Roads Infrastructure Funding and Financing for Namibia: A Case Study of the National Road Network

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DECLARATION

By submitting this dissertation electronically, I, Helvi Ndilimeke Petrus, hereby declare that the entirety of the work contained therein is my own, original work; that I am the sole owner of the copyright thereof (save to the extent explicitly otherwise stated); and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

H.N. Petrus March 2020

ABSTRACT

Namibia established a second-generation road fund with the aim of implementing a user-pays system by ensuring that road users pay for their consumption of road services. The national road network covers approximately 48 399 km and serves a vehicle population of approximately 371 281. Somewhat implicit in these road funds is the confidence that the Road User Charge System (RUCS) will deliver sufficient funding for the road sector. This exploratory case study investigated the funding and financing of the national road network in Namibia. The national road network constituted the population from which the hypothetical road samples were drawn. Several data-collection methods were employed, including document analysis and secondary data analysis. The research employed the Highway Development and Management (HDM-4) model to estimate the external costs of road use.

This research evaluated the relationship between the road-generated revenue (RGR) and its allocation towards the national road network expenditure and related these to international standards. The findings indicate that the Road Fund Administration (RFA) possesses high transparency in allocating RGR towards the preservation of the road network. This places Namibia among countries with high dedication of 80% and above towards road expenditure, together with the United States of America (USA) and Switzerland when compared to international standards. While revenue generated from road users are highly allocated to the preservation of the road network (0.96 ratio), a wide gap remains between the required funds and resources available for road expenditure. Financing for road expenditure was found to be a dilemma facing many developing countries, where revenue from road users does not cover the total road costs due to limited capacity and economics of use. Additional funding sources are therefore required to fund these deficits.

The research also demonstrated the applicability of the Highway Development and Management (HDM-4) model, to determine the Marginal External Costs (MEC) of road use. The results indicate that heavy vehicles impose the highest costs in terms of infrastructure damage and environmental costs when using the network. When applying marginal costing, the results indicate that heavy vehicles contribute approximately 98% (district road), 97% (main road), and approximately 98% (trunk road) in terms of external costs when using the respective network. Overall, light vehicles contribute the most to congestion and accidents costs when using the national road network. Although the results presented the national road network to be congestion free, relatively low congestion was traced on the trunk road, thus increasing the overall cost contribution for light vehicles from 2% (district road) and 3% (main road) to approximately 19% when using the truck road network. The findings indicate that

motorists impose some externalities when using the road network and it would make economic sense to internalise such costs to road users.

The research further assessed the implications of setting Road User Charges (RUC) at the Short-Run Marginal Costs (SRMC) of road use. The results indicate that setting RUC equal to correct prices leads to an estimated road funding deficit of N$5 062 746 on the sampled trunk road. These findings indicate that a marginal pricing approach in the Namibian context (expansive road network serving few users) might not necessarily raise the revenue required for the investment and maintenance of the network. This situation calls for an alternative approach to marginal pricing.

In exploring the second-best RUC suitable to the Namibian funding circumstances, this study explored what Namibia could learn from other countries with expansive road networks such as Australia and New Zealand. The findings presented the efforts Namibia that has made in terms of policy formulation and noteworthy institutional frameworks, which have made Namibia the leading country in sub-Saharan Africa in terms of road-quality rankings. However, Namibia needs to embrace technologies towards charging vehicles per kilometre. The existing Mass Distance Charges (MDC) attempted to solve the challenges associated with charging heavy vehicles according to distance travelled; however, the current MDC is a blunt instrument that does not adjust charges according to weight, time, and location. Reforming the current system with the focus on distinguishing suitable charges for light and heavy vehicles to account for their use of the road network per vehicle per kilometre according to time and location is something that Namibia could learn from Australia and New Zealand. Collaborating efforts from both the public and private sectors could be another step toward a road financing solution.

The contribution of this study revolves around adding to the existing knowledge relating to financing expansive road networks that serve a small vehicle population by assessing the RUCS with a particular focus on the user-pays principle and by estimating the MEC of road use by utilising the HDM-4 model.

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DEDICATION

In adoration, honour, and gratefulness to the almighty God, the pillar of my strength, knowledge, wisdom, and understanding, I dedicate this study to those interested in the roads transport sector within Africa and developing countries.

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LIST OF ABBREVIATIONS

AADT	Annual average daily traffic
ALF	Abnormal Load Fees
ALPR	Automatic License Plate Recognition
AMGB	Asphaltic mix granular base
AMS	Accident Management System
ATC	Average Total Cost
AVC	Average Variable Cost
AVLRF	Annual vehicle licence and registration fees
BMS	Bridge Management System
CBC	Cross-Border Charges
CCTV	Closed-circuit television
CH_4	Methane
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
dB	decibel
DBST	Double bitumen surface treatment
DSRDC	Dedicated Short-Range Communications
eNATIS	Electronic National Traffic Information System
eRUCS	Electronic road user charging system
ESAL	Equivalent Standard Axle Loads
EU	European Union
FHWA	Federal Highway Administration
GDP	Gross domestic product
GHG	Greenhouse gas
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
GRN	Government of the Republic of Namibia

GWP	Global warming potential
HC	Hydrocarbons
HDM	Highway Development and Management [model]
HDM-4	Highway Development and Management Volume 4
HGV	Heavy goods vehicle
HTF	Highway Trust Fund
IBMS	Integrated Business Management System
INDC	Intended National Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
IRI	International Roughness Index
IRMS	Integrated Road Management System
ISI	Institut System und Innovations Forschung
IWW	Inland Waterways
LPI	Logistics Performance Index
LRAC	Long-Run Average Cost
LRMC	Long-Run Marginal Costs
MAC	Marginal Accident Costs
MCC	Marginal Congestion Cost
MDC	Mass Distance Charges
MEC	Marginal External Costs
MENVC	Marginal Environmental Costs
MIC	Marginal Infrastructure Costs
MIS	Material Information System
MLTRMP	Medium to Long-Term Road Master Plan
MME	Ministry of Mines and Energy
MMS	Maintenance Management System
MoF	Ministry of Finance
MPC	Marginal Private Cost
MSC	Marginal Social Cost
MTEF	Medium Term Expenditure Framework
MVA	Motor Vehicle Accident [Fund]

MWT	Ministry of Works and Transport
MWTC	Ministry of Works, Transport and Communication
N_2O	Nitrous oxide
NAMPORT	Namibian Ports Authority
NDP4	Fourth National Development Plan
NDP5	Fifth National Development Plan
NEF	National Energy Fund
NIM	Network Integration Module
NOx	Nitrogen oxides
NPC	National Planning Commission
NPV	Net present value
NRSC	National Road Safety Council
NSA	Namibia Statistics Agency
NSTIFC	National Surface Transportation Infrastructure Financing Commission
NTC	National Transport Commission
OECD	Organisation for Economic Co-operation and Development
PCS	Project Control System
PCSE	Passenger car space equivalences
PCU	Private car unit
PM	Procedures Manual
PM2.5	Particulate matters
PMS	Pavement Management System
PPP	Public-private partnership
RA	Roads Authority
RAC	Roads agency costs
RCC	Roads Contractor Company
RDWE	Road deterioration and work effects
RF	Road Fund
RFA	Road Fund Administration
RGR	Road-generated revenue
RMS	Road Management System

RPS	Road Proclamation System
RRS	Road Referencing System
RSIMS	Road Safety Information Management System
RUC	Road User Charges
RUCRG	Road User Charges Review Group
RUCS	Road User Charge System
RUE	Road user effects
SACU	Southern African Custom Union
SADC	Southern African Development Community
SATC	Southern African Transport Conference
SBST	Single bitumen surface treatment
SEE	Social and environmental effects
SRF	State Revenue Fund
SRMC	Short-Run Marginal Cost
SSATP	Sub-Saharan Africa Transport Policy Program
STGB	Surface treatment granular base
TEU	Twenty-Foot Equivalent Unit
TRB	Transportation Research Board
TSS	Traffic Surveillance System
UK	United Kingdom
URMS	Unsealed Road Management System
US	United States
USA	United States of America
VAT	Value-added tax
VKT	Vehicle kilometres travelled
VMT	Vehicle miles travelled
VOC	Vehicle operating costs
VPD	Vehicles per day
VTDC	Vehicle Travelling Distance Charges

CHAPTER 1:
INTRODUCTION

> "*Namibia is a large country with a small population which makes it likely that her costs of road building and maintenance will be higher than elsewhere. The question is: what is the best way of funding the road network? The original intention of making those who use the road to pay for them was to have solved this problem but it appears to have run into serious problems. However, it is not clear whether this is because road users are simply not prepared to pay full cost of the road network or because the current system of management and administration is inefficient or users are paying and the current system is ok. The Road Fund Administration (RFA) Act is clear on this issue: road users should pay to the extent that costs can be justified on the grounds of economic efficiency. Government has to step in and contribute when this is not the case. The danger is that, for political reasons, government will continue to expand the road network at the expense of road maintenance where it really matters"* (Sherbourne, 2017:367). *There is a strong case to re-examine the current system with a view to estimate MEC toward internalisation of external costs into roads pricing.*

1.1 BACKGROUND OF THE STUDY

Most countries in sub-Saharan Africa, including Namibia, have established second-generation road funds for funding the road sector with Road User Charges (RUC) revenue streams that are deposited into a designated account. The aim of setting up second-generation road funds has been to commercialise the road sector (Heggie, 1995), by using a fee-for-service concept as applied in other services such as water and transit (Bird & Slack, 2017). The road sector is commercialised through the superficially economic concept of the user-pays principle, which ensures that road users are charged at the marginal social cost (MSC) rate. The MSC principle is justified by many researchers on the notion that consumers of a scarce resource (roads) should be held liable for the costs they impose on the road, and on other users by means of congestion and accidents and to the rest of society (Freeman, 1982; Nash & Mathew, 2005; Quinet, 2005). Despite the notion of bringing the road to the market place and running it like a business, many second-generation road funds, especially in developing countries, have been faced with a shortage of revenue for road maintenance, leading to an ever-growing backlog of deferred maintenance (Heggie, 1999; Heggie, 2003; Tembo, 2010). Although most countries have RUC instruments in place, many are yet to fully implement the user-pays concept, or introduce charging instruments that are set to reflect the additional cost that users impose on society, namely costs associated with kilometres travelled or additional trips made, without considering the infrastructure capacity increase (Nash, 2003).

Several policies, legal frameworks, and funding schemes to address the demands for road maintenance, rehabilitation, and new development have been drafted (National Planning Commission [NPC], 2015; Republic of Namibia, 1999c; Roads Authority [RA], 2015). The general theme of these policies seems to be the belief in the user-pays principle as the best option to fund roads. For example, the Namibian Transport Policy (Ministry of Works and Transport [MWT], 2017) recommends implementation of the user-pays principle in order to promote economic efficiency. The efficiency principle entails that RUC should be set to fully recover road-use associated costs from the road users. Economists refer to an efficient price of transportation as the one set at the short-run marginal costs (SRMC) associated with the use of roads. The equity criterion implies that capital costs not recovered through the marginal cost principles should be proportionally recovered from the road users who stand to benefit from the road system (Ministry of Works, Transport and Communication [MWTC], 2000). “User-pays” is therefore an umbrella term for efficient and equitable RUC that guide the setting of road pricing that is economically justifiable.

Economic theory suggests prices set to reflect MSC to be the optimal pricing for charging for the use of transport infrastructure (Stewart-Ladewig & Link, 2005). RUC that reflect the additional infrastructure and external costs signal to road users and the authorities the appropriate road prices drivers ought to pay. The social costs associated with road users travelling include operating costs of the road infrastructure, the traffic congestion they impose on other users, as well as the impact on the environment and society that arises from undertaking a journey (Rouhani, 2016). It is therefore essential to place monetary value upon externalities that arise from the use of roads and incorporating them into price mechanisms by directly charging the road users or when subsiding the road sector. In so doing, externalities costs will be taken into account by all stakeholders.

The Namibian White Paper on Transport Policy (MWTC, 1995) supported the creation of the Road Fund (RF) into which revenue generated from Road User Charges (RUC) should be deposited. Somewhat implicit in these policies and documents is the confidence that the user-pays principle will deliver sufficient funding for the road sector. The challenge with efficient prices, set at SRMC, is that under circumstances of low demand and excess capacity, these prices do not cover fixed costs (notably return on capital investments) that must be earned by the roads agencies (Kahn, 1988).

Issues of insufficient revenue generated from RUC have been observed in Namibia. In response to the plight of the road sector, the government of the Republic of Namibia (GRN), and the RFA in particular, has released press statements in the local media, seeking mechanisms and ways to improve revenue collection, including the possibility of establishing toll roads in Namibia. According to Gwilliam and Shalizi (1999), insufficient or uncertain budget allocation towards road networks leads to deteriorated roads with possible compensations and significantly increases the production and distribution costs of other economic activities. Experience shows that transport infrastructure is likely to have a longer life span if well maintained. However, unmaintained transport infrastructure mostly deteriorates rapidly, especially under harsh climatic conditions (World Bank, 2008).

Financing for roads rests on revenue generated from the RUC (earmarked taxes) versus the funds required for road expenditure. On the revenue side (supply), second-generation road funds or governments have decided on how to charge the road users, and thus have established appropriate RUC instruments. This intention of making those who use the service pay for their usage was intended to solve the challenge faced by many developing countries on how to fund their roads (Sherbourne, 2017). Somewhat implicit in implementing these second-generation road funds is the confidence that the RF, based on the user-pays principle, will deliver sufficient funds for the road sector.

On the expenditure side (demand), Bousquet and Queiroz's (1996) argument is based on the fact that funds allocated to road maintenance and rehabilitation are insufficient in many cases. Furthermore, uncertain budget or insufficient budgetary allocations to road maintenance have resulted in road deterioration, with a significant increase in transportation costs and a subsequently negative impact on the economy (Gwilliam & Shalizi, 1999). Limited financial resources provided to the roads agencies are the main constraint, which has created backlogs in road preservation for many roads agencies or authorities. The above-noted issues and arguments encouraged the researcher to conduct a study and explore funding for roads in Namibia according to a perspective of road pricing, revenue generation, distribution, and expenditure. During the 2016/2017 financial year, the RA, an organisation mandated to manage the national road network in Namibia, experienced a total shortfall of approximately N$1 311 206 000.00 of the required budget for road preservation submitted to both the RFA and to the State Revenue Fund (SRF) (government) through its line ministry, the MWT. The RA (2016b), in its Budget 2016/17, states:

> "The initial Roads Authority proposed budget for the FY 2016/17 submitted to the Ministry of Works and Transport and the Road Fund Administration for possible funding amounted was estimated at N$4,654,424,000. The proposal submitted to the Government of Republic of Namibia (GRN) through the SRF resides under the Ministry of Finance (MoF), including grants and loans, was estimated at N$2,584,760,000. However, of the total fund requested only N$1,608,058,000 was allocated to the Roads

> Authority, resulted in to N$976,702,000 budget shortfall. Similarly, the RFA could only allocate N$1,781,147,000 of the N$2,115,651,000 required budget, which resulted in to a shortfall of N$334,504,000. Therefore, the total shortfall for the 2016/17 Roads Authority annual budget resulted to N$1,311,206,000.00."

Given the presented scenario, it is worth investigating road funding for Namibia, by understanding the constraint the RFA is faced with in generating revenue from the RUC and the allocation of such funds to the approved authorities for road expenditures. On the other hand, the RFA is mandated to manage the RF and the Road User Charges System (RUCS) in a manner as to secure and allocate sufficient funding for the payment of road expenditure. However, the RFA depends on the RUC to fulfil its mandate based on the user-pays principle. RUC are imposed on road users utilising the road network, *inter alia*, through Fuel Levies (FL), Annual Vehicle License and Registration Fees (AVLRF), Mass Distance Charges (MDC), Cross-Border Charges (CBC), and Abnormal Load Fees (ALF). Chapter 5 provides a detailed discussion on the RUCS in Namibia.

1.2 RESEARCH STATEMENT

In Namibia, the potential for a self-funded road sector is not yet being fully exploited. Among other constraints to insufficient revenue generated from the RUCS is the inability of RUC to meet the national road network expenses. Despite implementing a seemingly sound institutional framework and having a sound policy on how to secure funding through RUC based on economic efficiency, the Namibian road sector is quite extensively served by a small vehicle population of 374 710 registered vehicles (RA, 2016). This implies that Namibian road users are likely to pay more, which spreads the costs of a large network over fewer users than elsewhere (Sherbourne, 2017). Namibia established a second-generation road fund supported by earmarked revenue generated from the implemented RUC. The common problem with the second-generation road funds is that they create the impression that all the revenue generated from the RUC should be sufficient to cover the road network expenditure.

The Namibian road fund approach differs from those found in other countries in that the legislation states that RUC should cover costs to include or also to cover expenditure to be incurred when undertaking justified new investments in the road sector (Bruzelius, 2000). The current RUC based on the stated principle of economic efficiency appeared to have run into serious problems and have proven to generate insufficient revenue to meet the investment needs of the current national road expenditure. The government must step in and subsidise the road sector (Sherbourne, 2017). However, government funds appear to be channelled towards developmental projects (construction of new roads) and not towards road maintenance, where funds are required for preserving the existing road network. There is therefore a strong case to conduct an empirical investigation into the current issues surrounding the road-funding model in Namibia and to address the existing gap in the conventional user-pays principle. The Namibian Transport Policy calls for the refinement of the current road user charges system to assess the feasibility of implementing the user-pays principle, and to ensure full-cost recovery from those who consume the road network for economic justification of road projects and programmes (MWT, 2017). The user-pays principle aims to hold road users accountable for the costs they impose on the infrastructure, on other drivers using the same facility (in terms of congestion and accidents risks), and on society.

Most countries in sub Saharan Africa use the Highway Development and Management (HDM-4) model to derive strategies for the maintenance and investment needs of the road network. Road authorities, however, have not used the software to assist in setting road pricing or to estimate the external rod user cost. Using a case study design approach, the study employed HDM-4 to estimate the marginal external cost (MEC) of road use. These MEC estimates could subsequently be used as input in setting road users charge tariffs. This process allowed for the internalising of external costs in the road user-funding framework. The main contribution of this work is therefore to demonstrate the applicability of the HDM-4 in to estimate marginal external cost of road use and as input in setting road use tariffs.

1.3 RESEARCH QUESTIONS

This study addressed specific questions, namely:

1) What are road users currently spending on road use and what portion of road-generated revenue (RGR) is allocated back to preserve the national road network?
2) What are the efficient RUC for Namibia based on the principle of MSC?
3) What is the magnitude of the financial gap in financing the national road network and what are the implications of implementing MSC principles?

1.4 RESEARCH OBJECTIVES

Following the research questions, the research addressed specific objectives, as follows:

1) To determine what Namibian road users are currently spending on road use and to ascertain how much of these funds are allocated to road infrastructure (maintenance, upgrade, and new construction) and relating these to international standards.
2) To estimate the financial implications of implementing MSC as RUC and to determine the magnitude of the possible financial shortfall in financing the national road network from this first-best RUC principle.

3) To explore possible second-best RUC based on the specific circumstances of Namibia to address the road funding challenges.

1.5 RESEARCH CONTRIBUTION AND RATIONALE FOR EACH OBJECTIVE

In 2000, Namibia undertook a road subsector reform, which resulted in the formation of three public enterprises. According to the MWTC (2000), this new reform and structure arrangement entailed the following:

- A self-financed road sub-sector, financed by the RUC. The self-funded system comprises of the RUCS and the RF managed and administered by an autonomous state agency under the MoF, known as the RFA.
- The Roads Authority (RA), another autonomous state agency under the MWT with the mandate to manage the national road network.
- The Roads Contractor Company (RCC), to execute the maintenance and rehabilitation of the national road network based on competitive bidding procedures with private companies.

