questionnaire Survey for LRT Users in Addis-Ababa

In order to acquire data based on to what extent the quality of service delivery was able to satisfy the light-rail users in Addis-Ababa, and also to triangulate some of the responses from the LRT experts, survey questions were administered in only Addis-Ababa, as the only city of the three in the research that had already started operations since October 2015. Questions to triangulate some questions from the experts were asked regarding concepts of quality of service for its citizens from the already adapted innovations in pricing and infrastructure. The main aspects of research design, included defining the target population, the type of survey and the data collection mode (Smith, 2010).

Designing a good survey instrument entailed selecting the questions needed to meet the research objectives, testing them to make sure they are able to be asked and answered as designed, harnessing them into a form, in order to maximize the ease with which respondents and interviewers can do their part of the research (Fowler, 2009).

## 1.9.9 Sampling Method for Survey

The sampling method used for the survey is the purposive sampling method, which was selected because it is based on the characteristics of the population (LRT experts), LRT passengers' and the objective of the study. The Coverage method entailed the coverage population, which included the Ethiopians (Addis-Ababa LRT experts working with ERC) and Chinese (LRT experts from the Chinese consortium working with CREC and SMG) for the qualitative approach. While the quantitative approach entailed the LRT passengers along the two available N-S and E-W lines in operation. This specific selection was made in order to acquire up-to date data and reasonable information from the multi-actors based on their respective daily experiences and direct involvement in the LRT on a more frequent basis with adequate expertise qualifications as mid and high-ranking experts. This enabled the respondents to relate their experiences on the ground with their expertise as engineers and managers. While the quantitative approach sample entailed the LRT passengers. Thus, concepts qualifying these interactions and processes were drawn from data acquired during the pilot test and semi-structured interviews.

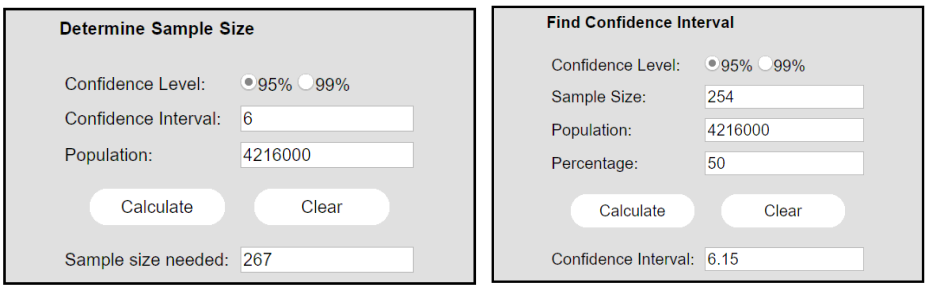
## 1.9.10 Sample Size for Survey Method

The 254 respondents comprised of passengers along the North-South (N-S) line 16.9 Km and East-West (E-W) line 17.35 Km. The East-West line runs from Ayat village via Megenagna, Legehar and Mexico Square to Torhailoch, and the North-South line links Menelik square, Merkato, Lideta, Legehar, Meskel Square, Gotera and Kaliti (Jemere, 2012).

The number of passengers surveyed resulted in an almost equal balance of respondents along the N-S and E-W lines in a percent ratio of 48% to 52% respectively. In addition, the quantitative approach first began with a qualitative approach, using a focus group discussion method with 6 respondents, who discussed questions that were meant for the survey, in order to get feedback on the real situation on the ground, which was essential in testing and re-structuring the final survey questionnaire in the context of events for LRT passengers in Addis-Ababa. The six focus group respondents comprised of two students, two civil servants, one entrepreneur and one technician, in a female to male ratio of 2:4. These selected respondents use the LRT on an average of 4 times per week.

To calculate the sample size and a confidence interval, the Addis-Ababa population statistics of 2015 was used as 4,216000 people. Therefore, using a confidence level of 95% and confidence interval of 6, the sample size needed was 267 users of the LRT. However, due to some non-response surveys which were detected, 254 were completely administered in total. The non-response survey parts accounted for a difference of 13, which is not significant enough to influence the total number surveyed, which is 254; as shown in Figure 2. Thus, the total sample size used is adequate and justified enough to generate reliable results.

**Figure 2: Determination of sample size and confidence interval**




## 1.9.11 Data Coding for Survey Method

The analysis instrument used to code the data gathered for this survey quantitative approach was the Statistical Package for The Social Sciences (SPSS). This further enabled the data from a purposive sampling to be better visualized during the coding system, in connection to the operationalization of the concepts, variables, sub-variables and indicators. In addition, the coded data was used to generate descriptive statistics, which has been described within the analysis of sub-question four.

## 1.10 Limitation of methodology

The three cities were comparatively analysed based on infrastructural innovations. Operational data for the Abuja and Lagos cites were not ready, as they had not yet

started operating the LRT during the research period, although it was initially planned for the researcher to include the pricing innovation in all three cities. However, only Addis-Ababa city was able to be analysed based on both pricing and infrastructural innovations.

Even though Lagos was initially part of the research design, it was included later so that it was possible to compare Abuja with Lagos. Since both Abuja and Lagos cities were at the same design and construction stages and had not started the operational phase like Addis-Ababa.

Abuja was initially meant to be compared with Addis-Ababa, the initial plan was to compare the three phases of design, construction and operation, which included both pricing and infrastructural innovations of a light-rail. However, because Abuja lacked operational data due to delays in starting the operations, Lagos city was included to be compared with Abuja, as both cities were at a similar stage of their LRT development at the time of research, and they both had only the information regarding infrastructural innovations.

Even though it was only possible to compare the two Nigerian cities with Addis-Ababa in Ethiopia, only during design and construction stages, having components for infrastructural innovations, it was still very useful.

Lagos was included in the research in order to be able to compare cities which were comparable to one another and were in the same phase of design and construction and not yet in operational. In this regard, since Abuja and Lagos cities in the design and construction phase are in the same country, it was assumed that they would possess similar characteristics, especially as they were both interacting with the same MNC, CCECC from China. This made the pilot interview that was conducted in Abuja still valid for Lagos, as they are both in Nigeria, while related questions asked during the first round of semi-structured interviews in Abuja, were also included in the questions during the Lagos city round one interviews.

Chapter four considered some contextual factors measured in all of the three cities, and it also focused upon some factors that were only particular to Addis-Ababa city, such as fare evasion from ticket sales, as this sort of operational data was not yet available for the Nigeria cases. Nevertheless, this methodology structure shows that it was more reliable and scientifically logical to study the cities with comparable levels of LRT implementation.

# Chapter 2: Frugality in Multi-actor Interactions and Absorptive Capacity of Addis-Ababa Light-rail Transport [1]

1 Frugality in Multi-actor Interactions and Absorptive Capacity of Addis-Ababa Light-rail Transport. Taslim Alade, Jurian Edelenbos, Alberto Gianoli. Article published 15th November 2019, in the Elsevier Journal of Urban Management. https://doi.org/10.1016/j.jum.2019.11.003.

## 2.1 Abstract

Cities in transition need strategies to do more and better using less or limited resources, to be frugal in their approach, especially when implementing expensive infrastructures. Addis-Ababa city, Ethiopia 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 know-how 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 a passenger survey, this article aims to know how the multi-actor interaction processes and absorptive capacity structures 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, also known as Bottom of Pyramid (BoP) passengers and a fraction of modal shift from other motorized transport modes to the light-rail public transport.

*Keywords*: Frugality; multi-actors; absorptive-capacity; Bottom-of-Pyramid; modal-shift, Light-Rail Transport.

## 2.2 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, despite complexities within the multi-actors (Bhaduri, 2016).

One out of three extensive innovation heuristics used in achieving frugality in service is identified as innovatively decreasing time wasting, human resources and materials to reduce cost and increase effectiveness (Prabhu and Gupta, 2014, McNicoll, 2013, Mukerjee, 2012). Little attention has been given to the study of frugality and frugal innovation as a non-technological and governance network related component, as this topic has been conventionally viewed from 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, et al., 2012, Zeschky; Widenmayer, et al., 2011, Prahalad, 2005, Prahalad, and Hammond, 2002) and technology (Altamirano and 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).

There is a need to critically and systematically investigate how frugality and frugal innovation outcomes in different parts of the world correlate to development, to effectively measure its transformational or developmental potential (Leliveld and 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 and Knorringa, 2018). A frugal viewpoint to development research is to classify under what circumstances such innovation processes are expected to contribute to more inclusive developmental results. In this sense, a critical and multidisciplinary method to frugal processes as well as an empirical approach is needed (Knorringa; Peša, et al., 2016). This need serves as one of scientific importance in 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 effect of this combination on the low-income earners, i.e., the Bottom of the Pyramid (BoP), as an inclusive developmental outcome.

Therefore, the aim of this paper is to know how the multi-actor interaction processes and absorptive capacity structure amongst the multi-actors have delivered frugality in LRT, what are the effects of the changes by the new LRT on the low income earners as the BoP? and whether there has been a modal shift from other motorized vehicles to the LRT?. What effect has this had on implementing the LRT despite inadequate country owned financial resources, less technological and knowledge capability of LRT and within a limited period of time? 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 in order to make optimum use of their limited financial, time and human skill resources. These important needs are also gearing towards the achievement of the ninth Sustainable Development Goal (SDG-9), stated as:

> *"building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation"* (UN Sustainable Development Goals, 2015)

as efficient transportation services generate employment and wealth and drive economic development.

The present-day dialogue on frugality in decision theory attempts to draw a conceptual roadmap to aid us fathom out frugality in the context of decision making (Gigerenzer, 2008, Gigerenzer and Todd, 1999). According to these authors, we need to analyze both the person taking the decision and the environment in which the decision has been taken, in order to comprehend frugality. Frugality needs to therefore, emphasize not only what is achieved, but likewise and possibly more importantly to know 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, but including all institutional, organizational, social, and political dimensions (Leliveld and Knorringa, 2018). Similarly, this articles also 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 Transport.

This newly introduced electrified LRT is necessary for a significant modal shift from other motorized means of transport to the light-rail public transport, as 2.2 million people use public transport in Addis-Ababa, consisting of 3.6 million trips per day (Fenta, 2014). Despite these trips per day, the limited providers are barely capable of dealing with the public demands for transportation (Fenta, 2014). This necessitated the introduction of the LRT, to supplement public transport with better affordability, safety, comfort, reliability, environmental friendliness, and accessibility to the physically challenged (Jemere, 2012).

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, using their variables and indicators; section three focuses on the methodology, which describes the mixed methods used as qualitative and quantitative research, section four is comprised of the empirical results and discussions; and section five contains the conclusions.

## 2.3 Theoretical Framework

The absorptive capacity concept is derived from three model theories. First is the theory of frugality in decision-making, to understand and highlight the role of tacit knowledge and learning strategies (Bhaduri, 2016). This theory describes a framework, which highlights three main characteristics of frugality in decision theory.

- 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

- Second is the theory of process in local capability formation in explicit and tacit knowledge transfer (Ernst and Kim, 2002*)*, between network flagships. which refers to MNCs or LRT innovation suppliers and local suppliers, i.e. local knowledge receivers or the innovation receiving city or institution
- Third is the theory of absorptive capacity for new knowledge as part of system antecedents for innovation (Greenhalgh; Robert, et al., 2004). The absorptive capacity concept was used because there is a need to understand how ERC fostered the management for the acquisition of knowledge transfer from the Chinese Consortium (CS). This is because knowledge transfer is one of its Key Performance Indicators (KPI), which makes it important to focus on, as it enables the context of frugal approach.
  In this context these frugal approaches are 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; Robert, et al., 2004), and the theory of sustainable collaboration (Fadeeva, 2005). In this research the multi-actor interaction concept was used because of the interactions between the ERC with four other multinational corporations, and to understand the patterns of their multi 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 and Knorringa, 2018, Pisoni; Michelin, et al., 2017, Bhaduri, 2016, Knorringa; Peša, et al., 2016, Prabhu and Gupta, 2014, McNicoll, 2013, Mukerjee, 2012, Tiwari and Herstatt, 2012).

The BoP concept is derived from two theories. First is the theory of business opportunities at the BoP, as a market base method to alleviate poverty (Hammond; Kramer, et al., 2007). Second is the theory of eradicating poverty by MNCs earning revenues at the BoP, generating mutual value (Prahalad, Coimbatore Krishnarao, 2002). The base or BoP, denotes to four billion persons in emerging economies, which is a high and significant part of the world's population (Hammond; Kramer, et al., 2007). The annual per capita income of these four billion people is less than $1,500 per year (London and Hart, 2004, Prahalad and Hart, 2002). $1,500 per year is considered as the minimum to sustain a decent life (List, 2017).

Multi-national corporations make significant efforts to include the poor BoP and lower-middle class passengers with reduced or relatively affordable versions of

provided products and services (Leliveld and Knorringa, 2018). This BoP group forms a mega portion of most populations worldwide, were the MNC's can locate their wealth by providing services that also target them (Prahalad and Hall, 2002). These types of services are significantly cheaper, affordable to low-income passengers, uphold technological usefulness, and are appropriate for resource-constrained cities (Bhatti, 2012). In this regard, the challenge is not only providing basic forms of products or services to middle and high income users, but in its place offer currently designed and context sensitive innovations with value that are actually well-suited with the conditions of people living in poverty (Nakata and Weidner, 2012).

The modal shift concept is coined from the travel behaviour theory, which in transport planning is traditionally divided into four parts in a model acknowledged as the four step model (Ortuzar and Willumsen, 2006). This deals with the behaviour of humans regarding travelling decisions. This article is concerned about the third part of the model, which is the modal choice, describing 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.

### 2.3.1 Relationships Between Multi-Actor Interactions, Absorptive Capacity and Frugality in Light-Rail Transport

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

Multi-actor interactions in MNCs are structured in a way that seeks to minimize the cost of construction and maintenance of a huge infrastructure investment like the LRT (Greenhalgh; Robert, et al., 2004). In this regard, a new LRT requires a frugal approach, to be used by the multi-actors of the concerned MNCs, during their various stages of interactions in the design, construction and operation phases (Leliveld and Knorringa, 2018, Bhaduri, 2016, Knorringa; Peša, et al., 2016, Pisoni; Michelin, et al., 2017, Prabhu and Gupta, 2014). To achieve this required frugality in Light-Rail Tansport, the multi-actors 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 Indicators (KPI) and a benchmark for assessing the progress amongst multi-actor interactions during various implementation processes.

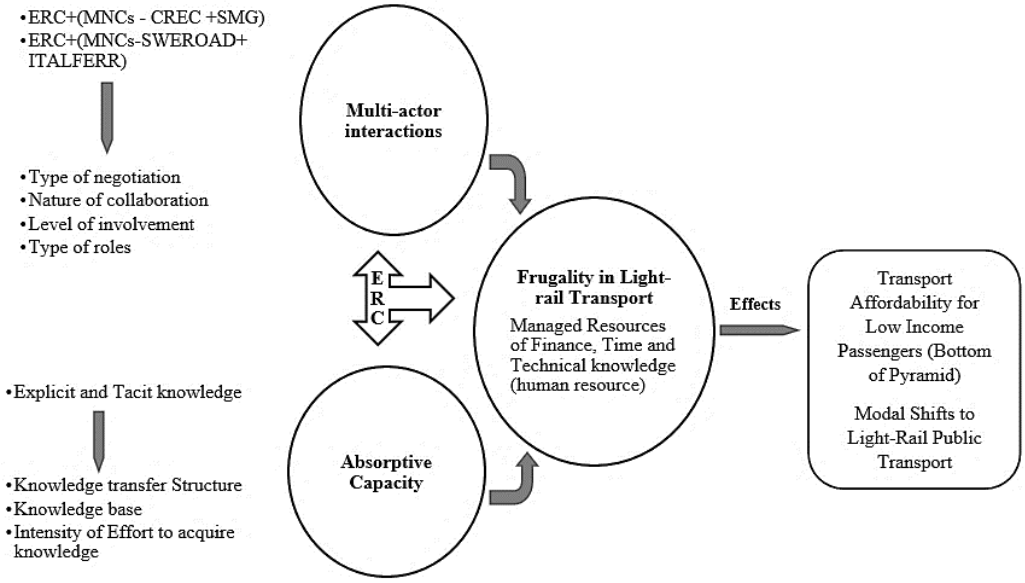
Thus, when acquiring the LRT technology transfer, the structure of its absorptive capacity, using tacit knowledge by the LRT receiving actor is vital, to maximize the provided explicit knowledge *(Ernst and Kim, 2002)* from the MNC providing the LRT (Ernst and Kim, 2002. This determines the rate at which it can be acquired within a limited time frame and the depth of how much of the technology and knowledge needs to be 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 on how best to minimize the cost of operating the LRT in the long run, using local personnel's as the human resource, within a limited budget or loan and with limited time resources,. as well as transferring knowledge regarding LRT technology. Considering and implementing all these points will guarantee the benefit of less costs in maintaining the LRT rolling stock in the long run, and by using local skilled engineers that are paid in local currency this will also reduce costs. If the expatriates are used to run the technology it will be more expensive as they are often paid in foreign currency rate from the foreign MNC, which is a higher rate than the locals.

If the above points are taken into consideration then it will benefit against negative trade-offs, such as overshooting stipulated budget or loans received and long-term use of foreign personnel's from MNC's. Absorptive capacity in terms of knowledge transfer, is aimed at the process of catching-up with advanced industrial countries (Fu; Pietrobelli, et al., 2011). It regards how to use the technology that has been provided by the advanced countries, in order to continue its use in a sustainable manner. Furthermore, possessing the important role of building innovation capabilities (Lim; Han, et al., 2013), management of knowledge transfer (Bencsik; Renáta, et al., 2016), using tacit knowledge to harness provided explicit knowledge (Ernst and Kim, 2002) of the MNCs.

The theoretical framework in figure 3 shows the relationships between multi-actors[2] interactions, and absorptive capacity, leading to frugality in LRT and its effect on the transport affordability of the BoP and modal shifts to LRT

[2] 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).

**Figure 3: Theoretical framework**




Source: Authors (2019)

## 2.4 Operationalization of Concepts

The operationalization in Table 4 and the theoretical framework in Figure 3 shows the four main concepts and their respective variables, sub-variable and indicators.

Indicators for frugality are related to the level of available finance, technical know-how, and phase periods. Indicators for multi-actor interactions focus on its nature, as formal negotiations or stakeholder dialogues, the multi-actor's level of involvement considering their types of roles. Indicators for absorptive capacity were developed based on what was officially provided to the ERC by the MNCs in the form of explicit knowledge, how the ERC structured themselves to receive the knowledge transferred in the form of tacit knowledge, leading to indicators, such as knowledge transfer structure, initial knowledge base, type of effort that is required to acquire knowledge, knowledge transfer ratio plans, types of knowledge transfer streams, multi-actor collaborations approach to knowledge transfer. The BoP concept focuses on methods of fare structure and ticket fare affordability by pricing through zone distances. The modal shift concept focuses on the modal choice of the passengers as one of the forms of travel behaviour and the use of LRT as a mode to replace other modes

**Table 4: Operationalization Table**

| Concept | Variable | Sub-variables | Indicators |
|---|---|---|---|
| Frugality | Resources | Type of resources | • Stipulated time used during three phases of design, construction and operation<br>• Level of budgeted finance used as compared to available budget<br>• Level of Technical know-how acquired |
| Multi-actor Interactions | Type of interactions/nature of collaborations | ❖ Type of negotiations/ dialogues<br>➢ Level of involvement<br>✓ Type of roles played | ❖ Formal negotiations<br>❖ Stakeholder dialogues<br>➢ very active, active, slightly active or passive<br>✓ Coordinator providing rules for check and balances<br>✓ Financier based on concession<br>✓ Technical, Research and Development (R and D) or Expert organization, providing technical and innovative support for better decision making |
| Absorptive Capacity | Knowledge transfer | • Explicit and Tacit knowledge<br>• Structure and Type of capacity building | • Knowledge transfer Structure<br>• Initial knowledge base<br>• Type of effort to acquire knowledge<br>• Knowledge transfer ratio plans<br>• Types of knowledge transfer streams<br>• Types of approach to knowledge transfer |
| Provision for Bottom of Pyramid (BoP) passengers | ❖ Methods of fare structure<br>❖ Ticket fare affordability and pricing by zone distance | ❖ Zoning coverage system of 2, 4 and 6- ETB | ❖ Affordability of fare price per zone |
| Modal Shift | • Modal choice of LRT over other modes based on their needs | | • Use of LRT to replace other modes |

## 2.5 Methodology

The research strategy is a mixed method, using a single case study. These mixed methods used a qualitative approach which has a pilot and semi-structured interview, and a quantitative approach which used a survey method. The qualitative approach, provided instruments for researchers to study complex phenomena within their contexts, which can be used by professional practices and serves as evidence-based decision making in policy settings (Baxter and Jack, 2008). This research uses the 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 in Addis-Ababa.

The case studies provides a more robust understanding of the social characteristics of adoption of innovation (Lawrence and Tar, 2013), in infrastructure provision and outcome of events (Radcliff, 2013). In addition, in the case of public transport institutional analysis, variables are better analysed qualitatively, which needs in-depth methodologies (Altmann and Engberg, 2016), such as semi-structured interviews, providing deeper and more comprehensive data (Groves; Fowler Jr, et al., 2009), enabling the researcher to analyse the specific context of the study and to take into consideration the actors actions and interactions (Santander, 2013).

The case study was conducted using a two-step approach of (a) pilot interviews using open-ended questions as a pre-test, carried out in 2015 followed by (b) two rounds of in-depth interview using semi-structured questions, first round in 2015 and second round in 2017. The reason for doing a second round of interviews in 2017 was to capture the operational phase data, which is well enriched with more related concepts of the research, issues and experiences after two years of operation.

Both approaches had a total of twenty-two respondents, five pilot in-depth interviews in 2015, six semi-structured interviews in 2015 and eleven semi-structured interviews in 2017. The pilot provided a credible and sound research approach and interview protocol (Willis, 2005), in which the pilot confirmed which variables should be measured and if they were actually relevant to the study area, as the area of research is a relatively new study area. The analysis from the qualitative analysis gave descriptive statistics, categorizing of the various levels of data, generating a robust data set, deducing categories and patterns, using Atlas-TI software.

The quantitative approach entailed the use of a survey questionnaire for a total of 254 passengers. These 254 respondents comprised of passengers along the North-South (N-S) line and East-West (E-W) line. The sampling method used was the purposive sampling method it was selected because it was based on characteristics of the population of LRT passengers along the two available N-S and E-W lines in operation and the objectives of the study. The analysis from the quantitative approach produced descriptive statistics, using the Statistical Package for the Social Sciences (SPSS) software. The analysis from the qualitative approach included the coding of responses from the LRT experts to form reliable trends and validate responses based on the number of occurrences using the ATLAS-TI software.

## 2.6 Empirical results and discussion

This section presents the empirical results and their related discussions based on multi-actor interaction processes, absorptive capacity, which leads to frugality in light-rail transport. The section further includes reasons why absorptive capacity and multi-actor interaction processes leads to frugality. In addition, how the new light-rail caters for the BoP passengers and how it has led to some fraction of a modal shift to the LRT which have also been empirically highlighted.

### 2.6.1 Frugality in Light-Rail Transport

Frugality in Light-Rail Transport 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, et al., 2017). This research highlights it as a variable resource, because the type of resources varies according to several factors, while its indicators are categorized as the 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 Transport was achieved* are:

#### Frugality of Time Resources

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

*Design Phase Period*: This was 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 privately and publicly owned assets along the LRT routes.

*Construction Phase Period*: Multi-actors' interaction between ERC and other MNC's – CREC, SMG, SWEROAD and ITLAFERR, was facilitated by ERC to timely construct the components of the LRT. This was also managed using the stakeholder dialogue method, having some of the steering committee members involved at every main construction facet. This ensures that most of the contracts within the different phases were approved as quickly as possible, not exceeding any of the stipulated periods of construction.

*Operational 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 the operation and maintenance were handled by the Ethiopians between two-three years after operation. This saved Addis-Ababa city via ERC, a 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.

### 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 costs were avoided in extending the five years concession to the Chinese, via appropriate knowledge gap filling by the Ethiopians, who received technical training a few years before, during and after the operational phase of the LRT. In addition, significant component of training on future routes of LRT in Addis-Ababa will be done by the Ethiopians, saving costs of hiring fresh hands from abroad and reduced costs of salaries during the implementation of the proposed expansion of the LRT routes in Addis-Ababa.

### Frugality in Finance

Using the limited available finances, borrowed as loans from China, Addis-Ababa city controlled the use of this resource through efficient use, because of both frugality in human resources and time. Frugality in human resources and time ensured that frugality is achieved in finance, because it aided expenditure in a more prudent manner, avoiding the request for more loans, which may have be required if the time of completion had been delayed and inflation had set in, affecting Addis-Ababa's counterpart funding and costs for components of the rolling stock. Thus, they managed to save costs in the present and future implementation of the LRT in Addis-Ababa. As mentioned by a top director,

> *"We did not have any reason to spend more than we budgeted for. This is because all components of the LRT were 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, which is paid in our local currency".*

## 2.6.2 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, culture and methods of implementing infrastructural projects. During these negotiations and dialogues, some actors are more active than others, some serve more as coordinators providing rules for check and balances, financier based on concession, provision of technical expertise.

These negotiations and dialogues were achieved as ERC coordinated the city authority organizations and the MNCs, with limited trade-offs as much as possible, ensuring less cost increment as a result of certain trade-offs between the MNCs and city authority organizations, such as resettlement claims, 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 a stake-holder dialogue with the related city authorities on behalf of Ethiopian government and Chinese consortium, as a form of informal dialogue, because some of our requests are not legally mandatory, as the LRT route was not in the Addis-Ababa master plan. So, we seek their support to carry out certain activities, such as relocation of their buildings through demolition along LRT routes, relocation of water ways, electricity and telecommunication cables and land reallocations".*

Thus, by interacting with the MNCs and city organizations to minimize the cost effects of each trade-off could increase the stipulated budget and time spent on each construction stage, leading to a frugal approach during interactions with the multi-actors. The multi-actor interactions that took place within the LRT adaptation processes between the Addis-Ababa and Chinese counterparts, focused on their roles and responsibilities, types of negotiations during the design, construction and operation phases, Key Performance Indicators (KPI's), resource management (financial, time and human). These are:

### 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, et al., 2010).

The nature of collaborations in the Addis-Ababa LRT are *basically stakeholder-dialogue and formal negotiations*. The government intervenes when the Addis-Ababa city administration faced challenges with other stakeholders. For example, as mentioned by an Ethiopian LRT expert:

> *"Some members of the federal governing board are also part of the steering committee, which provides a faster facilitation of decisions, through quick approval of proposals by government and little rejection of proposals".*

As mentioned by another LRT expert:

> *"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, when the final decisions will be made on the proposals submitted for approval and funding by the government, it becomes easier and moves faster".*

This serves as a benefit of minimizing the level of bureaucracy and provides a better understanding by avoiding a top-down communication, through the engagement of related top government officials positioned from the bottom. Thus, a bottom-up approach was used, the decisions were informally and substantially taken and understood at the bottom, before it proceeded to the top for the formal negotiations and final approval, revealing a smoother process, saving time and fostering faster LRT implementation.

While the formal negotiations happened in the top-level steering committee meetings and board meetings, where formal issues were discussed, such as funding, project progress and the interactions between the city administration organizations, such as utility companies and the ministry of transport and the Chinese consortium. As reported by an ERC high-level engineer:

> *"At the top level, meetings between the LRT steering committee, federal government and Chinese consortium, mainly revolves around funding and justification of proposals".*

This combination of stakeholder dialogue and formal negotiations, explains that the stakeholder dialogue prepares the way for a "soft-landing" during the formal negotiation phases, as the release of funds to support a timely completion of the LRT was made easier and more achievable, because the representatives of the federal government at the steering committee stage would also support ERC in defending the technical and cost implications during the top and formal management meetings with the Ethiopian government for LRT project and budget

approvals, which was able to be achieved in a fast and time saving manner. This "soft-landing" through stakeholder dialogues provided a benefit by generating an atmosphere of trust and transparency amongst the two parties, which further promotes mutual bonding, which provides a benefit for measuring trade-offs for specific implementation action. For example, one of the top ERC engineers mentioned that:

"We argued with the Chinese that the plan of using two doors as exit and two doors as entry to the LRT will not work due to the very high population of users, which would cause chaos during entry and exit, and the Chinese listened to us and allowed all doors for entry and exit. In the future when the people get used to the LRT and when the electronic cards are reintroduced, we may now use the two doors for exit and two doors for entry method."

*70% of the 17 respondents during the second and third round semi-structured interviews from ERC supported the claim that their dialogue with other multi-actors could be considered more of a stakeholder dialogue than formal negotiations, in the following ways*:

The coordination by the Ethiopian government, was also categorized as formal. In this case the formality was executed through government coordination, represented by a three-man committee, namely: the mayor of Addis-Ababa city (chairman of committee), Addis-Ababa transport bureau and a representative of the Addis-Ababa light-rail technical committee. This three-man committee had a final say as a final approval at different phases of the LRT.

The nature of other aspects, which took place in the remaining major part of the period were stakeholder-dialogues. This remaining part was major, because it complemented the formal dialogue and made the implementation effective. The stakeholder dialogues sometimes took place in informal settings, such as one on one side meetings (lobbying), amongst some groups of stakeholders, trying to influence their top decision makers through pre-negotiations of the technical things that were required by ERC, and how the decision makers, including the three-man committee that could be influenced through justification of their needs for the LRT implementation. One of the directors mentioned;

> *"We sometimes needed to explain the technicalities involved in the project to these political members, because sometimes, they only visualize things from a political angle, neglecting the economic, social and environmental angles of benefits or trade-offs".*

Thus, the stakeholder dialogue was used as a benefit to develop a stronger trust at the initial level, during the design, construction and operation phase of the LRT project, before sealing the agreements at the next steps during the formal negotiations. The ERC also facilitated interactions with the utility providers. These

were the Addis-Ababa Water Company, Addis-Ababa Electricity Company, Addis-Ababa road authority, Addis-Ababa Telecommunications Company, local Information-Technology (IT) companies and city security institutions such as city police and other private security companies. Also, the Addis-Ababa city mayor, the steering committee representing the Ethiopian government on the LRT project, Addis-Ababa transport bureau, Addis-Ababa city planning department, Addis-Ababa city administration and the citizens.