The road sub-sector reform was conducted in order to redirect the sector's focus from one funded by means of general taxation (consolidate budget) to one being funded through the RUCS. The main fundamental that initiated the drive was a motive of securing adequate funding for the road sector in order to preserve the national road network and other roads. In so doing, Namibia could better serve the needs of its neighbouring countries. The Fourth National Development Plan (NDP4) emphasised the country becoming a logistics hub and a gateway to international markets. During the period of 2012 to 2016, transport and logistics in general contributed approximately 4.7% to the country's gross domestic product (GDP); however, the sector has the potential to contribute more to the country's GDP (NPC, 2017). Transport is a catalyst for the NDP to realise its targets in other sectors, including mining, agriculture, manufacturing, fisheries, tourism, and rural and urban development.

It is in light of the above that NDP5 embarked upon a holistic and integrated multimodal and intermodal approach to transport planning in handling goods and services, thus meeting the domestic and regional transportation needs (NPC, 2017). The road mode in most African countries accounts for 80% to 90% of the total trade in goods and services (Pinard, 2015). In Namibia, roads are one of the dominant transportation modes, trading approximately 59% of the country‘s imports (Namibia Statistics Agency [NSA], 2016b). However, the imbalance between road preservation and new infrastructure development is one of the challenges that hampers the sub-sector's sustainability. In addition, the optimal allocation required by the RA to preserve the national road network is another challenge that is yet to be resolved.

> “The Medium to Long-Term Road Master Plan of 2012 (MLTRMP) advocated for the optimal funding for the road infrastructure within the RUC during the financial year 2015/16 at N$3.45 billion. However, the Road Fund could only avail N$1.98 billion. This has resulted into a funding gap of about N$1.47 billion initially required to cover the backlog in road preservation” (Road Fund Administration [RFA], 2015).

In his statement, while addressing the African Road Maintenance Funds Association, the chairperson of the RFA board of directors emphasised that the funding gap in road maintenance has accumulated for some years, especially because the funds must be balanced between road maintenance and new roads development (RFA, 2015). This is an important concern, as road sectors in most African countries suffer from a large and growing backlog of deferred maintenance (Heggie, 2003). Previous literature shed light and provided useful information concerning the growing gap on road funding and financing. Creightney (1993) indicates that the identified gap has been influenced by several factors, including absence of clear RUC (as per road use), inefficient user-pays policies (with references to equity, heavy vehicles, and fuel levy), and the nature of tax in place. This calls for strategic project planning and RUC that are set at the SRMC.

The interest of the Namibian Transport Policy (MWT, 2017) to reform the current RUC to accommodate the negative externalities that arise from the road use encouraged the researcher to investigate whether estimating the MSC or road use could yield results in road pricing for Namibia. While road authorities use the Highway Development and Management model HDM-4 to strategise on maintenance expenditures and motivate investment required for the national road network, the use of the HDM-4 to influence the present and future road pricing remains a grey area in the authorities’ domain.

Academically, there is a dearth of available research and published articles on road funding for Namibia (Bruzelius et al., 2000; Tekie, 2012; Runji, 2003; Bruzelius, 2010; Tekie, 2014). Given the importance of roads to Namibia’s vision of becoming a logistic hub and a gateway to international markets, and to that of contributing to the Namibian economy at large, it is worth conducting an empirical investigation to understand how revenue for road funding in Namibia is generated and to determine the allocation of these funds to “Approved Authorities” for road expenditure.

At sub-Saharan level, the World Bank has conducted several studies that tended to focus on strengthening institutional arrangements, the establishment of the so-called second-generation road funds, and cost recovery (Freeman, 1982; Heggie, 1995; Heggie & Vickers, 1998; Gwilliam & Shalizi, 1999; Gwilliam et al., 2008). This study therefore aimed to contribute to the body of knowledge concerning road financing both from optimal revenue generation and from optimal funds allocation.

This study explored the road funding in Namibia by focusing on the RUCS and the RF in terms of optimal revenue generation and the optimal allocation of funds towards the preservation of the national road network. The study predominantly focused on the RFA and the RA. Moreover, relevant information required to achieve the objective of the study was gathered from pertinent stakeholders such the MoF, MWT, Motor Vehicle Accident (MVA) Fund, Ministry of Mines and Energy (MME), as well as relevant Approved Authorities. The term "road-user charges" was used broadly in this study to refer to the user-charging instruments to charge for road use. Although the RFA also allocates funds to local authorities for urban street maintenance, this study only covered the national road network and referred to local authorities where it was deemed necessary.

The original contribution of this study can be regarded in the following ways. Firstly, there is a dearth of scholarly and academic research on MSC of road use in sub-Saharan Africa and in particular in Namibia. Extant research conducted in transport and logistics and in particular the road sub-sector in Namibia focused on road sector reform and road management systems (MWTC, 2000; Bruzelius et al., 2000; Tekie, 2012; Runji, 2003; Bruzelius, 2010; Tekie, 2014). This study placed it focus on road financing aspects by focusing on the revenue-generation side and the road expenditure side. Furthermore, the research also focused on funding for roads in Namibia by relating the current RUCS to efficient RUC that are based on MSC.

Secondly, the RF and RUCS have been in place for more than a decade in Namibia. However, to the researcher's best knowledge, there has never been any empirical assessments of the current road funding model with a particular focus on the user-pays principle estimating the MSC rate of charging users and the implications it may have for the road budget. This study thus addressed this urgent need by providing valuable empirical knowledge needed not only to ensure that RUC are charged as per the economic principle and set equal to SRMC, but also for the overall growth and development of the sector. If the user-pays principle, recommended by the Namibian Transport Policy (MWT, 2017), ought to be implemented and if the SRMC is perceived relevant for road pricing, then existing RUC require information on MSC for a true reflection of road use. This study thus revisited the economic theory of setting road charging at efficient pricing, which makes efficiency pricing as a policy strategy that links demand, price, investment revenues, and capital funding something that has been overlooked for many years in Namibia. This study also contributes to the body of research on MSC estimation by presenting estimates of the Namibian national road network.

Thirdly, the research initiates a new dimension to the press statement released by the RFA in seeking better methods to improving revenue collections for the road sub-sector.

This information is very much timely and an important input into the RFA Business Plan Review for the period of 2015 to 2022 (RFA, 2016).

Finally, the study utilised the World Bank Road User Model to demonstrate the applicability of the Highway Development and Management (HDM-4) in estimating MSC using case studies of a particular section of the Namibian national road network. The uniqueness of this study lies in using the data from the Road Management System (RMS) division of the RA. The results could be easily synchronised to influence present and future road pricing. It is anticipated that the estimation will provide guidance for planners, policymakers, researchers, and others involved in the transportation sector in order to create evidence-based solutions to the challenges faced by the sector.

This study's significance lies in its prospect of assisting policymakers in decision making, especially with regard to the transport and logistics sector. The main desired outcome of the NDP5 (2017-2022) is for Namibia to have a sustainable transport system supporting an excellent logistic hub connecting the Southern African Development Community (SADC) to international markets by 2022. In light of these views, Chapter 5 addresses the first objective and focuses on understanding the road funding regime in Namibia and compares Namibia to international practice. This was done by focusing on RGR from the RUC and optimal allocation to the relevant authorities. This chapter explored Gomez and Vassalo's (2014) financial techniques to analyse the funding regime in Namibia, which showed the RGR earmarked for maintenance and rehabilitation funds spent on Namibian roads on rehabilitation and maintenance for every dollar road user spent, and the relation between road expenditure and the national GDP.

Chapter 6 explores the possibilities of using the HDM-4 commonly used by road authorities for planning to estimate the MEC of road use in Namibia. The chapter attempts to address the gap between the recommended user-pays principle as a road pricing policy and strategy towards its implementation. In light of these views, the chapter envisages demystifying marginal externality cost estimations in order to help the road authorities to grasp the concept, as well as to internalise such externalities into road pricing.

Chapter 7 addresses the second and third objectives. The chapter assesses the implications of implementing RUC at MSC using fuel levies and MDC as a proxy to determine the revenue generated from the hypothetical case studies. These results are then compared to the MEC estimated in Chapter 6. It further explores the second-best RUC suitable for the Namibian case (expansive road network served by a small vehicle population) by deviating from the MSC principle while drawing some lessons from Australia and New Zealand.

The study will potentially act as a benchmark in creating awareness and availing information on road funding in Namibia and how the country could better utilise the Highway Development and Management (HDM-4) model of the World Bank in order to influence setting tariffs that internalise the external costs of road use.

1.6 ORGANISATION OF THE CHAPTERS

This dissertation is organised around three main themes within road funding in Namibia, namely road pricing, RGR, allocation, and expenditure; efficient RUC for Namibia based on MSC; and determining the second-best RUC.

The study began with the first chapter to introduce the subject matter and to highlight some debates around road funding. The overview of road funding in Namibia is presented in Chapter 2. Chapter 3 discusses the literature that guided the study on a broader level. Chapter 4 presents the overall research methodology; however, each main chapter employed its specific methodology. Chapter 5 begins with the empirical investigation into the road fund by calculating the RGR, the road allocation ratio, and the road expenditure ratio for Namibia and making comparisons to selected countries. It thus provides information on how much road users are currently spending on road use and how much of the road revenue is allocated back to road preservation of the road infrastructure. Chapter 6 explores efficient RUC for Namibia based on the principle of the MSC. Chapter 7 focuses on exploring the second-best road pricing approach for Namibia, thus deviating from the first-best road pricing approach while drawing some lessons from Australia and New Zealand. Chapter 8 presents the conclusions and policy recommendations.

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CHAPTER 2:
THE TRANSPORT AND ROADS SECTOR IN NAMIBIA: A NARRATIVE OVERVIEW

2.1 INTRODUCTION

This chapter presents a brief background on the Namibian economy with focus on the transportation sector. It further presents an overview of the Namibia transport and logistics sector with a particular focus on the road subsector, with descriptions of the road subsector. Furthermore, the chapter discusses the RUCS and its practice in Namibia. As informed by the motive behind this research, which was to conduct an empirical investigation into road financing in Namibia, it is deemed necessary to narrate the road subsector in Namibia with a particular focus on the national road network under the auspices of the RA. Finally, the chapter discusses the role of the transport sector in the economy.

2.2 OVERVIEW OF NAMIBIA

The Republic of Namibia is among the youngest economies in the world, having gained independence from neighbouring South Africa in 1990. Namibia is categorised as an upper-middle-income country, with a GDP estimated at US$10.3 billion and a per capita income of US$4 140 [N$55 144] (World Bank, 2016). Namibia is a vast country with 2.3 million inhabitants, with approximately 52% of the population residing in the rural areas of the 14 regions of country (NSA, 2017). The country has a total coverage area of 825 615 km^2 (population density of approximately 2.6 person per km^2). It is an arid country bordered by the Atlantic Ocean and the landlocked countries Botswana and Zambia, as well as Angola and South Africa. During the period 2012 to 2016, the Namibian economy recorded a growth rate of 4.6% per annum. Although the country recorded a relatively high GDP per capita and steady economic growth, Namibia registered the highest unemployment rate among other countries in sub-Saharan Africa. The 2016 Namibia Labour Force Survey report recorded the unemployment rate (broader definition) at 34%, approximately 6.1% higher than the 2014 unemployment rate of 27.9% (NSA, 2017).

2.2.1 The Namibian economy

Namibia is rich in natural resources and quite stable in terms of political and macroeconomic agendas. The country recorded slow growth in the 2000s; over the period 2012-2016, the economy grew by 4.6% per annum on average (see Figure 2.1) (NPC, 2017b).

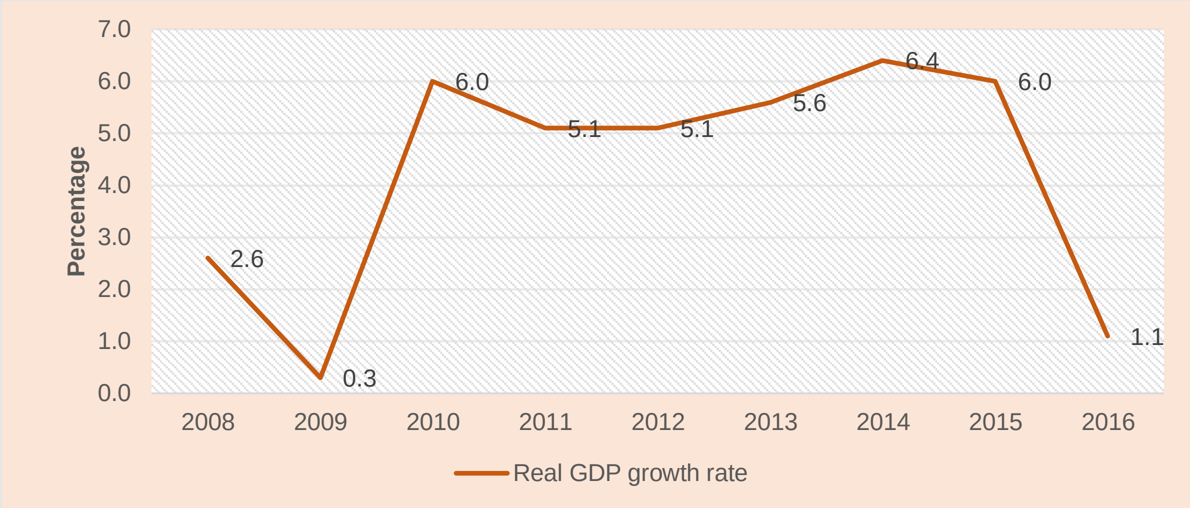


Figure 2.1: Real gross domestic product growth rate

Source: NSA (2016b)

Sector wise, tertiary industries have contributed the highest percentage to the Namibian economic growth. According to the NSA (2016b), tertiary industries contributed 57% to the GDP, followed by the primary and the secondary industries, with an overall contribution of 17.6% and 17.4% respectively (see Figure 2.2).

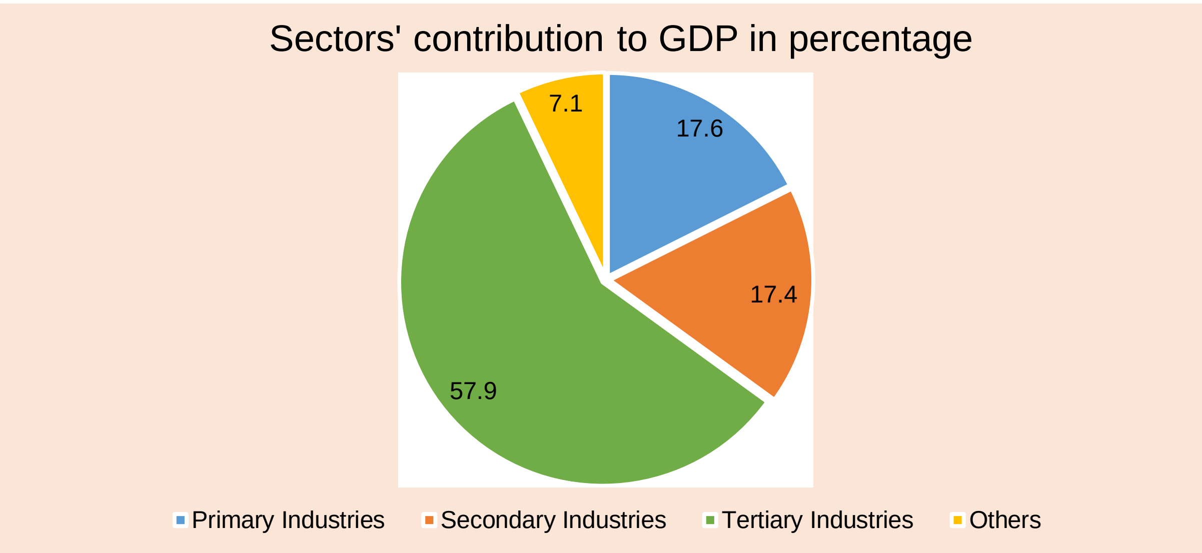


Figure 2.2: Industries' contribution to gross domestic product: Namibia 2016

Source: Author (Data from NSA, 2017)

Over the past decade, the mining and manufacturing sectors have been the country's largest contributors to the GDP (see Figure 2.3). According to the Bank of Namibia (2016), the construction sector has been growing at a steady rate but slowed down in the preceding years due to a decline in the construction investment programmes by both the public and private sectors. The transport and communication sector has contributed fairly over the years.

Transport activities have been increasing over the years despite the decline recorded in the export volumes and some mineral products. The increase in cargo volume was mainly reflected in sea cargo transhipment, as well as in road transportation (Bank of Namibia, 2016).

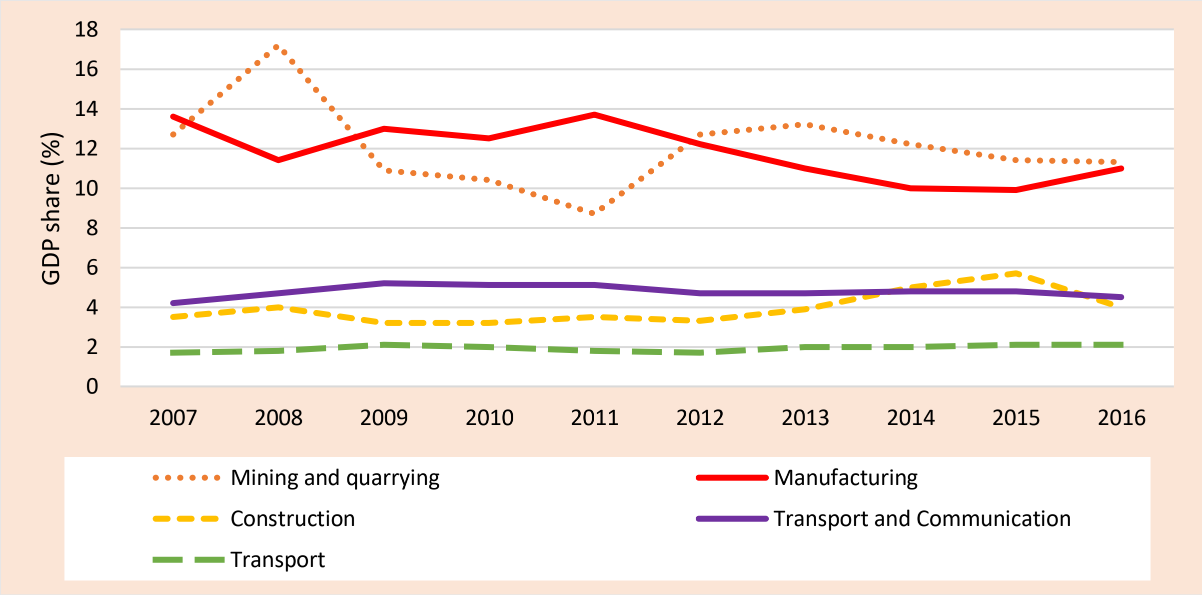


Figure 2.3: Percentage share of selected sectors' contribution to gross domestic product: 2007-2016

Source: Author (Data from NSA, 2017)

In contrast, external shocks, sluggish economic growth coupled with weak demand, a decline in commodity and oil prices, and the unfavourable exchange rate are some of the challenges faced by the Namibian Ports Authority (NAMPORT, 2017). These have resulted in a decline in cargo volume (from 6.5 million tonnes in 2012 to 5.6 million tonnes in 2016) handled by the Port of Walvis Bay over the past few years (see Box 2.1). The Namibian railway subsector is concomitant with aged and obsolete locomotives, as well as dilapidated infrastructure (NPC, 2017a). This resulted in shifting of heavy bulk transportation from rail to road, which placed immense pressure on road infrastructure. In Namibia, the transport industry relies heavily on the road sector for imports, moving approximately 62% of imports and exports of approximately 23% (NSA, 2018:22). Sea mode tops the country's exports, accounting for approximately 44% of Namibia's total exports, which is a positive indication towards attaining Namibia's vision in becoming a logistics hub and a gateway to the international markets (NSA, 2018).

Box 2.1: Namibia's economic corridors

Namibia has four main economic corridors of high-quality roads with the potential to provide the shortest route for Namibia to the international markets and becoming a logistics hub given its geographical location. The Port of Walvis Bay is the largest commercial port in the country, linking multimodal transport corridors to the domestic and regional (SADC landlocked) countries and international markets. According to Namibian Ports Authority (NAMPORT, 2017), the Port of Walvis Bay handles approximately five million tonnes of cargo and receives around 3 000 vessels each year. Namibia's port infrastructure ranks 26th on the international level (Schwab, 2018), positioning it among the best in Africa and offers competitive tariffs. Compared to its rivals in East and Southern Africa, the Port of Walvis Bay is less congested. The transport corridor network links the country's main port (Port of Walvis Bay) with the Southern African countries and in principle comprises:

- The Walvis Bay-Ndola-Lubumbashi Development Corridor, previously known as Trans-Caprivi Corridor: This route is accessible by both rail and road, and facilitates imports and exports to Zambia, the Southern Democratic Republic of the Congo, and Zimbabwe.
- The Trans-Kalahari Corridor: The route is served by both road and rail mode, mainly utilised by Botswana and the northern provinces (mainly Gauteng) of South Africa.
- The Trans-Cunene Corridor: The route facilitates trade with Angola and is accessible by both road and rail.
- The Trans-Oranje Corridor: The route is accessible by both road and rail, facilitating consignments from both the Port of Walvis Bay and that of Lüderitz, mainly to South Africa's Northern Cape province.

During the period of 2012 to 2016, Namibia underwent a significant decrease in cargo volumes from 337 000 Twenty-Foot Equivalent Units (TEUs) to 206 000 TEUs between 2012 and 2016 (NAMPORT, 2017). This decrease has been attributed to a reduction in container volume designated to Angola, which comprised approximately 30% of cargo volume at the Port of Walvis Bay. Since 2012, the Angolan government has upgraded its ports and thus made use of its own resources at hand, as opposed to the Namibian port. In addition, bigger vessels also started calling at other ports in the region that offer deeper draft, the latest equipment, and are faster and more efficient compared to what the Port of Walvis Bay offers. For the period of 2012 to 2016, the transhipment declined from 218 000 TEUs to 106 000 TEUs in 2017, a decrease of approximately 51% over the period under evaluation. In addition, transit traffic declined from 52 000 TEUs to 49 000 TEUs, which is approximately 6% per year over the same period (NAMPORT, 2017).

In order for Namibia to achieve its vision of becoming a logistics hub, strategic and infrastructure improvement is required to sustain the growth in the utilisation of the corridor. These include infrastructure investment of all modes, comprising (i) the Port of Walvis Bay expansion in order to respond to the ever-increasing freight demand; (ii) upgrading and replacing the railway infrastructure, thereby improving speed level, frequency, axle load, reliability, and safety and addressing the challenges of ageing and insufficient rolling stock the railway subsector is faced with; and (iii) upgrading and rehabilitating the road network, thus ensuring efficient flow of consignments to its neighbouring countries.

To date, the GRN has taken giant steps whereby it embarked on expanding the Port of Walvis Bay to accommodate a container throughput capacity from 355 000 TEUs to 1 005 000 TEUs per annum funded by the African Development Bank. Another strategic giant step was acquiring new locomotives. Finally, for the road subsector, the main contributor to imported goods, the government has initiated the policy review process of the "White paper transportation policy and emphasised that road users should pay for their consumption of the road infrastructure". All strategies taken towards transport and logistics sectors have the potential to induce trade flows, while taking advantage of rapid economic growth in a number of SADC countries. This is indeed one of the great opportunities for the country to position itself as a logistics hub. In conclusion, the transport and logistics sectors at large are likely to create employment opportunities for Namibians (African Development Bank, 2014:7).

The ultimate goal of attaining and sustaining economic growth is to yield improved socioeconomic development through employment creation, high income per capita, equitable income distribution, and poverty eradication (Nakale, 2016). Over the past decades since the country's independence, Namibia's economic growth translated into moderate per capita GDP, which resulted in its upper-middle-income status by 2009. Despite the country's satisfactory macroeconomic performance, Namibia is among the countries with a high unequal distribution of income as reflected by a high Gini coefficient of 0.572 (NSA, 2016a). In contrast, the poverty rate declined by approximately 10.7% from 28.7% in 2009/2010 to 18% in 2015/2016, meaning nearly 18% of the population lives in poverty (NSA, 2016a).

In comparison, unemployment rates remain high in Namibia. The 2016 Namibia Labour Force Survey recorded 34% unemployment as compared to 28% in 2014. Overall, the youth age group constitutes the highest unemployment rate. Approximately 54.9% of youths between 20 and 24 years of age are unemployed (NSA, 2017). The 2016 Labour Force Survey identified a skills mismatch as one of the contributing factors to the unemployment crisis in Namibia (NSA, 2017).

On the other hand, the manufacturing sector has the potential to contribute to sustainable economic and employment creation. However, the sector is somewhat small and limited in terms of export diversifications. Small manufacturing bases and low levels of diversification coupled with skill deficiency and policy constraints are some of the factors identified by Godana and Odada (2002) as hindering economic growth in Namibia. Seneviratne (2009) posits that an insufficient level of investment, especially those below 25% of the country's GDP, limits the possible potential towards economic growth.

2.2.2 The transport sector

Namibia is well positioned along the west coast of the Atlantic Ocean and has four main economic trade route corridors linking its neighbouring landlocked countries, as well as South Africa and Angola, to its ports. In Namibia, the transport and logistics sector plays a crucial role in the country's economic development.

The transport and logistics sector in Namibia covers not only road but also air, rail, and maritime modes. The railway sector is faced with dilapidated infrastructure and aged and obsolete locomotives (NPC, 2017). A shift of heavy bulk transportation from rail to road has put immense pressure on the road infrastructure. Although the transportation sector comprises maritime, roads, rail, and aviation subsectors, this research focused mainly on the road subsector, in particular the national road network managed by the RA.

Given Namibia's vastness and sparse population, the transportation mode is of great importance to its economy. Namibia is a unique country in terms of geographical size, with a relatively large road network covering 48 399 km (RA, 2016). The country has a small population of 2.3 million inhabitants (NSA, 2017), with around 371 281 registered motor vehicles (RA, 2017) and 266 673 foreign registered vehicles (RFA, 2017), travelling approximately 3 667 million km (RA, 2016) per annum. Approximately 7 165 km of the road network is paved and 39 212 km is unpaved. The replacement value of the top layer of the paved road network in Namibia stood at N$33 326 billion by 2015 (RA, 2015).

Namibia seeks to become a logistics hub and a gateway to the SADC region. The country appears to be on the right track as it is ranked 35th (out of 141) in terms of its efficiency of seaport services (Schwab, 2019). There is, however, still more room for Namibia to improve its airport connectivity, ranked 120th (out of 141), as well as mobile/cellular telephone subscriptions and fixed-broadband subscriptions per 100 of the population, ranked 81th and 103th (out of 141) respectively (Schwab, 2019). Namibia ranks 79th (out of 160) on the Logistics Performance Index (LPI) global ranking in comparison to its neighbours, South Africa and Botswana, who rank 20th and 57th respectively (see Figure 2.4).

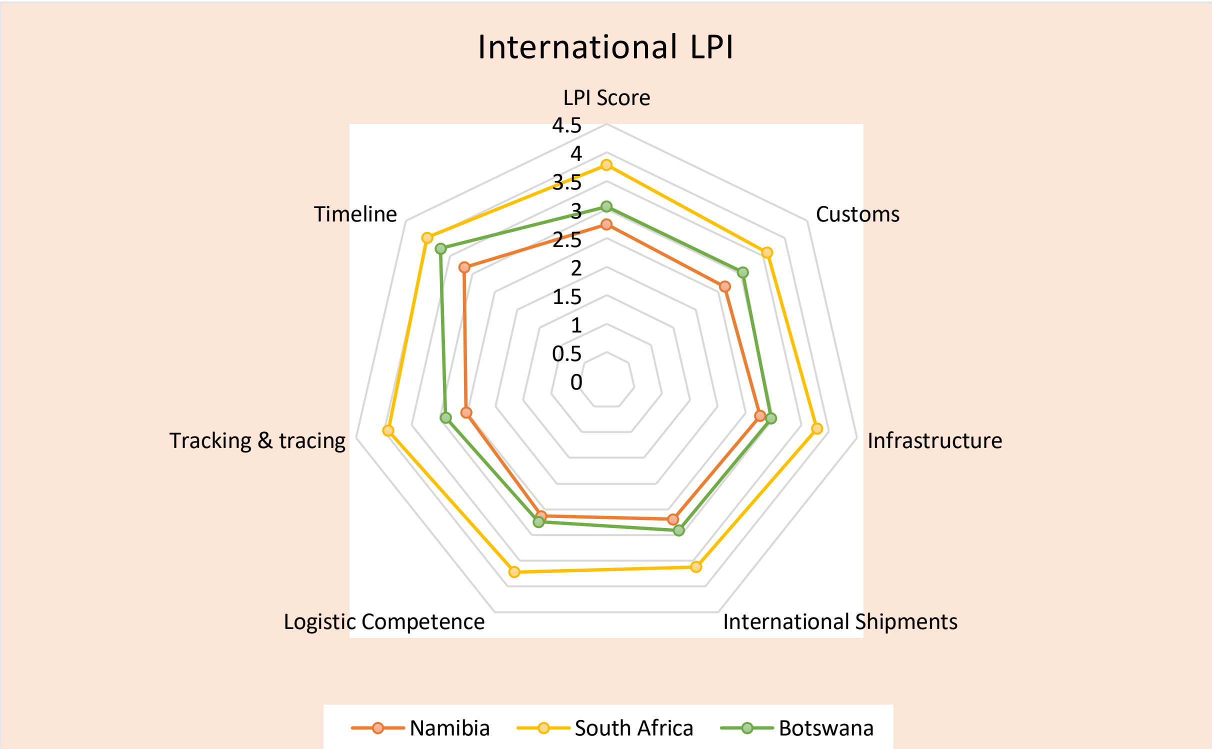


Figure 2.4: Global Logistics Performance Index comparing Namibia to South Africa and Botswana

Source: Author (Data from World Bank, 2016)

2.3 THE NAMIBIAN ROAD SECTOR

The Namibian government inherited a good road network at independence in 1990. During the South African regime, in particular the 1970s until the mid-1980s, infrastructure, including roads, was built with the motive to strengthen the ties between Namibia and South Africa, as well as to promote the apartheid policy (Bruzelius, 2000). Although road taxation was in place, in no way was the revenue from the road taxation earmarked for road maintenance (Runji, 2003). The government department responsible for road projects and programmes would therefore receive its annual budget allocation through general budget processes via parliamentary debate and approval. Namibia has some of the best roads in Africa; very extensive, high standard, and generally well maintained. The GRN therefore treasures the asset (road infrastructure) at hand and in a fundamental way thought of reforming the institutional arrangements in the road sector in order to earmark the road charges and implement a proper road network management.

Since Namibia gained its independence from South Africa in 1990, the road infrastructure has been under the management of the MWTC and financed through the SRF, with revenue generated from various taxes and tariffs (Chapter 5 discusses road funding in detail). The budget presented in the form of Medium Term Expenditure Framework (MTEF) is allocated to several implementing agencies such as ministries, government offices, parastatals, and regional and local authorities, and is done based on priority projects and programmes with high potential to contribute to the country's development agenda (NPC, 2017b). However, the national budget is subject to parliamentary debates and approval, as noted by Runji (2003). In addition, the allocation to the implementing agencies is done according to the availability of funds. Among other implementing agencies, the MWTC, prior to the road sector reform, executed all road-related construction, rehabilitation, and maintenance of the national road network, and received the annual road infrastructure budget, among others. In contrast, urban roads under the regional and local authorities' jurisdiction depended on miscellaneous sources of revenue. Apart from the so-called municipal rates and taxes, and fees imposed for services and allocation from the SRF, the authorities did not have any kind of mechanism or structure to charge for the provision or use of roads.

In 1993, the MWTC submitted a proposal on RUC, which the cabinet subsequently approved (Runji, 2003). The proposal paved the way for the formalisation of policy with the intention of de-linking the road financing from the SRF. Subsequently, cabinet approved the review of the draft White Paper on Transport Policy, adopted by the government in 1995 (Runji, 2003). The policy focuses on identifying fundamentals and the long-term policy objectives of the roads' function that should be provided and maintained at the minimal total costs of transportation, both to the supplier (infrastructure costs) and to the demand (road users, such as vehicle operating costs [VOC]). However, this necessitates a sound revenue stream, which was realised by the implementation of the RUCS. Runji (2003) argues that the RUC, which raise less-than-optimal funds required for road infrastructure, would at any point create a dependency on the SRF. Bearing that in mind, the White Paper recommended the economic (user-pays) principle of full cost recovery from road users (MWTC, 1995). In addition, the White Paper supported the creation of the RF, in which the revenue generated from RUC should be deposited. This RF should be legislated to secure its management and application (Republic of Namibia, 1999c).

2.3.1 Road sector reform

The Namibian government conducted a road sector restructuring in 1995 to ensure that efficiency is maintained (MWTC, 2000). In order to ensure adequate revenue and proper road network management principles for the road sector, the government established three key institutions with specific responsibilities towards the national road network. On 1 April 2000, the reform led to the formation of the three public enterprises, namely the RFA, the RA, and the RCC (Bruzelius, Poolman & Ravenscroft, 2000).

2.3.1.1 The Road Fund Administration

The RFA was established in accordance with the RFA Act (No. 18 of 1999) to manage the RF, to raise revenue through the RUC (licences and vehicle registration fees, fuel levies, MDC, CBC, and abnormal fees), and to regulate road funding based on the user-pays principle (Republic of Namibia, 1999c). The RFA imposed direct charges on motor vehicle owners using the Namibian roads. In addition, the RFA allocates funds towards sustaining and improving the national road network, as well as major urban arterials. Furthermore, the RFA allocates funds towards traffic law enforcement and traffic information systems, road research, and RFA and RA administrative costs (RFA, 2016).

2.3.1.2 The Roads Authority

The RA was established through the RA Act (No. 17 of 1999) and is mandated to manage the national road network, including planning, construction, and maintenance of all national roads. The RA uses the RMS to identify, quantify, and prioritise needs for the planning and management of the national road network. The RA does not carry out road maintenance, construction, or rehabilitation itself, but assigns such work to the RCC and other service providers (Republic of Namibia, 1999b).

2.3.1.3 The Roads Contractor Company

The RCC was established through the RCC Limited Act (No. 14 of 1999) and is responsible for construction, maintenance, and rehabilitation of the road network on a competitive basis with other service providers (Republic of Namibia, 1999a).

2.3.2 Institutional arrangements

The Namibian governance structure and road sector policy framework inherited a broader and more comprehensive approach that takes into consideration combined efforts by the political and administrative responsibilities of both government and ministerial (departments) and public enterprises (see Figure 2.5).

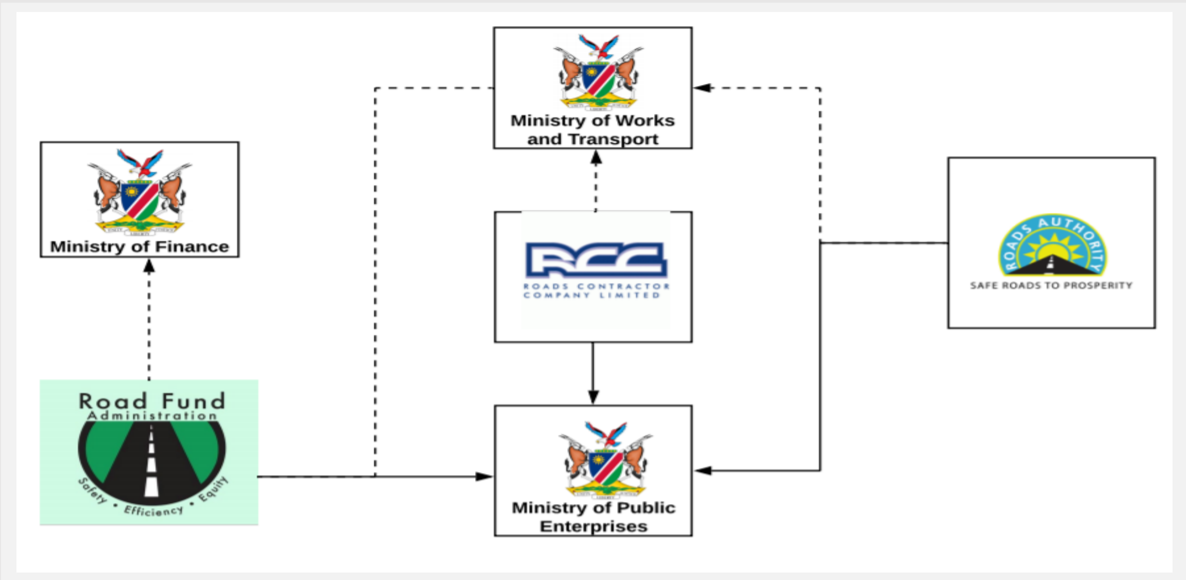


Figure 2.5: Namibian road sector governance structure in Namibia

Source: Author

Figure 2.5 depicts the main institutional arrangement of the national road network and does not include the local authority component responsible for urban and arterial roads network. The local authorities receive a budget from the SRF through the Ministry of Urban and Rural Development. In addition, approved authorities also receive a budget from the RFA revenue generated through RUC.

The Namibian road sector reform is one of the most far-reaching of its kind undertaken to date (Runji, 2003). The country is known for its noteworthy RFA, established according to the principles of the second-generation funds. These principles are discussed by Gwilliam and Ajay (2003) and entail (i) an RF managed through the RFA entity, responsible for managing the RUCS and channelling funds to the road authorities, (ii) independent board members comprise public-private nominees to oversee the RF, and (iii) generate revenue through the RUCS, among others fuel levies, AVLRF, ALF, MDC, and CBC.

Namibia has a dedicated RF under the umbrella of the RFA, where all revenue collected through charging instruments (RUC) are directed. The current RUCS in Namibia includes techniques to charge users, namely fuel levies, AVLRF, MDC, CBC, and ALF, as indicated in Box 2.2. Namibia has five RUC instruments in place, which, if adequately implemented, can be used as a starting point in promoting trade and sustainable travel and stimulating economic activities in the country and beyond.

The importance of this role has been recognised by the Namibian government, thus establishing the RFA mandated by the RFA Act of 1999 to establish and manage the Namibian RUCS and the RF. The RFA is also responsible for distributing and allocating funds to the approved authorities for the implementation of road projects and programmes. The revenue generated from the RUC is directed to the RF. According to the available audited financial reports and business plans of the RFA and RA, the current charging instruments have frequently delivered insufficient income for road maintenance. Lately, the RFA has issued several press releases calling for better instruments and mechanics on how to improve the revenue collection from road users. This confirms that the Namibian RUCS in its current state is not stable in terms of revenue-generation streams.