The act of stakeholder-dialogue came into play, as the ERC always needed to approach specific utility providers or city organizations to negotiate mainly through stakeholder-dialogues. Thus, for example, some location of some utilities for water, electricity, and telecommunications underground needed to be relocated to other areas or slightly moved some distance, in order to accommodate some LRT underground cables at different stations or routes of the LRT. Also some government buildings, private houses and land needed to be demolished in order to accommodate the LRT route, while a times an overpass infrastructure was needed to be built to accommodate the LRT route, when it became too expensive or there was a strong disadvantage in demolishing the structures along the way, as the new LRT was not in the Addis-Ababa master plan from inception, but was integrated into the plan afterwards over the last decade. This further led to the re-adjustments of certain areas within the city, to accommodate the LRT, such as constructing some of the LRT routes in the middle of the roads, the necessity to build over-passes and underpasses (tunnel), ticket shops at every LRT stop of about 1.5 - 2 minutes interval, creating U-turns for passengers and vehicles at further junctions as a right of way for the LRT, creating zebra-crossings as a right of way for the passengers, etc.

The ERC reported every quarter to the ministry of transport and received policy directions and critical decisions, in order to facilitate with other ministries, on issues such as right of way on the roads between the pedestrians, cars and the LRT, which had been a main issue that was given adequate support for safety, planning, law and order reasons.

In order to minimize risks and costs during the operational phase, as ERC had inadequate local capacity to handle the operations, the contract for the network operations was given to a consortium of CREC and Shenzhen metro company who were both from China. This implies that the concession type of Build-Operate-Transfer (BOT), was done with the building by CREC and operation by the two Chinese consortiums. In this manner, the Chinese consortiums would saddle any cost responsibility from a component failure or revenue shortage from a component during construction (building) or operation.

Stakeholder dialogue is used first, which was followed by the formal negotiations, especially when they were unable to reach a final agreement.

Levels of Involvement and Type of Roles Stakeholder dialogue is used first, which was followed by the formal negotiations, especially when they were unable to reach a final agreement.

### Levels of Involvement and Type of Roles

Levels of involvement were categorized in the surveys as; very active, active, slightly active or passive. The Addis-Ababa city administration, ERC and Chinese consortium were very active multi-actors. The reason was because the LRT was implemented inside the Addis-Ababa city, thereby needing to play a very active role of interacting with all of the cities multi-actors, such as the utility companies, the water and electricity utility companies, the Addis-Ababa road authority, the ministry of transport, the city security companies, etc. All these city multi-actors needed to interact with ERC on behalf of the federal government.

While the ERC also performed the role of an intermediary between the city multi-actors and the Chinese consortium, as the Chinese consortium was a client of ERC and needed the ERC to facilitate several issues, such as right of way, security matters, settlement demolition and resettlements, utility relocations, etc.

The federal government mainly played an active role, by financing the LRT counterpart funding and seeking for loans from the EXIM bank as a guarantor for the country. The government also played the role of providing rules to check and balances, especially from the Chinese consortium, such as fare regulation to avoid over charging the LRT commuters, quality control of the rolling stock that was provided and adherence to key performance indicators, such as knowledge transfer. In addition, the government also had the role of mediator, especially when there were any disputes among the multi-actors. Other multi-actors that played major active roles were the consultants that were hired by the ERC, such as the Italferr, a MNC from Italy and SweRoad, a MNC from Sweden. However, these MNCs participation was only for a limited period during the design and implementation phases only. Thus, no actor was ever considered to be lightly active or passive, as the interactions mainly revolved around the multi-actors that have been mentioned, of which some were classified as having a very active or active level.

## 2.6.3 Absorptive capacity

The ERC had a lower maintenance capacity to maintain the LRT infrastructure, due to the sophistication (complexity) of the LRT system. Therefore, there was a strong presence of knowledge transfer in the contract agreement between the ERC, CREC and Shenzhen metro, as this was incorporated from the start of the LRT project and it was categorized as one of the main Key Performance Indicators. Thus, the transfer of knowledge varied, depending on how the LRT receiving organization organized its tacit knowledge to assimilate and effectively use the explicit knowledge, they used various capacity building structures. These are shown 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 took place mostly between the ERC directors/mid-low experts and the Chinese consortium experts. The technical knowledge was 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 was also based on tacit knowledge, practiced by the LRT receiving organization, as knowledge profoundly embedded in the human body that it is difficult to codify and communicate. An example of tacit knowledge in Addis-Ababa was mentioned by one of the officials, he said:

> *"Sometimes, I have to reject some of the proposals made by the Chinese consortium, on the basis that I need more explanation, in order to know more reasons and acquire the knowledge behind the technical proposal, on why the Chinese designed or plan to implement some aspects of the LRT".*

This in turn enabled 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 taking over of the LRT driving from the Chinese within just six months after the start of operation, this was a result of continuous observation, face to face apprentice training, imitation and practice**.**

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

### 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 was expected to be in the ratio of Ethiopians 30% and Chines 70%. Meaning that the transferred knowledge was intended to be a bit above one quarter of the proposed total knowledge, expected to be transferred as one of the main key performance indicators.

Second year - Ethiopians 40%: Chines 60%: This ratio means that 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 year from 70% to 60%.

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

Fourth – Fifth year - Ethiopians 100%: By the $4^{th}$-$5^{th}$ year, it was expected that the knowledge transfer should be completed the whole 100% to the Ethiopians.

The progress from October 2015 was actualized as the knowledge transfer in 2017 was 296 personnel were Ethiopians and 117 Chinese. Human power improved after one year with good inputs, example in 2017, 100% Ethiopian LRT drivers were already driving the LRT, 100% of the operations control center was 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 were still building more capacity, aiming to reach the 100% by the 5$^{th}$ year.

### Medium- and Long-Term Training

Training 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, some staff were sent to China, parts of Europe and some trained locally and on the job during the construction and operational phase. However, 70% out of this 600 ERC were trained outside of Ethiopia before the commencement of the LRT project and the Chinese at times only need to fill in the gap where the ERC staff trainee fell short. Thus, the local staff already has some level of training before the Chinese counterpart arrived. An example of this was out of 600 Ethiopian personnel, 20 people were trained in China on signaling components. Some of the technicians and engineers that needed retraining were retrained in the short term.

### Nineteen (19) Mainstreams and Certifiable Positions in Operations and Maintenance

The knowledge transfer was divided into different components of trainings, which were embedded at all stages all stages of the process with a specific number of trainees. Such as: control centre, information dispatcher, power dispatcher, operation dispatcher, these were from the operational aspect. There were also maintenance aspects, 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.

### 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 had an Ethiopian manager working side by side as the local manager. In this way, the Ethiopians were able to learn on the job quickly, by working alongside the Chinese to see what needed to be done daily, ask questions and get clarity of understanding and purpose.

### 2.6.4 Reasons Why Multi-Actor Interactions and Absorptive Capacity Contributes to Frugality in Light-Rail Transport

The main stakeholder dialogues were about occasional formal negotiations by multi-actors and the use of absorptive capacity contributes to frugality in light-rail transport. This was because, the theory of frugality in decision-making theory 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 (Gigerenzer, 2008, Gigerenzer and Todd, 1999).

In addition, proactive steps of imitation and learning were used to adapt to context challenges in Addis-Ababa via demonstrated capacity to adapt. There was also 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 operational and maintenance activities within a stipulated time.

From the same perspective, frugality in Light-Rail Transport 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 gave the local authorities a competitive advantage because they regularly possess tacit knowledge about the particular local conditions, needs and local desires (Leliveld and Knorringa, 2018). This was realized from the use of tacit knowledge by the LRT receiving corporation – ERC in Addis-Ababa city, within unique and local contexts. An approach by MNCs included in designing, constructing, marketing or operating frugal innovations was consequently to involve local innovators and entrepreneurs in polycentric innovation and business networks, so that they were able to benefit from this valuable knowledge (Leliveld and Knorringa, 2018).

### 2.6.5 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 BoP through the provision of an affordable ticket fare price and structure. This fare structure that was provided by the multi-actors for the passengers was a zoning system of 2, 4 and 6 Ethiopian Birr ETB[3]. The two ETB fare was for short distances, passengers travelling within a certain short zone or few LRT stops. Four ETB fare was for intermediate distance travelled. Six ETB fare was for long and end-to-end distance travelled. *The multi-actors used the competition based method* (Kozlak, 2007, Rokicki, 2014), where the price is determined and reduced on the basis of price

[3] (ETB) Ethiopian Birr - Ethiopian national currency, with an equivalence present rate of 29 ETB to 1 USD (dollar) (December 2019)

analysis of competing services, such as competing private bus and taxi operators, and public bus operators (Kozlak, 2007, Rokicki, 2014. This was used as a benefit because it supports the provision of more affordable transport fare to the BoP, as compared to other main public transport modes, for the low-income earners to easily migrate to the LRT, which has a lower price than its competitors (Pansera and Owen, 2015). 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 on affordable ticket pricing in general to 87.7%, *thus fulfilling the target for the low-income passengers at the BoP, to increase accessibility and foster inclusion*.

The household survey of urban transport study in 2004/2005, revealed that the average house hold size of Addis-Ababa is 5.08 of an average age range from 18-40 years, and income level is low with an average household monthly income of 725 ETB (Abreha, 2007). Assuming a 15% inflation rate in the last decade, *the present average household monthly income can be approximated as 870 ETB*. Almost 50% of the population live below the poverty line, i.e., less than 500 ETB per household per month, and approximately 23% are in total poverty, i.e., less than 300 ETB per household per month (Abreha, 2007). Based on the occupation type of the 254 passengers surveyed, 62% of these passengers belonged to the *bottom of the pyramid as low income earners, earning between less than 300 to 550 ETB*. They were petty traders, street hawkers, shoe repairers, roadside traders, and the unemployed.

In addition, 85% of these 254 passengers do not use private cars as one of their modes of transport, as deduced from their modal combinations. While the remaining 38% of passenger's occupation status showed that they belonged mostly to the middle-income earners and few passengers were upper income earners. Most of the upper income earners still prefer to use their private cars and are not yet willing to change modes of transport.

In the survey the most popular middle-class categories were 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 part of BoP passengers to change their modal choice of transport from other public transport modes to Light-Rail Transport. This is partly due to the fact that the LRT has fare rates which are slightly more affordable than the white and blue minibus taxis, alliance buses and higher midi-buses, which have 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 were more affordable than the salon taxis, which cost at least triple the price of the LRT, depending on the distance covered, and

were usually patronized by the mid and high-income earners. The LRT is slightly less affordable than the Anbessa city buses which were 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 proximity to the LRT, have a better choice of shifting to the LRT, which has better safety, reliability, comfort, and cheaper fares except with the Anbessa city buses. This modal shift has been proven during the high peak-hour rate patronage of LRT per day in Addis-Ababa. The LRT has also provided an alternative to the use of taxis and other bus types by the middle- and high-income passengers.

### 2.6.6 Effects of New Light-Rail Transport as a Modal Shift from other Motorized Modes to LRT

An important change to the city due to 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 had a passenger capacity of 30 sitting and 70 standing, 10,000 white and blue minibus taxis with passenger capacity of 12 sitting, alliance buses with a passenger capacity for 40 sitting and 60 standing, 460 higher midi-buses sitting 22-27 passengers, 366 additional vehicles and 6500 salon taxis sitting 4 passengers (Fenta, 2014). Anbessa city buses were the most patronized mode of transport by the BoP, because it is the cheapest compared to other modes of transport. The Anbessa city buses were also characterized by 730,500 passengers per day with 100 passengers per trip, through 93 routes, average total of 6,352 daily trips, with the shortest route being 6.8 Km, the longest route is 47.2 Km and the total route length of 1207 Km (Abreha, 2007).

The total length of the LRT is 34.25 Km, which is currently sub divided into two lines within 41 stations, namely North-South (NS) line - 16.9 Km and East -West (EW) line - 17.35 Km, with a capacity of 80,000 passenger/hour (PPH), with a cost of 2, 4 and 6 ETB for short, average and long distance respectively per NS or EW line trip (Jemere, 2012). An East-West line runs from Ayat village via Megenagna, Legehar and Mexico Square to Torhailoch, and a north-south line links Menelik square, Merkato, Lideta, Legehar, Meskel Square, Gotera and Kaliti. The two lines share a section of track in the city centre. The network is designed to carry 15,000 passengers per hour per direction (PPHPD) and 115,000-153,000 passengers per day (PP/PD). The LRT has a maximum service speed of 80 Km/h, 286 passenger carrying capacity, headway time of 6 minutes, but presently experiencing 10 -15 minutes headway time, working between 16-18 hours per day (Jemere, 2012).

Considering the 153,000 passengers that currently use the LRT to the closest mass 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,

as an addition to the existing 41 LRT vehicles, to accommodate the high travel demand for the LRT and transportation needs of the over 4 million Addis-Ababa population (WPR, 2019). 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 had ever expected, and most of the day could be considered 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 into the city's air annually, which is two to six times higher than World Health Organization standards (Benjaminson; Shankute, et al., 2012).

## 2.7 Conclusion

The conclusion chapter shows how the combination of multi-actor interactions and absorptive capacity has delivered frugality in light-rail transport, and its effect on the BoP as an affordable transport fare than most of the existing modes of transport. What the possible added values could be for the benefit of future scientific studies have also been mentioned. In addition, it provides recommendations to decision makers on how to meet the demands of most of the BoP through vertical equity service for low income group targets.

### 2.7.1 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 the 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.

Processes relate to how ERC as the main actor interacts with other multi-actors. They mainly communicated via the stakeholder dialogue and some formal negotiations to interact between the Addis-Ababa city authorities and MNCs. The stakeholder dialogues led as the main type of multi-actor interaction, while the formal negotiation followed and provided the benefit of complimenting the stakeholder dialogues, especially when the stakeholder dialogues reached a standstill, formal negotiations were used to settle conflicts during interactions.

The stakeholder dialogues also provided 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 structures and multi-actor interaction processes, amongst ERC, MNCs and Addis-Ababa city authorities, to a large extent, enabled them to deliver frugality in Light-Rail Transport during the implementation phase, despite inadequate country owned financial resources, less technological and knowledge capability of LRT and the limited period of time resource of three years.

Thereby addressing the research question, to a large extent with the main use of structured absorptive capacity and stakeholder dialogue processes during multi-actor interactions, managed to deliver frugality regarding finance and human and time resources in the development of the Addis-Ababa Light-Rail Transport. As the frugal approach during the interactions was able to implement the LRT, within the stipulated budget, planned time of three years and managed the human resources that were available through strategies of appropriate absorptive capacity from knowledge transfer.

In addition, the multi-actor interactions produced a fare structure, which provided a more affordable transport fare for the BoP passengers than most of the other modes of transport, providing them with an inclusive leverage to use the LRT, as a cheaper, safer and more comfortable form of public transport, compared to the other available public transport modes in Addis-Ababa. 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 Transport and a zero-carbon emission transport system.

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, et al., 2011). The theory of frugality in finance, human and time resource management during multi-actor interactions, will be useful to further study how other emerging economies harness their limited resources to implement large infrastructural projects like roads, water ways and national railways 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 a LRT system, will be useful to further study different structures of knowledge transfer in different cities in transition. This will provide the understanding on how effective they are and reasons behind each structure, in order to see how some structures can be harnessed to better suit their socio-economic conditions and institutional contexts within cities.

Policy makers can make use of vertical equity services to target economic equity of the poor (BoP) and non-poor (Geurs and Ritsema van Eck, 2001),. This is to foster the inclusion of less mobile people or economically disadvantaged groups for improved mobility. Such as incorporating special fare structures as a subsidy for BoP passengers, old age pensioners, disabled people and students to reduce financial exclusion and provide strict measures in the occupation of disabled seating areas that are provided in the LRT, as the physically challenged cannot struggle for space with able bodied passengers in the LRT.

# Chapter 3: A Sustainable Approach to Innovation Adoption in Light-Rail Transport [4]

[4]A Sustainable Approach to Innovation Adoption in Light-Rail Transport. Taslim Alade, Jurian Edelenbos, Alberto Gianoli. Article published 10th February 2020, in the Journal of Sustainability. Section: Sustainable Transportation. https://doi.org/10.3390/su12031262.

## 3.1 Abstract

This article primarily aims to understand how the Light-Rail Transport (LRT) pricing and infrastructural innovations from a Chinese context have been adopted to the Addis-Ababa city context. Secondly, it wishes to show what were the economic, social, and environmental effects of these adapted innovations on passenger service delivery and Multi-National Corporations (MNCs), and what effects the resident's proximity had on commercial activities along the LRT route. Thirdly, it identified re-adaptations to a more sustainable LRT with respect to the passengers, MNCs, and residents. This study has revealed economic, social, and environmental effects that may influence innovation adoption, such as the following: reduction in carbon emissions; fare evasion; inconvenience; affordability; less revenue; less proximity to commercial activities; and an increase in travel distances for pedestrians. A mixed method for a single case study was used, including semi-structured interviews with light-rail experts and a passenger survey. The results show that economic sustainability factors account for 12 out of 14 sustainability factors and 2 out of 14 social and environmental sustainability factors. The results are intended to be used as a decision support system for innovation adoption in other cities with similar context, in order to develop a sustainable approach to LRT planning. View Full-Text

*Keywords*: sustainable transport; sustainability factors; pricing-innovation; infrastructural-innovation; innovation-adoption; contextualization; light-rail

## 3.2 Introduction

The provision of large-scale Light-Rail Transport (LRT) infrastructure that has been deprived of an adequate sustainability assessment may result in challenges that lead to high costs and undesirable socio-economic and environmental effects for the light-rail provider and users, especially for cities transitioning to LRT. Integration of sustainable development into local, state, and national development plans is very important and should be taken seriously when making the plans. In the past twenty years, there have been substantial changes in the provision of infrastructure facilities globally. The World Bank, governments of developing countries, and various donor agencies have been dissatisfied with the sustainability of their investments in public-sector infrastructure, especially during the 1980s and 1990s. These actors were all concerned that their investments were not having a lasting effect of the transport services, quality, and degree of usefulness that was initially anticipated, and they were also not in accordance with standards (Kenny, 2007).

The LRT system usually functions in urban surroundings and uses a rail-based technology to provide public transport. Vehicles are typically lightweight, move on steel rails, and are either driven by electricity (Marko; Soskolne, et al., 2004) or use

diesel as fuel. Addis-Ababa Light-Rail Transport is a sort of modern-day tram that has a reserved or segregated right of way on street segments and traffic lights (Topp, 1999). In the Addis-Ababa LRT case study that was carried out it was assumed that China replicated some of their innovations from the LRT in China to Addis Ababa since they are the custodians of the implementation and a major financier of the light rail system in Addis-Ababa (Alade; Edelenbos, et al., 2019a).

The following points can be made about the Addis Ababa LRT:

- Is an electrified light rail transit
- There are currently 41 stations
- There is a double track for the whole route which has a standard gauge of 1.435 m
- It is sub divided into two lines, namely North-South line—16.9 km and the East-West line—17.35 km, as seen in photographs 1 and 2
- It has a total length of 34.25 km
- The two lines share a 2.7 km section of the track in the city centre
- It operates between 16–18 h per day (Jemere, 2012)
- It has a targeted headway time of 6 min, but is currently only able to deliver 10 min due to the limited amount of LRT vehicles
- Every LRT has a maximum service speed of 80 km/h and an average operational speed of 65 km/h
- The network is designed to carry 15,000 passengers per hour per direction (PPHPD) (Jemere, 2012)
- It has a 286-passenger carrying capacity
- It has a capacity of 80,000 passengers/h (PPH)
- The network is designed to carry a maximum of 115,000–120,000 people per day (PP/PD)

**Photograph 1: Line-2 Menillik II Square-Kality (N-S Line)**

**Photograph 2: Line-1 Torhailoch to Ayat (E-W line)**

Sustainable development as explained in the United Nations World Commission on Environment and Development, acknowledged the Brundtland Commission

(1987): "is the development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Jeon and Amekudzi, 2005). The main aim of sustainable transport is to move goods and people, while at the same time contributing to realizing economic, social, and environmental sustainability (WHO, 2004). Sustainable transportation goals include the delivery of efficient, effective, and safe access to transportation in the future while also taking into consideration social, environmental, and economic aspects (Ramani; Zietsman, et al., 2009). The European Union's strategy for sustainable development defines sustainability with respect to transport as: "The ability to meet the needs of society to move freely, gain access, trade, establish relationships, and communicate without sacrificing other essential human or ecological values today or in the future" (Bojković; Macura, et al., 2011). Transportation system sustainability can also be defined as the results of the effects of the system on the social well-being, environment, and economy, which is measured by a system's efficiency and effectiveness (Jeon and Amekudzi, 2005).

The French Internal Transport Law (LOTI) necessitates that when cities are involved in major urban transport infrastructure systems which have used public funds, they assess the plans using criteria that confirm the socio-economic proficiency of the infrastructural assets. These assessments are implemented before and after the developments from a socio-economic perspective (Gleave, 2005). Evaluations therefore need to be provided in a structure that guides policymakers to pinpoint the main reasons that are used to assess their decisions. These factors highlight risks, uncertainties, and trade-offs in particular (Poutchy-Tixier; Bina, et al., 2004). The European Union (EU) urban transport has revealed that 15% of all greenhouse gas emissions, 80% of congestion costs, 20,000 road fatalities per annum, and upwards of 100,000 untimely deaths are caused yearly from air pollution (May; Page, et al., 2008). There is enough evidence that European urban transport strategies are presently not close to being sustainable, but there are laudable projects, such as bike and car sharing, and provision of more public transport using renewable energy, which will gradually close these sustainability gaps (Alade, 2013).

In several cities, urban rail transportation developments such as the metro, tram, and light rail systems have over the decades shown that they are the ideal key in providing sustainable mobility for the growing urban inhabitants. These forms of transport also provide additional advantages such as: high carrying capacities, shortened travel time, comfort, and more safety and reliability compared to other forms of transport. Rail systems are known to be very large projects that require high capital investments, particularly in the building of infrastructure and maintenance expenses. Excluding the economic profits, the environmental and social development benefits are also derived from rail system ventures (Cascajo, 2004). Therefore, the primary aim of this research was to identify how pricing and

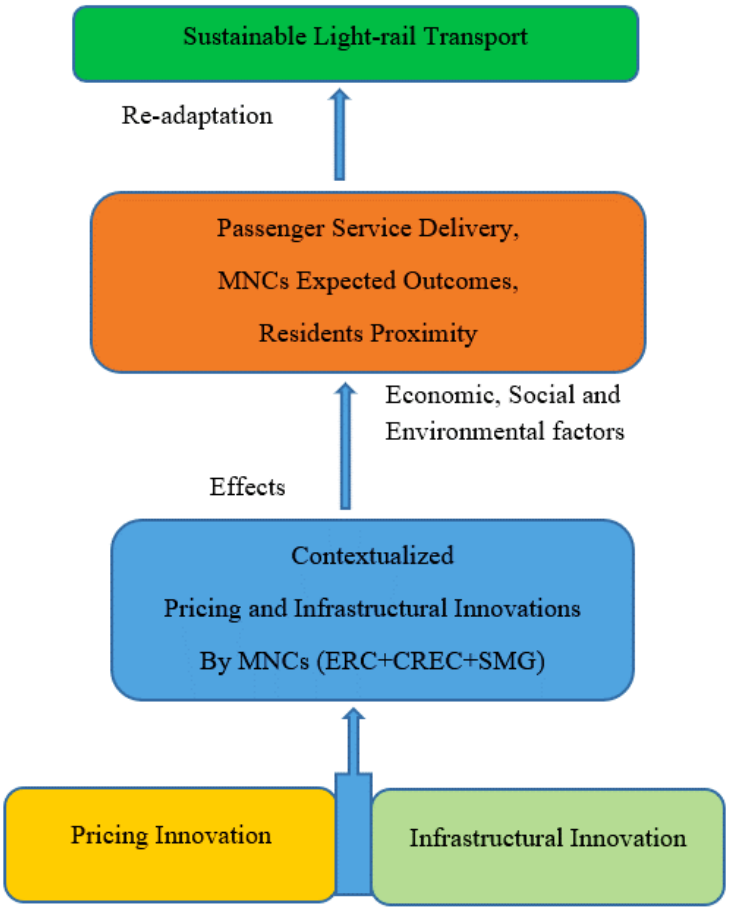
infrastructural innovations of a Light-Rail Transport (LRT) from a Chinese context was able to be successfully transferred to the Addis-Ababa city context. Secondly, the research aimed to reveal the economic, social, and environmental effects of these adapted innovations on passenger service delivery, what the Multi-National Corporations (MNCs) expected outcomes were, and what effect the resident proximity had while living and doing business along the LRT routes? Thirdly, it investigated what the identified re-adaptations to a more sustainable LRT might be with respect to passengers, MNCs, and residents.

This paper has been divided into the following sections; Section 1 is the introduction, Section 2 explains the theoretical framework, Section 3 is the methodology, Section 4 provides the empirical results and discussions, and Section 5 presents a conclusion.

## 3.3 Theoretical framework

In this section, as shown in Figure 4, the conceptual model describes the pricing and infrastructural innovation, and how they are both contextualized. In addition, the effects of economic, social, and environmental factors from the contextualized pricing and infrastructural innovations have been described. These effects are concerned with the passenger service delivery, Multi-National Corporations (MNCs) expected outcomes from the China Railway Engineering Corporation (CREC), Shenzhen Metro Group (SMG), Ethiopian Railway Corporation (ERC), and what effect the resident's proximity had while living and doing business along the LRT route. Furthermore, re-adaptations have been proposed, with ideas to provide a more sustainable light-rail transport that considers the social, economic, and environmental factors.

**Figure 4: Sustainable approach process by MNCs regarding pricing and infrastructural innovations to deliver LRT to passengers and provide MNCs with tangible expected outcomes**




Source: Authors (2020)

In the theoretical framework of Figure 4, sustainable Light-Rail Transport is the dependent variable, as it depends on the economic, social, and environmental factors in passenger service delivery, MNCs expected outcomes, and resident proximity. Pricing innovation, such as expected cash return for the MNCs, is dependent on economic factors after using a contextualized pricing system and effective use of electronic cards. Passenger service delivery is from infrastructural innovation. Infrastructure is needed at LRT stations, which need to be contextualized in order to suit the land space that is available, pedestrian needs, connectivity to other public modes of transport, spatial proximity to the stations by passengers, etc. (Alade; Edelenbos, et al., 2019a). Furthermore, the proximity of the residents along the LRT routes originates from the presence or absence of some LRT support infrastructure, such as the demarcation structures between the roads and the LRT routes.

Pricing innovation is a pricing system innovation that is designed by a transport associated corporation to provide transport services to passengers, and can be characterized into pricing, fare structure, ticket, taxes, and parking pricing (Hyard, 2014). This research focuses on components of the ticketing system and fare structure. This was chosen because they were the two notable aspects in the Addis-Ababa case study in the first two years of starting the LRT in Addis Ababa. Pricing innovations are comprised of the facilities which were supplied for the sale of fare tickets to the LRT passengers, such as ticket machines in LRT stations, sales personnel on the LRT vehicles, or outside of the LRT vehicles, such as ticket shops; ticket validation facilities on the platforms or inside the vehicles; types of fare structures according to zones, distance, or a flat rate for the whole distance.

The pricing innovation in the Addis-Ababa example was characterized into the devices or the places used in acquiring the tickets; the place where the ticket was validated before accessing the light-rail, at the entrance of the light-rail, or during the trip and the fare structure for passenger service delivery. The price is defined as the sum of money that a buyer or user must pay for a service or product (Kotler, 1999). Pricing refers to the delivery of a service to the passengers based on the value customers perceive to have been acquired from the product and what they are prepared to pay for it. Therefore, a suitable ticket price, regarding the service provided, can motivate the use of light rail based on some derived benefits, such as journey time and perceived value of time savings (Agajare; Marinov, et al., 2014). The pricing strategy is one of the most important fundamental concepts to the achievement of a sustainable LRT system. According to Piercy; Cravens, et al. (2010), pricing should be altered from being a simple planned tool into being a strategic tool. This is because it can alter a customer's actions and provide innovative market opportunities. Therefore, it should be acknowledged as an influential tool to promote user satisfaction and the firm's viability (Jarocka and Ryciuk, 2016), which provides diverse and viable choices of pricing systems for the benefit of both the LRT operators and passengers.

In economic theory, there are three methods of calculating prices, which may be applied to transport services (Kozlak, 2007, Rokicki, 2014).

Costs method: The price includes the unit costs incurred by the company to provide services, as a price margin. This method is usually used.

Demand method: This is based on determining the price as an existing or anticipated demand.

Method based on competition: This is the approach where the price is determined based on price investigation of contending services, such as competitors like public bus operators, Bus Rapid Transit (BRT), taxi, and private bus operators. The LRT in Addis-Ababa used this method.

Infrastructure innovation is comprised of support for infrastructure, provides structures essential to support a passengers use of public transport, such as pedestrian accessibility infrastructure, park and ride, information provision for passengers, and public transport measures (priority and increased frequency) (Hyard, 2014), thereby advancing the level of usage of the LRT public transport system. Infrastructure innovation is introduced to benefit the safe movement of passengers, provide a high travel demand, real-time trip information to passengers, better accessibility and proximity to LRT platforms, reduce congestion and encourage modal change from private to public transport, such as the use of park-and-ride facilities (Alade; Edelenbos, et al., 2019a).

### 3.3.1 Sustainability in Light-Rail Transport

Sustainable transportation can be considered as an expression and demonstration of sustainable development in the transportation sector. Therefore, there is a need to integrate sustainable transportation concerns into the activities of transportation agencies. It is important to develop methodologies that will address and evaluate sustainable transportation within the regular transportation-planning paradigm. It must be noted that planning for trade-offs in inter-generational equity has been known to be very challenging in developing countries where sustainability is an uphill task (Zegras, 2006). Sustainability can promote local economic growth and reduce air pollutant emissions through a modal shift from other motorized transport to the LRT. The social, economic and environmental effects can be deduced from their impact on the passengers, MNCs, citizens along the light-rail corridor, and the city.