Box 2.2: Definition of Road User Charge System, objectives, and current charging instrument in Namibia

Definition of an RUCS

The RUCS is a system for independent regulation of road funding in accordance with economic efficiency criteria and full cost recovery from the road users (RFA Act, No. 18 of 1999).

The objective of the RUCS

The RUCS in Namibia was developed to economically recover the full costs of road expenditure from the consumers of roads in an equitable manner. In accordance with the user-pays principle, the system determines the amount and manner of funds to be raised from the road users and successively determines the charging instruments to be imposed. The RUCS is intended to attain the following, among others:

- Ensure that revenue required to upgrade and maintain the roads is raised from the road users as opposed to general tax revenue.
- Pricing the use of roads, thereby improving economic efficiency in the road transport sector, removing price distortion, and charging users as per their consumption.
- Promote equity within the road sector (per categories).
- Fair competition between road/rail transport sector.

The RUC include:

- the determination of funding for road projects and programmes submitted to the RFA for funding;
- the determination of the rates of RUC as stipulated in section 18a of the RFA of 1999;
- the imposition and collection from the RUCS into the RF;
- refunding of the fuel levies on fuel used off-road; and
- the management of the RUC and RF by the RFA.

The current Namibian RUCS comprises:

- Fuel levies;
- AVLRF;
- CBC;
- MDC; and
- ALF.

Source: (Republic of Namibia, 1999c)

2.3.3 Road User Charge System: The Namibian experience

The RUCS was established in 1999 as a means of collecting revenue from road users. The principles underlying the present method of road pricing in Namibia are largely those stipulated in the RFA Act of 1999. The Namibian approach to road pricing has been shaped by two major parliamentary decisions. The RFA Act of 1999 and the Namibian Transport Policy (2017) state that road users should pay the full cost of their consumption (Republic of Namibia, 1999c; MWT, 2017). The RFA from time to time in consultation with the MoF may determine the level of charges to be imposed and issue a notice in the *Government Gazette*. While the RFA attempts to incorporate the latest knowledge in its calculation, stability in the method is also required, as fluctuations would create uncertainty and mask historic trends (Sansom et al., 1998). The Namibian Transport Policy (2017) recommends that road expenses should be fully recovered from the users, and it desires that each vehicle class should pay their costs accordingly (MWT, 2017). The present method is therefore based on a twin approach: one, on the evaluation of road expenditure; and, two, on the allocation of road expenditure to vehicle classes according to each class' responsibilities for road expenses. Road expenses are discussed in Section 5.5 of Chapter 5.

2.3.3.1 Road User Charges in practice

The current RUC applied to motor vehicles using the Namibian road network are based on distance travelled, which could be based on the mass, length, width, or height of the vehicle or its loading and axle numbers, or a combination of these factors (Republic of Namibia, 1999c). The charges are associated with an entry fee for vehicles not registered in Namibia and using the Namibian road network in the name of CBC, AVLRF for Namibian-registered vehicles, and heavy vehicle-based charges and fuel levies. These charges are set based on cost recovery for the national road network managed by the RA and other roads managed by the respective local authorities. The revenue generated from the RUC accrues to the RF managed by the RFA (see Chapter 5). This arrangement was enforced by the RFA Act of 1999 to ensure that revenue generated from the RUC is allocated back towards road-related expenditure (Republic of Namibia, 1999c). This arrangement foresees the established of the RF with the expectation for the RUCS to bring about desired results in terms of funding the road network from the revenue generated from the RUC.

2.3.3.2 Fuel levy

In Namibia, petrol and diesel are subject to a range of taxes and levies. In addition to value-added tax (VAT) is the customs and excise duty paid to the Southern African Custom Union (SACU). Other charges include the RFA and MVA Fund and the storage levy paid to the National Energy Fund (NEF). Existing evidence indicates that the pump price for petrol stands at N$12.95 (MME, 2019). From the pump price, N$1.36 per litre accrues to the RFA, N$0.503 per litre is channelled toward the MVA Fund, N$0.98 per litre accrues to the NEF, N$0.65 per litre is channelled to the MoF, and N$0.04 per litre is paid to the SACU.

Table 2.1: **Petrol and diesel taxation in cents per litre**

Valid as of	Unleaded petrol (95)		Diesel (500) (50)	
	Fuel tax	RUC	Fuel tax	RUC
1.2.18	40	122	40	122
1.3.18	40	122	40	122
1.4.18	40	122	40	122
1.5.18	40	122	40	122
1.6.18	40	130	40	130
1.7.18	40	130	40	130
1.8.18	65	130	65	130
1.9.18	65	130	65	130
1.10.18	65	130	65	130
1.11.18	65	130	65	130
1.12.18	65	130	65	130
1.1.19	65	130	65	130
1.4.19	65	136	65	136

Source: Author (Data from MME, 2019)

Table 2.1 shows the RFA fuel levy per litre for selected months. The values indicate that the fuel levy increased with the same percentage for both petrol and diesel in 2018 and 2019. However, raising the fuel levy to address the road transport funding gap will not ensure that users pay their fair share (Jones & Bock, 2017). A study by the World Bank (2008) found that 40% to 60% of people in developing countries live more than 8 km away from a health facility, financial services, and shopping centres. In Namibia, more than half of the population resides in rural areas (NSA, 2017), therefore raising the fuel levy is likely to place a heavy burden on low-income households (who may not be able to afford fuel-efficient and hybrid vehicles) and those who must drive longer distances in order to access other services, including hospitals and financial services. A recent study recommended distance charges as the best alternative to a fuel levy when charging users for road services (Jones & Bock, 2017). A lesson can be drawn from an Oregon experiment of per-mile fees as the best alternative to a fuel levy. The purpose of the experiment included to align transportation charges with road use, thus making drivers pay for road service consumed per mile: “For each mile driven, a driver contributes 1.5 cents, regardless of rural or urban location or whether the vehicle’s fuel efficiency is 150 mpg or 20 mpg. Each driver’s contribution on miles driven is equitable and sustainable” (Jones & Bock, 2017:3).

Currently, the fuel levy for both light and heavy vehicles could be taken as a proxy for distance travelled, given the rough approximate that the longer the distance travelled, the more costs the drivers could incur to fuel their vehicles. The problem with such a proxy is that it does not capture the location as the efficiency pricing does. However, the fuel levy as the main revenue contributor in many nations might see short-term success as hybrid and electric vehicles increase their market share, as these traditional charging instruments are projected to have a relative share of actual road use (Teodorovic, 2016). Smith (1975) alluded that qualified prices of diesel or petrol per litre of vehicle travelling on the network should reflect the relative costs of the trip. Smith (1975) further recommended that for the fuel levy to cover the variable maintenance costs of road use per trip, the fuel levy on diesel per litre should be higher than that of the petrol.

In the Namibian case, this could, however, be justified by the factor that most diesel-powered vehicles are commercial by nature and a huge portion represents heavy goods vehicles (HGVs) that also pay MDC and their vehicle licences fees are set to a certain degree to account for their weight (GRN, 2019). The ongoing debate points out that a fuel levy is best suitable for other objectives than that of setting road-use prices equal to the efficient price of SRMC. As fuel levy-generated revenue falls, new directions are pointed towards alternative funding instruments such as motor vehicle sale taxes and bonds, which are independent of network use and could lead transportation pricing and financing gears away from the desired marginal cost pricing (Teodrovic, 2016). Litman (2011) made an argument that such actions could lead to inefficient markets, where demand is independent of true transportation costs.

According to recent studies, revenue generated from a fuel levy is likely to shrink with the progression of fuel-efficient and electric vehicles (Organisation for Economic Co-operation and Development [OECD], 2019). There is therefore a need to anticipate the potential decline in fuel levy revenue and gauge alternative measures. There are currently no environmental taxes on fuel in Namibia. However, an environmental duty of carbon dioxide (CO_2) emissions applies to motor vehicles when manufactured in or imported in Namibia[1] (GRN, 2016).

2.3.3.3 Annual vehicle licence and registration fees

Every registered vehicle in Namibia, according to specified vehicle classes, pays annual motor vehicle licence and registration fees. The annual motor vehicle licence fee is related to the vehicle weight (see Table 2.2). Registration and licence fees are decided by the roads agencies in consultation with the MoF, which grants increases to the rate to be imposed. The revenue accrues to the RA and is then paid over to the RF (Republic of Namibia, 1999c).

[1] The environmental duty does not apply to vehicles imported by a tourist, visitor, and those in diplomatic missions (GRN, 2016). CO_2 emission is calculated using the emission stated in the CO_2 certificated obtained from the manufacturer of the motor vehicle.

Table 2.2: Annual motor vehicle licence fees

Vehicle class	Annual licence fee (N$)
Motor car	
0 <kilograms>750	463
12 001<kg>12 500	48 913.00
19 501<kg>20 000	92 756.00
20 000 kg< (increase by N$2 928.00 for every 500 kg)	
Trailers and semi-trailers	
0<kg>1 000	275
10 001<kg>11 000	30 113.00
19 001<kg>19 500	69 989.00

Source: Author (Data from GRN, 2019)

Table 2.2 presents a case where the vehicle licence and registration fees could be taken as a rough proxy for vehicle mass (loading), thus the licence varies with the weight. For instance, lighter vehicles (with tare kilograms less than 12 001 and greater than 12 500) pay N$48 913.00, which is less than a truck with tare kilograms less than 19 501 and greater than 20 000, which pays N$92 756.00 for its annual licence fee. The argument made with the fuel levy, however, applies in the sense that these proxies do not capture costs that are associated with the space and time that the vehicle utilises the network.

2.3.3.4 Mass Distance Charges

The paramount motivation for charging travelling distance is to capture and allocate the maintenance costs associated with heavy vehicle use of the road network (Rothengatter & Doll, 2002). In Namibia, heavy vehicles using the road network are subject to travelling distance charges. The travelling distance charges apply to every vehicle with a weight of more than 3 500 kg. In this study, the vehicles are categorised into four classes. Level 1 includes heavy vehicles with a weight of more than 3 500 kg and less than or equal to 7 000 kg and pays a charge of N$7 per 100 km. Level 2 consists of heavy vehicles with a weight value of more than 7 000 kg and less than or equal to 16 000 kg, which are charged N$8.40 per 100 km. Heavy vehicles of more than 16 000 kg and less than or equal to 34 000 kg under level 3 pay N$15.30 per 100 km. Trucks over 34 000 kg and less than or equal to 44 000 kg under level 4 pay N$30.80 per 100 km (see Table 2.3). Final heavy goods under level 5 weight of more than 44 000 kg pay more N$46.10 per 100 km (GRN, 2019). The current system is based on odometer readings as a main factor to determine the distance driven. However, such a system cannot serve as an efficient pricing system as its rates do not vary with location, nor do they reflect congestion imposed by a heavy vehicles utilising the road network. This implies that drivers are not receiving the right price signals that reflect the marginal damage heavy vehicles impose on the road surface (McInerney et al., 2010).

Table 2.3: Travelling distance charges for fiscal year 2019/2020

Travelling distance charges		
Vehicle Type	**Description**	**Charges (N$) per 100 km**
Heavy goods truck	V/D[2] value <3 500 kg and ≤7 000 kg	7.00
Heavy passenger bus Heavy goods truck	V/D value <7 000 kg and ≤16 000 kg	8.40
Heavy goods bus Heavy goods truck	V/D value >16 000 kg V/D value >16 000 kg and ≤34 000 kg	15.30
Goods vehicle truck-tractor	D value >16 000 kg and ≤34 000 kg	15.30
Goods vehicle truck	D value >34 000 kg and ≤44 000 kg	30.80
Goods vehicle truck-tractor	D value >44 000 kg	46.10

Source: Author (The *Government Gazette* GRN, 2019)

The OECD (2019) suggested a Global Positioning System (GPS) as an alternative instrument to odometer readings. The GPS has the ability to track vehicle location and can accommodate differentiated rates. From Oregon's distance-based charging experiment, GPS-based rates raised privacy concerns. However, privacy issues from both the Oregon experience and German trucking were addressed by destroying the drivers' information as soon as payment was made (Kirk & Levinson, 2016). The existing MDC attempts to ensure that heavy vehicles pay for the damage they inflict on the road network surface. However, it is a blunt instrument that does not adjust for the weight of the truck or the type of road the heavy vehicle drives on. Therefore, a travelling distance charge that is adjusted to time, location, and distance would have a huge advantage over the current system.

2.3.3.5 Abnormal Load Charges

Abnormal motor vehicles driving on the Namibian road network are subject to a permit fee that includes congestion cost of N$0.24 per km, E80 costs of N$0.65 per km, and a police escort fee of N$18.77 (see Table 2.4). Alternatively, a fixed permit can be purchased monthly, once every three, six, or 12 months.

Table 2.4: Abnormal Load Charges for the fiscal year 2019/2020

Abnormal load charges	
Cost description	**(N$/km)**
Congestion cost	0.24
E80 cost	0.65
Police escort fee	18.77
Fixed permits (minimum N$)	
1 month	477.64
3 months	557.62
6 months	1035.26
12 months	1455.14
Police escort fee	674.25

Source: Author (Data from GRN, 2019)

[2] D value implies the vehicle is not equipped to draw, and V value implies that the vehicle is equipped to draw.

2.3.3.6 Cross-Border Charges

Every foreign registered vehicle entering Namibia pays a fee according to specified vehicle categories, including MDC for all vehicles with a mass exceeding 3 500 kg. As it applies to domestic vehicles, MDC on foreign vehicles are aimed at recovering variable costs not recovered using fuel levies. Upon entering Namibia, the driver of the foreign registered vehicle is required to visit the RFA office at the respective border of entry and acquire the necessary permit to use the Namibian road network (see Appendix A for the fees applicable to different vehicle classes).

2.3.4 The national road network

The Namibian road network can be categorised into three main groups, namely the national road network, the urban roads, and the minor roads. The national road network comprises corridor (truck) roads (connecting Namibia with neighbouring countries), main roads (linking important centres in Namibia), district roads (carrying reasonable traffic), and farm roads (connecting important farming areas and other land uses).

2.3.4.1 Road type distribution

The Namibian road network consists of 48 399 km of roads, of which 7 165 km are paved roads and approximately 39 212 km are unpaved (RA, 2016). The national road network comprises 7 568 km bitumen roads, 25 675 km gravel roads, earth roads of 13 022 km, 304 km salt roads, and approximately 1 829 proclaimed roads (see Figure 2.6 and Table 2.5). The road network in Namibia is built to standards, in comparison to the best practice, and is in adequate good condition (RA, 2016).

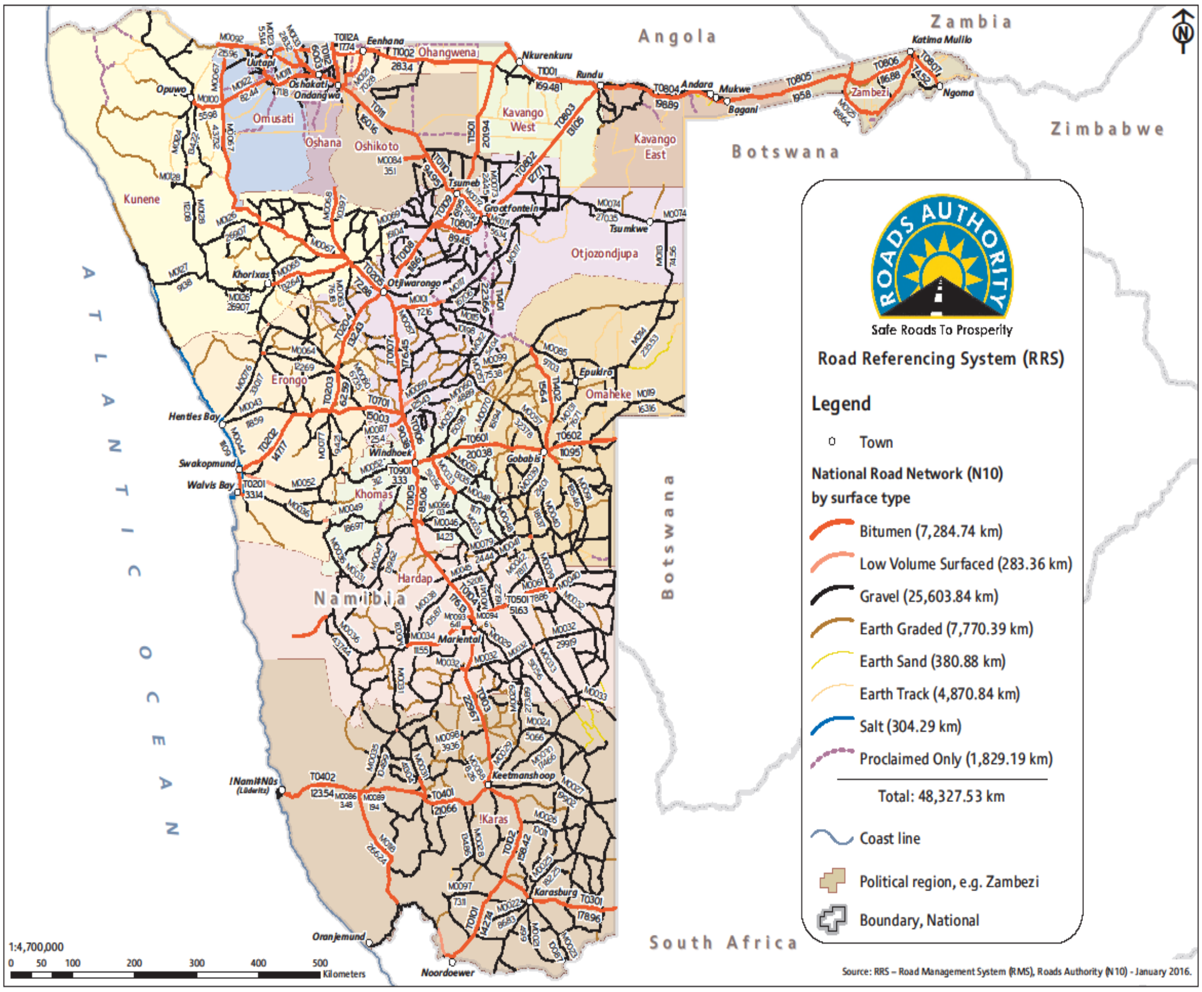


Figure 2.6: The Namibian road network per road category and surface type

Source: RFA (2016)

Since independence in 1990, the country has made substantial progress towards national road network development. The road network grew from 41 815 km (RA, 2015) at independence to 48 399 km in 2016 (RA, 2016), which is an increase of 15.7%. In contrast, the bitumen road network grew from 4 572 km at independence to 7 568 km by 2016 (RA, 2016). Table 2.5 presents the national road network statistics, which comprise approximately 15.6% of paved road (bitumen), 81% of unpaved roads (gravel, earth, and salt), and approximately 3.4% of proclaimed roads. While the RA manages the national road network, individual municipalities or town councils manage the urban roads, approximated at 6 387 km (RA, 2012).

Table 2.5: Namibia road network by road type

Road type (by surface)	2012 Distance (km)	2014 Distance (km)	2016 Distance (km)
Bitumen	6 664	7 165	7 568
Gravel	25 709	25 921	25 675
Earth	11 460	11 541	13 022
Salt road	288	304	304
Proclaimed road	1 524	1 446	1 829
Total	45 645	46 378	48 399

Source: Author (Data from RA, 2012)

2.3.4.2 Vehicle population and traffic distribution

In 2015, the total vehicle kilometres travelled (VKT) on the national road network was estimated at 3 667 million per annum (RA, 2016). Although the biggest portion (81%) of the road network is unsealed, such roads constitute only approximately 19% of total traffic volume. The distance travelled on bituminous roads (7 568 km) constitutes 81.69% of the traffic. HGVs make up 20% of the traffic (RA, 2016). The Namibian vehicle population increased by 12 705 to 374 710 (see Figure 2.7), which represents 3.5% annual growth (RA, 2017). An increase in traffic volume can be translated into a positive sign of a growing economy.