Socially, sustainable urban transportation can be defined as transportation that provides adequate access to transport that minimizes social exclusion and improves or does not reduce an individual's quality of life (Litman and Brenman, 2012). The three aspects of social sustainability research are comprised of: social equity, quality of life, and social exclusion, with a common chord being the fair distribution of society's benefits and challenges. Exclusion is the effect of spatial, temporal, financial, or personal challenges and quality of life, which can be measured subjectively. It is a multidimensional construct measuring the ability to seek happiness and fulfil needs, while equity means the fairness of allocating resources based on need, which can be varied in compliance with the total system's efficiency.

To be economically sustainable means to have the ability of transport investment to advance economic growth at both the local and regional levels. The major transport benefit has been identified as travel-time savings, other benefits including employment generation and income for the government (Alade, 2013). It is important for all concerned to provide a realistic measurement of these benefits (Banister and Berechman, 2001). How infrastructural investments can advance economic development is a vital question that decision makers are striving to

answer in a logical manner. Transport improvements are also intended to create better economic mechanisms within broader urban active clusters, and these are related to spatial agglomeration gains and are connected to innovation and monetary benefits of new knowledge (Lakshmanan, 2011).

The economic aspects of sustainable assessment in transportation are very crucial as they provide an enabling environment for investments to meet their profit margins, enabling them to maintain the systems. The concept of cost benefit analysis and multicriteria analysis is very useful in this respect, which also consequently determines the extent of funding instruments such as user-cost financing, public-private partnerships, and taxes (Barrella, 2012). A conservation ethic might increase energy prices, which can be through a carbon tax, while implementing programs to weatherize buildings, increase vehicle fuel efficiency, improve alternative modes of energy, and increase industrial efficiency so that manufacturers and consumers can meet their needs with less resource consumption (Chapman, 2007).

Environmental sustainability impacts of transport are geared towards attaining a reduction in local atmospheric pollution, global warming, negative impact on plants and animals, impact of solid waste disposal on the environment, etc. Over the years this has given rise to developments such as technology for more efficient solid waste disposal methods to reduce the solid waste disposal effects and use of alternative fuel to decrease the dependence on non-renewable resources, and to also reduce pollution from the use of fossil fuels (Alade, 2013). In order to reduce CO2 emissions from road transport, an initiative of a significant modal shift in public transport is required. Trains and buses provide the obvious solution. This initiative also facilitates state policies such as a greenhouse gas budget (Barrella, 2012). Therefore, offering sustainable transport choices, at a local level is important, as short-distance, local trips are where the biggest opportunities for people to change the way they travel can be found, as two out of three journeys are under five miles. Light rail schemes in operation have contributed to the removal of car trips from overcrowded roads which have led to the reduction in the amount of pollution caused by car exhaust fumes (Barrella, 2012).

### 3.3.2 Relationships between Contextualized Pricing and Infrastructural Innovations: *Effects of Economic, Social, and Environmental Factors on Passenger Service Delivery, Residents, and MNCs; and Sustainable LRT*

LRT was brought to Addis-Ababa city from China by CREC and SMG (Two Chinese corporations) in cooperation with the Ethiopian Railway Corporation (ERC), jointly they were able to design, construct and operate the Addis Ababa LRT. As the Addis-Ababa context is very different from any city in China, there is

a need to contextualize the pricing and infrastructural innovations that have taken place in order to design, construct, and operate the Ethiopian LRT. Pricing innovations, such as methods of ticket provision, validation, and fare structures were contextualized and modified where necessary to suit the Addis-Ababa city case. In addition, the infrastructural innovations such as type, style, and positioning of provided infrastructure were contextualized, modifying different areas of the infrastructure to suit Addis-Ababa.

After contextualization, the following points were analysed: economic, social, and environmental effects; how the passenger services were delivered for sustainable use; whether the MNCs expected outcomes were met; and what the effect was on the residents and business owners along the LRT. These sustainability factors as effects of the contextualized innovations are further discussed within the results section.

## 3.4 Methodology

In this section, the single case and mixed method of qualitative and quantitative research approaches employed is explained. The sampling methods, sample size, and different respondent groups are also fully described.

### *Research Strategy*

This research employed a mixed method of qualitative and quantitative approaches in a single case study of Addis-Ababa city (Baxter and Jack, 2008). The qualitative method entailed a two-step approach of (a) pilot interviews (Willis, 2005), using open-ended questions as a pre-test, carried out in 2015 followed by (b) two rounds of in-depth interviews using semi-structured questions. The goal of the pre-test was to guarantee that the types of instruments that would be used in the main test sufficiently communicated the anticipated research questions, values, reported facts, and behaviour's (Willis, 2005). Thus, the pilot interviews were able to provide a credible and sound research approach and interview protocol in which the pilot survey confirmed whether the variables that were measured existed in the study area, as the area of research was relatively new. This made it possible to streamline the related semi-structured questions from the pilot survey into more specific semi-structured questions during the first and second round interviews.

The first round of interviews took place in 2015, while the second round took place in 2017, both with a total of twenty-two respondents. The second round of interviews was necessary in order to collect data from the operational phase to be able to compare the responses over time. As there was a difference of almost two years between the first and second round of interviews which gave the experts about 24 months of experience with the operation of the LRT, in turn it would provide more comprehensive data on how the infrastructures and pricing systems had been adopted or changed within two years. Five respondents took part in the pilot

interviews in 2015, six during the semi-structured interviews in 2015 and eleven during the second round of semi-structured interviews in 2017. The research initially targeted double the executed sample size but was constrained due to the limited number of Ethiopian and Chinese LRT experts that were available to provide the specific and required feedback, i.e., targeting experts who were knowledgeable enough on how the cities were able to adapt the LRT. As one of the Ethiopian LRT top experts mentioned, "It has been commented by fellow workers that we are limited on the knowledge know-how, and lots of things are yet to be known".

Using case studies provided a more robust understanding of the social characteristics of adoption of innovation in infrastructure provision (Lawrence and Tar, 2013). This approach to research was applied to real-life settings, which also focused on studies with small units and large variables (Davenport and Prusak, 1998, Fennell and Warnecke, 1988). According to Altmann and Engberg (2016), in public transport institutional analysis, variables are better analysed qualitatively, which needs in-depth methodologies, such as semi-structured interviews which provides deeper and more comprehensive data, depending on the specific context of study. It makes the data that is collected more comprehensive, because it is obtained by collection of respondents' opinions, using various sources and concepts related to actors, their related groups, and their interactions are taken into consideration (Khan, 2014).

The quantitative approach entailed the use of survey questionnaires for a total of 254 passengers. These 254 respondents were comprised of passengers along the North-South (N-S) line—16.9 km and the East-West (E-W) line—17.35 km. The surveys were carried out during transit and finally resulted in almost an equal balance of respondents along the N-S and E-W lines, with a percentage ratio of 48% to 52%, respectively. In addition, the quantitative approach first began with a qualitative approach, using a focus group discussion method with 6 respondents to discuss questions which were proposed to be in the survey in order to get feedback on the real situation on the ground, which was essential in testing and re-structuring the final survey questionnaire for LRT passengers in Addis-Ababa. The pilot interviews and focus group discussions further establish the validity and reliability of the research instruments.

The 6 focus group respondents comprised of two students, two civil servants, one entrepreneur, and one technician in a female-to-male ratio of 2:4. These selected respondents used the LRT an average of 4 times per week. To calculate the sample size and a confidence interval, the Addis-Ababa population statistics of 2015 was used on 4,216,000 people. Therefore, using a confidence level of 95% and confidence interval of 6, the sample size needed was 267 users of the LRT, as deduced from the confidence interval and sample size calculator to be within the

required figure from the total population. However, due to some non-response surveys, eventually 254 were completely administered in total. The non-response surveys accounted for a difference of 13, which is not significant enough to influence the total number of 254 respondents surveyed. Thus, the total sample size used was adequate and justified enough to generate reliable results.

The sampling method that was used was a purposive sampling method which was selected because it was based on characteristics of the population, i.e., LRT experts and LRT passengers, and it also considered the objective of study. The processes of LRT adoption and actions involving many individuals within the light-rail organizations—ERC, CREC, and Shenzhen Metro were a basis for the interviews.

In the qualitative approach, the coverage method entailed the coverage population, which included the Ethiopians (Addis-Ababa LRT experts working with ERC) and Chinese (LRT experts from the Chinese consortium working with CREC and SMG). This specific selection was made in order to acquire up-to-date data and reasonable information from the multi-actors based on their respective daily experiences and direct involvement with the LRT on a more frequent basis with adequate expertise qualifications as mid and high-ranking experts. This enabled the respondents to relate their experiences on the ground with their expertise as engineers and managers. Thus, concepts qualifying these interactions and processes were drawn from the data that were acquired during the pilot test and semi-structured interviews.

While the quantitative approach entailed the LRT passengers along the two available N-S and E-W lines in operation, the analysis instrument used to code the data gathered for the qualitative approach was the Atlas-TI software, which facilitated the categorizing of the various levels of data, generating a robust data set capable of deducing categories from the data. The quantitative approach used the Statistical Package for the Social Sciences (SPSS), to code results before creating pie charts and percentage results where applicable. Table 5 shows the operationalization of different concepts, variables and indicators.

**Table 5: Operationalization table of concepts, variables and indicators (Hyard, 2012, Hyard, 2014)**

| Concept | Variable | Indicators |
|---|---|---|
| Pricing Innovation | Methods of Ticket provision<br>Methods of ticket validation<br>Fare structure | Paper tickets sold in shops at LRT stops<br>Paper tickets sold through machines at LRT stops<br>Digital loading of IC-cards using machines at LRT stops<br>On-board LRT ticket validation<br>Off-board LRT ticket validation<br>Fare price by distance<br>Fare price by Zoning<br>Flat rate fare price for all distances |

| | | |
|---|---|---|
| Infrastructural Innovation | Type, style and positioning of provided infrastructure | Accessibility support infrastructures<br>Ticket shop, ticket sale machine at platform or inside LRT |
| Contextualized pricing and infrastructural Innovations | None, partial or complete context modification in pricing system<br>None, partial or complete context modification in LRT support infrastructures | Types of context modifications at design stage<br>Types of context modifications at construction<br>Types of context modifications at operation phase |
| Passenger Service Delivery, MNCs expected outcomes and commercial activities | Economic, social and environmental effects; of contextualized pricing and infrastructural innovations on passengers, MNCs and residents | Type and effects on LRT passengers from pricing and infrastructural innovations<br>Type and effects on ERC and MNCs (CREC and SMG) from pricing and infrastructural innovations<br>Type and effects on Addis-Ababa resident's proximity along the LRT route from infrastructural innovations |
| Sustainability factors for a sustainable light-rail transport | Economic, social and environmental factors | Type of economic factor<br>Type of social factor<br>Type of environmental factor |

## 3.5 Empirical results and discussions

This section presents the empirical results and their related discussions based on contextualized pricing and infrastructural innovations; passenger service delivery; expected MNCs outcomes; and what effect the resident's proximity have living and doing business along the LRT route; and sustainable Light-Rail Transport.

### 3.5.1 Pricing Innovation

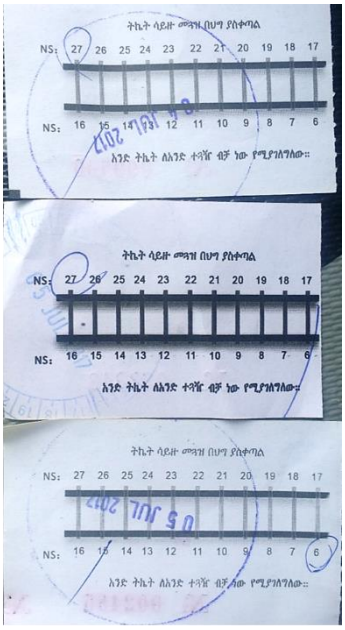
#### *Methods of Ticket Provision and Validation*

Ticket shops for the purchase of tickets by the passengers were not the original plan for the LRT system by the ERC and the MNCs. One of the top directors mentioned that "the ticket shops were an emergency plan after completing the LRT for operation, it was not part of the original plan of the ERC and MNCs". It became an emergency plan which was put into practice when the LRT started transporting passengers. The emergency plan was executed because the earlier plan of using digital Integrated Cards (IC) or electronic cards by the passengers, which would be validated on the already installed ticket validation machines in the entrance to the LRT vehicles, was not appropriate for use. This was due to the high travel demand of the LRT. The check in-out procedure in embarking and disembarking from the LRT became practically impossible and possibly dangerous due to the unforeseen large number of passengers. Thus, the ERC and MNCs decided to use paper tickets as an alternative solution, as shown in photographs 3 and 4. Paper tickets were sold

in ticket shops close to the LRT platforms at each LRT stop, while LRT stops with an interchange also shared one ticket shop. Therefore, the pricing system became an off-board ticket sale at ticket shops and on-board ticket validation by ticket officers who checked the tickets bought by the passengers before they boarded the LRT and inside the LRT during commuting (Alade; Edelenbos, et al., 2019a).

**Photograph 3: Front side of tickets**


**Photograph 4: Back side of ticket**




Photograph 3 shows the front side of the tickets. 4 Birr for a mid-range distance and 6 Birr for an end to end trip on a North-South (NS) route. Photograph 4 shows the back side of the tickets bought on the 4 and 5th of July 2017. The places circled with a pen refer to the LRT stop where the ticket was purchased. While the number marked with a line with a pen, refers to the LRT stop location where the LRT was disembarked.

## *Fare Structure*

In the economic theory, as mentioned in the theoretical framework, the three approaches of computing prices, relevant to transport services are costs, demand, and competition methods (Kozlak, 2007, Rokicki, 2014). The ERC and MNCs chose the method based on competition, this approach was achieved through a visibility study of the transport fares of private transport such as private and public taxis and buses, which used the same corridor route as the LRT since the LRT also used a large percentage of the road routes above ground as an over-pass and in some areas below the ground as an under-pass. This method was used as a comparison with the LRT competitors, such as the taxis and buses, in order not to charge the passengers the same price and be competitive. The passengers were charged a lower fare than most of the other transport modes so that it was a competitive price and affordable to the passengers.

Consequently, the fare price was introduced as pricing by zoning system, with a price of 2, 4, and 6 Ethiopian Birr ((ETB) Ethiopian birr—Ethiopian national currency, with an equivalence present rate of 27.7 ETB to 1 USD (dollar)); as shown in photographs 3 and 4, for the 4 and 6 Birr. Under half the route costs 2 Birr. Between half and three quarters of a route costs 4 Birr. Three quarters and a whole route costs 6 Birr. The initial master plan of using the electronic cards had a fare structure based on a distance method. Whereby the passengers paid based on every stop, meaning every LRT stop had a slight difference in price compared to the other. One of the top-level engineers mentioned: "We are presently thinking of using a flat rate of 5 birr for everybody, regardless of if it is short or long distance, to curb this fare evasion menace".

## 3.5.2 Infrastructure Innovation

### *Type, Style, and Positioning of Provided Infrastructure*

### *Type of Head-Way Time*

The minimum headway is the shortest distance or time achievable by the LRT without a reduction in the speed of the vehicles. The ERC, CREC, and SMG targeted frequency of the LRT to be a maximum of 6 min headway time, with plans to further reduce the headway time for better reliability in the future. However, the delivered head-way time of the LRT was 10 min on average, this was due to the limitation of only 41 LRT vehicles, which was not enough, considering the number of passengers using the light-rail.

The high demand for the LRT exceeded the capacity provided, which consequently led to some negative effects, such as the LRT being less comfortable for the passengers due to the congestion during peak periods, as shown in photograph 5; unrealistic swiping of electronic cards on validation machines on the LRT; fare evasion; and loss of income revenue to ERC and MNCs from ticket sales due to fare evasion. A senior engineer shared his viewpoints: "Our plan is to achieve a 98% reliability factor for the LRT, but for now we only have 41 light-rail vehicles on the ground, each with a 286-passenger carrying capacity, therefore we are unable to meet our targeted plan of 6 min. But we believe we can achieve it when we have more finance to purchase more LRT vehicles."

**Photograph 5: Photographs of the well-used and congested LRT**

Photograph 5 show photographs of the well-used but congested LRT during peak periods and most of the day. The card-swipe machines, that were designed to check in and check out of the LRT are located close to the door, which is fully blocked by passengers standing inside the LRT. The passengers are standing with less than three inches from the door, which makes it very unrealistic for passengers to swipe an electronic card on the electronic card machines when coming in or leaving the LRT.

## *Park and Ride*

Park and ride facilities were planned for 6 LRT stations. The park and ride facilities were planned to be part of commercial mega malls as a Transit-Oriented Development (TOD). Cars and other vehicles can park with a fee, and then they are able to continue their journey using the LRT. Drop off points were provided, and more will be provided for other public transport systems, like buses and taxis, to be able to drop off passengers who intend to use the LRT or transport the passengers home on routes that the LRT does not cover. Thereby serving as a feeder system, to support travel demands and maintain a good flow of passengers changing their transport modes from busses or taxis to LRT or vice versa, which consequently fosters modal change to LRT, as a public transport.

As of June 2017, 12 escalators and 25 lifts were provided in certain stations based on needs, such as elevated platforms and interchange stations. These aid faster access to the LRT, and they support the elderly for easy access to the LRT (Alade; Edelenbos, et al., 2019a). A mid-level engineer mentioned that: “The stations with park and ride facilities will generate income for us to further support the maintenance of the rolling stock, as a TOD, since the LRT system is for non-profit”.

### *Ticket Shops*

Ticket shops were constructed as an emergency measure, as the already installed ticket validation machines were unable to work due to the non-envisaged travel demand, which made the use of a check-in and check-out processes of ticket validation impossible. The use of ticket shops with ticket sale agents was the only option that was adapted. Electronic ticket sales or top-up machines at designated LRT stations and a turnstile as a validation machine on the platforms were still being debated upon as a more appropriate option to further support the already existing ticket shops at every station. The ticket shops had their own problems such as pedestrian safety while crossing the road to purchase tickets and rushing back with speed to catch a LRT which was about to move (Alade; Edelenbos, et al., 2019a). It is not possible to buy a ticket from the LRT officials, as they only check the already bought tickets to validate them. A mid-level engineer explained that: "We hope the electronic tickets and other information technology related devices which are presently being discussed as options to reduce the crowd buying tickets at the ticket shops will come into reality soon".

## 3.5.3 Re-Adaptation for Sustainable Light-Rail Transport

The effects on passenger service delivery, MNCs expected sustainable positive outcomes and the effect of the resident's proximity to living and doing business in the areas along the LRT route was also expected to be positive. If the residents living and doing business along the LRT routes were discontent with the LRT, then this would need to be analysed as to why and if necessary, further re-adapted would need to occur if the results were negative.

Contextualizing innovations when the LRT was initially constructed did not automatically guarantee a positive outcome. It forced the ERC and MNCs to re-evaluate and consequently go through another process of negotiations as multi-actors to re-adapt certain aspects of the pricing and infrastructural innovations. How each of these contextual factors have influenced some level of re-adaptation are explained in the paragraph below.

The non-availability of ticket sensor barriers on the platforms caused a high level of fare evasion. This forced the multi-actors to go back to the drawing board to find a solution to this problem, they subsequently built emergency ticket shops. The option of barriers such as turnstiles is currently being strongly considered as a re-modification of the current station, as the electronic devices which were in the original plan were unable to be activated for use. Even though the LRT has narrow platforms which does not favour the construction of barriers on the LRT platform itself. The possibility of expanding the platforms was not an option at this late stage but it is being considered for new LRT stations in the future. The use of turnstiles is also being considered because the multi-actors are not satisfied with the

emergency plan of paper tickets, which has also caused fare evasion. As confirmed by one of the top engineers, who said, "We are considering constructing some sensor barriers at the platforms, because the fare evasion is high, but the platforms are not that big to allow better flow on the platforms during rush hours, however it may cause some traffic at the platforms, which may extend into the roads, causing concerns for human safety on the roads".

The travel demand was underestimated as to what degree of the population of Addis-Ababa city would embrace the LRT. A few weeks after the start of the LRT, it was observed that the use of LRT was overwhelmingly embraced by the people, most of the users used it during the peak periods which caused a high level of congestion during these times. This caused a congested travel pattern at the entrance and exit to the platforms, which made the original plan of an electronic card system of mounted sensor devices onboard the LRT useless. This necessitated a complete re-adaptation of the fare pricing system from an electronic device on the LRT platforms to the 'emergency plan' of ticket shops at every LRT station, which are approximately two minutes by LRT from each other.

It was confirmed by a top ERC engineer that there was an average of 30% fare evasion due to the less secured use of paper tickets. The negative impact of fare evasion encouraged the multi-actors to re-think what was needed to re-modify the fare system again to either a flat rate of 5 Ethiopian Birr (0.178 US Dollars), regardless of the length of the trip, or re-invent the electronic card devices, perhaps on the LRT vehicles, instead of being on the platforms, or provide barriers at the platforms. It was noted that by increasing the number of agents that checked the tickets on the LRT was not an option as they would be unable to effectively handle the overwhelming numbers of commuters during the rush hours.

### 3.5.4 Re-Adapted Pricing and Infrastructural Innovations

#### *Types of Re-Adaptations to LRT at Design, Construction, and Operational Phases of the Pricing System and LRT Support Infrastructure*

The original pricing system needed to be changed, which was comprised of a method of ticket provision, a method of ticket validation, and a fare structure. In the pricing system, at the design stage, it was designed as an on-board ticket validation system using integrated cards and specific doors as an entry to and exit from the LRT. However, due to the non-envisaged high travel demand and the ticket validating machines non-functioning issues, from the commencement of the operation stage the whole system was completely changed to using paper tickets which were bought from ticket shops and ticket officials to sell tickets. One of the top ERC engineers revealed that "The challenge was foreseen during the design/construction phase, but the rolling stock has already been integrated with the installed ticket validation machines by the CREC, hoping it may be useful in the

future, as having a ticket validating machine on board a LRT is one of the best standard practices".

There were some changes in the modifications of the support infrastructure during the period when the LRT was being built. These modifications included the bridge over-passes and the underground tunnel under-passes and provision for the non-envisaged ticket selling shops. The over-passes and under-passes were not foreseen as necessary, but when it was not possible to relocate some major buildings, utilities or roads, at the construction stage, the design was partially altered, and they built extra bridges and tunnels. This was considered challenging, as it took more time to implement. Electricity and telecommunication lines as well as water utilities, which were under the ground also had to be taken into consideration. As a proportion of the LRT shares the road with other vehicles, this also needed to be integrated into the road infrastructure that already existed, a right-of-way system was necessary for the LRT, which also had to be incorporated into the infrastructure plans.

### 3.5.5 Social and Economic Effects of Re-Adapted Pricing Innovation on LRT Passengers

#### *Inconvenience to Passengers*

The inconvenience to passengers due to the re-adapted pricing innovation was considered a social effect, as it hampered their safety, well-being, and quality of life with stress and inconvenience in order to purchase a ticket. There were complaints from the passengers who were required to cross busy roads to buy tickets, as the ticket booths were located only on one side of every LRT station. This also generated safety issues, as some people crossed the road to return to the LRT platforms without using the zebra crossings, which were provided for pedestrians. Vehicles also needed to be more careful, as passengers crossed the roads in a haphazard manner, which in turn generated confusion and safety issues to drivers and pedestrians crossing the road. One of the mid-level engineers stated that "We have been told by some passengers that sometimes they struggle to run back to the LRT platform after buying a ticket across the road, because the ticket shops are located only on one side of the road close to the platforms". As the pedestrian does not want to miss his/her train, they try and take a shortcut and often cross the road without using the provided zebra crossings, which can cause chaos between the potential LRT passenger(s) and motorists who are also in a hurry to move, which itself is a safety concern, as shown in photograph 6.

**Photograph 6: An LRT passenger quickly trying to cross the zebra crossing**

Photograph 6 shows an LRT passenger quickly trying to cross the road using a zebra-crossing to reach the LRT platform after having bought a ticket at the ticket shop behind him. This is to access the LRT platform on-time before he misses the required LRT. Because he is in a rush to access the LRT, he is not waiting for the cars to stop because he does not want to miss his LRT that is approaching the platform so that he does not have to wait for the next LRT which will be in approximately 10-15 minutes.

### *Unrealistic Swiping of Electronic Cards on Validation Machines on the LRT*

The LRT in Addis Ababa is exceedingly well used, but unfortunately it is also very congested with passengers both sitting and standing. The already mounted validation machines were not as handy as first predicted when they were mounted in every LRT. The passengers were either unable to reach them when either getting into or getting out of the LRT or it took too much time to swipe the cards which held up the transport.

Consequently, with the introduction of a paper ticketing system it had economic effects, as it made some passengers pay slightly above what they would have paid if they were able to use the electronic cards to pay according to their distance and not according to the price zoning system of 2, 4, and 6 Birr, some paid less and some avoided paying at all. One of the high-level engineers from Ethiopia mentioned that "We envisaged this challenge of inability to use the electronic machines before the operations, but the LRT rolling stock had already been manufactured in China, although we mentioned that we foresaw such issues arising it was not taken into consideration by our Chinese partners". Another mid-level engineer re-affirmed this, saying, "We envisaged that it would not be possible to

only use two doors for entry and two doors for exit, because the travel demand was expected to be high, and it was foreseen that the passengers would not be able to patiently wait to swipe their cards before entry and exit, and it was not taken into consideration that the people of Addis-Ababa would be new to using the new electronic card machine in the transport system", as shown in photograph 7.

**Photograph 7: Electronic card sensor machine**


Photograph 7 show electronic card sensor machines that are functioning but not in use. They were in the original design from China and are attached to the back of the seats, close to the entrance of the LRT After two and half years of operation they are not able to be used, this is due to the very high travel demand, which is a contextual factor, which should be strongly considered during the construction and coupling of the LRT from China. Inset, it is written on the electronic machine – authorization fail, the machine can't operate today, please shut down. This was the reason why emergency ticket shops were built.

### *Time Wastage due to Ticket Sales in Ticket Shops*

Long queues were often experienced when purchasing a ticket, especially at interchange stations, of which both have the N-S and E-W lines passing through them, and at stations in highly populated areas. This makes the passengers miss their LRT connections sometimes or make them run across the road to the LRT platform in a haphazard manner, with less caution for safety just to save travel time. This leads in turn to the economic effect of time resource waste. A mid-level transport engineer mentioned that "This situation is very common, especially during the peak hours 8 am to 11 am and 4 pm till 8 pm, we see people moving in a haphazard manner, trying to buy their tickets in a long queue, as shown in photograph 8, or a crowded setting. This sometimes raises issues of security, such as theft and safety such as accidents while crossing the roads at the zebra crossing or not, with fast moving vehicles on the road". These safety and security issues are classified as a social effect, because it is related to quality of life, as represented in Table 6.

**Photograph 8: Passengers queuing at one of the ticket shops**

Photograph 8 shows people queuing trying to buy their tickets so that they do not miss their LRT. Two lanes have formed to queue-up and buy tickets. Waiting in a queue can be discouraging and time wasting.

**Table 6: Effects of adapted LRT on passenger service delivery and their sustainability factor**

| SN | Effects on Passengers Service Delivery | Sustainability Factor |
|---|---|---|
| 1 | Inconvenience and possible danger to passengers needing to crossroads to buy tickets located only on one side of every LRT station | Social |
| 2 | Unrealistic swiping of electronic cards on validation machine inside the LRT | Economic |
| 3 | Time wastage due to ticket sales in ticket shops | Economic |

## 3.5.6 Types of Effects on MNCs Outcomes due to Re-Adaptation

The following effects on MNCs, which have been represented in Table 7, explain some of the outcomes as a result of re-adaptation, especially if the outcomes are negative.

**Table 7: Effects of adapted LRT on MNCs outcomes and their sustainability factor**

| SN | Effects on MNCs Outcomes | Sustainability Factor |
|---|---|---|
| 1 | Fare evasion—Loss of income revenue to ERC and MNCs from ticket sales | Economic |
| 2 | Extra expenses incurred in selling tickets at ticket shops | Economic |
| 3 | Difficulty locating closer points for ticket shops | Economic |
| 4 | Extra cost of resettlements for relocated buildings due to third-party issues | Economic |

### *Fare Evasion*

Evasion of fare payments on public transport is a major problem for not only buses and trams but also LRT systems around the world that have not implemented an effective method of fare enforcement. As well as the ethical issues it raises, evasion can if unchecked, become a major contributor to an operating deficit (Troncoso and De Grange, 2017). Due to non-consistent ticket validation by ticket officials on the LRT platforms and inside the LRT, and not enough ticket officials to deal with the excessive numbers of passengers, caused an inadequate coverage of ticket checks. This consequently caused fare evasion by some of the passengers, which has led to an economic effect, as shown in Table 7. This effect is partly because the tickets have not been checked before entering the LRT or during transit and due to the LRT being a very popular mode of transport with a high clientele.

All interviewed respondents mentioned fare evasion as the major negative effect for the MNCs. One of the directors said: “Some passengers just want to have a free ride, by buying a ticket for a short distance but going from the beginning to the end, because we don’t have enough ticket checking officials inside the LRT”. Another high-level engineer emphasized that: “Some passengers don’t even buy a ticket, they just go on the LRT, since there is no barrier before entry onto the platforms and use the LRT for free”. “We noticed and calculated that at least about 30% of the passengers evade the fare one way or the other”.

It was further explained that the platforms were narrow, so therefore it was impossible to meet the requirements to be able to install an off-board ticket-validating machine on the platforms, such as a turnstile, which only opens automatically when in contact with an electronic ticket. However, the use of this type of turnstile on the narrow platforms would result in elongated queues from platforms into the nearby roads, causing road congestion that could be dangerous. This was one of the reasons that the paper tickets and ticket shops were adopted at every LRT stop, it was an emergency plan, which in turn caused fare evasion. A senior director in the service department mentioned that "Our initial targeted plan was to provide automated cards only at designated areas of the city, whereby the passengers could easily purchase them throughout the city".

### *Loss of Income Revenue to ERC and MNCs from Ticket Sales due to Fare Evasion*

An average of 30% of passengers are guilty of fare evasion in Addis Ababa, as mentioned by 15 out of 17 respondents during the semi-structured interviews. People struggle to get a space to stand inside the LRT, and if you wish to get a seat then you need to commence your journey from the beginning of the LRT line.

The paper tickets were dysfunctional, as they were unable to sustain the revenue needed for cost recovery over the concession years and LRT maintenance needs, which has caused a reduced cost recovery. One of the top directors stated that "The 30% average of fare evasion is quite huge, which will strongly affect the cash flow as income revenue, if not stopped in the long-run, because we know the LRT is for non-profit, but at least we need the revenue from tickets to maintain the LRT rolling stock, as much as possible".

This economic effect means that fare evasion can lead to poor maintenance of the LRT in the long run, if something is not done about it, this could lead to a loss of concession revenue for the ERC and MNCs.

### *Extra Expenses Incurred in Selling Tickets at Ticket Shops*

The tickets shops were built as an emergency alternative so that the LRT could commence public transport as soon as possible in 2015. The ticket shops were built at every LRT stop or station, which has an average of two minutes between each stop. This resulted to building many tickets shops at a cost, these costly expenses were not planned for within the operation, and it also led to an unexpected employment of ticket officials who needed to receive a monthly salary. This consequently led to an economic effect, which caused a search for more finance to build the ticket shops, as it was not part of the initial budget, however it may still be within the extra contingency budget. One of the top managers re-affirmed that: "We did not spend beyond the normal allocated budget for the LRT, it is within the budget".

### *Difficulty Locating Closer Points for Ticket Shops and Extra Cost of Resettlements*

There were challenges in locating suitable locations at a good proximity to the LRT platforms for the ticket shops. This was accomplished by buying property, and financially compensating residents who owned the buildings and had to be relocated. It also had an economic effect of higher costs. A mid-level head of unit mentioned that "We went through a lot of challenges, trying to secure ticket shop spaces with good proximity to the roadsides, where the LRT will follow. It was a tough battle, but we were able to secure most of the shops at good proximity locations to the LRT stops using monetary means to resettle the original dwellers". These resettlements were characterized by third-party issues, which are buildings belonging to third parties (public), who dwell along the LRT routes.

## 3.5.7 Type of Effects on Addis-Ababa Resident's Proximity and Business Owners Along LRT Routes

### *Economic Effects on Resident's Proximity and Business Owners Along the LRT Routes*

The two sides of the rail tracks are separated from the roads by a fence of 1.2 m in height and 2.4 m in length, these fences were placed as a safety measure, in order to avoid pedestrian accidents. Zebra crossings were only located in the vicinity of LRT platforms along the LRT routes. These are on average 0.8 km apart from each LRT station. As the zebra crossings are only at the stations it is not possible for the general public to cross the roads between the stations. Thus, causing difficult access to shops on either side of the fences.

This has had some economic effects and substantial monetary loss to some business owners. As mentioned by one of the respondents, "Shop owners are frustrated, because they have lost customers who visited them from the opposite side of the road, as there is no possibility to cross the road near their shops, thereby decreasing their customer patronage and personal business income". Another shop owner added that "We no longer get as much customer patronage as we used to before the construction of the light-rail, as people need to walk a greater distance before being able to access our shops." The fences run along all the 34.25 km railway lines, having a pedestrian crossing space at 39 points that are all reserved for railway stations. Among the 39 stations, 3 are located underground, 9 on bridges, and 27 at ground level. More overpasses and other crossing points are currently being built to ease the movement of people.

Roadsides along the LRT routes are dominated by commercial shops engaging in various commercial activities, such as telecommunications, restaurants, food shops, electronic shops, fashion shops, etc., which are all a source of livelihood for the shop owners. Before the LRT, the residents were able to cross at any point to get to

the other side of the road, but after the construction of the LRT, they were forced to walk an average of five to ten minutes before they are able to cross to the other side of the road. Only shops located next to LRT stations have easy access to the other side of the road via the LRT platform, which takes less than one minute. The LRT safety barriers have caused a loss of time for the residents who want to purchase things on the opposite side of the road, and it has reduced sales for the commercial shop owners along the LRT route. Both are economic effects which are described in Table 8.

**Table 8: Effects of adapted LRT on residents along LRT route and their sustainability factor**

| SN | Effects on Residents Along LRT Route | Sustainability Factor |
|---|---|---|
| 1 | Reduction in sales from commercial activities due to reduced proximity to the commercial centers | Economic |
| 2 | Increase in fare rate by taxis along LRT-route due to extended length of road by LRT protection fence | Economic |
| 3 | Increase in travel distance and time for pedestrians living far from zebra crossings along the LRT route | Economic |

### *Increase in Fare Rate by Taxis Along LRT Route due to Extended Length of the Trip due to the Safety Barrier*

Taxis in Addis-Ababa have had to increase their commercial rates slightly, due to the fence demarcating the LRT from the roads. Before the LRT they were used to manoeuvring at junctions or U-turns at short distances, but now their journeys have increased in order to make a U-turn in order to be able to drop a passenger at the other side of the LRT route. This was noted during a personal conversation with a taxi driver that charged the author more than expected on a route that had been taken several times before. When the taxi driver was asked for the reason, he answered that, “Before we don’t have the LRT dedicated route, so we can make a U-turn within short distances. But now, we need to go extra distances before we can access a U-turn, thereby burning more fuel and using more time, which demands for more money from our passengers”. Thus, the LRT safety barriers have led to an economic effect of more financial spending by the taxi owners, as they need to purchase more petrol or diesel to cover longer distances before accessing the U-turns, as shown in photograph 9.

**Photograph 9: Intersections constructed and opened-up, with red and white colours bars, for the passage of vehicles at U-turns.**

As shown in photograph 9, the vehicle's pass through these barriers only when the LRT is not on sight, because it cuts across the LRT dedicated lane. The yellow and white colour is the route protection barrier for the LRT lane, to prevent accidents by collision between vehicles and LRT.

## *Increase in Travel Distance and Time for Pedestrians*

Pedestrians living far from zebra crossings along the LRT route now need to walk an average of an extra distance of 1 km before reaching their destination. Although this has a health benefit, some pedestrians are discontent as they are not used to walking such distances before reaching their destinations. Thus, having an economic effect due to wasted time is a resource, which can be used for other things to generate money. One of the pedestrians said, "It is a bit frustrating that we need to walk for more than 5 minutes to places we need to just cross over to the other side of the road, which usually takes us less than 15 seconds."

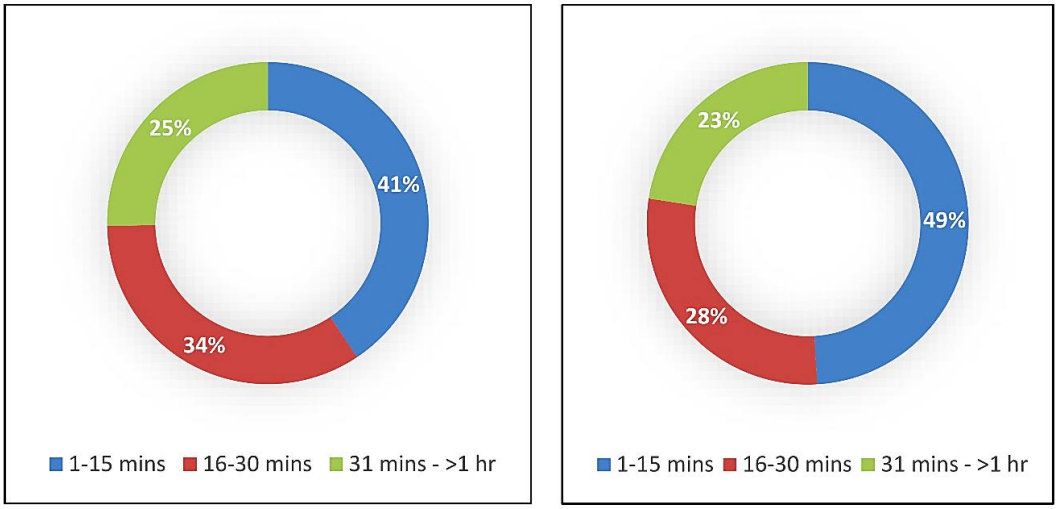
It was also observed that the intersections where the pedestrian crossings exist do not only have the LRT passenger traffic to access the platforms, but they also have people using the crossing to buy paper tickets, or to cross the road to do their usual daily business, as shown in photograph 10.

**Photograph 10: Pedestrians crossing the road**

Photograph 10 shows some Addis-Ababa residents crossing over to the other side of the road. The other side of the road is dominated by commercial shops engaging in various commercial activities, such as telecommunication, restaurants, electronics, fashion shops, etc., as a source of livelihood. These residents were able to cross to the other side of the road easily, but after the construction of the LRT, they need to walk for an average of five to ten minutes before they are able to access the other side of the road, while only those located around the LRT stations can easily cross to the other side using the paths on the LRT platforms which takes less than one minute.

Passengers use different modes of transport before reaching the LRT platforms, as seen in Figure 5. On the average, it shows that a substantial number of passengers get to the platform in a fairly good time of between 1–15 minutes. This implies that the platform distance to the passengers is fairly-good but can be improved during future LRT route analysis and proximity to settlements on LRT corridors.

**Figure 5: Level of accessibility to LRT-platforms during weekdays (left) and weekends (right).**




The results for the weekends compared to the weekdays, shows that passengers may get to the platform a bit quicker due to less peak periods during the weekends. In this regard, 41% of the passengers during the weekdays and 49% during the weekends perceived that their accessibility to the LRT platforms as adequate, as 1–15 min is relatively the most adequate period to access a light-rail platform. Photograph 11 depicts the LRT platform in the underground tunnel.

**Photograph 11: Platform in the underground tunnel with passengers in two lines queue**

Photograph 11 shows an underground tunnel with passengers standing on a platform in a two-lines queue for the LRT. An insight are the employed armed security officers to keep law and order and protect the passengers.

### 3.5.8 Environmental Effects of LRT on Addis-Ababa City from Modal Shift of Motorized Transport to LRT

Addis-Ababa city has witnessed a gradual reduction of carbon emissions from other motorized transport due to the modal shift by a fraction of the passengers now using the LRT. This serves as a positive effect to the environment, as seen in Table 9. To assess the level of modal shift, the approximation for other transport modes capacity have been assessed and compared to the capacity of the LRT, which was in order to provide an estimate of the modal shift (Alade; Edelenbos, et al., 2019b). In this regard, other modes of public transport which include: 460 Higer Midi-buses that have a capacity of 22–27 passengers/Midi bus; 10,000 white and blue minibus taxis with a capacity of 12 sitting passengers/minibus taxi; 487 Anbessa city buses with the capacity of 70 standing and 30 sitting passengers/bus; 366 additional vehicles and 6500 salon taxis that have a capacity of 4 passengers/vehicle or taxi; the Alliance buses have a capacity of 60 standing and 40 sitting passengers/bus (Fenta, 2014). The Anbessa city busses are the cheapest available public transport, which are used to assess the proportion of passengers that the LRT can transport from the modal shift. It is also categorized with 100 passengers per trip; 730,500 passengers per-day; 93 routes, with an average total of 6352 daily trips; 6.8 km as the shortest route; total route length of 1207 km; and the longest route is 47.2 km (Abreha, 2007).

**Table 9: Effects of adapted LRT on Addis-Ababa City and their sustainability factors**

| SN | Effects on the Addis-Ababa City | Sustainability Factor |
|---|---|---|
| 1 | Reduction in carbon emissions by other motorized transport due to modal change to LRT (it also reduces congestion) | Environmental |
| 2 | Better affordability for LRT-users due to modal change by public and private transport users of the LRT | Economic |
| 3 | Change of transport use status of low-income passengers from other public transport to a safer and more affordable transport | Social and Economic |
| 4 | Increased Transit Oriented Development (TOD) along LRT-route | Economic and Environmental |

If we compare the 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 (Alade; Edelenbos, et al., 2019b). This shows that there is a high travel demand for the LRT and the transportation needs of the over 4 million Addis-Ababa population (WPR, 2019). Presently, a top director in the operations department acknowledged that: “We barely have off-peak periods, the people of Addis-Ababa use the LRT as a transport mode more than we anticipated, and it is most of the time, a peak period occupied to its full capacity”.

In addition, 85% of these 254 passengers do not use private cars as one of their modes of transport, as deduced from their modal combinations in the survey. While,

38% of passenger's occupation status showed that they belonged mostly to the middle-income earners; 52% belong to the low-income group; and 10% of the passengers were upper income earners. Most of the upper income earners still prefer to use their private cars and are not yet willing to change modes of transport (Alade; Edelenbos, et al., 2019b).

This gradual modal shift will consequently decrease congestion on the roads and lessen the level of CO2 emissions. As the 275,500 Addis Ababa vehicles are discharging between 25,000 and 32,000 tons of hydrocarbons and 49,000 to 58,000 tons of carbon monoxide into the city's air per annum, which is two to six times higher than World Health Organization standards (Benjaminson; Shankute, et al., 2012).

### 3.5.9 Economic and Social Effects of Fare Affordability and Pricing by Zone Distance on the Low-Income Group

The LRT was provided for the transport needs of the public, including the low-income groups for whom it also has an affordable ticket fare price and structure. The fare structure that has been provided is a zoning system of 2, 4, and 6 Ethiopian Birr ETB ((ETB) Ethiopian Birr—Ethiopian national currency, with an equivalence present rate of 29 ETB to 1 USD (dollar).) per E-W and N-S line's trip, integrated into the short, intermediate and long or end-to-end zone distance passengers respectively. The LRT multi-actors used the competition-based method (Kozlak, 2007, Rokicki, 2014), where the price has been decided upon and made more affordable compared to the price of contending public transport, for example the competing private taxi's, bus operators, and public bus operators. This provided a benefit because it fostered the delivery of an affordable transport fare for the low-income groups (Pansera and Owen, 2015), compared to other key public transport systems, which made it easy for the low income groups to simply shift from other transport modes to LRT, which is relatively low in price compared to all of the other modes of public transport.

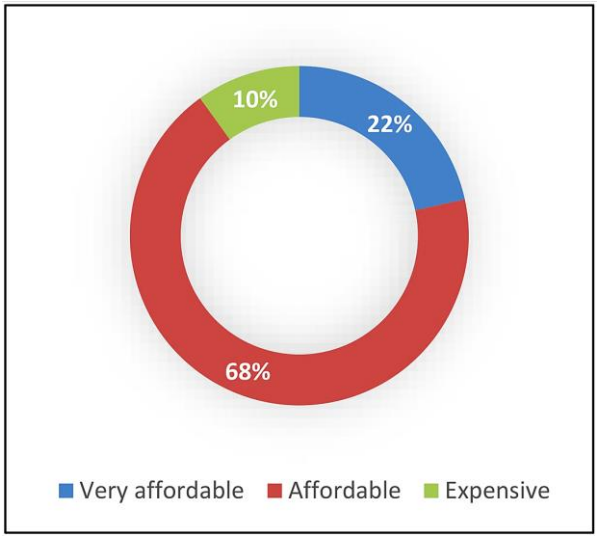
In Addis Ababa the LRT fare rates was slightly more affordable than the Alliance bus and Higer midi-buses, the White and Blue Minibus Taxi's, which have a price range from 2.5 ETB for 2.5–7 km, 4.5–5.5 ETB for 8–15 km, and 7 ETB for 15–25 km. The LRT, to a significant extent, is more affordable than the Salon taxis that cost at least triple the price of the LRT, depending on the trip distance, and were usually used by the mid and higher income wage groups.

However, the LRT is still slightly less affordable than the Anbessa city buses which were mainly used by the lower income groups, with prices extending 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. Therefore, a portion of the lower income groups used other modes of transportation. The lower income groups who live close to the LRT platforms have

a better option of shifting from buses to the LRT, which is also safer, more reliable, more comfortable, and cheaper in fare than other modes of transport, except the Anbessa city buses. The LRT also provided a way to travel that is not dependent on taxis and other sorts of buses for the middle and high-income passengers (Alade; Edelenbos, et al., 2019b).

In the survey conducted by 254 passengers as respondents, 68% perceived this ticket fare as affordable (just OK), 22% perceived it as very affordable; whereas 10% perceive it as expensive, i.e., not affordable, as shown in Figure 6. Thus, the total percentage perceived by the passengers as affordable ticket pricing in general represents 90%. Therefore, fulfilling the target for at least a portion of low-income passengers, whereby it increases accessibility and promotes the inclusion of the lower income groups. This consequently provides an economic benefit for the lower income passengers to save money by not using more expensive public transport and improves their social status by using the same public transport as middle- and higher-income groups as shown in Table 9.

**Figure 6: Affordability of ticket fare**




Nevertheless, it can be debated that the lower income groups in Addis-Ababa were the 10% who perceived the fares to be too expensive. Therefore, the LRT is still in the process of integrating more lower income groups, as approximately 50% of the population earns less than 500 ETB per household per month, and approximately 23% of the population are in total poverty, i.e., less than 300 ETB per household per month (Abreha, 2007). Nonetheless, the LRT has commenced a goal towards affordable transportation, which is to include the lower income groups through the regulation of the prices by the ERC, in a way that is able to accommodate a

significant number of the lower income groups, which may however not be able to cover all of the potential lower income LRT users (Alade; Edelenbos, et al., 2019b).

### 3.5.10 Economic and Environmental Effects of Transit-Oriented Development Along LRT Routes

Addis-Ababa provided Transit Oriented Development (TOD) in six LRT stations with a plan to increase it over a period. This TOD entails structural developments along the LRT routes, to promote commercial activities, providing the economic benefit of internal revenue to the city government and other amenities for the public (Alade; Edelenbos, et al., 2019a). In addition, the TOD infrastructure, such as mega malls, office complexes, and other commercial activities provides an environmental benefit of reduced transport by individuals to other areas within the city with similar needs for infrastructure, as seen in Table 9.

Consequently, reducing the carbon emissions from vehicles that would have been used to travel to other parts of the city, which has more trip distance than doing basic commercial activities within a TOD. This was observed as some individuals do their shopping, commercial activities, and meet their other basic needs at the TOD centres, saving them time and trip distance, rather than going to other areas of the city for the same needs; leading to an economic benefit. Over time, the use of more TOD by the city populace will gradually depict some significant measures of reduced carbon emissions from reduced transport movements by the people, especially those using private vehicles.

## 3.6 Conclusions

The conclusions answer the three research questions which characterize the predominant sustainability factors as effects from the adapted pricing and infrastructural innovations of the LRT. In addition, as a benefit, it provides contributions to scientific literature and also outlines guidelines to help the sustainable transport sector; it highlights some further research questions; proposes sustainable recommendations to support decision and policymakers on how to adapt the LRT from other countries with different socio-economic and technological backgrounds, thereby serving as a societal benefit.

The pricing and infrastructural innovations were transferred to the Addis-Ababa context from China, amidst considerations for the context and circumstances at hand; and their sustainability factors were based on economic, social and environmental factors. In addition, a re-adaptation process took place whenever a sustainability factor was not favourable.

The economic effects on passenger delivery were unrealistic swiping of electronic cards on validation machine inside the LRT and time wastage due to ticket sales in

ticket shops. The social effects include the inconvenience to passengers having to cross the roads to buy tickets.

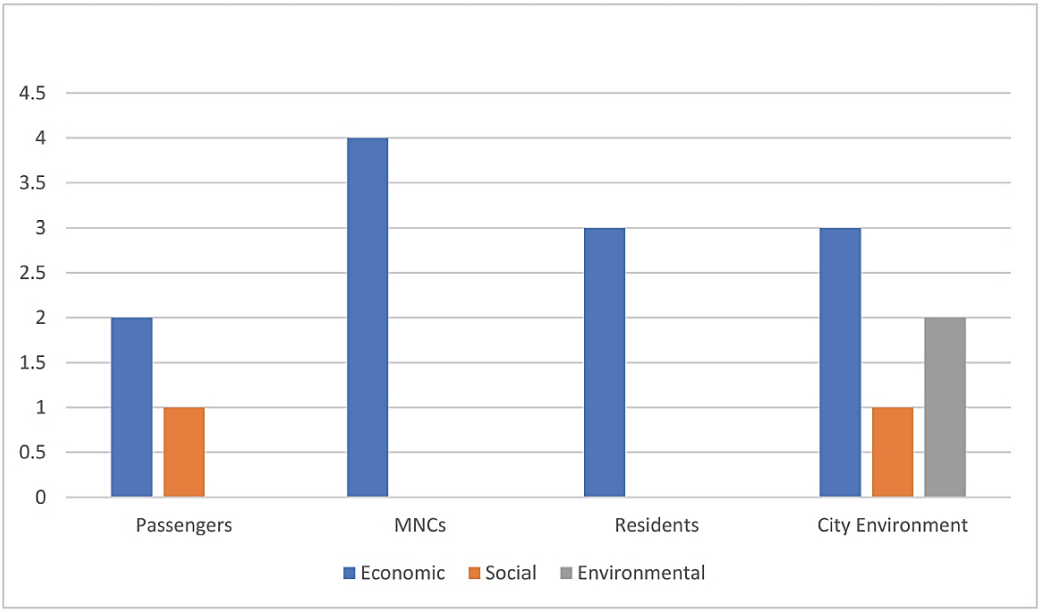
The economic effects on MNCs were fare evasion leading to loss of revenue; extra expenses due to emergency ticket shops; difficulty locating closer points for ticket shops; and the extra cost of resettlements due to third-party issues.

The economic effects on residents living and engaged in commercial activities were reduction in sales due to less proximity of people to access the commercial shops; increase in fare rate by taxi drivers; and an increase in travel distance by pedestrians.

Regarding the Addis-Ababa city environment, the environmental effects were reduction in carbon emissions from reduced use of motorized transport and TOD. The economic effects were affordability to LRT users and TOD. The social effect is the change of transports social status for low-income groups as a new, more comfortable, and safer mode of transport.

In addition, this research revealed that the economic sustainability factor is the most predominant effect as a result of the adapted LRT, which can be seen in Table 6, Table 7, Table 8 and Table 9. Overall, the economic sustainability factor accounts for 12 out of 14 sustainability factors. Each of the social and environmental sustainability factors accounts for 2 out of 14 sustainability factors, as shown in Figure 7.

**Figure 7: Sustainability effects of LRT on passengers, multi-national corporations, residents and city environment**



The identified re-adaptations to a more sustainable LRT as a recommendation to some of its major effects were: The newly proposed method of validating tickets on the platforms, as an off-board ticket validation system and the use of electronic cards by the ERC is one of the most suitable solutions to curb fare evasion. This will also provide a better cost recovery mechanism for both Addis-Ababa and China MNCs, and a fair system to short and long-distance travellers using electronic cards charged per kilometre. In this regard, construction of platforms during the design and construction stages should support long queues from highly populated cities with a high travel demand from their commercial activities, fostering and creating enough room for the use of off-board ticket validation systems, such as the turnstile machines and as an LRT accessibility support infrastructure. Although it is more costly, more over-passes and under-passes should be built to sustain the business flow along the LRT routes and reduce the number of shut down U-turns on roads, in order to reduce the distance travelled by commercial vehicles and people in need of a U-turn to cross to the opposite side of the road.

An inclusive option for future installation of validation machines should be provided, while it can start with ticket validations on the platforms, pending the period when the travel behaviour data has been recorded for at least a year. Validation of the tickets on the platforms is safer for cost recovery and enforced reduction of fare evasion and without the use of human effort, such as ticket officials. This would further avoid the cost of the emergency construction of ticket shops, which were not included in the original budget. Fare subsidies should be introduced in order to attract more potential passengers from the lower income groups, such as targeting special provision for people living below the poverty level, children below twelve years and the elderly above sixty-five years (Alade; Edelenbos, et al., 2019b).

The scientific value of this research emphasizes the need to provide a tailor-made LRT to cities in need of a sustainable transport through the assessment of positive and negative effects of the implemented light-rail. They need to consider the socio-economic and environmental factors to guide in the design, planning, construction, and operation of the LRT, which provides sustainable benefits, especially to cities with a similar socio-economic and environmental context in transition to the LRT. Thus, lessons learnt from this research, due to its local extent and context, further recommends that cities with similar conditions should aim to match the travel demand with an adequate number of light-rail vehicles, this will avoid the negative spin-offs which can hinder normal operations and maintenance activities and it will avoid low cost recovery on the investment. In addition, this will promote more a modal shift from other motorized transport to the LRT, reducing carbon emissions and city pollution.

Furthermore, this research has added a niche to the theories on pricing and infrastructural innovations, especially the theories provided by Hyard (2014, 2012) on how it relates to contextualization and its delivery of service to the LRT passengers with respect to sustainability factors.

The societal relevance is associated with better affordability and accessibility for the public through a better managerial practice of pricing systems, market competition, more passenger use options, and an increase in the use of public transport to reduce the level of private owned cars, thereby reducing greenhouse gas emissions, which can transcend into transport policy for climate change, by decision-makers in the transport sector. This can be implemented in such a way that other non-technological innovations such as green logistics and traffic management, can reduce carbon emissions related to road transport (Button, 2010). Thus, filling related gaps, using a sustainable approach to assess and contextualize the pricing and infrastructural non-technological innovations, which consequently promotes positive sustainability factors with a specific focus on light-rail public transport.

Further research questions can be formulated based on this study for example: To what extent can sustainability factors influence the positive outcomes of a light-rail transport in cities? How can sustainability factor assessments be incorporated into the LRT implementation plans at the design stage? What are the policies formulated to reduce the negative outcomes of sustainability factors of the LRT implementation? In what ways can sustainability factors promote smart city public transport planning?

Moreover, classifying the sustainability factors enables decision makers and policy makers to tailor their solutions by specifically considering the extent and context of the economic, social and environmental factors as spin-offs from the LRT implementation. Despite some negative sustainability factors emanating from fare evasion and emergency ticket shops; the positive effects emanating from the use of the electrified LRT for zero carbon emissions, TOD, affordable, safe, and comfortable LRT outweighs the negative effects because the LRT was overwhelmingly embraced by the public; and the LRT in Addis-Ababa city has overall more benefits that have been able to improve the socio-economic and environmental factors of the city as a whole, which serves as a public good.

# Chapter 4: Adapting Urban Light-Rail Transport to the African Context

A Process by Transport Authorities and Chinese Rail Corporations in Addis-Ababa, Abuja, and Lagos[5]

[5] Adapting Urban Light-Rail Transport to the African Context: A Process by Transport Authorities and Chinese Rail Corporations in Addis-Ababa, Abuja, and Lagos. Taslim Alade, Jurian Edelenbos, Alberto Gianoli. Article published 3rd December 2019, in the Journal of Urban Science. https://doi.org/10.3390/urbansci3040109.

## 4.1 Abstract

A contextual approach to Light-Rail Transport (LRT) needs to be tailored towards specific contexts, in terms of situations or contingencies, such as socio-economic and environmental factors. This research intends to provide societal benefits comprised of well-informed contextual factors for policymakers and urban transport authorities, to enable them to be able to formulate objective policies for the city's socio-economic development. *The aim of this article is to analyze the contextual factors in three cities which are responsible for the contextualization of infrastructural innovations of urban light-rail transport from China.* The methodology that has been used is a qualitative method using multiple case studies, which includes a pilot and semi-structured interview. The analysis compares the similarities and differences within Nigeria, and between Nigeria and Ethiopia. The most perceptible contextual factors which influence infrastructural innovations in Nigeria include electric energy supply, modernization of LRT and their stations, Transit-Oriented Development (TOD) and seamless integration of LRT with other transport modes. Whereas the most conspicuous factors in Ethiopia are emergency ticket shops, seamless integration of LRT with other transport modes, and Non-Motorized Transport (NMT). Common to Nigeria and Ethiopia is the seamless integration of LRT with other transport modes. Therefore, academically analyzing contextual factors helps to unravel the poly-contextualization and context-specific decision-making processes in LRT implementation.

**Keywords:** infrastructural-innovation; innovation-adaptation; contextual-factors; poly-contextualization; urban light-rail transport; context-specific decision-making

## 4.2 Introduction

Research has shown that a contextual approach is required in the implementation processes for Light-Rail Transport (LRT). This is based on contextual factors which contend with the new innovations in LRT (Ortt and van der Duin, 2008). This method requires a tailor-made process towards its specific context, in terms of particular situations or contingencies, such as the organizational structure of the various firms (Drejer, 2002), socio-economic and environmental factors, culture, procedure differences, travel demand gap, city governance and the technical capability gap (Wisdom; Chor, et al., 2014, Cheng and Huang, 2013, Tsui, 2006). The various methods of contextualization for LRT innovations from China to fit into the specific characteristics of Addis-Ababa, Abuja, and Lagos are key elements of this research. At the organizational level, researchers have generally defined innovation as the development or generation and adoption of new ideas or behaviors (Damanpour and Schneider, 2006, Fariborz and Marguerite, 2010). Organizational and process innovation (Pansera, 2017), supports the use of a novel method to

generate or commercialize products or services (Prabhu, 2017). The idea or actions may relate to product(s), service(s), technology, system(s), or practice(s). The adoption of innovation is a process that results in the assimilation of product(s), process(s), or practice(s), because it is new to the adopting organization (Fariborz and Marguerite, 2010). In addition, using a contextual approach introduces the theory of a context-specific decision-making process, between experienced based local knowledge of local transport authorities and expert's knowledge from Chinese rail corporations, used to adapt to practical situations at-hand, using their demonstrated capacity for learning and imitation (Bhaduri; Sinha, et al., 2018).

This research provides an academic approach to identify new contextual factors in rail transport sciences and it relates the already known factors in literature to present events during LRT implementation in the three cities. It also explicates how multi-actors can implement a Light-Rail Transport system using context-specific decision-making processes, despite the innumerable challenges faced due to city level contextual factors, through poly-contextualization and re-modification. An attempt has also been made to provide societal relevance benefits through the provision of well-informed contextual factors to policy makers and urban transport authorities, to formulate objective policies for a city's socio-economic development, which will consequently provide a sustainable LRT and satisfaction to the LRT users.

In this regard, the research aims to analyze the contextual factors in these three cities, showing who is responsible for the contextualization of infrastructural innovations of an urban Light-Rail Transport. The LRT innovations have been imported from a Chinese context, to an Addis-Ababa, Ethiopian city context, and to the Abuja and Lagos contexts in Nigeria. The import of the LRTs was made possible with some modifications in order to suit the context of these three cities.

Therefore, this article aims to answer the research question: *What are the factors influencing the contextualization of infrastructural innovations in an urban Light-Rail Transport, from a Chinese context to Addis-Ababa, Abuja and Lagos city contexts?* The significance of this study is further visualized as a case study research which incorporates practical examples of innovation management, making it possible to comprehend how and reveal the reasons why it should be done in practice in a certain way. Although a remarkable amount of empirical research has been conducted, there is still further investigation necessary to decipher conditions for and consequences of innovation(Kimberly and Evanisko, 1981).