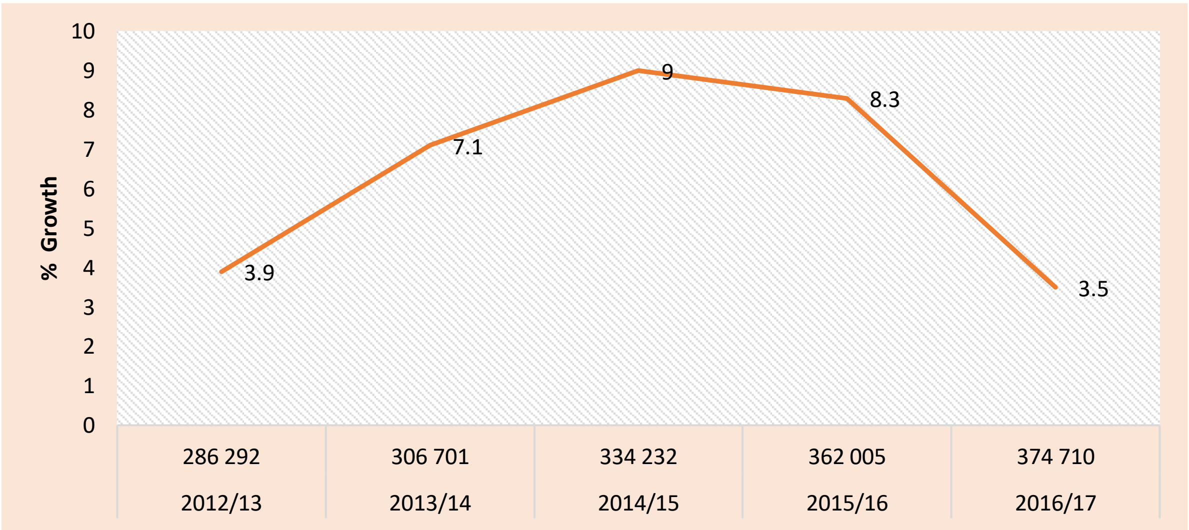


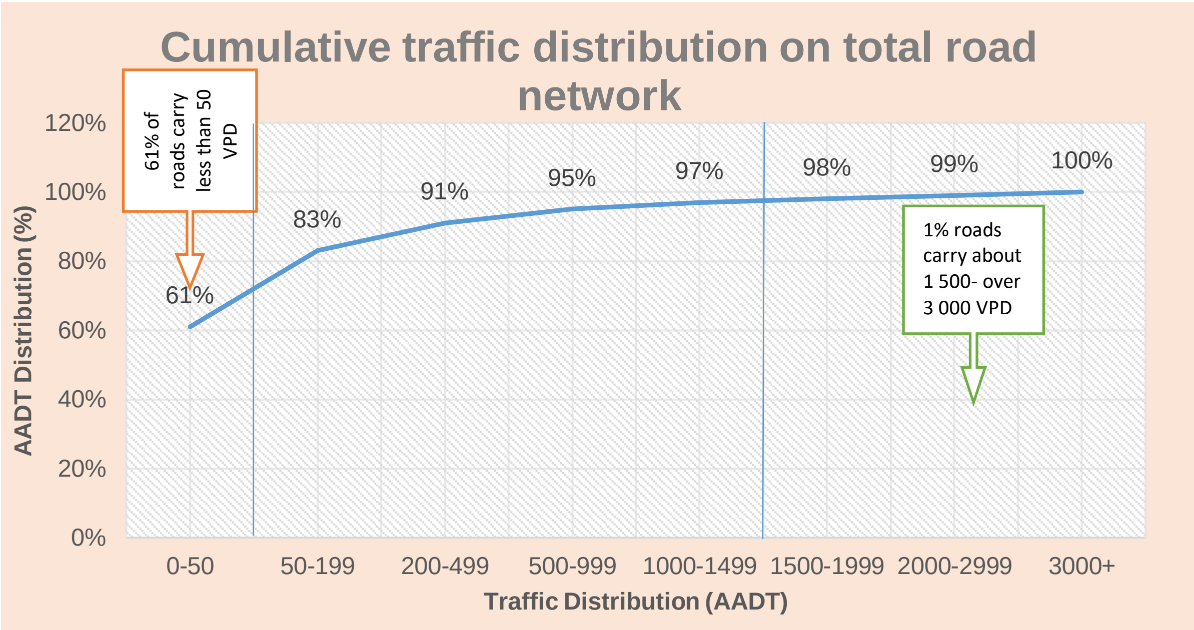
Figure 2.7: Namibian vehicle population growth in percentage

Source: Author (Data from RA, 2016)

The national road network comprises 7 892.7 km of paved roads and 26 046.5 km of unpaved road[3] (RA, 2018). Approximately 84% of the national road network is unsealed and consists of low-volume traffic of approximately 19% of travel. An interesting aspect of Namibian roads is that, apart from the bituminous trunk roads, almost 61% of the road network carries less

[3] Unpaved roads exclude 299.9 km of salt roads and 13 315.6 km of earth roads. The total road network amounts to 47 554.7 km and 48 875.27 km including the proclaimed roads of approximately 1 320.60 km.

than 50 vehicles per day (see Figure 2.8). The RA (2018) recorded that only 1% of the road network carries over 3 000 vehicles per day. This implies that Namibian roads are not congested.



AADT = Annual average daily traffic; VPD = Vehicles per day

Figure 2.8: Daily traffic on national road network

Source: RA (2017)

2.3.4.3 Motor vehicles per 1 000 people

Namibia is compared to South Africa, which is a top performer in the region with regard to motor vehicles per 1 000 inhabitants. Although these two countries differ significantly in terms of population and GDP, they fall in the same income group category (upper middle income). Out of 191 countries, South Africa is ranked 83rd, with 165 motor vehicles per 1 000 of the population. However, Namibia can also be compared to other countries in the same income group and population range. Botswana outperformed Namibia, being ranked 94th in the world with 133 motor vehicles per 1 000 people. Namibia is ranked 102nd in the world in terms of vehicles per capita. This translates into 107 motor vehicles per 1 000 inhabitants. Namibia outperformed Lesotho, which ranks 184th with four motor vehicles per 1 000 people (see Figure 2.9).

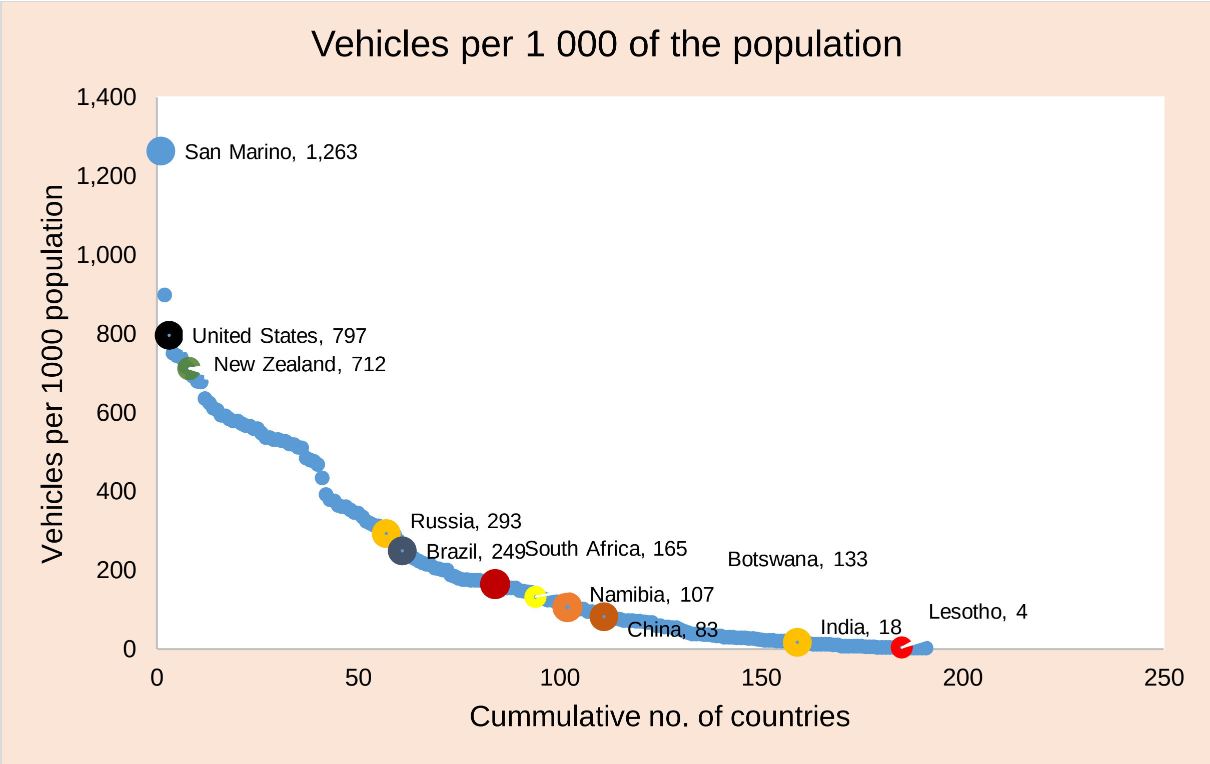


Figure 2.9: Cumulative number of countries' vehicles per 1 000 of the population

Source: Nation Master (2014)

In summary, it is therefore evident that a relatively smaller vehicle population servicing Namibia's extensive road network (see Figure 2.10) could have implications for road-user cost responsibility and ability to pay for their road use. The divergence between the road network size in terms of the supply versus the number of vehicles (demand) implies that funding requirements for routine and periodic maintenance, rehabilitation, and upgrading will be proportionally more for Namibia as compared to countries where the road network and road users are balanced. A desired position for any country will be for a bigger road network with relatively more road users, otherwise few road users will pay more charges in countries with a bigger road network.

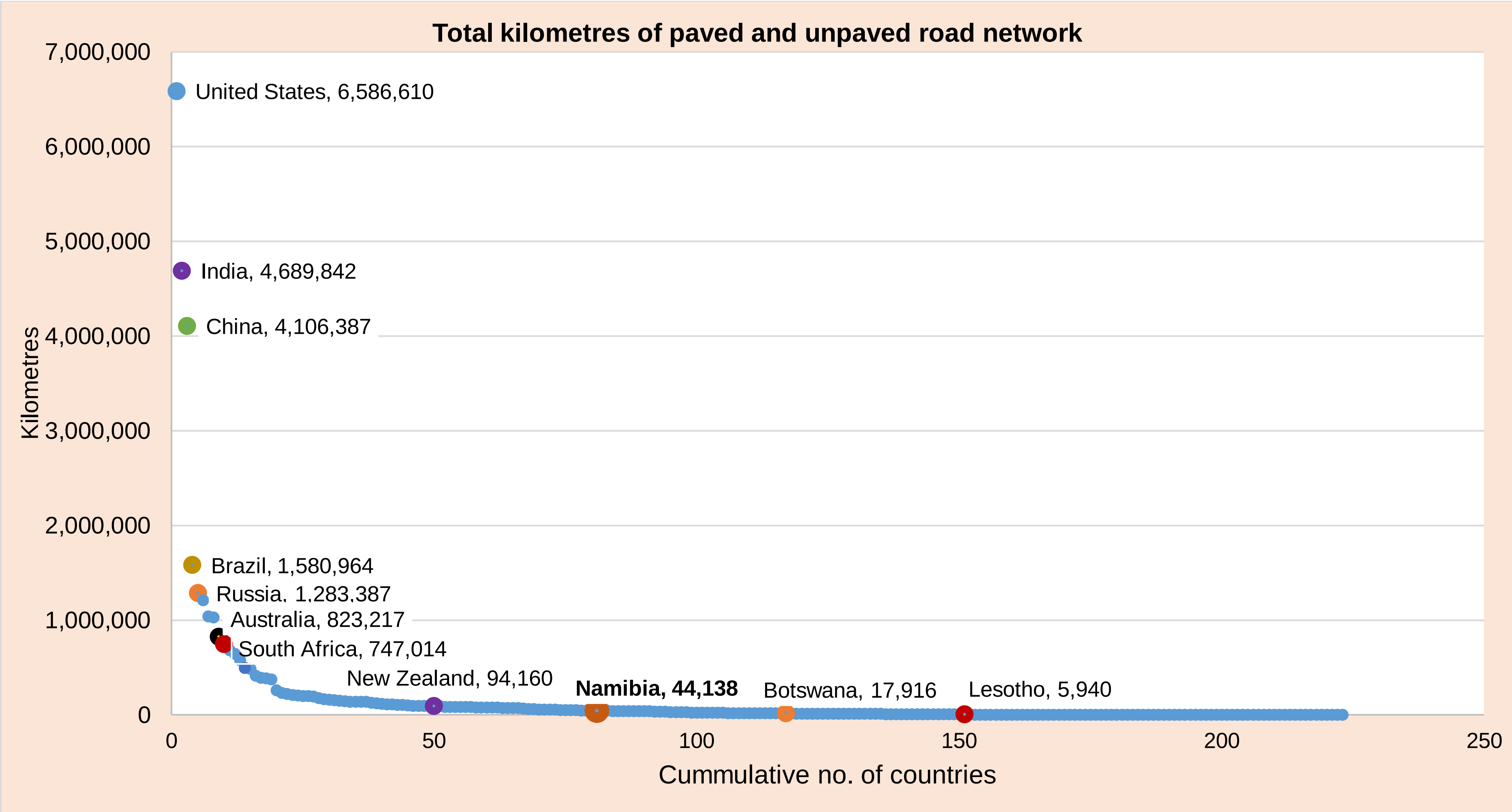


Figure 2.10: Cumulative countries' total kilometres of paved and unpaved road network

Source: NationMaster (2014)

Although Namibia is a country with few inhabitants and quite an extensive road network with a small vehicle population, the country is fairly aligned with the best international standards in terms of its road network. Namibia takes pride in the fact that it is leading in sub-Saharan Africa in terms of quality road infrastructure. The Competitiveness Report for 2017/18 (Schwab, 2017) ranked Namibia at 31st position of the quality of road infrastructure out of 137 countries assessed. Although Namibia moved from the 23rd position (out of 138) countries assessed in 2016/2017, it is still at the top of sub-Saharan African countries in terms of the road infrastructure quality index (see Table 2.6).

Table 2.6: Top 10 African countries with quality roads 2016/2017 and 2017/2018

		2016/2017 World Ranking			2017/2018 World Ranking		
#	Countries	Score out of 7	World Ranking (out of 138)	#	Countries	Score out of 7	World Ranking (out of 137)
1	**Namibia**	**5.2**	**23**	**1**	**Namibia**	**5.0**	**31**
2	South Africa	5.0	29	2	Rwanda	5.0	32
3	Rwanda	5.0	31	3	Swaziland	4.7	39
4	Cote d'Ivoire	4.7	42	4	Morocco	4.5	43
5	Mauritius	4.7	44	5	Mauritius	4.5	48
6	Morocco	4.4	55	6	South Africa	4.4	50
7	Kenya	4.2	61	7	Seychelles	4.4	53
8	Botswana	4.1	62	8	Kenya	4.3	60
9	Cape Verde	4.1	66	9	Cape Verde	3.9	77
10	Senegal	4.0	71	10	Botswana	3.8	80

Source: Author (Data from Schwab, 2018)

Roads are the dominant mode of transport in sub-Saharan Africa, carrying over 75% of both freight and passengers (Beuran, Gachassin & Raballand, 2013). Namibian road quality outperforms other indicators such as GDP per capita and GDP purchasing power parity, which ranked 128th and 134th (out of 191) respectively. The country's position and logistics performance at the international level indicates that policy interventions must be directed at physical infrastructure with the aim of equalising the basic provision of infrastructure domestically, linking the country to the greater Southern African region, thereby promoting regional trade and cooperation (Runji, 2003). Given the broader picture on the Namibian economy and the transport sector, it is important to understand the importance of transport investment and associated benefits. The next section discusses the significant role of transportation in the economy.

2.4 CONTRIBUTION OF ROAD TRANSPORT TO ECONOMIC DEVELOPMENT

This section sets out the significant role of transportation in and its impact on the overall economy. As the motivation behind this research was to conduct an empirical investigation into Namibian road sector funding, it is deemed necessary to outline the relationship between road and economic development and indicate whether transport effects bring about long-, medium-, or short-term improvements.

2.4.1 The significant role of transportation in the economy

The NDP4 (NPC, 2012) revealed the country's aim of becoming a logistics hub and a gateway to the SADC region. This vision has led to a significant investment in transport infrastructure (maritime, rails, roads, and aviation) to meet international standards (Walvis Bay Corridor Group, 2016). Transport infrastructure investment also drives the country's long-term logistics. This acts as a catalyst to productivity, growth, job creation, improving social prosperity, and, to a greater extent, intra-trade within the continent (NPC, 2017a).

In its own right, it suffices to say that the transport and logistics sector plays a significant role in the economy. According to the Namibia Labour Force Survey, the overall transportation sector employs approximately 22 175 persons, which accounts for 3.3% of the total work force in Namibia (NSA, 2017). In addition, the transport and logistics sector contributes approximately 4.7% to the country's GDP (NPC, 2017a).

The transportation sector can have a wider effect on the economy both at the investment and operational (expenditure for operating a vehicle) levels. The direct effects of transportation investment are to reduce the operating costs of transport and lead time and enhance access to destinations within the network[4]. In addition, transportation investment may also lessen economic disadvantages in the case where upgrading infrastructure may result in congestion and accident reduction in a particular road network. Transportation investment benefits are measured through cost-benefit analysis (Ustaoglu & Williams, 2019). For example, the expansion of road infrastructure from single lane to dual carriage may reduce congestion and accidents. Effects on productivity and the spatial pattern of economic development are other indirect significances of transport investments. Improved transport links business to their suppliers and provides access to regional markets. Increased access and connectivity result in trade opportunities, competition, and specialisation, which bring about longer-term productivity gains. Improved transport will stimulate efficient spatial patterns of households and businesses, which potentially spur economic development (Banister & Berechman, 2000; Quium, 2019). However, unless necessary transport investment is undertaken, development will be stunted.

[4] Improved transport links services, lower cost, and enhances market accessibility for businesses to access raw materials. This may increase trade opportunities, specialisation, and competition, which results in longer-term productivity gains.

In developing countries, public investments are likely to have a multiplier effect on GDP in the short run (Meersman & Nazemzadeh, 2017). Moreover, the multiplier effect is likely to be higher in countries with insufficient infrastructure; for example during the road construction phase, activities such as employees required for construction; surveyors to map the site, site manager, engineers, and accountants; and purchasing of all kind of equipment needed, trigger economic activities in the short run (Meersman & Nazemzadeh, 2017).

Most countries commit to increasing substantial resources in the road sub-sector. In so doing, the road network is improved, which subsequently enhances road-user safety and reduces vehicle operating cost, increases production, and lowers commodities' prices (Heggie, 1995; Orondje, Rambo & Odundo, 2014). Historically, transport provides access both for business and household sectors between spatially separated locations. For the business sector, transport connects businesses to their source of input and to their markets and provides interaction opportunities for business-to-business trading. For the household sector, this involves access to employment opportunities, medical and education facilities, recreation places, shopping centres, and a medium to their holiday destinations.