Section one presents the introduction. Section two explains the theoretical framework, which describes the relationships between infrastructural innovation, contextual approach and contextual factors. Section three focuses on the research method. Section four entails the empirical results and discussion. Section five

contains the conclusions, added values to academic research and the transport industry, recommendations and further research areas.

## 4.3 Theoretical framework

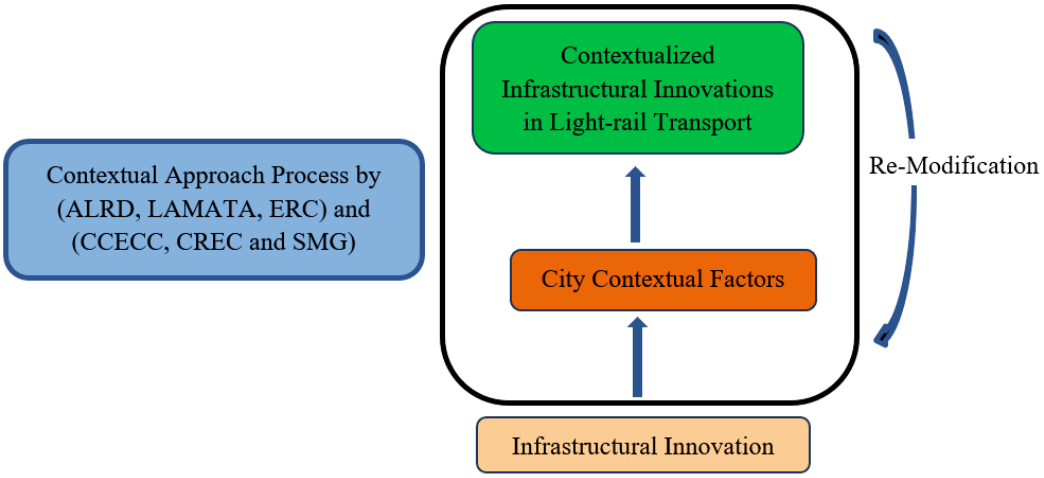
This section presents the conceptual model to describe the LRT infrastructural innovation and contextual approach based on contextual factors that have been used by multiple actors from Nigeria, Ethiopia and China. Furthermore, the relationships are explained between contextualized infrastructural innovation, contextual factors and the process of contextual approach by the three African cities and China. Abuja Light-Rail Department (ALRD), Lagos Metropolitan Area Transport Authority (LAMATA), and the Ethiopian Railway Corporation (ERC) were the LRT Rail Receiving Authorities (RRA) from Abuja, Lagos, Addis-Ababa cities respectively. The China Railway Engineering Corporation (CREC), Shenzhen Metro Group (SMG), and the China Civil Engineering Construction Corporation (CCECC), were the Multi-National Corporations (MNCs) Rail Providing Corporations (RPC) from China.

As seen in Figure 8, the dependent variable has been contextualized as infrastructural innovations and independent variable(s) are the city contextual factors. The contextualized infrastructural innovation depends on several specific city contextual factors, which were common to each city, they were the independent variables, to deliver the LRT to the cities.

Re-modification, as a process, occurred after the first phase of contextualized infrastructural innovations took place which then needed to be re-modified at the second phase, which was based on the prevailing city contextual factors. An in-depth analysis is also performed regarding the relationships between infrastructural innovation and the process of contextual approach by the multi-actors at play. Both cities in Nigeria dealt with only one Chinese corporation, namely CCECC. While ERC of Addis-Ababa city worked with two Chinese MNCs, namely CREC who dealt mainly with the light-rail construction and SMG who dealt with operations.

Contextualized infrastructural innovations based on contextual factors, a contextual approach process by Chinese MNCs providing the light-rail (RPC) and LRT city authorities in Nigeria and Ethiopia, receiving the light-rail (RRA) as a collaboration to deliver LRT.

**Figure 8: Framework**




## 4.3.1 Infrastructural Innovation as a Non-Technological Innovation

Infrastructural innovation is often referred to as non-technological innovation (Hyard, 2014). However, infrastructural innovation in transport can be approached from a technological and non-technological innovation viewpoint. This research has focused on the latter. The study of non-technological innovations has been minimally analyzed compared to the study of technological innovations. In high-tech predicting and social modification literature many scientific papers emphasize the function of technological inventions within a transport's broad spectrum (Moore and Pomrehn, 1971, Sahal, 1980, Sviden, 1988), and particularly with regard to sustainable transport (Turton, 2006, Hillman and Sanden, 2008, Steenhof and McInnis, 2008). Very little has been documented regarding non-technological innovations from a sustainable transport point of view (Tuominen and Ahlqvst, 2010).

The role of institutional innovations that assist in generating public support to support the creation of extra ecological means of transportation is also important (Kemp and Rotmas, 2004). Sustainable transport leverage with non-technological innovation, as a foundation to position the transport industry not only in the manufacturing sector, but in addition as a service providing industry (Hyard, 2012). Non-technological innovation is a significant component within organizations' infrastructure adoption actions, which together adds more value, complementing the technological innovation. Non-technological innovation is profoundly related to marketing and organizational innovation, which has been defined as the introduction of fresh organizational techniques or the incorporation of new

marketing procedures (Schmidt and Rammer, 2008), and the bottom-up effects from context-specific decision-making processes (Bhaduri; Sinha, et al., 2018), among the city transport authorities and rail corporation experts, which fosters frugality in time, finance and human resources.

Non-technological innovations are characterized for sustainable transport into three main groups (Hyard, 2012), namely: pricing, infrastructure and regulation. This research focuses only on the infrastructure innovation aspects of light-rail public transport, because it is a common aspect among the three cities, during the design and construction phases of the LRT adoption by the RRA's, as the operation phase commenced only in Addis-Ababa during the fieldwork of research.

Infrastructural innovation is defined as supportive infrastructures, provided as components required to aid the passenger service use of public transport, such as infrastructures for multi-modal integrations, park and ride, pedestrian accessibility infrastructure, public transport measures (priority, increased frequency), information provision to passengers (Hyard, 2014), etc., thereby increasing the level of usage of the LRT public transport. Infrastructure innovation entails the innovative availability and positioning of infrastructure, style of provision and its components, the availability of different types of information facilities and what sort of method(s) or style(s) have been provided. Such as electronically provided information using electronic boards on platforms and up-to date online trip information in the LRT vehicles during trips. The infrastructure innovation aids the safe flow of passengers, providing high travel demand, better accessibility and proximity to LRT platforms, provides near real-time and real time trip information to passengers, reduce congestions, and supports modal change from private to public transport, etc.

### 4.3.2 Contextual Factors and Contextual Approach Process

Context is defined as specifics of political climate, organizational-setting, peculiar challenges at hand, etc., that can affect innovation adoption (Wisdom; Chor, et al., 2014). These authors further explained context as the extent of flexibility of the intervention allowed e.g., similar innovation(s) can be adopted in a different way by diverse organizations, and the degree of dependence on the context in which the infrastructural adaptations are implemented. Understanding the various innovation management methods, from the view point of the organization and governance of innovation processes, and their corresponding advantages and disadvantages is a requirement to choose the most suitable method in a specific context (Ortt and van der Duin, 2008).

In general, it appears that more corporations are integrating a contingency style to innovation management, adjusting their innovation management procedures to their business context, which is known as contextual innovation (Ortt and van der Duin,

2008). In literature, contextual factors are defined as the political and legal system(s), culture, history, ecology, geography, the stage of economic development and economic system(s) at a specific period of time, including all emerging contexts within a frame of time and space, which has shaped the components and reasons a context is currently utilized (Tsui, 2006). In addition, contextual factors also include technological environment, economic environment, and social influence (Cheng and Huang, 2013). Contextualization is defined as integrating the context in understanding, defining and hypothesizing about the phenomena within it (Tsui, 2006). Consequently, due to the diversity of the context, poly-contextualization is introduced (Von Glinow; Shapiro, et al., 2004), to define the procedure of integrating various scopes of a context, for a comprehensive and valid knowledge of any phenomena in it. Cross-cultural relationships are not only necessary but indispensable for success in the contextualization of a Light-Rail Transport (Tsui, 2006).

Contextual approach in this research means the adaptation of certain components of the LRT, such as the infrastructural innovation which has been adapted to suit the context setting of the three cities and their commercial activities as the LRT is produced and coupled from another country, which is China. Contextual approach in technological and non-technological innovations are important for suitability and a sustainable long run operation of the LRT. This is because when a large infrastructure like the light-rail does not suit the context of the receiving city, huge amounts of money is wasted or there is extra money spent to make it fit the system or it poses maintenance problems, leading to extra costs and time wastage (less frugal).

Furthermore, it is pertinent to state that these city transport authorities' value their long term goals and the sustainable operation of the LRT, therefore the use of a context-specific decision making process is crucial, as the exchange of practical city context knowledge from the RRAs and light-rail expert knowledge from the RPC (Bhaduri; Sinha, et al., 2018). This context-specific knowledge fosters a bottom-up approach implementation of the LRT, providing necessary knowledge support from the RRAs to the RPCs during all stages of the implementation. A re-modification of the infrastructural innovation processes occurs when a negative outcome is observed in the contextualized infrastructural innovations and needs to be re-modified.

### 4.3.3 Relationship between contextualized infrastructural innovation, contextual factors and the process of contextual approach by RRA and RPC

China's RPCs produced the LRT rolling stock for Nigeria and Ethiopia, interacting with their RRAs, to finally design and construct (build) the LRT. However, there was a strong need to use a contextual approach, considering the different city levels

of contextual factors currently on-ground in these cities, since they are different from cities in China. In this regard, the specific types of contextual factors found at certain areas along the LRT routes, determined the extent and method to which the infrastructural innovations were contextualized, to suit the area of concern. The multi-actors went through this contextual approach process, which mostly tried to have leverage on the value for money for the citizens, through providing what is expected to the three cities. Thereby innovatively contextualizing the infrastructural innovations, together with other city authorities, who were linked to the implementation of the LRT, such as the ministry of transport, water authorities, electric and telecommunications companies, ministry of lands and their relocation/compensation departments, etc.

Thus, the infrastructural innovations, such as type, style and the positioning of the provided infrastructure also went through the process of a contextual approach, modifying different areas of infrastructure to individually suit the three cities. After going through a contextual approach, considering the contextual factors, it led to modifications in the infrastructural innovations, which sometimes demanded a complete or partial modification, that came with extra cost, time and demanded more technical personnel.

## 4.4 Methodology

In this section, the concepts and their core variables have been further defined with indicators have been further operationalized, as shown in Table 10. Furthermore, the qualitative research strategy that was used has been explained in detail. The pilot interviews, in-depth semi-structured interviews, sampling method(s), sample size(s) and different respondent groups are fully described.

## 4.4.1 Operationalization of concepts

**Table 10: Operationalization table showing concepts, variables and their respective indicators**

Taken from: (Hyard, 2014, Wisdom; Chor, et al., 2014, Cheng and Huang, 2013, Tsui, 2006).

| Concept | Variable | Indicators |
|---|---|---|
| Infrastructural innovation | Type, style and positioning of provided infrastructure in 3 cities | • Accessibility support infrastructures<br>• Trip information infrastructure<br>• Ticket shop, ticket sale machine at platform or inside LRT |
| Modification of innovations | None, partial or complete context modification in LRT support infrastructures | Types of context modifications at design or construction stage. |
| City contextual factors amongst the 3 cities of Abuja, Lagos and Addis-Ababa | ➢ City Economic development<br>✓ City Technological environment<br>• City Culture<br>❖ Geography | ➢ Cost<br>➢ Operation and maintenance<br>➢ Transit Oriented Development (TOD)<br>✓ Safety<br>✓ Energy Supply<br>✓ Non-Motorized Transport (NMT)<br>✓ Seamless integration of transport modes<br>• Modern rolling stock<br>• Modern aesthetic stations<br>❖ Rocky deposit<br>❖ Swampy areas |
| Contextualized infrastructural innovations | Effects of contextual factors on types of modifications | Types and extents of Contextualization by re-modification |

## 4.4.2 Research Strategy

The methodology used in this research was a qualitative method of a multiple case study research, using the pilot interviews and two rounds of semi-structured interviews. This provided instruments for researchers to study complex phenomena within their contexts (Baxter and Jack, 2008), which should enlighten expert practice and served as evidence-based decision-making for policy settings. This affords researchers the opportunity to describe and explore an occurrence in context, using various information sources. It also permits the scholar to discover entities or establishments, caused by multifaceted relationships, involvements, programs and groups (Yin, 2003). Furthermore, it provided the deconstruction and

successive reconstruction of several phenomena. The multiple case studies of Addis-Ababa, Abuja and Lagos, provided effective avenues for recognizing and collecting data from different contexts (Gibbert; Ruigrok, et al., 2008). The multiple case study approach allowed for an in-depth study of variables and relationships between variables, due to the specific contexts of the cases. This approach to research has been applied to actual settings (Davenport and Prusak, 1998, Topp, 1999, Fennell and Warnecke, 1988). In addition, for public transport institutional analysis, variables are better analyzed qualitatively, which needs in-depth methodologies (Altmann and Engberg, 2016), such as semi-structured in-depth interviews, which was able to provide in depth and more comprehensive data, which was able to take into consideration specific contexts of the study. It made data collected more comprehensive, as it was attained by the gathering of respondents' views, using various sources and concepts related to actors, their related clusters, and interactions (Santander, 2013).

The sampling method used was purposive sampling. It was selected because it is based on the characteristics of the population (LRT experts) and the objectives of the study. This enabled the respondents to relate their experiences on the ground with their expertise as engineers and managers. The population coverage included Nigerian, Ethiopian and Chinese LRT experts. In Nigeria; the Abuja and Lagos LRT experts working with ALRD and LAMATA respectively, and in Ethiopia the Addis-Ababa LRT experts working with ERC. The Chinese LRT experts who worked with CCECC in Nigeria and CREC/Shenzhen metro in Addis-Ababa. The coverage method used in collecting social context of survey respondents, were developed mostly to estimate the respondent's network size, or degree (McCormick and Zheng, 2015). There was a pre-test of 3 respondents, 5 respondents during the 1st round of interviews and 9 respondents during the 2nd round of interviews, making a total of 17 interviews. The sample size in the semi-structured interviews in Lagos city was 11 respondents of LRT experts, comprising of 9 Nigerians and 2 Chinese. The sample size in Addis Ababa in the two-step approach of pilot interviews and semi-structured interviews had a total of 22 respondents. 5 respondents in the pilot interviews in 2015, 6 in the semi-structured interviews in 2015 and 11 in the second round of semi-structured interviews in 2017. The data gathered was codified using the Atlas-TI software, which facilitated the categorizing of the various levels of data, generating a robust data sets capable of deducing categories from the data on design and operation phases of the LRT in the three cities. The unit of analysis was studying the processes and actions which involved many individuals (Khan, 2014), representing actors within RRA and RPC.

## 4.5 Empirical results and discussion

This section first analysed the similarities and differences within Nigeria, i.e., between Abuja and Lagos. Secondly, it analysed the similarities and differences

between two countries, i.e., between Nigeria and Ethiopia, showing the similarities and differences between these cities and countries.

### 4.5.1 Similarities in contextual factors used during contextual processes between Abuja and Lagos within Nigeria:

The two cities in Nigeria went through contextualization, as a form of partial to complete modifications to suit the city context required, the following contextual factors that were responsible for their similar contextualization were analysed as shown in Table 11.

#### Seamless integration of transport modes

In Abuja and Lagos cities, the need for seamless integration of LRT with other modes of transport was the first contextual factor. Thus, in Abuja, there was a complete re-modification of the Abuja airport light-rail route, as a re-alignment to other existing transport modes, for seamless inter-modal transfer, between air and rail modal transport of passengers. In Lagos, seamless integration was the core of consideration, as the LRT stations were re-designed to accommodate seamless integration and operation with other transport modes such as water and road transport, since an ample percentage of Lagos is surrounded by water. This was re-designed to ensure that water and road transport passengers would have easily access the LRT and it would be connected to other parts of Lagos. Furthermore, a flyover bridge was replaced by a tunnel for the LRT passage at ring road one, Nnamdi-Azikwe express way at the intersection of the national rail transport (Abuja to Kaduna) and city light-rail transport (within Abuja city only). This was done during construction as it was observed after the design that the national rail also needed to pass through the same intersection later when the national rail route is completed. Thus, allowing for a seamless integration between the national rail and city light-rail. In addition, the Abuja city later made inclusions of more access roads during the construction of the LRT, which were not incorporated in the initial design stage. These access roads were included to aid the seamless integration of the private and public transport road users to enable them to have easy access into the LRT stations, which consequently allowed for road users to feed the LRT with passengers coming from different areas across the capital city of Abuja.

#### Transit Oriented Development

All the Abuja LRT stations were completely re-modified after its initial design proposed for implementation by the Chinese. This complete re-modification was to provide a better Transit Oriented Development (TOD) to all the stations and their connecting routes. Thus, serving as a policy to attract and encourage private developments near all the light-rail stations in Abuja, which provides the benefit of internal generated income to the Abuja city government. This internally generated income from rental charges of private development in the TOD arrangement, augmenting the fare charges from passengers and budget commitments from the

government. This augmentation from the TOD proceeds provided more support to the sustenance of operations and maintenance of the light-rail rolling-stock, since the public LRT is partially non-profit for the government. Thus, the floors were increased to one instead of an earlier proposed bungalow level, and other facilities were expanded to provide more business opportunities for the private sector, which fostered economic interactions. This was also evident in Lagos, as all stations were partially re-designed to accommodate more business activities, such as multi-story buildings for commercial carparks and other commercial facilities for private sector development.

### Non-Motorized Transport

In Abuja city, another over-pass was added as a re-modification after the initial design. This was to provide Non-Motorized Transport (NMT) better proximity and easy accessibility to people along the rail tracks, as the people were not yet used to walking about one kilometre or more to be able to cross the road. This sort of NMT around the stations is also very evident in Lagos city, with the inclusion of a "Sky walk way" at some of the LRT stations, to allow passengers go from one mode of transport to another, while walking within the same station, as the walkway is attractive containing good NMT facilities.

### Preference for a modern light-rail for good aesthetics and passengers' satisfaction

After the initial design phase, the managers of the Abuja and Lagos city LRT, made a change from the initial LRT vehicle as rolling stock, which was initially proposed by the Chinese, to a more modern LRT, with modernized facilities. The Abuja city went through a complete change of type of LRT vehicle from a simple looking vehicle to a more modern looking LRT vehicle. Lagos city also changed to a LRT vehicle that included air-conditioning for better air quality for passengers during travel, and back-up batteries to save power during motion to avoid sudden power outage before moving the light-rail to its safe parking lot.

### Inadequate energy supply

Abuja re-modified the design of stations, by choosing the use of staircases as a major priority over escalators, while also providing lifts for the passengers. This preference for the use of staircases was to avoid the breakdown of the escalators due to inadequate power supply. The Lagos city opted for a change in the LRT vehicle for the one with back-up batteries to avoid stoppage of the LRT during operation, which may have affected the electrified LRT during operation, due to its inadequate electric supply.

**Table 11: Summary of similar contextualization factors in Lagos and Abuja within Nigeria**

| Contextual Factor | Abuja | Lagos |
|---|---|---|
| Seamless Integration of transport modes | Complete re-modification of the airport light-rail route, as a re-alignment to other existing transport modes, for seamless inter- modal transfer, between air and rail modal transport passengers. | LRT stations re-designed to accommodate seamless integration and operation with other transport modes, such as water and road transport. |
| Transit-Oriented Development (TOD) | All LRT stations completely re-modified to provide TOD. Floors increased to one, other facilities expanded to provide more business opportunities for the private sector. | All stations partially re-designed to accommodate more business activities, such as multi-story building for commercial carparks and other commercial facilities for the private sector. |
| Non-Motorized Transport (NMT) | More over-passes added as a re-modification after the initial design, to provide NMT, for better proximity and easy accessibility for people along the rail tracks. | Inclusion of "Sky walkway" at some LRT stations, to allow passengers to go from one mode of transport to another, while walking within the same station with walk-friendly infrastructures of NMT. |
| Modern light-rail for better aesthetics and passengers' satisfaction | Provided a complete change of LRT vehicle type from a simple to a more modern looking LRT vehicle. | Changed LRT vehicle to include air-conditioning for better air quality for passengers during travel, and back-up batteries to save power and avoid sudden power outage during operation. |
| Inadequate energy supply | Re-modified the design of stations by changing escalators to concrete staircases as a major priority and retaining the complimentary electric lifts and escalators in some stations, to avoid breakdown of escalators due to inadequate power supply. | Opted for a change to LRT vehicle with back-up batteries, to avoid stoppage during operation, which may affect the electrified LRT during operation, due to unforeseen interruption of electricity supply. |

## 4.5.2 Differences in contextual factors between Abuja and Lagos within Nigeria

The contextual factors responsible for the differences in contextualization between Abuja and Lagos are analysed and depicted in Table 12.

Abuja city is characterized by its peculiar contextual factors, which are two Geographic and one Energy related contextual factors in two situations. These are: Construction of an overpass (bridge) instead of the earlier planned underpass (tunnel) along the airport on lot 3 LRT route, due to a barrier of massive underground rock deposit; Bridge span extended from 1 to 26 spans, i.e. the length of the beam between two bridge supports, to provide multiple forms of support on a super structure bridge for a longer overpass for cars due to a lengthy swampy area.

During the construction phase, the energy contextual factor was considered, whether to use a concrete staircase or an electrified escalator in addition to the already included lifts. Due to the inadequate power supply in the city, the concrete staircase was chosen, which led to the re-modification during the construction, while incorporating an escalator as an extra, in some areas that needed it in the LRT stations.

**Table 12: Summary of differences in contextualization factors between Lagos and Abuja within Nigeria**

| Abuja | Lagos |
|---|---|
| Three distinct contextual factors: Two geographic and one energy related contextual factors.<br>**Geographic:**<br>• Construction of an overpass (bridge) instead of earlier planned underpass (tunnel) along the airport on lot 3 LRT route, due to barrier of massive underground rock deposit.<br>• Bridge span extended from 1 to 26 for multiple support on a super structure bridge for a longer overpass for cars due to the extensive swampy area.<br>**Energy:**<br>• Modifications to augment electric escalators and elevators by constructing concrete staircases. | Three distinct contextual factors:<br>• Effective operations/maintenance and modernization: Marina station of initial 2 tracks changed to 3 tracks to meet up with current best practices.<br>• Avoids extra costs of implementing LRT: By re-routing LRT along areas with less third - party issues.<br>• Safety of LRT passengers: Modification made to allow passengers access to open doors, to avoid accidents during emergencies. |

Lagos city is characterized with its three distinct contextual factors. The first is on achieving effective operations/maintenance and modernization; second is to avoid extra costs of implementing LRT by re-routing LRT along areas with less third-party issues (private and public buildings and facilities along LRT routes); and third concerns the safety of the LRT passengers. In achieving effective operations, the Marina station designed by CCECC with 2 tracks was changed to 3 tracks, which was proposed by LAMATA. This was to provide a place to park all LRT coaches in case of a break-down of the light-rail during operation. The increased number of tracks at this location was also implemented to meet current best practices, thereby modernizing the tracks. To avoid extra costs on implementing the LRT, one of the main routes was completely changed, by re-routing it from Iddo light-rail station through Ijora-Olopa to Marina. This was done to keep the cost within the expected Lagos city budget, due to the higher settlement of third parties along the earlier designed route of Iddo. As a safety measure, modification of LRT doors was implemented, to allow passengers to have control on the doors, to avoid challenges

during emergencies. As the initial design provided the door control to the LRT driver alone.

### 4.5.3 Similarities in the contextual factors between Nigeria and Ethiopia

The contextual factors responsible for the similarities in contextualization between Nigeria and Ethiopia are analysed and depicted in Table 13.

#### Cost effective LRT route

The first is the need for a *cost-effective LRT route, minimizing expenditure in relocating third parties' facilities*. This was re-echoed during the Lagos interview as one of the top Chinese engineers mentioned, "The Lagos city should tidy up all their third-party issues before constructing the LRT, to minimize the cost and waste of time".

#### Seamless integration of the LRT with other modes of transport

The second is the need to provide *seamless integration of the LRT with other modes of transport*. As major LRT stations are not far from public road transport in all three cities and including water transport for Lagos city. Access roads and right-of-way were re-modified for seamless integration between other transport modes and the LRT.

#### Fostering TOD and NMT

The third similarity embedded in the two countries, is the need to *foster TOD and NMT*. This is very important for these countries, because LRT is for the public and not intended for significant profit investment by the government. However, maximizing the benefits of LRT, through the provision of TOD infrastructures, such as mega malls, office complexes and other commercial activities along these routes, provides some profits to the government, for adequate maintenance of the rolling stock. While the NMT is visualized in Abuja as the re-modification of LRT route closer to the airport buildings to foster NMT between air and rail passengers, and re-modification through provision of more over-passes and walk-ways for pedestrians. In Lagos through the re-modification of major LRT stations to accommodate "Sky-walk" as a user-friendly pedestrian walkway within the LRT stations linking the road and water transports. Addis-Ababa has re-modified road networks to improve pedestrian accessibility to the LRT platforms, providing improved right-of-way structures for the pedestrians to walk on roads close to the LRT stations and to better link other transport modes, using walkways along such areas and linking to the LRT platforms.

**Table 13: Summary of Similar contextualization factors between Nigeria and Ethiopia**

| Contextual Factors | Nigeria | Ethiopia |
|---|---|---|
| **Cost effective LRT route** | LRT route modified to avoid third-party issues beyond government allocated budget. | Additions and extent of underpass (LRT tunnel) and overpass (bridges) initially not in the original design. |
| **Seamless integration of LRT with other modes of transport** | • LRT routes in proximity to other transport modes.<br>• Access roads added to allow for integration between public roads and water transport with LRT. | • Access roads and right of-way re-modified for seamless integration between other transport modes and the LRT.<br>• LRT routes near other transport modes. |
| **Foster TOD and NMT** | • Re-modification of LRT route closer to airport buildings to foster NMT between air and rail passengers.<br>• Re-modification through provision of more over-passes and walk-ways for pedestrians.<br>• Re-modification of major LRT stations to accommodate "Sky-walk" as user-friendly pedestrian walkway within the LRT stations linking the road and water transport. | • Re-modifies road networks to improve pedestrian accessibility to the LRT platforms.<br>• Provides improved right-of-way structures for the pedestrians to walk on roads close to the LRT stations, for better link with other transport modes, using walkways along such areas linking to the LRT platforms. |
| **Safety** | • The 460 meters thickening of wall inside lagoon to avoid city flooding. Change of LRT doors-use to passenger friendly doors during emergencies.<br>• Provision of more overpasses and underpasses, for safe pedestrian and cattle movements. | • Incorporates the use of intermittent automatic train protection system after the LRT has been ordered during the operation phase.<br>• Barriers built along the roads sharing same level with the LRT, to prevent accidents by vehicles running into the LRT. |
| **Modernization of LRT to current best practices** | • Complete change in the initial proposed LRT vehicle from a simple to a modern LRT with better aesthetics.<br>• Changed the LRT vehicle to include air-conditioning and back-up batteries. | • Changed the earlier plan of using different entry and exit doors of LRT for passengers, to using all doors for entry and exit, as a more user friendly method, avoiding chaos, especially during peak periods. |

### Safety

The fourth similarity is the need for *safety across the board in the two countries*. This was demonstrated by thickening the wall inside Lagos lagoon measuring 460 meters, to avoid city flooding, and a change of door use to more passenger-friendly doors, which can be opened also by the passengers, especially during emergency periods. Abuja also provides more overpasses and underpasses, for safe pedestrian and cattle movements. While the Ethiopians incorporated the intermittent automatic train protection system after the LRT was ordered during the operation phase, to provide automated safety measures for the LRT drivers. *Barriers* were also built along the roads which shared the same level as the LRT, *to avoid accidents* by vehicles from running into the LRT.

### Modernization of LRT to current best practices

*Modernization of LRT to current best practices*. Abuja completely changed the initially proposed LRT vehicle from a simple to a modern LRT vehicle with better aesthetics; Lagos changed the LRT vehicle to a type that includes air-conditioning and back-up batteries; Addis-Ababa changed the earlier plan of using different entry and exit doors of the LRT for the passengers, to using all doors for entry and exit, as a more user friendly method, avoiding chaos, especially during peak periods.

## 4.5.4 Differences in the contextual factors between Nigeria and Ethiopia

The contextual factors responsible for the differences in contextualization between Nigeria and Ethiopia are analysed and shown in Table 14.

### Ticket Stations

The first difference is characterized by the *construction of emergency ticket shops* in Ethiopia. Unlike Nigeria, which has all her ticket shops within the ticket stations. This emergency plan by Ethiopia was the only option based on the context of the situation at hand, they were not able to use the installed electronic ticket-validation system on board the LRT vehicle, due to high population and lack of barrier turnstile at platforms. This created a sense of urgency to build ticket shops at every light-rail stop, and the difference in time between each light-rail stop or platform is an average of 2 minutes. This caused extra expenditures for building the ticket shops within 2 minutes time difference from each light-rail stop, employing ticket salespersons at each ticket shop in every light-rail station, and ticket officials inside the LRT. This use of paper tickets led to a significant level of fare evasion, approximately 30%, as mentioned by an ERC top engineer. This significant percentage of fare evasion is because the few ticket officials are overwhelmed by the highly populated LRT, in which the passenger's tickets cannot be adequately confirmed by the ticket officials during the trips inside the LRT or before boarding at the station platforms. Thus, leading to the free ride (fare evasion) by some

passengers who sometimes travel far distances, but pay for short distance, or do not pay at all for a whole trip.

### Energy

The need to *complement for energy failure* was prominent in Nigeria, characterized by the need for back-up batteries on the electrified LRT in Lagos and the preference for a concrete staircase over escalators in Abuja. While Ethiopia has a more stable electricity supply, using dedicated power supply for its LRT and in general having a more reliable electric supply than Nigeria.