In line with the Transport Master Plan and Master Plan of an International Logistics Hub for SADC Countries, the NDP5 (NPC, 2017a) embarked on a holistic and integrated approach to transport planning that is both multimodal and intermodal for transporting people and service provision. Although there is no doubt that the transportation and logistics sector can support economic development, especially in Namibia and other developing countries, the relationship between transport and economic development should be understood. Transport facilitates a wide range of social and economic interactions. The quality of transport links intermodal and multimodal transfer facilities, which can effect relative competitiveness of an area over another area, lowers costs to markets and resources, facilitates access to larger markets, and improves quality of life.

In most developing countries, like Namibia, transport plays an important role in the economic development of the country. Moreover, further investment in a well-connected transport infrastructure network of high quality expands industrialisation and trade, which instantly leads to economic growth. Reliable transport infrastructure reduces the inventory cost of firms, which leads to just-in-time delivery, allows firms to realise economies of scale, and interregional and global specialisation. Cheaper transport ushers the industry into better accessibility to demand and supply markets, firms discovering new markets, access to skill labour, and better and cheaper raw materials (Meersman & Nazemzadeh, 2017). On the contrary, a weak infrastructure network is likely to bring about inefficiency in the transportation of production inputs, as well as potentially leading to increases in their prices. Therefore, the limitation of basic infrastructure (which links producers to the source of raw materials and their customers), inefficiencies, and competitiveness may impede economic development (Demurger, 2001). Infrastructure enables private businesses and individuals to produce goods and services more efficiently (Stupak, 2018). In the short run, infrastructure development is likely to stimulate demand and subsequently result in increased overall productivity in the long run.

2.4.2 The relationship between roads and economic development

Transport is demand driven; its demand arising either from economic or social activities (There is a need for raw materials (production inputs) to be transported to production centres, which creates demand for freight services; whereas households require transport to work places, shopping centres, medical and education facilities, as well as for social needs. Transport investment is necessary; however, on its own it is not sufficient to generate significant growth at national or regional level. Broader interaction takes place within the firm and between firms, within sectors and between sectors, as well as between households and organisations, as noted by Lakshmanan (2011). Transport investment such as constructing new road infrastructure, rehabilitating, and upgrading existing road infrastructure opens up markets and create conditions of spatial agglomerations and technical change, which may lead to improved economic wellbeing, thus generating longer-terms benefits.
Economic benefits that may arise from transport investments can best be understood from a broader perspective. Figure 2.11 presents the relationship between transport intervention, funding, social wellbeing, and economic development.

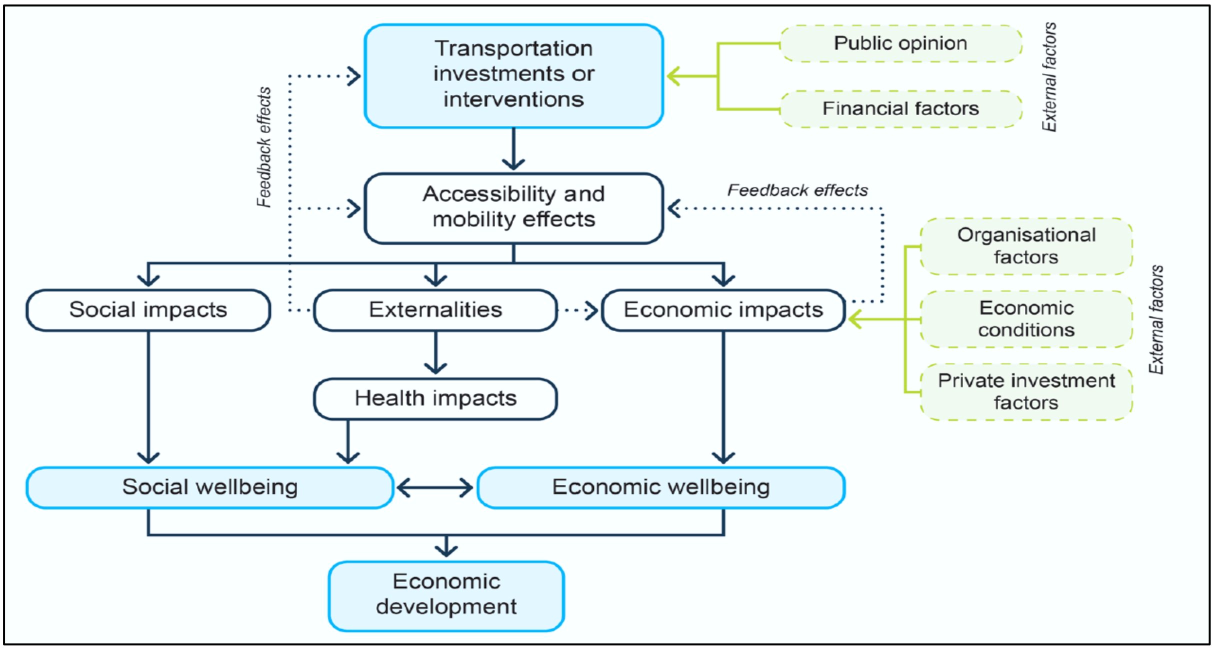


Figure 2.11: Relationship between transport investment and economic development

Source: Saunders and Dalziel (2014)

Lower transportation costs and improved accessibility promote market expansion and encourage businesses to flourish. Increased accessibility and connectivity present trade opportunities, which can lead to business competition and specialisation and result in long-term productivity gains. In the long run, sustainability in transport infrastructure and technology stimulates structural changes in national and regional economies. Table 2.7 provides a summary of the effect of transport infrastructure investment.

Table 2.7: Effect of transport infrastructure investment

Features	Short-term effects	Medium to long term	Long term
Effects	• Reduction in congestion. • Lower VOC. • Enhanced accessibility. • Just-in-time delivery. • Increased demand and output. • Reduction in inventory costs. • National and regional growth. • Employment creation (construction sector).	• Expansive market for products, labour, and services. • Enhanced export opportunities. • Free entry and exit of firms. • National and regional integration. • Industrial cluster formation. • Commercial cluster formation.	• Promotion of globalisation processes. • Sustainable regional competitive advantages. • Global market (distribution and production).
Underlying processes and contextual factors	• Increased competition. • Supply and demand forces.	• Economies of scale. • Agglomeration. • Cumulative interconnection. • Increased competition. • Endogenous growth. • Monopolies may emerge.	• New economic geography emerges. • Confluence of technical and organisational or institutional and production sector.
Description and measurement of effects	• Cost-benefit analysis.	• Growth models. • New economic geography theory. • General computable equilibrium models. • Gain from trade.	• Economic history analysis.

Source: Meersman and Nazemzadeh (2017)

2.5 SUMMARY

This chapter sought to narrate an overview of the transport and logistics sector in Namibia with particular focus on the road sub-sector. Although the country has taken a giant step towards infrastructure development in an effort towards attaining its vision of becoming a logistics hub and a gateway of Southern African countries and to the international market, there is still potential to enrich the sector. The road sector is the main mode for importing goods into the country. Policy and strategies, aimed at ensuring that the scarce resource (road) is maintained, are in place. The policy advocates that the road users, as the consumers of the scarce resource, should be made to pay for their consumption at the or closer to the point of use.

To that effect, the road reform resulted in establishment of the three public enterprises with mandates that ensure that RUC are in place, that funds are deposited to a designated road funds, and that they are effectively allocated to the relevant authorities. Although there is an RF in place, the budget allocated towards maintenance and rehabilitation of the national road network is still not sufficient for the roads authorities to execute their planning and meeting the demand for the national road network. Generating sufficient revenue will not only ensure well-maintained roads, but it will also reduce total transportation cost and facilitate trade flows.

Transport is demand driven and on its own does not yield economic development. Transport infrastructure is a catalyst that complements other sectors and together contribute to economic development. Given its small domestic economy, Namibia must take advantage of its international corridors that link its ports to the SADC region and the rest of the world. Diversifying the country's economy into more productive activities will not only position Namibia in becoming a logistics hub for the SADC region, but it will also eventually stimulate the economic growth needed to achieve the country's Vision 2030, as emphasised by Diop, Kagia, Panzer and Schuler (2012).

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CHAPTER 3:
ROAD PRICING AND TRANSPORT INFRASTRUCTURE FUNDING: A LITERATURE REVIEW

3.1 INTRODUCTION

This chapter briefly explains the available literature on the subject of road pricing and funding, as well as policy instruments applied worldwide. The emphasis is on theoretical concepts, frameworks, and approaches to road pricing. While there is an assortment of literature on road pricing (Hau, 1992; Hau, 1995; Gomez-Ibanez & Small, 1994; Johansson & Mattsson, 2012; De Percy, 2018) and road funding (Infrastructure Partnerships Australia, 2014; Dumortier, Zhang & Marron, 2017; Winder, 2018), this literature review focuses on prominent issues for the road sector on selected continents, including transport policies, economic principles for road pricing, and internalisation of external costs. A critical review of available studies on the road sector seeks to ensure a systematic analysis of relevant thematics for this research. Therefore, the chapter provides a conceptual framework that aims to guide the objectives of this study. Moreover, Chapters 5, 6, and 7 attempt a detailed discussion and broader literature review aimed to address the specific objective set for each chapter.

3.2 INTERNATIONAL RESEARCH ON ROAD PRICING

Road pricing implies direct charging of a price for the use of a road network (Australasian Railway Association, 2010) and it is often introduced as a method to internalise the externalities generated by road use (Johansson & Mattsson, 2012; Fridstorm, 2019). Road infrastructure investment is an expensive undertaking, in particular with the rising concern of the “user-pays” principle, which is justifiable on the notion that it is fair to hold accountable users of scarce resources (roads) for the full cost of road provision and use (Brid, 2001). The theoretical economic principle recommends road pricing to be set at the SRMC (Hau, 1992). It is worth noting that the concept of MSC has received substantial attention in the international research sphere. Innumerable transport policy documents have been produced with strategies for implementation and exploring various ways of charging users for road use. However, every geographic region (for example Asia and the Pacific, Europe, the United States of America [USA], and Africa) seems to follow a different approach with respect to the concept of road pricing and charging for road use. For instance, the European Commission (1998), in the policy paper titled “Fair payment for infrastructure use”, focused on a progressive harmonisation of charging principles in all major commercial modes of transport across the European Union (EU) community. In the USA, the report of the National Surface Transportation Infrastructure Financing Commission (NSTIFC, 2009), titled “Paying our way:

A new framework for transportation finance", focused on the development and use of options and evaluation tools. In Asia and the Pacific, the Asian Development Bank (2012) aims to coordinate the systematic overhaul of the road-funding regime. To that effect, it proposed the establishment of institutional reform into an institution that manages road funding. In Africa, the focus is on the establishment of road funds and administration operating under the so-called "second-generation road funds" (Heggie & Vickers, 1998; Heggie, 1995). The next section of this study unpacks main research areas from each geographic region.

3.2.1 Road pricing studies in Europe

The European Commission and countries on the continent have funded research aimed at relating road charges closely to the MSC principle associated with the use of road infrastructure. This implies charging road users for the use of infrastructure that not only reflects the costs of providing and maintaining the facilities but also reflects the externalities costs, including congestion, environment, and accident costs (European Commission, 1995). The EU places greater weight on economic instruments as a way of tackling the negative externalities that arise from road use (Nash & Matthews, 2005). The key focus of most European studies has been charging the price at SRMC. The MSC aims to internalise all the external costs, such that environmental costs, congestion costs, and other negative external costs that form part of the charges that road users pay for their consumption when using or closer to the point of using the road infrastructure. Other EU research studies' focus has been on developing methodology on measuring the MSC of transport (see Table 3.1) and using the developed methods and tools to estimate the MSC when setting tariffs. Table 3.1 indicates sample research conducted in the subject area of measuring external costs in Europe.

Table 3.1: Review of studies on estimation of transportation external costs

Year	Study	Source
2004	External cost of transport Developing harmonised European approaches for transport costing and project assessment (HEATCO)	INFRAS and IWW (2004) Institut Fur Energiewirtschaft and Rationelle Energieanwendung (2004)
2008	Handbook on estimation of external costs in the transport sector Internalisation measures and policies for all external costs of transport in Europe	INFRAS, CE Delft, Fraunhofer Gesellschaft ISI and University Gdansk (2008)
2011	External costs of transport in Europe	CE Delft, INFRAS and Fraunhofer ISI (2011)
2012	The true costs of automobility: External costs of cars. Overview of existing estimates in EU-27	Technical University of Dresden (2012)
2013	Internalisation of external costs of transport- A target driven approach with focus on climate change	Musso and Rothengatter (2013)
2014	Methods for estimation of external costs of transport	Jokanovi and Kamel (2014)
2014	Update of the handbook on external costs of transport	DIW Econ, CAU and Ricardo-AEA (2014)
2019	Handbook on external cost of transport, Version 2019 (No.18.4K83.131)	Ce Delft, INFRAS, TRT and Ricardo (2019)

Source: Gavanas, Tsakalidis and Pistsiava-Latinopoulou (2017)

MSC pricing has been associated with various limitations. Critique of the approach (Rothengatter, 2003; Nash, 2003) asserts that the SRMC principle is limited to the verification of certain underlying assumptions. Quinet (2005) suggests that in overcoming the SRMC shortcoming, deviations must be considered to explore average cost, development cost, and Long-Run Marginal Cost (LRMC). However, the road-pricing concept has been in place across Europe, with Norway as a leading example of having established several urban pricing schemes since 1986. Some countries seem to favour marginal cost pricing by applying both SRMC and LRMC. For instance, SRMC can be related to the heavy vehicle fee introduced by Switzerland in 2001 (Nash & Matthews, 2005), whereas London implemented the urban road pricing scheme in 2003 based on SRMC.

3.2.2 Road funding research in the United States of America

In the USA, most roads were financed by the states and later by the federal government through gas tax (Levison, 2002). It was further recognised that the inter-state defence network (later renamed the inter-state highway network), as noted by Heggie (1999), could not continuously be funded by the federal budget. This thus resulted in the establishment of the Highway Trust Fund (HTF) in 1956. The snowballing of fuel-efficient vehicles is well acknowledged in the American market and as a result has contributed to the waning of the fuel levy's purchasing power. According to the Federal Highway Administration (FHWA, 2017), the federal gas tax was charged at 18.4 US cents (about N$2.55 per litre[5]) since 1993 (NSTIFC, 2009:2). It is recorded that the HTF-generated revenue has been inadequate to support the federal spending levels (NSTIFC, 2009). The funding gap was recorded at nearly US$400 billion during the period 2010 to 2015 and is projected to grow further to approximately US$2.3 trillion through to 2035 (see Figure 3.1).

[5] At the exchange rate of N$1 = U$13.86.

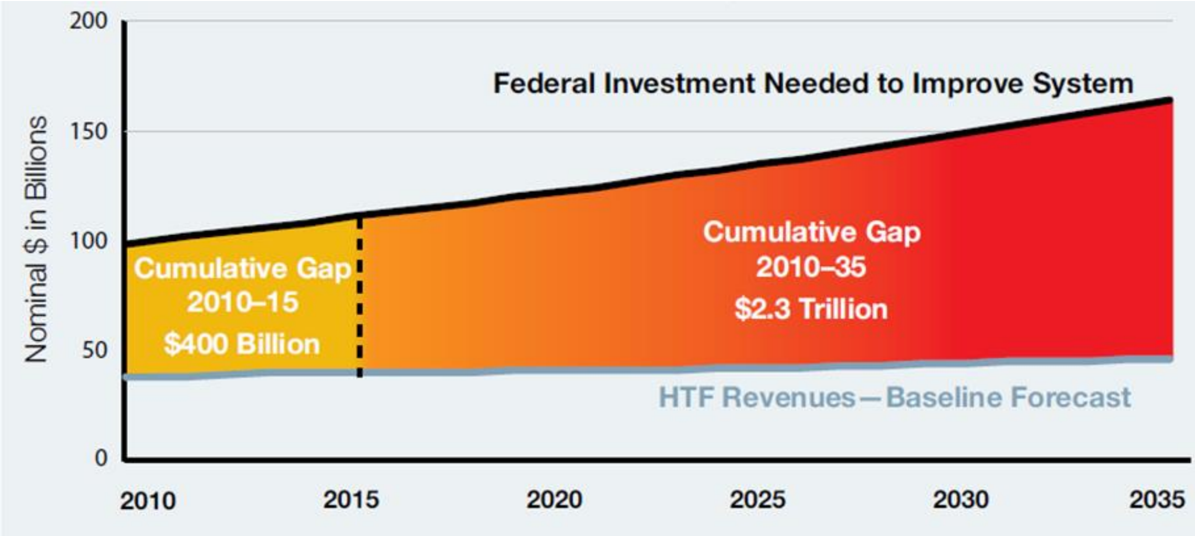


Figure 3.1: The widening gap between federal revenues and investment needs: 2010-2035

Source: NSTIFC (2009)

The NSTIFC (2009) final report argued that the challenge is not heavily based on insufficient investment, but that the gap results from the underpriced system. Basic economic principles narrate this case better, in that, when a good or service is provided for an amount less than its true costs, the demand for such a product tends to be higher, resulting in a shortage, which instantly manifests as congestion in the case of a road system. Road users often pay less for their consumption of the road system than the cost of providing the transportation facility.

Underpayment contributes to less efficient use of the road system, and results in increased externalities associated with the use of roads infrastructure (NSTIFC, 2009). According to the NSTIFC (2009:4),

> "[i]f the federal government fails to act now, the future administration and next American generation will reap heavy repercussion. Additionally, America will face increased deteriorating roadways, bridges, and transit systems. Likely to result in increased accidents and facilities as well as increase in environmental and congestion (longer journey time, robbing businesses of vital economic activity and productivity) costs".

Various researchers have explored the road instrument charges per vehicle characteristics and kilometres travelled using the latest satellite technologies (Greaves & Figliozzi, 2008; Zupan, Barone & Whitmore, 2012). With respect to road pricing, the United States (US) Department of Transportation has sponsored various road-pricing experiments, including San Francisco's Golden Gate Bridge, Interstate 95 near Miami, SR520 near Seattle, and Interstate 35W near Minneapolis (DeCorla-Souza, 2004; Gibson & Carnovale, 2015).

3.2.3 Road funding studies in the Asia-Pacific region

In Asia, the Asian Development Bank advocates for restructuring the road fund and administrative arrangements for scoping for a fuel tax reform. According to Gwilliam (2003), countries that lack well-coordinated road revenues have led to uncertainty in revenue allocation for road investment. The Asian Development Bank (2012) therefore deemed it necessary to establish road trust funds for improved administration and to navigate new funding mechanisms.

Japan seems to have set a trend in Asia by establishing a road fund (the Road Improvement Special Account) early in the 1950s. Such a development was of necessity after the end of the war, thereby developing a road network capable of supporting Japan's rapid economic growth (Heggie, 1999). With respect to road pricing, Singapore seems to be the founder of road pricing with notable developments since 1975.

New Zealand pursued the agenda of a technology-based RUC towards minimising evasion of the system within the road transport industry. Approximately 30 000 vehicles in New Zealand in 2008 were fitted with a Global Navigation Satellite System (GNSS) fleet tracking system (McBride & Parker, 2008), and they have projected a monthly increase of approximately 500 vehicles. Experience suggests that a technology-based RUC has the potential to reduce evasion by as much as US$80 million per annum, or some 2% below evasion (McBride & Parker, 2008). These facts seem to have placed New Zealand on the global map as the leading country in the Asia-Pacific region with direct application of the RUC.

Australia, with its intelligent access programme, uses GNSS for fleet tracking and monitoring. It is a voluntary programme that permits qualifying operators to have higher mass and dimension limits in exchange for safety requirements to ensure compliance (McBride & Parker, 2008). The automated systems generate non-compliance reports for the enforcement agency whenever the operator is outside the set parameters.

On road pricing and its reforming agendas, the Australian government advocates adopting a user-pays system towards full market reform of road pricing. The Australian Department of Infrastructure, Transport, Cities and Regional Development upholds the National Heavy Vehicle Charging Pilot (Australian Department of Infrastructure, 2019). The pilot is likely to be a success with advocacy for reform reinforced by diverse stakeholders, including private transport companies, peak industry bodies, and policymakers (Mrdak, 2019; O'Keeffe, 2019). According to the Australian Department of Infrastructure (2019), the pilot envisages "to design and test options for replacing heavy vehicle registration fees and fuel-based charges with a more direct charging system". The pilot sought to provide insight to the industry and businesses on how the envisaged new charging system ought to work, and participation was on a voluntary basis. The collaboration of the Australian and New Zealand School of Government promotes road pricing reform by connecting the government with academia, which is a notable effort in delivering the required research to identify the possible solution that could usher the Pacific into future economic prosperity (Mrdak, 2019).

3.2.4 Road funding research in sub-Saharan African countries

In sub-Saharan Africa, the Africa Transport Policy Program (SSATP) was launched in 1987 in order to promote the concept of road commercialisation. This led to the creation of second-generation road funds and roads agencies in many countries (Runji, 2015). Road research in many African countries focuses on establishing a noteworthy road fund and administration, to be in a position to identify potential sustainable sources of revenue generation. African countries are faced with multiple socioeconomic challenges; from small vehicle populations with expansive road networks (Petrus & Krygsman, 2018) to road users with fewer abilities to pay the prominent user charges. This is a situation that has resulted in road funds generating revenues that are not sufficient for the road maintenance required. The World Bank has conducted several studies advocating for the implementation of “second-generation funds”, of which fuel levies are the main source of income in many countries (for instance, Namibia, South Africa, and Tanzania) (see Chapter 5 for a thorough discussion of second-generation road funds).

Most governments in Africa are responsible for setting the general state tax revenues and nominating road board members, which determines the road-user instruments to be charged and how generated revenues should be managed (Heggie, 1995). Moreover, independent agencies are in place and are mandated to maintain the road network. The second-generation road funds are recommended to manage and allocate resources in the most efficient manner in order to bring about a balance between the quality of roads and what road users should pay for consuming the roads. On transport externalities-related issues, a report conducted by Schwela and Hag (2012) of the Transport and Environment Science Technology network deliberated on transportation-related issues, including air pollution, road safety, traffic flow management, equity, and climate change. It further drew best practice and made several recommendations.

3.3 NAMIBIAN ROAD FUNDING AND POLICY

At the regional level, in an effort to contribute toward harmony, balance, equity, and sustainable development, the SADC Protocol on Transport, Communication and Meteorology

(2006) in Articles 4.5 and 4.6 proposed some guidelines on funding for road infrastructure. Namibia is well known for its established and noteworthy RFA, that to a certain extent seems to have set a model for other developing countries to follow. Although the public enterprises were established, the MWT remained the custodian of policy and regulations. According to the Public Enterprises Governance Act (Act 1 of 2019), the Ministry of Public Enterprise acts as the overseer of the public enterprises, but is not directly involved in the day-to-day business (see Chapter 2, Figure 2.5). Table 3.2 presents some studies conducted in Namibia within the area of transportation externalities.

Table 3.2: Studies on transportation external costs of road use in Namibia

Components	Study area	Source
Accident	Accidents Cost of accidents to the Namibian economy	National Road Safety Council (NRSC) (Ernst & Young, 2016)
Environment	Namibia National Inventory Report	GRN (2016)
RUC	Accompanying measure for the sector-wide approach to the road sector for the Republic of Namibia.	MWT (Aurecon) (2013)

Source: Author

3.4 GUIDING PRINCIPLES FOR A TRANSPORTATION INFRASTRUCTURE FUNDING AND FINANCING FRAMEWORK

The NSTIFC's (2009) report discusses the following six key guiding principles when designing a funding and financing framework:

- The funding and financing framework should support the overarching transportation goals of enhancing the mobility of all users;
- Generating sufficient revenue that would meet the network needs on a sustainable basis;
- Ensuring road users bear the full costs of using the road network to the greatest extent possible. Kelly (2016) suggested that whenever this is not the case, cross-subsidies could be applied in a transparent manner and should be applied in an equitable manner;
- Revenue generated should be reinvested in the transportation system, aiming at closing the significant funding gap;
- Equity considerations (horizontal and vertically) should form part and parcel of the framework; and
- Synchronised with a broader public policy of environmental protection and demand management.

These principles are crucial when determining which charging instruments to employ for a selected road network. The ideal framework should take the form of an RUCS. This implies a system to guide policymakers by ensuring that those driving on road networks contribute their fair share towards infrastructure costs (Atkinson, 2019). The principal motive driving the RUCS in many countries include gauging against the growing fuel-efficient and electrified motor vehicles that could bring about unsustainability in road funding as the fuel levy loses its prowess as the main revenue contributor (van Rensburg & Krygsman, 2015; Krygsman, 2018). Therefore, a charging system could be the answer to such a challenge by exploring technology to charge per vehicle per kilometre travelled. Atkinson (2019) posited that this could collect adequate revenues from hybrid and electric vehicles, as well as assisting the roads agencies to charge actual costs imposed on the road infrastructure.

On the contrary, issues of privacy associated with the latest technology used to charge users based on location and time of the day have been a concern surrounding the concept of RUC. Atkinson (2019) stated, however, that previous studies revealed that such concerns have been taken out of context or they do not hold water. Recommendations by various studies established that roads agencies, when introducing a new instrument, should include a transition period for road users to adjust to the new technology.

A study by Atkins, Houghton and Johnstone-Burt (2012) on the road pricing scheme in Australia discussed the three main types of technology as follows:

- GNSS such as the GPS. The roads authorities mostly use satellite location systems such as GPS to determine vehicle position and to measure location and distance travelled mainly for charging and access control (FHWA, 2008).
- Dedicated Short-Range Communications (DSRDC) systems using tags and beacons and wireless communication systems (e.g. electronic tolling technology). The system is commonly used on free-flow toll facilities. It utilises on-board units, also known as tags or transponders. These technologies communicate with gantry-mounted equipment at checkpoints, and roadside equipment identifies and verifies the vehicles' on-board unit by either processing charges from its linked account or affording rights of access, mainly depending on the system in place (FHWA, 2008).
- Closed-circuit television (CCTV) and Automatic License Plate Recognition (ALPR) as applied by the London Congestion Scheme. The scheme entirely relies on ALPR as an enforcement system (FHWA, 2008). Other cities, including Toronto's 407 toll facilities and Tampa's Selmon Expressway use ALPR to record toll transactions, and drivers may use their licence plates as identification for paying the toll fee (FHWA, 2008).

According to the report and practical experience, DSRDC technology is recommended for cordon or specific roads (geographical constrained schemes with high volumes of traffic), whereas GPS-based systems best suit distance-based schemes. CCTV and ALPR technology are considered inferior to GNSS and DSRDC technology (Atkins et al., 2012). There is no one-size-fits-all technology, however; they differ depending on the network. Each scheme is therefore associated with its own limitations and a combination of technology might apply for a single scheme. The funding framework should encourage efficient investment in the transportation system (NSTIFC, 2009), taking cognisance of the inherent differences between and within transportation modes. The NSTIFC (2009) report also proposed a shift from road funding based on indirect user fees in the form of federal motor taxes, towards more direct user charges in the form of a vehicle-miles-travelled charging system.

3.5 TRANSPORTATION INFRASTRUCTURE COST AND THE CONCEPT OF MARGINAL COST

Basic economic theory explains that marginal cost involves the expected future costs that could arise from additional utility consumed or future cost reduction (for investment yet to be undertaken) and rarely deal with fixed costs (those that do not vary with facility use) or historically sunk costs (Kahn, 1988). The NSTIFC (2009) report suggested that the funding framework in place should cause users and direct beneficiaries to bear the full cost of using the transportation system, including externalities costs, in order to promote the efficient use of the system. While the argument for the user to bear the full cost seems to be valid, there must be a distinction as to whom and in what scenario users should be held accountable for the full cost of transportation facilities. The assumption on infrastructure costs follows an argument by Gomez-Ibanez (1999) that, in the short run, marginal cost pricing is prescribed to optimise the efficient use of the existing infrastructure. Moreover, SRMC pricing compromises the efficient allocation of resources in the long run in a situation where such a facility generates insufficient revenue to cover both maintenance and new infrastructure investment or a case where the government is not able or unwilling to supplement the road budget out of the consolidated budget (Gomez-Ibanez, 1999).

The principal rule for efficient pricing advocates that users of transportation must pay the marginal cost of each journey made (Petrus & Krygsman, 2019). The principle is quite complex and there is ambiguity about its requirements (Boyer, 1997). When the price is set below marginal costs, then the demand for transportation increases. In contrast, when the price is set above the marginal cost, demand for transportation will decrease, leading to wasting resources (under-consumption of transportation) as users tend to opt for the next best alternative (Kahn, 1988).

The issues that continue to receive more attention among transport economic researchers involve an attempt to clarify unresolved issues on road pricing, such as (i) whether the capital cost of road pricing should form part of RUC and (ii) whether the users should be responsible for projected investments or only for the maintenance of the current facilities (Newbery & Santos, 1999; Dutzik & Weissman, 2015; Bird & Slack, 2017).

Transportation facilities exhibit economies of scale and scope (Haritos, 1974); in other words, facilities that are too small or too large for existing traffic. The principle of marginal costs poses many challenges to roads that are used sporadically. This implies that marginal costs to the roads authorities on rarely used roads might be close to zero (Kahn, 1988). In this case, few users utilising the road facilities are expected to pay RUC that are equal to their marginal benefit of road use. There is thus no equality between marginal cost and marginal benefit in this case. The revenues raised from RUC for rarely used roads cannot cover the cost of the provision of the roads (capital cost).

Nash (2008) postulates that the application of marginal cost pricing in many countries would lead to higher charges for road users, which might have an impact on countries' competitiveness. The characteristics often exhibited by transportation facilities render marginal costs relatively low in comparison to the average cost of road use. Therefore, capital or sunk costs are too large to be covered by the marginal costing principle and thus should not form part of road pricing (Kahn, 1988). If at all applied, this implies that RUC should be so immensely high that the users opt to drop out and kill their own demand (Kahn, 1988).

In the short run, traffic levels on a given facility can increase (resulting in a shortfall) or decrease (resulting in excess capacity). Planning for the facilities' expansion or building requires a long-term plan. Gomez-Ibanez (1999) explains that capacity turns out to be "lumpy" in that it may appear to be economically beneficial to invest in a four-lane as opposed to a two-lane road. Gomez-Ibanez (1999) further argues that although it is cheaper to invest in a four-lane road, such a facility might end up underutilised in the short run. However, from the investment point of view, such an investment is worth undertaking, given that traffic is projected to grow. In addition, infrastructure managers can take advantage of low discount rates at the point of investment.

3.6 APPLICATION OF THE ECONOMIC PRINCIPLE TO ROAD PRICING

Economists argue that if the economic principle ought to be of relevance to road facilities' utilisation, then the RUC of their use ought to be set equal to the SRMC (Kahn, 1988). Marginal cost implies additional costs of allowing an additional vehicle to the existing traffic volume or the avoidable cost that the infrastructure manager could save by limiting the traffic level.

The concept deals with cases in which the supply of a service or community need should be assured beyond a minimal capacity in order to meet the demand (Bird & Slack, 2017), with the exception when demand is too low to yield a revenue that covers the cost of that facility's minimum capacity supply. For instance, a sporadically used road meets the description of the latter.

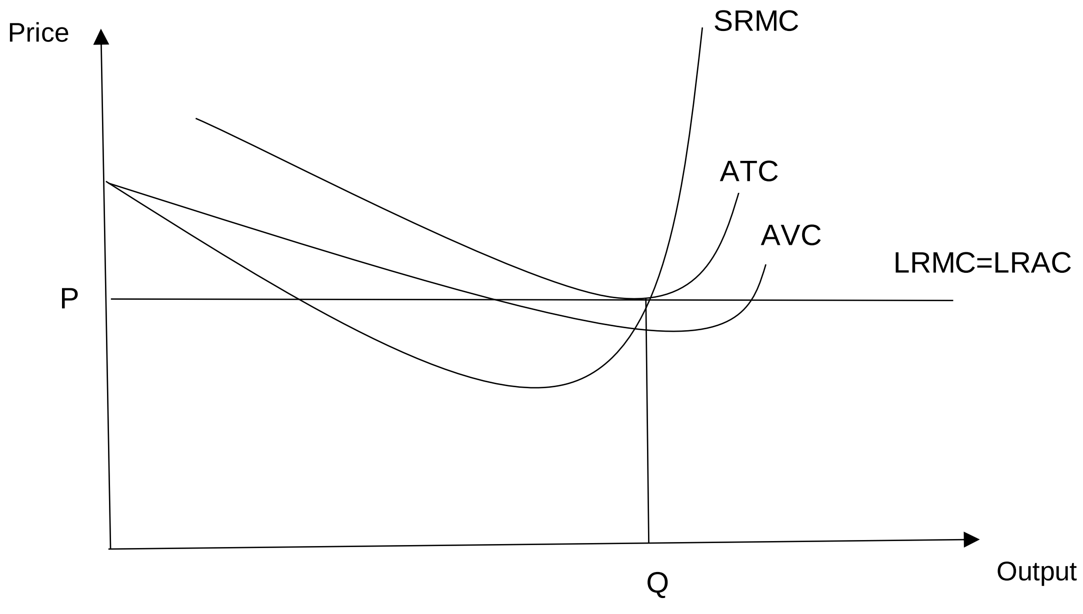
The concept of SRMC is not unique to the transportation sector. The principle is also applied to other public service utilities, including electricity, information and communications technology (Bird & Slack, 2017). The principle implies that it is worth doing business or supplying a service (good) as long as an additional revenue earned from selling such a service covers the additional cost of supplying such a service. In a purely competitive industry, the infrastructure manager would increase road charges up to the equilibrium point where marginal cost equals price. As it applies in other industries, the competition behaviour implies that road users (consumers) are free of choices and it should result in optimal resource allocation. There are several assumptions that marginal cost pricing must conform to. For instance, market distortion is likely to be minimised if prices for road and rail use are both set at SRMC (Kahn, 1988).

3.6.1 Economic resource allocation

Infrastructure managers often make decisions on economic resource allocation based on the short-run or long-run period. There are two basic criteria associated with the principle of marginal cost pricing (Kahn, 1988). The chief criterion is that the RUC of the highway should be set equal to the SRMC. The other consideration is that road users should bear the additional costs of road use imposed on the infrastructure, to other users, and to the rest of society (Kahn, 1988). It is therefore necessary to identify the components of marginal costs and indicate which of the costs should feature in marginal cost pricing.

The long run is the period within which all inputs are variable for any investment decision made (Vilton, 1980). For instance, in the long run, infrastructure managers make decisions on the number of lanes to be built or expansion required for current facilities. In the short-run period, some inputs are variable and some are fixed. Variable costs entail any sacrifice of future value or future realisation of higher costs that are causally attributed to the present value (Kahn, 1988). In the short run, capital structures are assumed to be in place and infrastructure managers should ensure that there is a pricing mechanism in order to control the use of the facility. For example, a toll facility on the road network must be decided on. The two decision periods are not made in isolation. At both levels, the optimal investment is found at the equilibrium were marginal consumer benefits equal the marginal cost of road capacity (Kahn, 1988). The difference appears at the optimal investment level between Average Variable Cost (AVC) and the SRMC imposed on the road by an additional user (Keeler & Small, 1977).

The ideal price should cover fixed costs such as depreciation, cost of capital, and other overhead expenses (Kahn, 1988). However, fixed cost does not belong in marginal cost computation. Average Fixed Costs (AFV) is found by dividing total fixed costs by output. It implies that for a given network will continuously fall as output increases. It does not consider the variable costs associated with use and does not reflect external costs. Kahn (1988) states that additional repair and rehabilitation costs only form part of marginal cost if there is a relative chance that they will be incurred and that demand is sufficient to justify such additional expenses. Kahn (1988) further argues that as long as road users are willing to pay a price covering the SRMC and the variable cost of the facilities' operation (including the current equivalent of whatever salvage value of the equipment), it suffices to say that the roads agency and society should charge road users a price set at SRMC and continue their operation. The operation of such a facility should continue until the time when the higher operating costs of a deteriorated network reach a peak point and it is no longer possible to postpone the required maintenance or replacement of such a facility, which could drive the SRMC above the RUC (price) and force a shutdown (Kahn, 1988).



LRAC = Long-Run Average Cost

Figure 3.2: The unit costs of the road infrastructure investment under long-run constant returns

Source: Kahn (1988)

Given the fact that a road network is already in place, when price (RUC) appears to be greater than SRMC, there is a need for the government to subsidise the roads agency to ensure the continuation of business. Kahn (1988) posits that at such a point an efficient price is forgone. Moreover, for expansion purposes, no business should be undertaken, unless it is projected that associated costs both in the short and long run will be covered. On the other hand, when price (RUC) is less than SRMC, the marginal cost will generate revenue only sufficient to cover the variable cost and not sufficient to cover fixed costs (Kahn, 1988).

Figure 3.2 demonstrates that short-run AVC per unit of output can never be greater than Average Total Cost (ATC). However, depending on the market demand or the facility capacity, SRMC can be lower, equal to (P=Q), or higher than ATC. In a competitive market, the equilibrium is presented in Figure 3.2 at point P where SRMC intersects with the ATC. In the long-run, LRMC is equal to LRAC. The LRMC (the total additional costs per unit of additional blocks of output, when capacity is altered so as to produce the larger output at a minimum cost), is illustrated at point P where LRMC=LRAC. Kahn (1988) explains that the transport industry operates under conditions of long-run constant cost, implying that if infrastructure managers plan to generate more or less Q, such can be achieved when charges are at the lowest P. In support, Keeler and Small (1977) state that under constant return to scale, some roads will generate sufficient revenue and some will generate insufficient revenue. At the decreasing return to scale, the facility will earn a surplus. In competitive industries, this point is represented in Figure 3.2 at point P=Q, where SRMC, LRMC, and ATC intersect. At the increasing return to scale, the road will have to be subsidised for efficient operation. The ideal position to demonstrate this point is where both SRMC=LRMC intersect and at that point ATC would not be covered by the revenue generated.

To summarise, as demonstrated in Figure 3.2, at any point (between Q and P), infrastructure managers could raise the RUC as long as there is an increase in variable costs (unit Q). Therefore, marginal cost pricing is never formulated to cover long-run or fixed costs, yet at a certain time, when demand is sufficient, it will cover the fixed cost or even generate excess funds. Economically, it makes sense to set all RUC at the SRMC and it should cover all present or future as well as associated private costs. Taking the second-best pricing into consideration, efficient price is worth emphasising and where circumstances permit, such costs should be embodied in the rates. However, this idea is argued not to be feasible or even desirable in the real world (Kahn, 1988) for many reasons and challenges associated with the concept of marginal costs.