### TOD and NMT

Nigeria demonstrated *more in-depth modification of stations to improve TOD and NMT*. Mainly because all Nigeria stations are bigger, which requires the need to maximize the space by integrating other modes with better NMT for pedestrian's accessibility and improve economic activities at the LRT stations and routes. While in Ethiopia, not all the LRT stations can incorporate facilitates to support TOD, as some of the stations are only in-between roads and therefore possess less space to implement adequate TOD. Thus, causing the stations sharing the road with vehicles to have limited space to expand for a more robust TOD and NMT. However, some strategically selected stations with more space have improved TOD and NMT facilities in Ethiopia.

### Modern aesthetics of both the rolling stock and station areas

Nigeria was peculiar with the modern aesthetics of both the rolling stock and station areas, as her cities have bigger stations with more passenger facilities and a higher population. This is because Nigeria incorporated the LRT into her masterplan from the onset of their city planning, opposed to Ethiopia who included her LRT design in recent years. Addis-Ababa is satisfied with the aesthetically electrified LRT provided by the Chinese, even though they have less choice to be able to enlarge all their stations, as only some strategic stations were enlarged to have TOD. Therefore, some LRT stations in Ethiopia share the road with vehicles on the two sides. The LRT has the major right of way. In the Nigerian cities, Abuja and Lagos are the present and former capital cities of Nigeria, which due to this fact seeks for an aesthetically beautiful rolling stock and station areas, which was requested by the RRA in Nigeria, as the initial plan of LRT by RPC needs to be modified. This can be viewed as a cultural need for Nigerians to prefer not only functional technology, but they are aesthetically inclined, and it is also befitting for the capital cities.

**Table 14: Summary of differences in contextualization factors between Nigeria and Ethiopia**

| Nigeria | Ethiopia |
|---|---|
| All ticket shops are within enclosed ticket shops inside the stations. | Construction of "emergency" ticket shops, based on the context of the situation at hand, of not able to use the installed electronic ticket system on-board the LRT vehicle, due to high population and lack of barrier turnstile at platforms. |
| Need to complement for energy failure. Seen in the use of back-up batteries on electrified LRT and preference for concrete staircase over escalators. | More stable electricity supply, using dedicated electric power supply for its LRT. |
| More in-depth modification of stations to improve TOD and NMT. Mainly because all Nigeria stations are bigger, which requires the need to maximize the space by integrating other modes with better NMT for pedestrian's accessibility and improve economic activities at LRT stations and routes. | Not all LRT stations can incorporate facilitates to support TOD, as some of the stations are only in-between roads and therefore possessing less space to implement more TOD. Thus, causing some stations to share roads with vehicles, which have limited space in expanding for a more robust TOD and NMT. However, some strategically selected stations with more space has improved TOD and NMT facilities. |
| • Need for modern aesthetics of both rolling stock and station areas, with bigger stations and more passenger facilities to serve more populated cities.<br>• LRT plan present in the city master plan | • Both electrified LRT and station areas are already aesthetically adequate. Only strategically selected stations were expanded for TOD.<br>• LRT plan absent in the city master plan until recently. Therefore, use of middle of roads for some of the LRT routes, giving priority and right-of-way to LRT. |

## 4.5.5 Highlight of Congruent and Divergent Contextual Factors between Nigeria and Ethiopia

The congruent contextual factors in Abuja and Lagos cities of Nigeria highlights the major and similar contexts in both cities due to peculiar challenges and situations at hand. These are evident in the electric energy supply due to the general inadequate electric energy supply in Nigeria; modernization of the light-rails and their stations because the two cities prefer more aesthetic-looking light-rail with modern features, as compared to the proposed light-rail and stations by the Chinese rail corporations; TOD as a means to promote business activities for the private sector and support the government finance on operations and maintenance through rent charges at TOD designated areas along the LRT routes, which is partly due to more spacious areas of the light-rail stations; NMT within the TOD areas and along the LRT routes to facilitate pedestrian movements; seamless integration of LRT with other modes of transport, which was mainly due to the presence of the LRT in their master plan, to support its integration with their national rail systems, Bus

Rapid Transit (BRT), water transport and other private and public road transport modes.

Whereas, the contextual factors in Addis-Ababa, Ethiopia revealed its divergence to contextual factors in Nigeria, as emergency ticket shops due to non-functioning electronic ticket machines on-board the LRT, consequently from over populated peak-hour travel by passengers; less capacity for TOD as they were only present in some designated light-rail stations due to less space to develop the TOD; NMT are mainly along the LRT stops to provide better safety due to right-of-way issues on the roads and safer accessibility into the LRT, as the light-rail and other motorized transport share the roads in more than half of the light-rail stops.

## 4.6 Conclusions

The conclusion reveals lessons learnt from the poly-contextualization between the three cities of the two countries. These lessons learnt unravels sets of eminent contextual factors with a stronger influence on the contextualization; answers the research question; shows benefits to filled gaps in academic literature and benefits for the transport industry; provides key recommendations for the transferability of research findings to other local contexts; and guides towards areas of further research.

### Lessons Learnt from Contextual Factors as a Benchmark to Poly-Contextualization between Nigeria and Ethiopia

The eminent contextual factors having stronger influence on the contextualization of infrastructural innovations in Nigeria are electric energy supply, modernization of LRT and their stations, TOD and seamless integration of LRT with other transport modes. Out of these four factors in Nigeria, modernization of LRT rolling stock and their stations is the strongest of all factors, as various re-modifications were made on the LRT rolling stock and LRT stations to modernize them with best practices to suit the former and present capital cities. Prominent contextual factors with more effect on contextualization of infrastructural innovations from Ethiopia are emergency ticket shops, seamless integration of LRT with other transport modes, and NMT. This is specifically to improve the safe right-of-way for pedestrian's accessibility to LRT in Ethiopia, since a significant route of LRT is in the middle of roads, sharing roads with other modes of transport, such as public transport and private busses and cars. Out of these three factors in Ethiopia, emergency ticket shops stand as the strongest factor, as it was the most unexpected event, due to non-functional electric ticket-validation machines inside the LRT, leading to fare evasion. Common to both Nigeria and Ethiopia, the seamless integration of LRT with other transport modes stands out. Thus, answering the research question: What are the factors influencing the contextualization of

infrastructural innovations in an urban light-rail transport, from the China context to Addis-Ababa, Abuja and Lagos city contexts.

Furthermore, from the insights of this research and observations during fieldwork in both countries, it can be argued that an effective contextual approach to implementing a sustainable LRT depends more on the LRT receiving city authorities political will, related to political system in literature (Tsui, 2006); the level of technology transferred, i.e., technological environment (Cheng and Huang, 2013), from the Chinese to the two countries on operations and maintenance of the LRT; and thirdly on the combination of a context-specific decision-making process of the RRA and expert light-rail knowledge from the RPC (Bhaduri; Sinha, et al., 2018). Nigeria, Ethiopia and China have demonstrated adequate context-specific decision-making processes during the implementation of the light-rail, which serves as a benefit to both the RPC and RRA. This is because more cities in transition to light-rail will be encouraged to partner with RPC, leading to more symbiotic relationships between RRA and RPC, since the collaboration fosters adequate context-specific decision-making processes, which aids better knowledge transfer and implementation processes.

This research departs from the theories of contextual factors (Tsui, 2006, Cheng and Huang, 2013), poly-contextualization (Von Glinow; Shapiro, et al., 2004), and context-specific decision-making process (Bhaduri; Sinha, et al., 2018). This research correlates with the statement that all factors that emerged in time and space, have defined the reasons why a context is specifically the way it is presently (Tsui, 2006). In addition, it correlates with the concept of poly-contextualization, describing the procedure of integrating various scopes within a context aimed at a complete and objective comprehension of any phenomena in it (Von Glinow; Shapiro, et al., 2004). Findings from this research, supports the theories that contextual factors depend on a the particular challenge at hand (Wisdom; Chor, et al., 2014). The context-specific decision-making process is evident in the adequate cooperation of the RPC's rail experts with the local and crucial knowledge from the RRA, which forms a symbiotic relationship, as the expert knowledge relies on the local context knowledge to accomplish the light-rail infrastructure.

Therefore, this research was able to expand the current academic literature by filling in some literature gaps. This is especially in the area of infrastructural innovation adaptation in urban transport sciences, with specific contextual factors that have emerged overtime and in space that have shaped the implementation processes of a Light-Rail Transport in three African cities, and results shows the reasons why a context is the way it is currently in the two countries. Furthermore, it provides meaningful data about contexts in different types of cities with similar and diverse socio-economic conditions, for appropriate decision making, on cost and energy efficient LRT; good quality; and user friendly for the light-rail passengers. This

contextual process is necessary because it also shows how capable the RPC from China are in terms of contextualizing the LRT to any city's contexts. These contextual processes are sometimes complex and requires both the technical and local context capacities from both parties to implement the light-rail. Thus, the RPC will run the risk of poor warranty to RRA or other potential clients in other countries interested in investing on the LRT from MNCs in China in the future, if they do not have the capability to innovatively contextualize cities LRT to their contexts. However, results in this research shows that the RPC has demonstrated an adequate level of capability to contextualize these contextual factors with the RRA. Consequently, if the LRT receiving cities through their engineers, scientists and managers do not provide the necessary local context ideas, that will aid the MNC and city LRT to implement a contextualized LRT system, they will run the risk of system dysfunction and a low cash return rate if certain aspects of the LRT infrastructure are not properly contextualized. The RRA within the three cities also demonstrated an adequate level in the use of their local context knowledge during the implementation processes.

The key recommendations for the transferability of this research findings to other local contexts are derived from lessons learnt from each city case study. Therefore, it is recommended that cities with an inadequate power supply should use other sources of energy apart from electric energy, or use hybrid energy (such as electric and diesel) LRT systems, such that the system can use diesel or similar forms of energy and easily switch to electricity when it is adequate or more stable. To augment inadequate electric energy, this should include the use of renewable energy, such as solar energy by other infrastructures, such as escalators, lifts, ticket machines and the whole light-rail station building in general. Back-up batteries should also accompany the use of electricity in the operation of the light-rail, such that the light-rail can be parked safely during electric power failure.

Cities with limited space for barrier turnstiles at light-rail platforms, should provide more light-rail vehicles to augment the existing ones, thus reducing congestion in the LRT due to high travel demand, especially during peak hours, which consequently allows for the use of electronic tickets via swiping of cards on ticket machines inside the LRT and reduces the level of fare evasion. TOD and the land value along the LRT route should be adequately designed and captured respectively, to maximize its internally generated income, which augments income from fare charges and government committed funds, to support the operations and maintenance costs. To encourage better public transport use, the LRT connectivity to other transport modes should be improved by constructing or redirecting other transport routes to the LRT route. Such as BRT stops or airport terminals with 2-5 minutes walking distance of the LRT stops or stations. Apart from including air-conditioning systems in the light-rail for the comfort of the passengers during warm temperatures, it is recommended to have windows that can be slightly opened to

allow fresh air into the light-rail without opening the windows completely. This is to avoid discomfort when the electric energy fails or when the temperature becomes too warm to bear by the passengers, which improves the air quality inside the light-rail. To save a significant amount of money and time, i.e., to be frugal, it is recommended that cities should tidy-up their third-party issues before implementing the LRT. This entails policies to prevent unwanted buildings along the LRT routes, and settling any existing third-party issues through compensation, relocation or demolition as the legitimate situation demands. This will prevent delays and unnecessary expenditures during the implementation of the LRT.

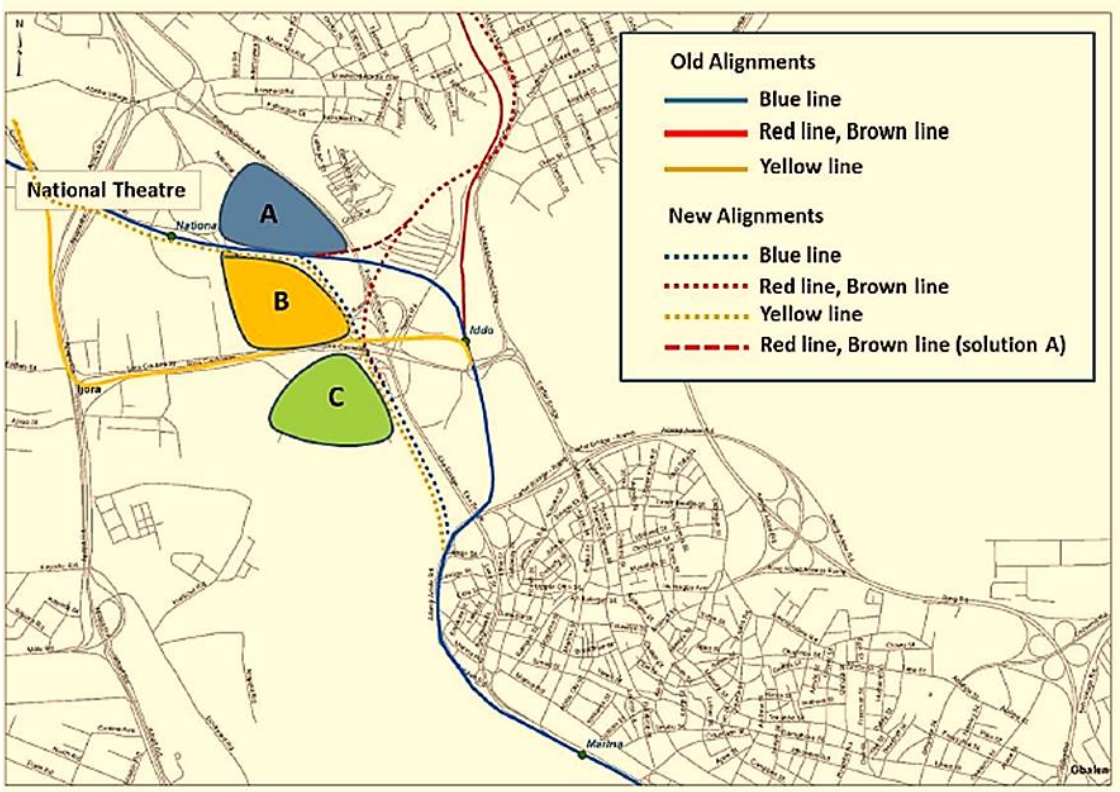
Further research questions are eminent and grounded on the results of this research. These are: Why are certain contextual factors common in certain cities than others during the implementation of LRT? To what extent does a Build Operate and Transfer (BOT) or Design and Build (DB) business model provide a more sustainable LRT? How can city governments create an enabling environment for LRT implementation, where investors can gainfully invest, while city governments only regulate? How can multi-national corporations from China and other advanced rail transport countries collaborate more effectively to deliver LRT, with an affordable cost, less third-party issues and sustainable rail technological transfer?

## 4.7 Appendix Chapter 4

**Photograph 12: Rail Infrastructure for Lagos LRT**

Photograph 12 above shows some of the constructed infrastructures to carry the LRT as a bridge, with roads and waterways beneath it, along the national theatre route in Lagos city.

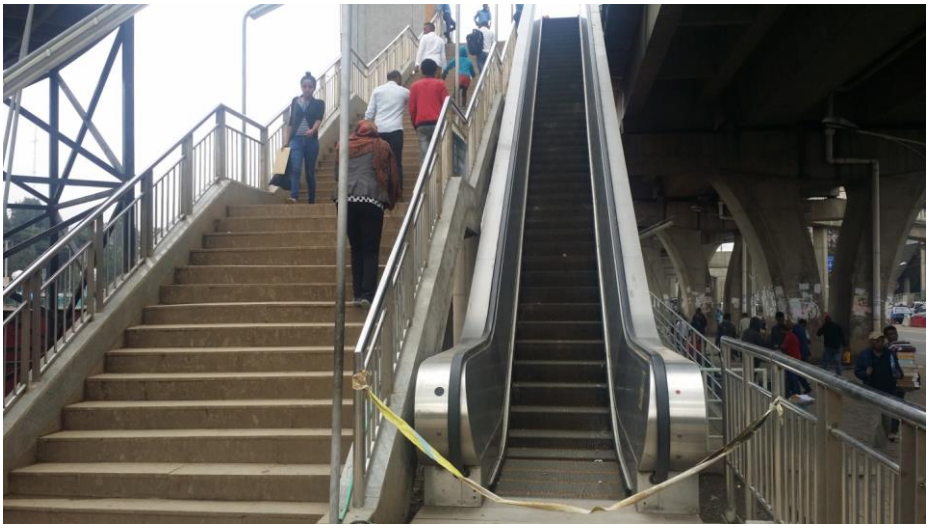
**Photograph 13: Map showing possible options for the location of the Central Station replacing Iddo**




In photograph 13, as explained in the STMP, after consultations with LAMATA, option B, which refers to the "National Theatre Station" was chosen, due to its proximity to the National Theatre. In spite of this final choice of location for the Central Station, Iddo will remain a key activity area for Mainland Central and Lagos. Therefore, full access from Iddo to the National Theatre Station was guaranteed through an appropriate link, fully accessible to non-motorized vehicles and pedestrians, as well as mixed uses including commercial developments. Another experienced top engineer reaffirms, "initially we were supposed to go from National Theater to Iddo, then from Iddo to Marina area, but we completely changed the alignment from National Theater straight to Marina, instead of going through Iddo, because of several third party issues that we were not able to solve. We also discovered that it was not necessary; we can do without going to Iddo. We initially made it Iddo station because we wanted the blue and red line to meet at Iddo. We later discovered that we can make them meet at Marina. Therefore, instead of going through Iddo, which has so many third-party issues. This was also part of the things that caused delay in the implementation of the LRT". These third-party

issues range from high cost of relocating some settlements to high cost of re-aligning some telecommunication utilities and demolition of houses and commercial activity areas, which has negative consequences on the livelihoods of the people.

**Photograph 14: Constructed elevators in Addis-Ababa to support the use of stairs for access to the LRT platform**



**Photograph 15: Idu station in Abuja showing the front view with more space to accommodate Transit Oriented Development (TOD)**

**Photograph 16: Idu station in Abuja showing the side view**

**Photograph 17: Abuja light-rail platforms showing wider spaces for the use of turnstile system of ticket validation**

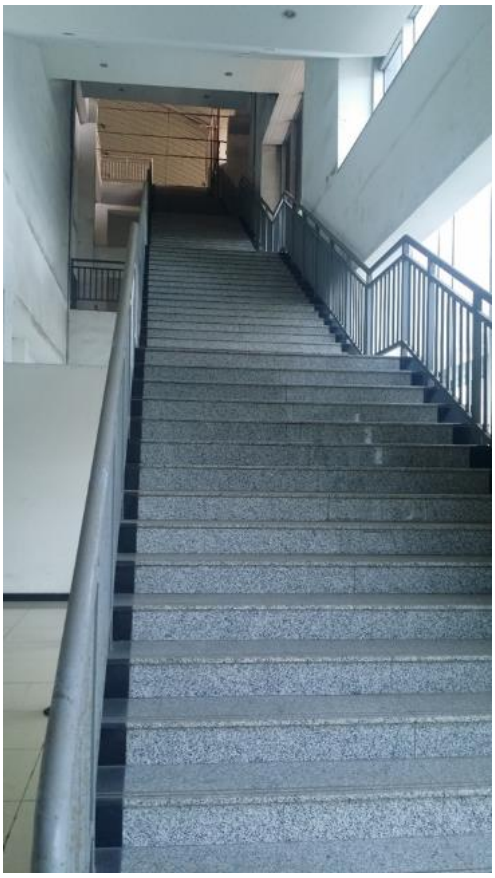
**Photograph 18: Abuja ticket office as a point of entry before accessing the LRT platform**


**Photograph 19: Addis-Ababa ticket office close to the LRT platforms**

**Photograph 20: Addis-Ababa light-rail approaching as passengers wait on the platforms**

**Photograph 21: National theatre station at Lagos LRT**

**Photograph 22: Staircase at National theatre station Lagos LRT**



**Photograph 23: Electric lift at Idu station Abuja**

**Photograph 24: Electric lift at National theatre station Lagos**

Photograph 22 is the staircase at the National theatre station of Lagos LRT; Photograph 23 is the electric lift at Idu station in Abuja; and Photograph 24 is the electric lift to augment the concrete staircase at the National theatre station at Lagos LRT.

# Chapter 6: Conclusions and Discussions[6]


[6] Part of conclusion section submitted as a book chapter, in a book titled: Lessons Learned for Urban Management and Governance. Second submission on 2nd January 2020, after first review in the last quarter of 2019.

## 6.1 Introducing the Conclusions

This conclusion chapter has been divided into five sections. The *first* section introduces the conclusions in general, considering the problem statement, which provides reasons as a need for cross-national comparison and transfer in transport infrastructure innovations. The *second* section answers the research questions, and it also includes contributions as benefits to scientific literature and societal relevance and provides a link-back to the applicable theoretical contributions. The *third* section provides additional directions for future research. The *fourth* section entails policy recommendations for contextual adaptation of light-rail transport. The *fifth* section contains the closing remarks, as a clarion call for an extra-ordinary and systematic action for cities in transition to Light-Rail Transport.

Inadequate adaptation of technological and non-technological innovations in a sustainable manner are perceived as a global problem. Such as observed in the French scenario with the inability to fit in their newly imported light-rail vehicles to their already existing platforms, causing a waste of extra 50 million euros (Willsher, 2014). In addition the insufficient familiarization by the Dutch planners with advances in other countries on best practices in spatial and infrastructural development, in which limited awareness and overestimation of Dutch abilities have hindered the Netherlands in making sufficient use if this for more timely and adequate development (de Roo, 2002, de Jong, and de Vries, 2003).

Furthermore, this research shows the mismatch of the pricing innovation using paper ticket instead of the planned electronic ticketing brought with the LRT vehicles from China. This mismatch was due to an underestimation of the population that would use the LRT, in the Addis-Ababa context, leading to unwanted fare invasion at 30% rate, which is huge and has negative consequences on the cash returns from sales of tickets meant to cater partly for the operations and maintenance costs. The non-consideration of the need for more Transit Oriented Development (TOD) at the Abuja station buildings which did not suit the architectural culture and preference of Abuja, also faced a redesigning procedure after the already designed station buildings architecture from China. Substantial third-party issues caused a long-term delay in the Lagos city context, allowing for inflation of foreign currency to cause extra costs on the imported LRT infrastructures, which were not adequately considered from the Lagos city context before starting the LRT implementation, just to mention some of the inadequate adaptations of LRT.

If one looks at non-technological innovations, they sometimes do not suit the city context, because of issues like technology transfer gaps (absorptive capacity), institutional gaps, LRT support infrastructure gaps, pricing for affordability, passenger travel culture, congestion or population demographics and other socio-economic factors. Adapting innovations requires strategies to reduce the level of

risks, using innovative and a contextual approach, which upholds the continuity of a company, avoiding its extinction (Olleros, 1986, Tellis and Golder, 1996).

A number of generations of innovation management happened in different times and in completely diverse contexts, demanding for diverse forms of innovation processes (Niosi, 1999). This necessitates that innovation managers ought to habitually focus on how to manage their innovation process based on their specific contexts (Ortt and van der Duin, 2008).

Understanding cross-national comparisons between countries and a transferal or transplantation in infrastructural implementation helps detect the challenges in the cross-country context, thereby learning from the multi-actor bottlenecks from these countries, which are more advanced in transport infrastructure, in order to avoid the similar potential challenges. It is pertinent to know that similar transplantation has a lower probability of erupting problems than dissimilar transplantation in transport infrastructure innovations (De Jong; Lalenis, et al., 2002). These scholars further re-affirmed that as long as the institutional differences are acknowledged and accepted, and the execution process is observed and there is a need to provide levels of freedom to multi-actors in the national domain to structure the transplantation in a self-governing manner.

Regarding the inadequate adaptation of technological and non-technological innovations of a Light-Rail Transport, this research aimed to gain a better understanding of how the light-rail transport infrastructure can be adequately adapted in a cross-national context between China from Asia, and two countries in Africa: Nigeria (Abuja and Lagos cities) from west Africa and Ethiopia (Addis-Ababa city) from east Africa. All three countries having different institutional contexts and diverse technological, socio-economic and environmental contextual factors.

## 6.2 Answering the Research Questions

The overall aim of this research was to understand, categorize and assess the processes of how light-rail infrastructure is transferred from one city context to another, amidst multi-actor complexities and limited resources. In addition to provide insights for cities in light-rail transition, delivering pathways to achieving a properly adapted light-rail, based on different technological, socio-economic and environmental contexts, particular to diverse cities.

This research focuses on the adapted LRT from China into the 3 cities (Addis-Ababa, Abuja and Lagos) employing an overall research question:

*How can pricing and infrastructural innovations be adapted to Urban Light-Rail Transport using a frugal approach?*

To answer this overall research question, four sub-research questions were formulated with reasons, with sub-question three having three sub-questions, due to its contextual factors and combination of pricing and infrastructural innovations. These four sub-questions are as follows:

1. How do multi-actor interactions and absorptive capacity processes deliver frugality in Addis-Ababa Light-Rail Transport and what are the effects of the light-rail transport on modal-shift and the low-income earners (bottom of the pyramid users of the transport)?

2a. How does pricing and infrastructural innovations of a Light-Rail Transport from China contextualized to the Addis-Ababa city context?

2b. What are the social, economic and environmental effects of these contextualized innovations on passengers, MNCs expected outcomes, the city environment, and resident's proximity and business activities along the LRT routes in Addis-Ababa?

2c. Why do the effects of the contextualized innovations on the passengers, MNCs, and residents lead to re-modifications in Addis-Ababa?

3 What are the factors influencing the contextualization of infrastructural innovations from the Chinese context to Abuja, Lagos and Addis-Ababa cities context?
4 To what extent does the targeted and delivered service qualities', using frugal approach by multi-actors satisfy the perceived service quality from passengers?

The next sub-sections intend to provide specific answers to each sub-research question and at the end answer the overall research question.

### 6.2.1 How do multi-actor interactions and absorptive capacity processes deliver frugality in Addis-Ababa Light-Rail Transport and what are the effects of the light-rail transport on modal-shift and the low-income earners (Bottom of the Pyramid users of the transport)? (RQ1)

The combination of absorptive capacity structures 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 process, despite inadequate country owned financial resources, less technological and knowledge capability of LRT and a limited period of time resources of only three years.

Structured absorptive capacity refers to the knowledge required to use or adapt innovation, which provided a knowledge transfer ratio plan, medium and long term training, knowledge transfer division to 19 mainstreams and certifiable positions in

operations and maintenance, and the pairing of every Chinese manager by their Ethiopian equivalent in the main departments.

The multi-actor interaction process used systematic multi-actor interactions in a complex network society of multi-actor networks with main actors and several city actors (Van Buuren and Edelenbos, 2002). ERC was the main actor, they were able to successfully interact with other multi-actors, using mainly a systematic combination of stakeholder dialogues and formal negotiations to interact between the Addis-Ababa city authorities and the MNCs.

The stakeholder dialogues were the main sort of multi-actor interaction, while the formal negotiation that followed was able to provide the benefits of complimenting the stakeholder dialogues, especially when the stakeholder dialogues reached a standstill, formal negotiations were used to settle the problems during complex multi-actor interaction processes. The stakeholder dialogues also had a soft-landing benefit for the formal negotiations, they were able to stimulate faster approvals and help avoid complex bureaucracy to a reasonable extent.

The multi-actor interactions also were able to produce a fare structure, which in turn provided a more affordable transport fare for the BoP passengers than most of the other modes of transport in the city, providing them with an inclusive leverage to use the LRT.

By providing cheap, safe and comfortable public transport compared to the other available public transport modes in Addis-Ababa, helped the LRT to be, in the long run, more sustainable (Jeon and Amekudzi, 2005).

This has consequently also led to a fraction of modal shift from other motorized modes of transport to the light-rail transport, which is progress towards the reduction of road congestions and Addis-Ababa city air-pollution from vehicles, which is two to six times higher than WHO standards (Benjaminson; Shankute, et al., 2012).

This study has provided the *scientific importance* of showing how the delivery of frugality was achieved in the delivery of LRT, via multi-actor interaction processes and absorptive capacity. It was very significant as until now only few researchers have documented how diverse kinds of governance affect frugal processes, and how effective governance frameworks can influence the development and diffusion of frugality and frugal innovations (Hillman; Nilsson, et al., 2011). In addition, this study will benefit scientific literature, in the theory of frugality in finance, human and time resource management during multi-actor interactions, when trying to implement frugality in service. It will also be useful to further study how other emerging economies may be able to harness their limited resources to implement large infrastructural projects like roads, water ways, national rails, LRT etc. (Prabhu and Gupta, 2014, McNicoll, 2013, Mukerjee, 2012).

The study has brought specifically the frugality within the transport governance domain and the theory of absorptive capacity in the context of multi-actor interactions of LRT systems. It will be useful to make further studies regarding different structures of knowledge transfer in different cities in transition and knowledge required to adapt an innovation

In addition, this study is of societal relevance for decision and policy makers, it helps to understand how to organize multi-actor interaction processes with MNCs and how to structure absorptive capacity in order to make optimum use of limited financial, time and human skill resources. This societal relevance is also directed towards the realization of SDG-9, stated as:

> *"Building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation."* (UN, 2015)

As efficient transportation services generate employment and wealth and drive economic development.

### 6.2.2 How does pricing and infrastructural innovations of a Light-Rail Transport from China contextualized to the Addis-Ababa city context? (RQ2a)

### What are the social, economic and environmental effects of these contextualized innovations on passengers, MNCs expected outcomes, the city environment, and resident's proximity and business activities along the LRT routes in Addis-Ababa? (RQ2b)

### Why do the effects of the contextualized innovations on the passengers, MNCs, and residents lead to re-modifications in Addis-Ababa? (RQ2c)

(RQ2a) Pricing and infrastructural innovations were contextualized using the contextual approach, which was based on city level contextual factors, formulated as a result of the challenges related to the social, economic and environmental effects on passenger service delivery, MNCs expected outcomes and the resident's proximity; to suit the Addis-Ababa context. These new contextual factors include:

- Fare evasion
- Level of travel demand
- Non-use of electronic devices for pricing (on-board ticket validation)
- LRT Platform size
- Non-availability of ticket sensor barriers on the platforms (ticket sensor barriers)
- The use of lifts and escalators at specific LRT stations (movement support infrastructures).

(RQ2b) The results further show the social, economic and environmental effects of the contextualized innovations on passengers, MNC's, the city environment and residents as shown in the tables below:

**Table 15: Effects on Passengers Service Delivery**

| SN | *Effects on Passengers Service Delivery* | *Sustainability Factor* |
|---|---|---|
| **1** | Inconvenience and possible danger to passengers needing to crossroads to buy tickets located only on one side of every LRT station | Social |
| **2** | Unrealistic swiping of electronic cards on validation machine inside the LRT | Economic |
| **3** | Time wastage due to ticket sales in ticket shops | Economic |

**Table 16: Effects on MNCs Outcomes**

| SN | *Effects on MNCs Outcomes* | *Sustainability Factor* |
|---|---|---|
| **1** | Fare evasion - Loss of income revenue to ERC and MNCs from ticket sales | Economic |
| **2** | Extra expenses incurred in selling tickets at ticket shops | Economic |
| **3** | Difficulty locating closer points for ticket shops | Economic |
| **4** | Extra cost of resettlements for relocated buildings due to third-party issues | Economic |

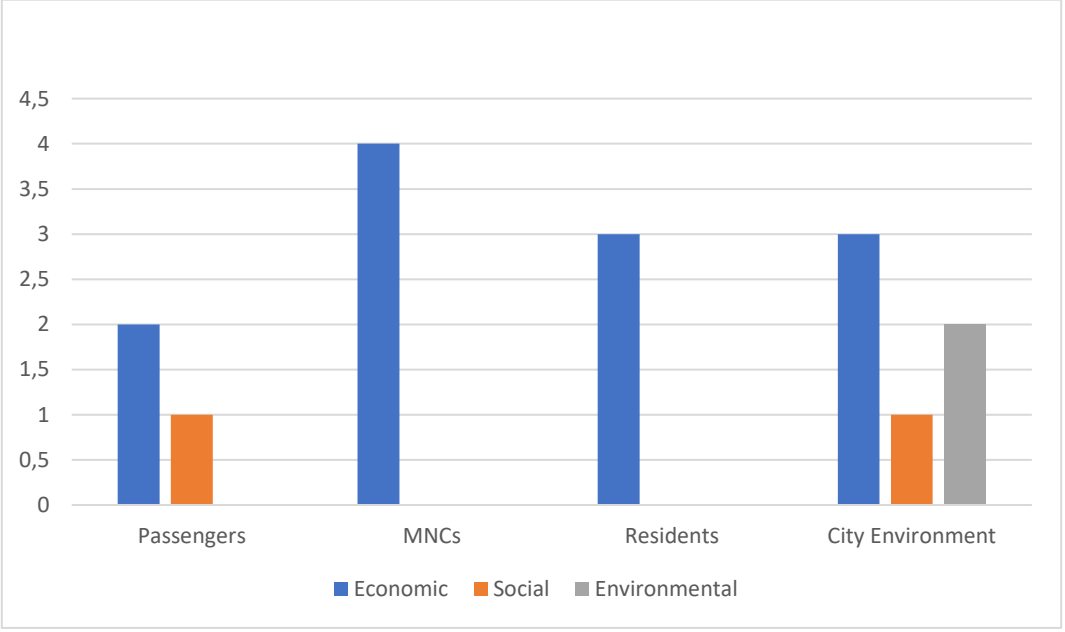
**Table 17: Effects on residents along LRT route**

| SN | *Effects on residents along LRT route* | *Sustainability Factor* |
|---|---|---|
| **1** | Reduction in sales from commercial activities due to reduced proximity to the commercial centres | Economic |
| **2** | Increase in fare rate by taxis along LRT route due to extended length of road by LRT protection fence | Economic |
| **3** | Increase in travel distance and time for pedestrians living far from zebra crossings along the LRT route | Economic |

**Table 18: Effects on the Addis-Ababa City**

| SN | *Effects on the Addis-Ababa City* | *Sustainability Factor* |
|---|---|---|
| **1** | Reduction in carbon emissions by other motorized transport due to modal change to LRT (it also reduces congestion) | Environmental |
| **2** | Better affordability for LRT users due to modal change by public and private transport users of the LRT | Economic |
| **3** | Change of transport use status of low-income passengers from other public transport to a safer and more affordable transport | Social and Economic |
| **4** | Increased Transit Oriented Development (TOD) along LRT route | Economic and Environmental |

**Figure 9: Summary of Effects of LRT on Passengers, Multi-National Corporations, Residents and City Environment**




Nevertheless, despite these effects, a very significant credit needs to be given to the ERC of Addis-Ababa and the Chinese consortium for accomplishing to build and put into use the LRT within the short amount of time of three years and within its stipulated budget. This was their first time to implement the LRT in Ethiopia, which qualifies this project as a learning by doing and doing by learning project.

(RQ2c) The effects of these contextualized innovations on passengers, MNC's and residents also led to re-modifications or re-adaptations, because there was a need for the Chinese LRT to fit in an Ethiopian habitat in a functional manner. The re-

modification process was intended for a better innovation adaptation considering the risks and complexity, tri-ability and compatibility (Greenhalgh; Robert, et al., 2004). Thus, contextualizing the non-technological innovations, in line with Hyard (2012), as pricing and infrastructural innovations, the multi-actors used the contingency theory because the contextual factors represented new and specific challenges that were encountered that influenced innovation adaptation (Wisdom; Chor, et al., 2014). Thus, innovation adaptation needs to consider compatibility, complexity, reinvention, tri-ability and risk, for a more sustainable light-rail transport with positive impacts of the system on the environment, economy, and social well-being, which is measured by system effectiveness and efficiency (Jeon and Amekudzi, 2005).

The contextualization of pricing and infrastructural innovations in Addis-Ababa, has been able to add value to scientific literature, as a *scientific benefit* in the domains of urban public transport planning and transport governance, using the newly established city level contextual factors. The newly established contextual factors were connected to the ones that were already mentioned in scientific literature.

According to Tsui (2006) fare evasion is connected to economic development and as Cheng and Huang (2013) point out technological environment. If one can understand the reasons why fare evasion occurs and the rate it occurs helps to measure how economically viable the pricing systems need to be, in this case during the operations of the Light-Rail Transport. Thus, fostering better decision making based on empirical facts. In this example, it was also connected to technology, as fare evasion was mainly due to the use of paper tickets and not electronic ones as first planned. The technological environment of the pricing system was adapted, using paper tickets instead of electronic tickets or built in sensor barriers for passengers at platforms before accessing the Light-Rail Transport. In addition, the acquisition of adequate light-rail vehicles to decongest the LRT system would help lessen fare evasion.

Tsui (2006) mentions that the level of travel demand is connected to human geography of the city. City travel demographics on travel population and modal use of different public transport can show the usage of the LRT in a specific area. Non-use of electronic devices for pricing (on-board ticket validation) and the non-availability of ticket sensor barriers at platforms (ticket sensor barriers) hinders collecting these demographics (Cheng and Huang, 2013).

The on-board ticket validation system, which were designed to be on the Addis Ababa LRT, was unable to function due to the high demand of the light-rail transport. Similarly, the platforms were not broad enough to cope with the amounts of people checking in and out of the LRT, which caused safety issues as well as slowing down the LRT.

The LRT platform size and the use of lifts and escalators, or tunnels or overpasses at specific LRT stations, known as movement support infrastructure, are also factors that influence the technological environment. The LRT system's need to integrate infrastructure such as platforms or escalators or checking in and out barriers. The platforms need to have adequate space for the passengers, they should be large enough to be able to accommodate the number of passengers that need to go through the platform sensor barriers at rush hour. Technological consideration of use of movement infrastructure to support accessibility to platforms, especially for the physically challenged, elderly, people with young children, and individuals carrying large amounts of luggage also need to be taken into consideration. If these factors are taken into consideration it also has a positive social influence (Cheng and Huang, 2013).

Cities in transition to LRT can follow the contextual factors mentioned in this document, which can help during the contextualization process of their pricing and infrastructural innovations. In this regard, the *societal relevance* of this book is associated with better affordability and accessibility for the public, through; better managerial practices of pricing systems, being compatible within the market, more passenger use options, and it increases the use of public transport. This reduces the levels of privately-owned cars, thereby reducing greenhouse gas emissions, which can transcend into transport policy for climate change, by decision-makers in the transport sector.

This aspect of research has used a contextual approach to contextualize the pricing and infrastructural non-technological innovations, with specific focus on light-rail public transport provided to Addis-Ababa from China.

### 6.2.3 What are the factors influencing the contextualization of infrastructural innovations from the Chinese context to Abuja, Lagos and Addis-Ababa cities context? (RQ3)

The following tables depicts the summary of factors influencing the contextualization of infrastructural innovations from the Chinese context to Abuja, Lagos and Addis-Ababa contexts.

**Table 19: Summary of similar contextualization factors in Lagos and Abuja within Nigeria**

| Contextual Factor | Abuja | Lagos |
|---|---|---|
| **Seamless Integration of transport modes** | Complete re-modification of the airport light-rail route, as a re-alignment to other existing transport modes, for seamless inter- modal transfer, between air and rail modal transport passengers. | LRT stations re-designed to accommodate seamless integration and operation with other transport modes, such as water and road transport. |
| **Transit-Oriented Development (TOD)** | All LRT stations completely re-modified to provide TOD. Floors increased to one, other facilities expanded to provide more business opportunities for the private sector. | All stations partially re-designed to accommodate more business activities, such as multi-story building for commercial carparks and other commercial facilities for the private sector. |
| **Non-Motorized Transport (NMT)** | More over-passes added as a re-modification after the initial design, to provide NMT, for better proximity and easy accessibility for people along the rail tracks. | Inclusion of "Sky walkway" at some LRT stations, to allow passengers to go from one mode of transport to another, while walking within the same station with walk-friendly infrastructures of NMT. |
| **Modern light-rail for better aesthetics and passengers' satisfaction** | Provided a complete change of LRT vehicle type from a simple to a more modern looking LRT vehicle. | Changed LRT vehicle to include air-conditioning for better air quality for passengers during travel, and back-up batteries to save power and avoid sudden power outage during operation. |
| **Inadequate energy supply** | Re-modified the design of stations by changing escalators to concrete staircases as a major priority and retaining the complimentary electric lifts and escalators in some stations, to avoid breakdown of escalators due to inadequate power supply. | Opted for a change to LRT vehicle with back-up batteries, to avoid stoppage during operation, which may affect the electrified LRT during operation, due to unforeseen interruption of electricity supply. |

**Table 20: Summary of differences in contextualization factors between Lagos and Abuja within Nigeria**

| Abuja | Lagos |
|---|---|
| Three distinct contextual factors: Two geographic and one energy related contextual factors.<br>Geographic:<br>• Construction of an overpass (bridge) instead of earlier planned underpass (tunnel) along the airport on lot 3 LRT route, due to barrier of massive underground rock deposit.<br>• Bridge span extended from 1 to 26 for multiple support on a super structure bridge for a longer overpass for cars due to the extensive swampy area.<br>Energy:<br>• Modifications to augment electric escalators and elevators by constructing concrete staircases. | Three distinct contextual factors:<br>• Effective operations/maintenance and modernization: Marina station of initial 2 tracks changed to 3 tracks to meet up with current best practices.<br>• Avoids extra costs of implementing LRT: By re-routing LRT along areas with less third-party issues.<br>• Safety of LRT passengers: Modification made to allow passengers access to open doors, to avoid accidents during emergencies. |

**Table 21: Summary of Similar contextualization factors between Nigeria and Ethiopia**

| Contextual Factors | Nigeria | Ethiopia |
|---|---|---|
| **Cost effective LRT route** | LRT route modified to avoid third-party issues beyond government allocated budget. | Additions and extent of underpass (LRT tunnel) and overpass (bridges) initially not in the original design |
| **Seamless integration of LRT with other modes of transport** | LRT routes in proximity to other transport modes.<br>Access roads added to allow for integration between public roads and water transport with LRT. | Access roads and right of-way re-modified for seamless integration between other transport modes and the LRT.<br>LRT routes near other transport modes. |
| **Foster TOD and NMT** | Re-modification of LRT route closer to airport buildings to foster NMT between air and rail passengers.<br>Re-modification through provision of more over-passes and walk-ways for pedestrians.<br>Re-modification of major LRT stations to accommodate "Sky-walk" as user-friendly pedestrian walkway within the LRT stations linking the road and water transport. | Re-modifies road networks to improve pedestrian accessibility to the LRT platforms.<br>Provides improved right-of-way structures for the pedestrians to walk on roads close to the LRT stations, for better link with other transport modes, using walk-ways along such areas linking to the LRT platforms. |

| | | |
|---|---|---|
| **Safety** | The 460 meters thickening of wall inside lagoon to avoid city flooding.<br>Change of LRT doors-use to passenger friendly doors during emergencies.<br>Provision of more overpasses and underpasses, for safe pedestrian and cattle movements. | Incorporates the use of intermittent automatic train protection system after the LRT has been ordered during the operation phase.<br>Barriers built along the roads sharing same level with the LRT, to prevent accidents by vehicles running into the LRT. |
| **Modernization of LRT to current best practices** | Complete change in the initial proposed LRT vehicle from a simple to a modern LRT with better aesthetics.<br>Changed the LRT vehicle to include air-conditioning and back-up batteries. | Changed the earlier plan of using different entry and exit doors of LRT for passengers, to using all doors for entry and exit, as a more user-friendly method, avoiding chaos, especially during peak periods. |

**Table 22: Summary of differences in contextualization factors between Nigeria and Ethiopia**

| Nigeria | Ethiopia |
|---|---|
| All ticket shops are within enclosed ticket shops inside the stations. | Construction of "emergency" ticket shops, based on the context of the situation at hand, of not able to use the installed electronic ticket system on-board the LRT vehicle, due to high population and lack of barrier turnstile at platforms. |
| Need to complement for energy failure. Seen in the use of back-up batteries on electrified LRT and preference for concrete staircase over escalators. | More stable electricity supply, using dedicated electric power supply for its LRT. |
| More in-depth modification of stations to improve TOD and NMT. Mainly because all Nigeria stations are bigger, which requires the need to maximize the space by integrating other modes with better NMT for pedestrian's accessibility and improve economic activities at LRT stations and routes. | Not all LRT stations can incorporate facilitates to support TOD, as some of the stations are only in-between roads and therefore possessing less space to implement more TOD. Thus, causing some stations to share roads with vehicles, which have limited<br>space in expanding for a more robust TOD and NMT. However, some strategically selected stations with more space has improved TOD and NMT facilities. |
| Need for modern aesthetics of both rolling stock and station areas, with bigger stations and more passenger facilities to serve more populated cities.<br>LRT plan present in the city master plan | Both electrified LRT and station areas are already aesthetically adequate. Only strategically selected stations were expanded for TOD.<br>LRT plan absent in the city master plan until recently. Therefore, use of middle of roads for some of the LRT routes, giving priority and right-of-way to LRT. |

The eminent contextual factors that have had a strong influence on the contextualization of infrastructural innovations in Nigeria are electric energy supply, modernization of LRT and their stations, TOD and the seamless integration of the LRT with other transport modes. Prominent contextual factors which had a noteworthy effect on contextualization of infrastructural innovations in Ethiopia were the emergency ticket shops, the seamless integration of LRT with other transport modes, and NMT.

Infrastructural innovation as a non-technological innovation, went through re-modifications with the aim of attaining sustainable urban Light-Rail Transport in all of the three cities (Hyard, 2012). They all had the intention of fostering constructive effects on the economy, social well-being and the environment, which is quantified by system effectiveness and efficiency (Jeon and Amekudzi, 2005). During the re-modifications for innovation adaptation, concepts of relative advantage, compatibility, complexity, triability, reinvention and risk were all taken into consideration (Greenhalgh; Robert, et al., 2004). Furthermore, results support the concept of poly-contextualization (Von Glinow; Shapiro, et al., 2004), which refers to the scopes of a context for valid understanding of contextual factors within it and that contextual factors depend on a particular challenge at hand (Wisdom; Chor, et al., 2014).

This research analyses the LRT from a different view point, but is complementary to the literature regarding contextual factors, defined as the political and legal systems, culture, history, ecology, geography, the stage of economic development and economic systems at a specific period of time and all that has emerged over time that have shaped what and why a context is the way it currently (Tsui, 2006). In addition, it is also complementary to the technological, environment and social influence (Cheng and Huang, 2013).

This research provides *benefits to academic literature*, using its derived contextual factors from the three cities which is able to fill some literature gaps, especially in the area of *infrastructural innovation adaptation for transport sciences*, such as: Seamless integration of LRT with other modes of transport; TOD and NMT; implementation models as BOT or DB; Ticketing infrastructure; and Passenger satisfaction.

In addition, other factors which are concerned with the contextual factors mentioned earlier in the theories includes the following:

- Cost effective LRT route, related to economic development in theory
- Inadequate energy supply, related to technological environment
- Safety, related to technological environment and legal system
- Modernization and aesthetics of LRT for best practices, related technological development
- Massive underground rock deposits and lengthy swampy area, related to geography
- Operation and maintenance, related to technological environment and economic development
- Third-party issues, related to geography, economic development, culture, legal and political system

All these points contribute to the in-depth knowledge of adaptation for LRT. Furthermore, this research has provided societal relevance from lessons that have been learnt in the direction of transport sciences which is a benefit to the rail transport industry and their stakeholders, which has been achieved by using the derived contextual factors which act as guidelines to adapt infrastructural innovations in cities with similar socio-economic, geographic and technological circumstances, as examples of cross-national lessons that have been learnt (De Jong and Geerlings, 2005).

### 6.2.4 To what extent does the targeted and delivered service qualities, using frugal approach by multi-actors satisfy the perceived service quality from passengers? (RQ4)

To a high-level extent, of above 70%, 12 out of 15 light-rail transport service qualities that were delivered by the multi-actors were perceived as satisfactory or comfortable. Except for the comfortability level during peak hours, the air-conditioning inside of the LRT and the time to reach the platforms.

During peak-periods there were more passengers than available transport, the carrying capacity of 285 passengers per trip, causing congestion inside of the LRT and accounting for 86.5% of the passengers perceived that they were uncomfortable. The air-conditioning parameter has a 47.7% of passengers that found it uncomfortable. It takes 1-15 minutes by 40.2% passengers during weekdays and 46.8% passengers during weekends to reach the LRT platforms.

During the delivery of the LRT by multi-actors, cost implications made them approach the pricing and infrastructural innovations (Hyard, 2012) with a frugal approach to manage available financial, human and time resources, while at the same time providing quality service to the passengers (Tiwari and Herstatt, 2012). In addition, to achieve this frugality in LRT, innovation adaptation concepts, such as compatibility, triability and understanding the LRT complexity (Greenhalgh; Robert, et al., 2004) were employed, in order to assess its economic aspect for a more sustainable urban light-rail transport for a positive impact on the city's economy (Jeon and Amekudzi, 2005).

However, the delivered LRT is perceived by the passengers in different percentages of satisfaction. These levels in percentages are important, as they support the multi-actors to know which of the delivered infrastructures have met the passenger's expectations or have not delivered a targeted service quality. Thus, serving as a *societal relevance*, using the passenger's level of satisfaction as a benchmark in providing service quality, to consequently satisfy the multitudes, especially the low- and medium-income earners in the society, in the use of cheaper and comfortable LRT. Therefore, knowing the extent of satisfaction or comfortability of the passengers on different parameters of the LRT aids the knowledge of specific

aspects of the LRT that may need a change or improvement. In addition, this research provides *scientific importance* as it benefits existing literature in order to understand, develop implementing methods and practice the process of frugal innovation in urban public transport, to achieve a significant balance between delivered service quality and its satisfaction to passengers.

### 6.2.5 How can pricing and infrastructural innovations be adapted to Urban Light-Rail Transport using a frugal approach? (Overall RQ)

Pricing and infrastructural innovations have been adapted in urban Light-Rail Transport with a frugal approach.

Firstly, by the LRT receiving cities structuring their absorptive capacity and using mainly stakeholder dialogues and partly formal negotiations in their multi-actor interactions. These consequently had positive effects, providing more affordable, safer, and comfortable modes of transport; gradual modal shift to the LRT, with reduced congestion and city air-pollution.

Secondly, by understanding how the pricing and infrastructural innovations were contextualized and re-adapted to implement the LRT, within the context of the city; which further unravels the social, economic and environmental effects on the MNCs, passengers, residents along LRT route and city environment. This contextual approach further unravelled the specific contextual factors which were specific to the different cities; thereby depicting the similarities and differences within three cities, which can be useful to other cities in transition to LRT.

Thirdly, by empirically defining the extent to which these targeted and delivered pricing and infrastructural innovations service qualities, using a frugal approach by multi-actors, can satisfy the perceived service quality of the passengers. This enables the multi-actors measure the extent to which their frugally adapted pricing and infrastructural innovation in the LRT are perceived as satisfied by the users, to provide measured re-adaptation where there are negative outcomes or inadequacies; and to know if the frugal approach used to manage the resources was effective.

## 6.3 Paths to Future Research

As a *scientific relevance* it is beneficial to identify other paths where this already concluded research may lead, in order to foster developmental research that will provide empirically valid and reliable results in years to come. In this regard, this research has charted some paths that facilitates more research in the same domain of transport governance but in different related aspects to be measured and form part of a niche in scientific literature. Therefore, the following *seven main future research questions, six sub questions* and their main conceptual considerations as paths with their research approaches were deduced from this research:

How can African cities harness their learnt experiences from the Chinese and other light-rail transport advanced countries, to build a light-rail knowledge economy? To approach this research question, it is important to identify contextual factors responsible for the success and challenges in different cities. This will further provide insights into how different LRT providers interact with the multi-actors in the LRT receiving cities and the different outcomes of such interactions, which should include how these were handled using various strategies of local inventions and known international best practices. The proposed methodology here should be a qualitative approach of comparative research in the different cities. Preferably among cities with similar and dissimilar socio-economic, political and technological city characteristics (De Jong and Geerlings, 2005).

How can African cities maximize the use of frugality and frugal innovations in the implementation of their light-rail? It is pertinent to draw-in the different types of resources available in different cities acquiring the Light-Rail Transport, such as finance, human and time resources. Following this, the unique way each city systematically applies frugality to manage these resources should be categorized, as cities have different ways of practicing frugality. As seen in Addis-Ababa, where frugality was achieved with a combination of multi-actor interactions and a structured absorptive capacity. This is because over many years, other cities might already have a productive structured absorptive capacity and multi-actor interaction processes but need to build effective policies or involve the general public in a way that they might lead to some dimensions of frugality. The research approach suggested for this question is a mixed method of quantitative and qualitative approaches.

How can African cities engage multiple rail advanced countries in the development of light-rail transport, in a competitively healthy manner? In this question, different LRT contract implementation types should be analysed, such as Build Operate and Transfer (BOT), Build and Transfer (BT), Design and Build (DB), etc. These diverse contract types would show how each model fits in to specific cities for effective implementation. Cities with similar socio-economic, political and technological characteristics, but with a different implementation model should be considered and vice versa. This is relevant as it would at the end reveal why and how the different contract implementation models have influenced an effective or less effective implementation of LRT. To analyse this, a mixed method should be used, because it will use various empirical metrics in the contract as a quantitative approach and qualitative approach to explain the process of implementation using the specific models. Furthermore, three sub-questions to this question can be further deduced:

- To what extent is BOT contract among multi-actors productive than BT? This will provide the empirical extent to which the different implementation models have adequately implemented the LRT in the various cities.
- How can the most suitable rail contract or concession type, specific to African economies, be selected and implemented in a sustainable manner?
- To what extent does a Build Operate and Transfer (BOT) or Design and Build (DB) business model provide a more sustainable LRT?

Why are certain contextual factors common in certain cities than others during the implementation of LRT? In this question, various contextual factors responsible for different re-modifications should be categorized, considering their city contexts. Furthermore, these categories should be mirrored with socio-economic, political and technological reasons responsible for the factors, in order to see where the contextual factors really originate from. Knowing this aids the prompt curbing of contextual challenges and forecasting of the same challenges in cities with similar characteristics. This will provide insights into how best to handle the challenging factors. The research method proposed here is a multiple and comparative case study of cities, because it enables a concrete comparison among cities, providing richer categories to deduce more lessons, scientific and societal benefits.

How can city governments create an enabling environment for LRT implementation, where investors can invest, while city governments only need to regulate? This research requires the conceptual understanding of how country governments interplay between the LRT providers, users and city transport implementation authorities. Since it is expected that the country government should only regulate, while allowing MNCs to invest in the city, and implementing city authorities interact more actively with the MNCs and LRT users. A comparative research approach using mixed methods is recommended here, because it entails some empirical data from the LRT users as a quantitative approach and qualitative approach for the MNCs and city/county government.

How can multi-national corporations from China and other rail advanced countries collaborate more effectively to deliver LRT, within an affordable cost bracket, with less third-party issues and with a sustainable rail technological transfer? This research demands for a frugal approach, with emphasis on affordability of LRT rolling stock, technology transfer, and third-party issues such as obstruction on the LRT route by private and government assets causing significant delays for more costs. Thus, more effective implementation processes among multi-actors is desired and should be focused on, to foster effective and efficient implementation of LRT in cities, considering their city context characteristics. A mixed method regarding a single case study is proposed, because all these multi-actors' and city factors can be analysed more in-depth in a single case study. Furthermore, a sub-question can be deduced from this question, as:

- How can multi-national corporations invest in cities in light-rail transition with minimal risks and better cash returns from concessions?

This emphasizes the risks and cash returns on concessions as a contract with the multi-actors.

What are the strategies to self-sufficiency in light-rail rolling-stock production, construction, operation and maintenance? These questions provides a research opportunity to understand the relationships between effective acquisition, construction and operation of a LRT system, while balancing it with maintenance, which is very important because there is no point in the long term when cities acquiring LRT can only acquire and operate the LRT, but are unable to maintain it. Furthermore, this research delves into the ability to maintain LRT in the short term and produce the main components of the LRT rolling stock in the long term as self-sufficiency in LRT, such as China and The Netherlands. Thus, the research approach proposed here is a mixed method on comparative case studies, because there is a need to integrate city empirical data, especially during operations and maintenance as a quantitative approach with the qualitative approach.

A comparative analysis between north Africa and sub-Saharan Africa or between cities from the four regions of Africa can be comparatively analysed. This will provide more context specific factors during rail transport adaptation, which aids pre-adaptation of light rail for other countries, fostering sustainable light-rail development. Thus, a research question can be:

- How are different contextual factors between cities in north and sub-Saharan Africa used in formulating policies for sustainable light-rail adaptation?

A mixed method, using surveys and interviews is suggested to implement this further research question. A spatial component could also be introduced to see how city planning influences some policy formulations. The research question for this could be:

- What types of policy directions can be deduced from the spatial planning of a city for light-rail transport adaptation?

A mixed method of surveys, interviews and spatial analysis methods using Geographic Information System (GIS) and remote sensing could be used for this question.

## 6.4 Policy Recommendations

Formulating policies for a sustainable Light-Rail Transport can be better achieved through a deliberate consideration of the Sustainable Development Goal SDG-9, which states:

> "*Building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation*" (UN, 2015)

as efficient transportation services generate employment and wealth and drive economic development. However, this research argues that SDG-9 can be better achieved through a systematic process using a cross-national and institutional context of transport governance. To support this argument, de Jong and Geerlings (2015) mention to achieve a successful practice of institutional transplantation, a minimum of two conditions serves as a pre-requisite. These are: A comprehensive understanding of how the original transport sector is performing and a pro-active incorporation process in the national policy domain, leading to actors operating there to actually assimilate it (Rose, 1993, 2001, De Jong; Lalenis, et al., 2002)**.**

A clear sense of the experience abroad is an up-hill task, nevertheless since attainable solutions have the tendency to be entangled with institutional contexts in which they reside, understanding this allows for clarity. Clarity on how and in how far the perceived accomplishment of a country is linked with it, and what transplanting it entails. Clearly discerning what is happening abroad is not always easy because attractive solutions tend to be intertwined with institutional contexts in which they are used. Insight into this clarifies how and in how far the perceived success of an example relates to it and what transplanting it implies (De Jong and Geerlings, 2005).

In this regard, the policy recommendation is divided into two parts. The first part deals with four general policy recommendations relating to the different aspects of the thesis. The second part focus on two main policy recommendations on frugality and context transfer of light-rail infrastructure, which are further sub-divided into specific policy directions as recommendations.

## 6.4.1 General Policy Recommendations

### Bottom of Pyramid Policy

Formulating a policy to foster the light-rail use by the BoP users, has a stronger link to SDG-10, which is to reduce inequality within and among countries, and it can be achieved using the vertical equity service (Geurs and Ritsema van Eck, 2001). The vertical equity service can be used to target economic equity of the poor as BoP users and non-poor. This serves as a benefit to foster the inclusion of less mobile people or economically disadvantaged groups for improved mobility. Such as incorporating a special fare structure as a subsidy for BoP passengers and students to reduce financial exclusion and provide strict measures in the occupation of disabled spots provided in the LRT, as the physically challenged cannot struggle for space with able bodied passengers in the LRT.

### African Union of Science and Technology Policy

I recommend that the African Union (AU) should provide a policy platform within the AU for science and technology, to bring together African stakeholders from cities who are already using LRT and those planning to implement it. This is to foster discussions that would highlight pitfalls, challenges, successes and ways they productively interacted with their Chinese counterparts in a frugal manner. This will enable African cities to negotiate with the Chinese with one voice, providing better benefits of costs, technological transfer and smooth bilateral relationships with the Chinese government. Such policies should mention that cities planning to implement the LRT should also, at first, have two pre-requisites when considering cross-national and institutional context of transplanting a LRT. These are, the comprehensive understanding of how the original place where the transport infrastructure will be transplanted from is performing, and a pro-active incorporation process in the national policy domain, facilitating actors functioning there to really adapt it (Rose, 1993, 2001, De Jong; Lalenis, et al., 2002). As a result, this will serve as a facilitator for transport infrastructure transfer to Africa, as presently there is no infrastructure adaptation policy by the AU, for an African platform.

### Third-party Policy

To avoid time and money wastage, there should be a policy for the settlement of third-party issues before the construction of the LRT. This will serve as a benefit of avoiding inadequate designs before construction, without confirming if some assumed relocations along the LRT route would be possible. As social, safety or other socio-economic and technological reasons may hinder the possibility of relocating some of these built-up areas.

### Decentralized Authority Policy

This policy path is to provide a decentralized authority for the transport authorities, by providing them with total autonomy to perform, as significantly observed in LAMATA of Lagos, to a fairly- significant extent in ERC of Addis-Ababa and fairly in ALRD of Abuja. A decentralized authority in transport institutions will provide the benefit of innovative strategies through more robust infrastructure implementation models and being a stronger authority to deal with difficult transport problems. This is because, a decentralized authority is characterized by a private sector system, but in this case with sound regulative functions in place to stop inequalities among transport operators and passengers and reduces the bureaucracy that can be found when implementing transport projects.

## 6.4.2 Policy Recommendations on Frugality and Light-rail Infrastructure Transfer

Policies regarding LRT transfer together with infrastructure without adequate consideration for the city or country context that they are aimed at, may likely fail

(De Jong and Geerlings, 2005). This is because policy directions cannot be formulated regardless of the city context development and challenges, this should be debated upon during multi-actor interaction processes. The subject of understanding and transferring policy models between authorities and multi-actors has received an increased level of attention (de Jong and Edelenbos, 2007), but less in sub-Saharan Africa. The multi-actor interaction process is dynamic and complex, which requires a robust connective capacity (Edelenbos; Bressers et al., 2013), amongst the concerned multi-actors within the context of infrastructural policy direction and adaptation. In real-world events however, practitioners must deal with circumstances in which all factors are dealt with simultaneously, including all factors that are thought to be important (Bressers and O'Toole, 2005). Therefore, as a contribution to literature, this article adds a niche to the existing literature in the area of policy formulation through policy directions, as deduced from contextual factors from countries in transition to light-rail transport adaptation, such as Ethiopia and Nigeria in sub-Saharan Africa. As a societal benefit or common good to LRT users, MNCs and city transport authorities; this thesis provides policy for decision makers with context specific factors, which aids formulating context policy directions and providing the opportunities of replicating policies with similar country contexts.

Tailored city-context policies can be represented in different directions, such as regulatory (prescription and prohibitions), economic incentive (grants, subsidies, taxes and user charges), technological, (clean technology and user-friendly devices) (Bressers, et al., 2016, Van Bueren, 2009, Bemelmans-Videc; Ray, et al., 1998).

### 6.4.2.1 Policy Recommendations on Frugality

Policy direction for frugality provides societal benefits for the light-rail users like affordable fare prices and subsidies. In addition, it serves as economic benefits to the MNCs as derived from taxes and user charges and prescribed methods. Furthermore, it is beneficial to the CTAs through taxes, user-charges, technical devices and clean technologies.

#### Grants policy direction

This can be achieved through dedicated funds for research and development for rail transport. For example, there is a need to strengthen some existing railway institutions like the African Railway Centre of Excellence (ARCE), Addis Ababa Institute of Technology, Addis Ababa University, that offers courses like MSc and PhD in Railway Engineering. The Railway Technology Training Centre in Abuja, and Nigeria Railway Technical Institute Yaba-Lagos, needs adequate and advanced technologies to fully participate in the operation and maintenance of an advanced LRT from China. As a policy, dedicated budgets could be made available for rail transport research and professional training. In addition, countries supplying the LRT like China, are encouraged to provide technical personnel in these academic

and professional institutions. This will provide a benefit of functional rail institutions capable of incorporating its students into the operations and maintenance skilled force of the implemented light-rail transport systems in both countries at far cheaper costs and technology transfer within cities.

### Subsidies policy direction

This is achieved targeting the users of the light-rail. In this regard, elderly people from 70 years and above, students in primary and secondary schools, and children under 12 years of age, should be provided with some subsidies to encourage these age groups to use the light-rail transport system. There is a plan to do some or all of these in both countries, but it is yet to be implemented after 1 and 3 years of adaptation in Nigeria and Addis-Ababa respectively. This will provide affordable transport to specific vulnerable age groups.

### Tax policy direction

This is the collection of taxes by the city government from major commercial activities along the LRT route as a Transit Oriented Development (TOD) tax. It provides the benefit of an income to the city government to be able to repay the light-rail concession loans and it is used for operation and maintenance of the rolling stock.

This needs to be incorporated and planned into the city master plan and measured to quantify its financial viability and the extent to which it will be able to pay back the loans from China and other light-rail advanced countries supplying the LRT. This will complement the ticket fare income for the government, with a concrete budget for operation and maintenance costs, which in turn provides sustainable light-rail transport, sustaining passenger use and its cash flow, avoiding technical breakdowns and loss of income through the non-use of the LRT.

### User-charges policy direction

These are charges paid by the fare evaders using the light-rail. 30% of the light rail users commit fare evasion in Addis-Ababa, as a result of paper tickets instead of automated ticket use. Fare evasion makes it very difficult to obtain the required cash return rates from user tickets, which is meant to pay a part of the operations and maintenance costs after the adaptation. The user charges policy is achieved through a penalty to the fare evading light-rail users, such as a fine of 10 times the amount meant to be paid when caught evading the normal fare payment. Nigeria had bigger platforms, so was able to implement an automated turnstile barrier system at the platforms, which will be used to validate the tickets before the users accessed the light-rail platforms. This provided a benefit of a reduced loss of income and reduced fare evasion by users, thus affirming the usefulness of the enforced user-charge penalty for fare evasion, especially when the turnstile barrier system is absent.

### 6.4.2.2 Policy Recommendations for Light-Rail Transport Infrastructure Transfer

Transferring LRT infrastructure from a different city context to another requires a regulatory policy direction, using a prescribed method for knowledge transfer policy and technological policy.

#### Knowledge Transfer Policy

A knowledge transfer policy direction has been deduced from the Addis-Ababa city case. Considering the logical reasoning that there is no benefit transferring the LRT innovation, without also transferring the knowledge of how best to operate and maintain it. In this regard, the cognitions practiced by Addis-Ababa city is a policy direction that other City Transport Authorities (CTAs) in Nigeria and other cities in transition to LRT can emulate.

Knowledge transfer policy directions can be formulated to include - types of knowledge transfer structure, knowledge transfer ratio plans, and types of knowledge transfer streams, as a multi-actors process of interactions and strategies. This is advised to be incorporated into the adaptation agreement between the MNCs and CTAs from the inception of the project but before the adaptation.

It is advised that cities enforce a structured technological transfer as one of their Key Performance Indicators (KPI), which should be included in their contract agreements with other multi-actors within and from abroad. This will guarantee its frugality and a sustainable operation and maintenance of the light-rail rolling stock within controlled costs and will over time provide a platform for the local production of light-rail software and hardware components. In addition, this can be complimented through documentation of knowledge transfer, from experienced staff through audio-visual means, to reduce brain drain of skilled labour in the transport sector and provide documented technical assistance to new and younger engineers and scientists, as planned by LAMATA in Lagos city.

#### Technological Policy

The technological policy direction is the use of technologically inclined devices for the benefit of the light-rail users, MNCs and CTAs. These types of devices include the use of automated ticket validation machines on-board the Light-Rail Transport or/and an automated turnstile system on the platforms like in Nigeria. If an automated ticket validation machine is used on-board the light-rail transport or at the platforms like in Nigeria it will prevent fare evasion.

LRT can use clean technology, by using electricity to power the light-rail transport like in Addis-Ababa, although diesel fuel is used in Nigeria which is not classified as a clean technology. The use of clean energy like in Ethiopia reduces carbon emission pollutants and promotes zero carbon emissions, tending towards SDG-7 which is one of the Sustainable Development Goals (SDG) for clean and affordable

energy. Therefore, there is a need to enforce the use of electric energy on LRT vehicles, to promote zero greenhouse gas emissions and sustainable energy best practices.

Cities in Nigeria with electric energy challenges could perhaps take this as an opportunity to partner with private companies in providing stable electric energy which is dedicated to the LRT. Not only will the private companies benefit from the LRT concession plans, the LRT will be provided with more stable electricity which could also be used for the city.

## 6.5 Authors Closing Remarks

The author is making a clarion call for an extra-ordinary and systematic action for cities in transition to adapt to light-rail transport.

Adapting light-rail transport for the first time by cities in transition to LRT might initially be an uphill task, depending on how the receiving city understands how to interact with the LRT providers and international multi-actors, while managing the limited human, financial and time resources using a frugal approach. To achieve this, an extraordinary effort is required by the LRT receiving city, to systematize the process that will guarantee the success of the LRT implementation.

There is a crucial need for transport authorities in cities to be more proactive and innovative in the manner that they adapt transport infrastructure. Insights from this research and observations during the fieldwork from both countries, give examples of an effective contextual approach that can be used to implement a sustainable LRT which strongly depends on the receiving city authority's political will, as strongly observed in Addis-Ababa, which can also be related to political systems mentioned by Tsui (2006).

Secondly it depends on the level of technology transferred from the Chinese LRT to the receiving countries, regarding operations and maintenance of the LRT, to ensure a long term sustainable operation of the LRT (Cheng and Huang, 2013). Adequate technology transfer is achieved through structured absorptive capacity and stakeholder dialogues, as experienced in Addis-Ababa (Cheng and Huang, 2013).

Thirdly, the contextual factors that were mentioned in chapter 4 are also important to be considered during the contextual approach process between the LRT receiving transport city authorities and the multi-national rail corporations from China; as observed in Abuja, Lagos and Addis-Ababa. They are important in providing a better chance of implementing the LRT in a more systematic and effective manner. Due to the multiplicity of different contexts in cities, the word 'poly-contextualization' was introduced (Von Glinow; Shapiro, et al., 2004). This is an understanding of the process of incorporating various scopes of context that

together make a complete and valid comprehension of any phenomena within it to deliver a suitable LRT. Specific contextual factors during the light-rail transport adaptation served as a logical and measurable opportunity to comprehend and initiate context policy directions which could protect and nurture the newly adapted light-rail transport for a sustainable long-term use.

Therefore, this research is making a clarion call to cities in transition to LRT, for an extra-ordinary and systematic action to adapt during the LRT implementation. In this regard, cities should have a strong political-will to strengthen the transport institutions; by providing adequately structured technological transfer components and the use of poly-contextualization method; via a decentralized transport authority for different cities that are based on their diverse contexts, which will in turn enforce better adapted methods, processes and policies.

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# Appendix 1: Propositions

1. Frugal approach is a necessity for cities with constrained financial, human and time resources (this thesis).
2. Frugality in light-rail transport strongly depends on the structure of absorptive capacity and the process of multi-actor interactions (this thesis).
3. Inadequate adaptation of pricing and infrastructural innovations can cripple multinational corporations' economic outcomes, which may lead to unpaid loans by city transport authorities (this thesis).
4. Adaptation of a sustainable light-rail transport requires a contextual approach, tailored towards contingencies and its socio-economic, environmental and technological contexts, to reduce the waste of financial, human and time resources (this thesis).
5. Measuring the gap between targeted and delivered service quality provides societal relevance to policy makers, for the delivery of adequate service quality to passengers (this thesis).
6. Responsibilities, knowledge and skills transferred amongst urban actors are sometimes inadequate, which demands for a decentralized authority policy, to effectively govern the implementation of the light-rail transport.
7. The light rail transport that has been implemented in Ethiopia and Nigeria is perceived as a common good for all actors, and not only a system for capital flight to boost China's Foreign Direct Investments (FDI).
8. Inadequate adaptation of technological and non-technological innovations are a global problem with negative effects on modal shift and for the Bottom of Pyramid users.
9. Attaining a balance between delivered and perceived service qualities is a difficult task for transport authorities that can only be achieved through ample commitment to the targeted service quality.

10. Strengthening the light-rail transport authorities requires an adequate level of technology transfer, which includes the knowledge of poly-contextualization.
11. “Instincts under pressure crush the carbon of conformity and create diamonds. Each new season of life offers to train us for the next season if we pay attention and adapt.” (Jakes, 2014, pp. 60-66). Instinct: The Power to Unleash Your Inborn Drive.

# Appendix 2: Portfolio

**My portfolio mainly revolves around academic and research activities as written below.**

**Teaching Experiences**

1. **Course:** Urban Competitiveness and Resilience
    - Level – MSc
    - Year: 2015
    - Role/responsibility – Lecturer
    - Themes thought: Application of Geographic Information System to Urban Economic Development and Resilience
    - Types of Assessment: Classwork using ArcGIS software to solve urban economic development problems, using results as a decision support system for policy makers.
    - Type of teaching activities: Presentation, problem solving approach using hands-on exercises with ArcGIS software.
    - Students evaluations are attached as official university document

2. **Course**: Infrastructure and Green Cities
    - Level – MSc
    - Year: 2019 and 2020
    - Role/responsibility – Lecturer
    - Themes thought: Application of Geographic Information System to Managing Infrastructure and Green Cities
    - Types of Assessment: Classwork using ArcGIS software to solve Infrastructure and Green Cities problems, using results as a decision support system for decision or policy makers.
    - Type of teaching activities: Presentation, problem solving approach using hands-on exercises with ArcGIS software.
    - Students evaluations are attached as official university document

3. **Course**: Elective course on application of GIS to Urban Management and Development
    - Level – MSc
    - Year: 2019
    - Role/responsibility – Lecturer
    - Themes thought: Application of Geographic Information System Urban management and Development

- Types of Assessment: Classwork using ArcGIS software to solve various Urban management and Development real case scenarios, using existing data. Results serves as a decision support system for decision or policy makers.
- Type of teaching activities: Presentation, problem solving approach using hands-on exercises with ArcGIS software.

4. **Course**: Transport Governance on Transport Infrastructure Management: A case of Lagos city, Nigeria.

   - Level – MSc
   - Year: 2018, 2019 and 2020
   - Role/responsibility – Lecturer
   - Themes thought: Transport governance for multi-actors in Lagos city transport
   - Types of Assessment: Classwork using real scenario case study of transport activities between several transport actors
   - Type of teaching activities: Presentation, problem solving approach using class activity and group presentation on the real scenario of transport challenges in Lagos city.

5. **Course**: Urban Management Tools for Climate Change (UMTCC)

   - Level – MSc
   - Year: 2017 and 2018
   - Role/responsibility – Lecturer
   - Themes thought: Application of Geographic Information System to Climate Change
   - Types of Assessment: Classwork using ArcGIS software to solve climate change adaptation and mitigation measures, using results as a decision support system for decision or policy makers
   - Type of teaching activities: Presentation, problem solving approach using hands-on exercises with ArcGIS software

6. **Course**: Surviving your master's degree with Excellence

   - Level – MSc at Erasmus University and BSc at The Hague University of Applied Sciences
   - Number of times and Year: twice in both universities in 2018 and 2019
   - Role/responsibility – Guest lecturer
   - Themes thought: Use of learning techniques and emotional state management to succeed during students' academic program

- Types of Assessment: Question and answer sessions
- Type of teaching activities: Presentation of learning techniques and emotion management, sharing of self and others real-life experiences on academic challenges, and solutions to attain academic excellence

7. **Course**: Securing 'well located' land for the vulnerable (Poor, Women and Youth)

    - Level – MSc, Postgraduates and PhD
    - Year: 2016
    - Role/responsibility – Guest lecturer
    - Themes thought: Application of GIS to Location-Allocation and Geo-data for land acquisition concepts
    - Types of Assessment: Question and answer sessions
    - Type of teaching activities: Presentation of concepts related to locating land for the vulnerable, using geo-data for land acquisition and administration

**MSc Thesis Supervision Experiences**

**Co-Supervision 2014**

1. Level of Service Delivery of Public Transport and Mode Choice in Accra, Ghana
2. Evaluating Commuter Rail Ridership in Accra Ghana

**Supervision 2016**

3. Interactive Coordination for Road Network Management: A case study of the Guicadale Platform in Albay, The Philippines.
4. Demand Forecast, Financial and Economic Assessment of the Light Rail Transit (LRT) Line 2 Project Metro Manila, The Philippines.
5. Infrastructure Networks and Foreign Direct Investment (FDI): Hard Connectivity of Lagos – Abidjan Economic Corridor of west Africa.
6. The impacts of physical infrastructure on Foreign Direct Investment (FDI) inflows in East African Sub-region.

**Supervision 2017**

7. The influence of road connectivity on livelihood: A case study of Tawang in Balbalan Municipality, Kalinga Province, Philippines
8. Explaining Complexities of Road Reserve Space Encroachment from a Governance Perspective in Kampala City.
9. Factors influencing West Africa's cocoa production industry to compete in the global economy with Western Europe.

**Supervision 2018**

10. The influence of Ridership Drivers on the uses of BRT in the Peri-Urban areas of Dar es Salaam City, Tanzania.
11. Assessing Non-Motorized Transport Infrastructure in the Urban Transport System of Nakuru Municipality in Kenya.
12. The effects of Institutional Framework on the Urban Public Transport Service Provision in Dar es Salaam, Tanzania.

**Supervision 2019**

13. A City with limited access to water: The use of rainwater harvesting as an alternative water supply source in Vittin-Tamale, Ghana.
14. Effects of Stakeholder Participation on the Quality of Bicycle Infrastructure. A Case of Rattanakosin Bicycle Lane, Bangkok, Thailand.
15. Living with floods: The influence of adaptive capacity on willingness to relocate from flood prone areas. A case study of Aplaku and Bortianor communities in Ga South Municipality, Accra.
16. The Rezoning of Urban Green Spaces to other Land Use Types. A case Study of Lusaka City, Zambia.
17. Effect of Perceived Service Quality on Modal Choice of Trans Metro Bandung, Indonesia.
18. The Shape of Travel Behaviour: The Effects of Street Network on Travel Behaviour among residents along Masaya Highway, Managua city, Nicaragua.
19. The influence of physical, social and safety aspects on walkability in neighbourhoods of Rotterdam, the Netherlands.

**Supervision 2020**

20. Supervision of master's thesis on topics related to transport governance, urban mobility, sustainable transportation and urban infrastructure management topics in cities across the world.
21. Co-reader of master's thesis at the Rotterdam School of Management (RSM), on topics related to urban management, transition in the energy sector and sustainability in cities, in the Netherlands and other parts of Europe.

**Conferences Attended and Research Papers Presented**

1. Empowering Cities and Citizens, IHS, Erasmus University Netherlands 6-7 November 2018. Research paper presentation on Innovation Adaptation in Urban Light-rail Transport: Adapting Pricing and Infrastructural Innovations using Frugal Approach in Ethiopia and Nigeria. A case study of Addis-Ababa, Abuja and Lagos City Contexts from China Context.
2. Second International Conference on Smart and Sustainable Planning for Cities and Regions (SSPCR), March 22-24, 2017, Bolzano, Italy, 2017. Research

paper presentation on Adapting Innovations for Sustainable Application of Service Delivery in the Urban Light-Rail Transport.

3. Africa Forum in Nigeria: Building Capacity for Efficient Logistics and Transport Services in Africa 14-16, March 2018. The Chartered Institute of Logistics and Transport. Research paper presentation on Achieving Frugality Amidst Limited Resources and Urban Complexity: Frugality in Multi-actor Interactions and Absorptive Capacity of Addis-Ababa Light-rail Transport.
4. Panel discussant at Africa-Asia 'A New Axis of knowledge 2' Conference 20-22, September 2018. Dar es Salaam, Tanzania. “Chinese Engagement in African Cities: A stakeholder perspective”. Paper presented on China-Africa Multi-Actor Interactions and Knowledge Transfer in the Light-Rail Transport System in Addis-Ababa, Abuja and Lagos.
5. Participant at - Beyond Smart Cities Today 18-19 September 2019, Rotterdam, Netherlands. The Leiden-Delft-Erasmus Centre for BOLD Cities.

**Projects Participation**

1. GIS analyst in the IHS-Erasmus University team, for the World Bank Project on Sustainability Benefits Assessment (SBA) on Green Growth projects in urban areas (2014-2015). I played the role of a GIS expert on the Handbook for Green Growth projects in urban areas, Erasmus University Rotterdam, 2014-2015. Geographical Information Systems (GIS) based decision support tool was used as a useful tool for some assessments in need of initiatives to progress in a sustainable manner. It also provides a systematic framework for evaluating various options. It has the potential to be used as a tool for sustainability assessment, because it can bring together the sustainability criteria from all pillars, social, economic and environmental, to give an integrated assessment of sustainability. GIS analysis enhances the monitoring and evaluation of sustainability benefits.
2. GIS analyst in the IHS-Erasmus University team for African Economic Outlook 2016, Sustainable Cities, Structural Transformation by the AFDB, OECD/UNDP (2015-2016). (Page 9). I played the role of the main GIS expert amongst the team of the IHS, Erasmus University for the African Economic Outlook, 2015-2016 project. This African Economic outlook shows that the continent is performing well concerning economic, social and governance issues and has encouraging prospects for the near future. With its special theme on sustainable cities and structural transformation, this edition looks closely at Africa’s distinctive pathways towards urbanization and at how this is increasingly shifting economic resources towards more productive activities. In 2016, the common African position on urban development and the emerging international New Urban Agenda offer opportunities to discuss options and start articulating those new urbanization policies around strategies for Africa’s structural transformation.

https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/AEO_2016_Report_Full_English.pdf

3. GIS analyst and co-author of part B, chapter 5, for the UN-Habitat project on the geography of African investment, for inclusive economic growth, 2018. https://www.afdb.org/en/documents/document/the-state-of-african-cities-2018-part-b-106760

**Academic Courses Attended**

- Certificate/ECTS courses at TRAIL – Research school for transport, infrastructure and logistics at University of Technology Delft (TU-Delft), the Netherlands; 2014-2015.
- Certificate courses related to scientific research design, methodology and analysis, at the post graduate Erasmus school of social and behavioral sciences (ESSB), Erasmus university Rotterdam; 2014 – 2018.
- Diploma in Research Data Management, Design and Implementation of Surveys GESIS School in Survey Methodology, Cologne Germany; 2015.
- Certificate course on teaching in the international classroom: internationalizing the curriculum at Erasmus university, Rotterdam; 2018.
- Certificate course on the "decolonization" of international education, teachers in the international classroom, strategic programme for internationalization of education in Erasmus university Rotterdam; 2017.
- Diploma course in university teaching qualification (UTQ), a basic didactics course on educational development, teaching activities and student guidance. Risbo, Erasmus university Rotterdam; 2017.

# Appendix 3: Curriculum Vitae


## Taslim Alade

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PhD in Urban Development and Governance
GIS and Data analyst with twelve years of work experience
A trained project manager by the United Nations International Charter, Space and Major Disasters (UN-SPIDER). Core competencies are in sustainable urban development, GIS and data analysis, and satellite image processing

## Experience

**PhD in Urban Development and Governance,** Erasmus University Rotterdam, The Netherlands. 2014 – 2020

- PhD Research on Innovation Adaptation in Urban Light-Rail Transport: Adapting Pricing and Infrastructural Innovations using Frugal Approach in Ethiopia and Nigeria. A case study of Addis-Ababa, Abuja and Lagos City Contexts from China Context.
- Master's thesis supervision of over 20 MSc students (2015-2020) on topics related to Urban Environment, Sustainable Transportation, Transport Governance, Sustainability and Climate Change; Infrastructure and Green Cities; and Geographic Information Systems (GIS), at the Institute for Housing and Urban Development Studies, Erasmus University Rotterdam.
- Co-reader of MSc thesis, related to Urban Management, Sustainability, and Transitions in the Energy Sector (2020), at the Rotterdam School of Management (RSM), Erasmus University Rotterdam.
- Teaching master's students (2016-2020) on topics related to Urban Transport Governance; Urban Infrastructure and Green Cities; Application of GIS to Managing and Financing Urban Infrastructure; Application of GIS to Urban Environment and Climate Change; and Application of GIS to other domains of Urban Management and Development.
- Vice-chair of the PhD council at Erasmus University, Rotterdam and the president representing PhD candidates at IHS, Erasmus University, Rotterdam (2015-2016).

**GIS analyst/Space Applications Scientist,** National space research and development agency (NASRDA), Abuja, Nigeria. 2008 – 2014

- Project manager for the United Nations international charter, space and major disasters. Functioned as a project manager and GIS analyst for disasters in Nigeria, providing spatial data from global space agencies as a decision support system to flood management authorities, such as the Adamawa/Taraba states flood and other disasters.
- Key resource person on training of staff for urban managers, National Emergency Management Agency (NEMA), ministry of water resources, town planners' council, infrastructural management, etc., on the application of GIS as a value-added analysis for better policies and measured assessments for local and national decision making.

- Proposal writing and Project implementation of space application on urban and environmental management, national land use/cover mapping, infrastructural mapping, spatial decision support systems and integrated missions for sustainable development.

**GIS and data analyst,** sustainable systems company, the Netherlands. 2014 – till date

- GIS analyst in the IHS-Erasmus University team, for the World Bank Project on Sustainability Benefits Assessment (SBA) on Green Growth in urban areas (2014-2015).
- GIS analyst in the IHS-Erasmus University team for African Economic Outlook 2016, Sustainable Cities, Structural Transformation by the AFDB, OECD/UNDP (2015-2016). https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/AEO_2016_Report_Full_English.pdf. (Page 9).
- GIS analyst and co-author of part B, chapter 5, for the UN-Habitat project on the geography of African investment, for inclusive economic growth, 2018. https://www.afdb.org/en/documents/document/the-state-of-african-cities-2018-part-b-106760.

# Education

**PhD Urban Development and Governance**
Erasmus University Rotterdam, The Netherlands. 2014 – 2020

**MSc Urban Management and Development**
Erasmus university Rotterdam. 10/2012 – 09/2013 (Thesis grade 8.3)

**MSc Geographic Information System (GIS)**
the university of Ibadan, Nigeria. 07/2006 – 02/2008

**BSc Geography**
Bayero University kano, Nigeria. 01/1999 – 09/2004

**Diploma in Space Applications**
International Space University (ISU) France, at University of South Australia, Adelaide, Australia. (GIS, space science and technologies, space policy and economics, and space business) 01/2012 – 02/2012.

**Diploma in Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA)**
Geo-Information Science and Earth Observation (ITC) University of Twente, Enschede, the Netherlands. 06/2016 – 07/2016.

**Certified project manager by the United Nations International Charter, Space and Major Disasters (UN-SPIDER)**
DMC IMAGING (DMCII), United Kingdom and United States Geological Survey (USGS). 02/2010.

**Certificates (44 ECTS) in scientific research design, methodology and analysis courses**
Erasmus Graduate School of Social Sciences and the Humanities (EGSH), Erasmus University Rotterdam. 2014-2019; and
TRAIL – Research School for Transport, Infrastructure and Logistics, University of Technology Delft (TU delft). 2014 – 2015.

**Diploma in Research Data Management, Design and Implementation of Surveys**
GESIS School in Survey Methodology, Cologne Germany. 08/2015.

**Diploma in University Teaching Qualification (UTQ)**
A didactics course on educational development, teaching activities and student guidance. Erasmus University Rotterdam. 08/2017.

**Certificate course on teaching in the international classroom**
Internationalising the curriculum and strategic program for internationalisation of education in Erasmus University Rotterdam. 11/2017 and 11/2018.

# Publications

- A Sustainable Approach to Innovation Adoption in Light-Rail Transport. Journal of sustainability, 2020. https://doi.org/10.3390/su12031262.
- Frugality in multi-actor interactions and absorptive capacity of Addis-Ababa light-rail transport. Elsevier's journal of urban management, 2019. https://doi.org/10.1016/j.jum.2019.11.003.
- Adapting Urban Light-Rail Transport to the African Context: A Process by Transport Authorities and Chinese Rail Corporations in Addis-Ababa, Abuja, and Lagos. Journal of urban science, 2019. https://doi.org/10.3390/urbansci3040109.
- Geography of African investments (UN-Habitat), 2018. Infrastructure Networks and Foreign Direct Investment. Chapter 5. https://www.afdb.org/en/documents/document/the-state-of-african-cities-2018-part-b-106760.
- Space-Based Disaster Management: The Role of the International Charter "Space and Major Disasters" (2013). Online.
- Geospatial Analysis of Landslide Vulnerability in Kuje and Environs, Abuja, Nigeria. West Africa Built Environment Research Conference (WABER). Abuja, Nigeria (2012). Online.
- Tele-reach 2020 for the Global South: International Space University (ISU) - Southern Hemisphere Summer Space Program (SHS-SP), Adelaide, Australia. White Paper on infrastructure, policy, and economic frameworks to enable sustainable operation of tele-reach solutions. Online.
- Developing Real Time Model for Road Safety Measures in Nigeria, Using G.I.S and Remote Sensing. 61st International Astronautical Congress, IAC, Prague, Czech Republic, (2010). Online.
- Delivering Targeted Service Quality to Light-Rail Transport Passengers. Article under review in the international peer review journal of Sustainable Transportation (Tailor and Francis).
- The Light-rail as a Common Good or a System for Capital Flight to China: The Transfer of Responsibility and Knowledge among Urban Actors. A book chapter in Lessons Learned for Urban Management and Governance (under review).

# Skills

- GIS, remote sensing and data analysis: Excellent skills in the use of spatial and data analysis software's, such as: ArcGIS, QGIS, Erdas Imagine, FME, SAP, and SPSS.
- Programming proficiency: Structured Query Language (SQL) and Python.

- Excellent presentation and listening skills in English language and presently learning the Dutch language.
- Customizing the application of GIS to different disciplines, such as: Urban Management and Development; Urban Infrastructure and Green Cities; Urban Environment and Climate Change; transport analysis; Urban Governance; Urban Competitiveness and Resilience.
- Data processing and applications to different socio-economic and environmental purposes using the SAP software.

# Professional Membership Activities

- Geoinformation Society of Nigeria (GEOSON)
- Dutch Society of Real Estate Researchers (VOGON)
- Chartered Institute of Logistics and Transport (CILT) International
- The American Society for Photogrammetry/Remote Sensing (ASPRS)

# Awards

- Award for dispensing spatial knowledge with poise by UMD-15 master's students 2018-2019. 20th September 2019. Institute for Housing and Urban Development Studies, Erasmus University, Rotterdam, The Netherlands.
- Two Dean's Award for multidisciplinary excellence for presenting the most creative and feasible research proposal at the Dean's master Class - 'The Brain' on May 11th, and 'The City' on 13th February - 2017. Presented by the Dean of Erasmus Graduate School of Social Sciences and the Humanities; Prof. Dr. Liesbet EA van Zoonen, Erasmus University, Rotterdam.
- Young professional award by the International Astronautics Federation (IAF) at the 61st International, Astronautical Congress (IAC, Prague, Czech Republic) 2010.