3.7 TRANSPORT POLICY AND EQUITY CONSIDERATIONS

The funding and financing framework should incorporate equity considerations (NSTIFC, 2009). Levison (2010) suggests that equity issues surrounding road pricing should have the ability to raise revenue, as well as offering the ability to manage demand on the road network at a given location and time of the day. Equity refers to the fairness with which benefits and cost impacts are distributed (Litman, 2019). This implies equity considerations with respect to general equity across income groups, across modes, and geographic equity. Road pricing affects mobility, and the pricing decision could affect equity through the distribution of externalities, charges, and the way in which revenue is spent. There are various ways to define equity, including horizontal equity and vertical equity, with regard to income and social class, as well as ability and mobility needs (Pereira, Schwanen & Banister, 2016; Litman, 2019).

3.7.1 Horizontal equity

Horizontal equity is concerned with the distribution of impacts between individuals and groups in terms of their needs and abilities. It is often referred to as egalitarianism[6] (Litman, 2019). This implies that public policies should treat equal individuals or groups the same when distributing resources or in terms of benefits and costs. Jones and Nix (1995) calculated roadway cost allocation (share of roadway imposed by different types of vehicles) by applying the horizontal equity principle. They then compared the cost imposed by different vehicle classes by revenue generated from RUC collected from the various classes. Litman (2019) summarised the cost allocation study conducted by the FHWA (1997). Table 3.3 summarises the results of a major cost allocation study, which concluded that user fees fund approximately two-thirds of the roadway facilities in the USA.

Table 3.3: Roadway cost responsibility

Vehicle class	VMT[7] (Millions)	Federal costs (US$)	State costs (US$)	Local costs (US$)	Total costs (US$)	Total user payments (US$)	External costs (US$)
Automobiles	1,818,461	0.007	0.020	0.009	0.035	0.026	0.009
Pickups and vans	669,198	0.007	0.020	0.009	0.035	0.026	0.003
Single-unit trucks	83,100	0.038	0.067	0.041	0.146	0.112	0.034
Combination trucks	115,688	0.071	0.095	0.035	0.202	0.157	0.044
Buses	7,397	0.030	0.052	0.036	0.118	0.046	0.072
All vehicles	2,693,844	0.011	0.025	0.011	0.047	0.036	0.010

Source: FHWA (1997)

[6] Egalitarianism implies levelling the playing ground and treating everyone equally regardless of their race, gender, or income (Litman, 2019).

[7] Vehicle miles travelled.

Cost studies that consider total transportation costs, including externalities (accident risks, air pollution, congestion, etc.), found out that the greater the cost consideration, the greater the inequity (Litman, 1999). Litman (2019) illustrated this by arguing that motor vehicles are often subsidised by approximately one cent per mile just for roadway costs not borne by the RUC. It thus requires a greater subsidy to account for externalities (for example accidents, pollution, and environmental impacts) not accounted by the road users. Bandegani and Akbarzadeh (2016) employed a field survey to assess the horizontal equity of a distance-based public transit fee structure. Their study considered fee elasticity of demand and trip length passenger transit distributional probability. The Gini coefficient index and the revenue-to-cost ratio for each transit passenger was employed. The study findings indicated that the Gini coefficient decreased from 0.38 to 0.17 when switching from a flat to a distance-based structure. The ratio shows that the revenue or cost per mile/kilometre curve tended to be significantly flat after switching to a distance-based fee structure. This indicates similarity of wealth levels among passengers.

Horizontal equity and economic efficiency can be differentiated in the sense that horizontal equity focuses on group-level average costs, whereas economic efficiency focuses on marginal costs per drivers' individual trips and ignores sunk costs and fixed costs; however, the two tend to merge over the long run, where most cost turns out to be variable (Litman, 2019).

3.7.2 Vertical equity

Vertical equity is involved in the distribution of resources between individuals and groups that differ in terms of income or social class (Litman, 2019). Vertical equity is mainly categorised in terms of income and social class, as well as individuals' or groups' mobility needs and abilities. It caters for social justice and environmental and social inclusion. Transport policies tend to be equitable when they favour disadvantaged groups socially and economically by compensating for any inequity (Rawls, 1971). Transport policies are either progressive (if pro-poor) or regressive (if not favouring disadvantaged groups). Such policies advocate for special services or subsidies for lower-income groups and ensure that transport facilities and services meet the needs of all users, including those with special needs. Litman (2019) argues that in most instances, the two policies overlap or conflict with each other. For instance, the horizontal policy advocates for users to be held responsible for their usage of transport facilities or service, whereas vertical policies promote subsidies for disadvantaged groups. Transport policies therefore often involve a trade-off between different equity objectives (Litman, 2019).

Vertical equity is applied in many studies. For instance, Brown et al. (2008) assessed the time and money costs across jobs within several demographic groups and recommended various transit-oriented planning strategies that would potentially improve opportunity and fairness. In a recent study, Creger, Espino and Sanchez (2018) identified ways in which planning could better respond to disadvantaged groups. In investigating the equity impact on the fuel price, Leung et al. (2018) argue that although fuel taxes tend to be regressive, the revenue generated is often less than other funding options. Fuel taxes regressively tend to decline with improved accessibility routes for lower-income travellers (Leung et al., 2018). Ramjerdi (2006) conducted an evaluation of mobility management transport policies, including road pricing, parking pricing, and public service improvements in Oslo, Norway. The vertical equity analysis used various measures to reflect several assumptions and perspectives such as the Gini coefficient and the Lorenz curve in order to measure wealth inequality.

The overall equity in transportation pricing depends on who pays the price, how prices are set or structured, and the transport alternatives available (Schweitzer, 2009; Golub, 2010; Manville, 2017; Cortright 2017, 2018). In addition, equity in transportation also has an impact on how revenue is allocated and used and the motive for undertaking a journey (necessity or leisure). When good alternatives are available (Litman, 2019), the revenue generated from the facilities is used to benefit (subsidise) disadvantaged groups.

3.7.3 Efficiency

Efficiency requires pricing at the marginal cost of road use (Litman, 2017). Andreson and Thompson (2014), however, argued that in an economic setting of economies of scale, efficient pricing might not cover the full cost of providing and maintaining the transportation infrastructure, especially for sporadically used roads. Andreson and Thompson (2014) further proposed a two-part tariff approach for low-volume traffic roads aimed at incorporating a flat fee with variable charges in order to possibly attain a sustainable financial mechanism. Their research addressed two pressing issues as advocated by the strategic goal of the US Department of Transportation, mainly aimed at improving highway maintenance and improving economic competitiveness.

3.7.4 Accessibility and mobility

Accessibility refers to people’s abilities to obtain desired service and activities. Litman (2003) discusses various factors that could influence transport accessibility, including mobility, connectivity and affordability, geographical sphere, and mobility service substitution (such as telecommuting). Accessibility recognises the significant role that active and public transport plays in an efficient and equitable transport system (Litman, 2019). In order to address bias in transportation modelling and economic evaluation, Litman (2019) recommends that transport improvements should be primarily guided by accessibility as opposed to mobility. This implies that improvement should take into consideration people's accessibility of public services (transport) to places of work, health facilities, and education, while also considering other options such as travel time, financial budget, and ability to walk or drive, and not only saving travelling time. Litman (2019) also argues that travel-time saving for lower-income mobility should receive higher monetary value than high-income people's mobility. Such an action is likely to increase consumer welfare and efficiency by allowing disadvantaged users access to education and employment opportunities.

Mobility refers to a transportation system designed to increase access to high-quality mobility options, reduce transport externalities, and enhance economic opportunities for low-income groups (Creger et al., 2018). In recent research, Creger et al. (2018) conducted a robust policy investigation aimed at prioritising the mobility needs of low-income people in California and to attend to unaddressed historical experiences. They developed a framework envisaged to assess and maximise transportation planning and decision making that better address community-identified mobility needs.

3.8 POLICY GOALS FOR A ROAD USER CHARGE SYSTEM AND ROAD PRICING

Generally, the motives for an RUCS can be divided into three broad categories, namely:

- raising revenue;
- allocating road-use costs among different user groups; and
- internalising externalities.

Interestingly, the demarcations between the three categories are not entirely independent. For instance, charging users for emissions resulting from their activities associated with the road use certainly boosts revenue and may be helpful in allocating costs according to different vehicle classes of user groups. Table 3.4 shares some international experience on policy objectives that guide direct pricing schemes.

Table 3.4: Policy objectives of international Road User Charge Systems

Scheme	Key policy objectives
Germany: Heavy vehicle RUC	Raise revenue based on user-pays system
Singapore: Area network charging	Demand management
Stockhölm: Cordon pricing scheme	Reduce congestion, increase accessibility, and improve the environment
London: Area-wide scheme	Traffic and congestion reduction in central London, and provide funding for transport investments

Trondheim: Multi-zonal charging	Raising private sector revenue to support needed urban transport infrastructure investment
Manchester: Rejected multi-cordon pricing	Raise revenue for public transport investment and control congestion
Gauteng	Demand management, raise revenue based on user-pays system
Sydney Harbour bridge: Harbour bridge	Address congestion on Sydney Harbour Bridge
Northern Gateway toll road: Interurban	Raise revenue and demand management

Source: Author (Infrastructure Partnerships Australia, 2014:39)

3.8.1 Raising revenue

The current discussion on a potential policy for raising revenue has been the argument on road-use revenue with a particular concern with the projected decline in the fuel levy as the major contributor to the RGR (MWT, 2017). It is argued in the literature that the fuel levy has not been kept on par with inflation for several decades and has led to growing shortfalls in RGR (Transportation Research Board [TRB], 2005; MWT, 2017). Another point of concern with the fuel levy has been the entrance of electric-powered motor and hybrid vehicles that use less or no fuel (Krygsman, 2018; Van Rensburg & krygsman, 2019). These, in coming years, if no alternative measures are put in place, will likely exacerbate the road-funding dilemma facing many countries. Therefore, policy goals should aim at preventing foreseen erosion in road-use revenue and where possible should strive towards closing the funding gap. The literature recommends that a good policy is one that establishes a balance between managing demand and raising revenue (Atkins et al., 2012). The literature offers some international experience on road pricing aimed at revenue generation, including Scandinavian (Norwegian and Sweden) toll rings (Small & Gomez-Ibanez, 1998; Schuitema, 2007) and demand management as applied in Singapore, London, New York, and California (Schuitema, 2007; Levison, 2010). Chapter 5 of this dissertation presents a detailed literature review on revenue and several instruments utilised to charge users.

3.8.2 Allocation of road-use costs among different user groups

The argument in the literature around cost allocations calls for proper description of the damage imposed on the road network by various vehicle groups. The amount of damage on the road network heavily depends on the axle weight of the vehicle, as well as the engineering design standards of the road[8] (Sorensen et al., 2009). A light vehicle traveling on a trunk road network imposes relatively little road wear as compared to the damage a heavy vehicle with axles travelling on urban street road could inflict. It is notable that cross-subsidies among different users are likely to happen between light vehicles and heavy vehicles; for instance,

[8] Generally, national road networks, particularly national corridors and inter-urban roads, are designed to accommodate heavier loads than urban street roads.

lighter trucks with more axles and heavier trucks with fewer axles (Small, Winston & Evans, 1989). The policy on cost allocation aims to estimate the cost of each vehicle class per distance travelled towards accounting for more accurate damage that particular vehicles impose on the network and then structuring the per-km RUC accordingly (Sorensen et al., 2009).

3.8.3 Internalising externalities

When a vehicle utilises the road network, it imposes costs on the road surface (wear and damage), on other users (in terms of congestion and accidents), and society (environment). A policy towards internalising externalities is engineered towards decreasing congestion delays and reducing emissions and greenhouse gas (GHG) emissions (Monsalve, 2013). Several commentators have made efforts to measure the externalities of road use. To that effect, several studies used the contingent valuation method, mostly using a survey or open-ended questionnaires to determine respondents' willingness to pay for non-market goods' quality, including the desired change in air (environmental) quality (Ligus, 2018; Wang et al., 2015), noise reduction, minimising travel time, and reducing accident risks. Chapter 6 of this dissertation presents a detailed literature review of the internalisation of external costs.

3.9 THE ROAD PRICING THEORY

For decades, in particular in developing countries, the most popular road policy response to increases in revenue was the annual increment in levies and charges. However, for many reasons, including social and political interventions, road-user levies and charges, especially the fuel levy, the highest contributor to the revenue generated from the RUC, could not be raised on an annual basis (MWT, 2017). This resulted in less revenue for road maintenance and rehabilitation, with further implications for road networks, which have rapidly deteriorated over the past decades (RA, 2018). In searching for new mechanisms and strategies to increase revenue while managing demand and reducing accident risk and environmental risks, policymakers, as well as infrastructure managers, have increasingly become interested in policies that aim to address negative road externalities (MWT, 2017). Although road infrastructure brings about both positive and negatives externalities, it is rare that negative externalities are accounted as a component of road pricing, especially in many developing countries.

3.9.1 The first-best pricing theory

Road pricing has evolved since Pigou's study in the 1920s, launching the "Pigouvian tax" (Pigou, 1920), which aimed to internalise negative road externalities by imposing levies and charges to the users. Imposing Pigouvian tax implies charging road users at the so-called economic efficient price (MSC) as it takes into consideration both the Marginal Private Costs (MPC) and the MEC (Santos, 2017). The fundamental concept of road pricing follows the pricing mechanisms as applied elsewhere in a market economy (Yang & Huang, 2005). In line with this fundamental concept, the theoretical framework guiding this study was the failure of implementing RUC set at an economically efficient price based on the principle of MSC.

Setting RUC at the optimal level influences revenue generation and resource allocation (Heggie & Fon, 1999). In order to maximise net economic benefits, road pricing should be set equal to the SRMC of road use. Investigations have been conducted on how this first-best pricing theory would work in practice; for example charging for transportation externalities such as environmental costs (see Van der Bossche et al., 2001), accident costs (Lindberg, 2002), congestion costs, and infrastructure damage costs (see Newbery, 1988; Bruzelius, 2004). Verhoef, Nijkamp and Rietveld (1996) argue that first-best road pricing would improve the road sector's status quo. However, setting the price equal to MSC does not guarantee an increase in revenue generated from RUC. RUC could lead to a revenue deficit or surplus (Proost & van Dender, 2003). As a matter of fact, the literature suggested the calculation of the optimal user charges to see whether they would yield a deficit or surplus and the results should serve as a point of departure (Walter, 1968). On the other hand, the process of introducing road pricing might be slow due to various reasons, including political interventions and social, practical, and technical barriers (Verhoef, 1998). Several shortcomings of the SRMC principle are outlined by Rothengatter (2003). Despite the difficulty in implementing the MSC principle, road pricing should aim to attain economic efficiency in order to reduce vehicle operation cost, increase safety, revenue generation, and significantly to bring about gains in economic development.

3.9.2 The second-best pricing theory

Despite the fact that the theoretical foundation of the first-best road pricing is established, optimal pricing schemes lack practical implementation. Economic theory postulates that the price of a product or service is likely to be affected by the price of its complements or substitutes (Richa, 2019). Since road transportation has substitutes or complements, market failure and distortion can be experienced in the transportation sector. Therefore, if other modes are not priced at marginal cost, then road pricing should not be priced at first-best pricing either

(Verhoef, 1998). Therefore marginal pricing might conflict with equity issues if not considered when setting the road pricing. Even within the road sector, the first-best pricing theorem is met when the entire road network is priced at the MSC. Rouwendal and Verhoef (2003) made an illustration of two road links from the same origin and heading to the same destination; where Road A is a private (tolled) road; whereas Road B is public (non-tolled) road. Road B is likely to attract more traffic (excess demand), leaving Road A with underutilised infrastructure.

Second-best pricing theories are considered when it is not possible to implement the first-best pricing policies due to market failure or distortion elsewhere in the economy (Maffi, Parolin & Ponti, 2010). The second-best pricing theorem received attention for the past decade with researchers (Lindsey & Verhoef, 2000) investigating the optimal level and efficiency of the second-best pricing scheme. Given this theory, this study explored efficient RUC for Namibia based on the MSC principle. The literature review on the component of the MSC to consider when setting the price equal to MSC is presented in Chapter 6.

3.10 CONCEPTUAL FRAMEWORK

Road transport abounds with externalities. Externalities arise whenever one road user makes another user or society worse or better off (Cowen, 2019), yet not bearing the costs associated with the use of the road. The implication of not accounting for these externalities and internalising them into road pricing so that they influence the present and future price of road use, is generally less known. The literature presented price set equal to the SRMC to be the recommended point to charge road users (as discussed in Section 3.6). The challenge recorded in the literature is associated with the complexities in measuring and implementing such road pricing, more so in developing countries that have not invested in research associated with the MEC of road use. Fortunately, many of these developing countries, including Namibia, use the HDM-4 model as a way to determine budget allocation, to identify projects for implementation, and to undertake economic evaluation. The RA uses the HDM-4 to strategise for maintenance expenditure and to motivate investment needs for the national road network (see Figure 3.3). The use of the HDM-4 to influence the present and future road pricing remained a grey area in the authorities' domain despite road pricing presenting a more efficient way of allocating resources (including road space). The HDM-4 contains most of the data for estimating the MEC of road use, although the undertaking is not a straightforward exercise.

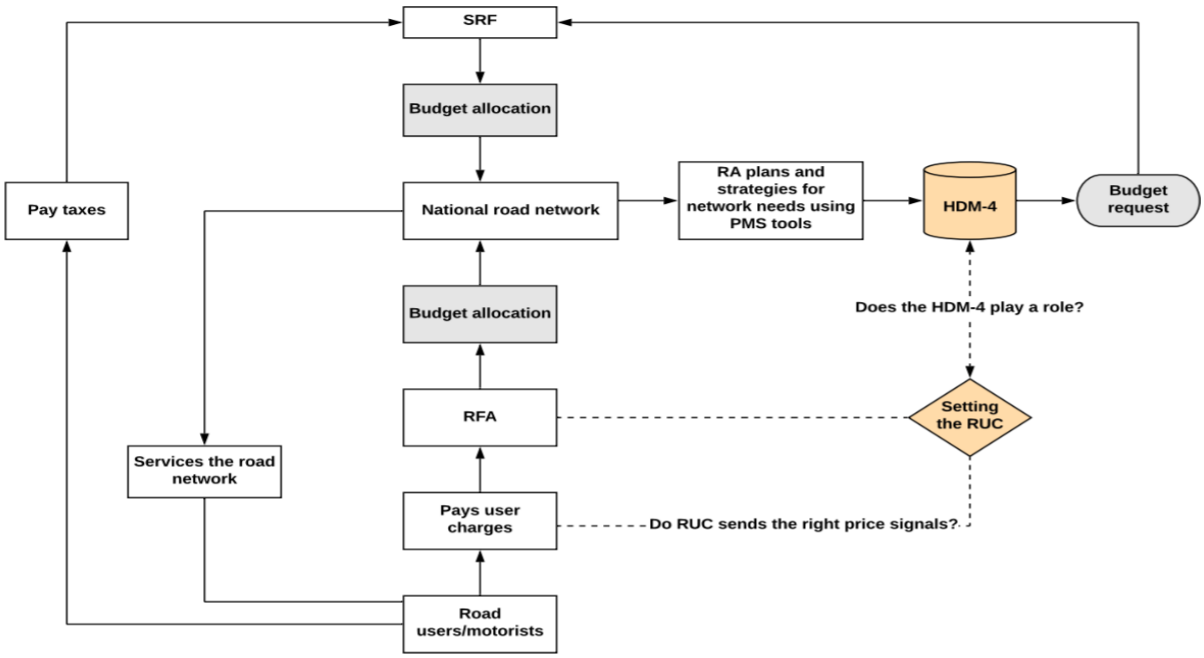


Figure 3.3: The use of HDM-4 for road-user planning and strategies

Source: Author

As the case may be with road users not taking into consideration the costs they impose on others, the implication of not factoring externalities costs into road pricing also applies to the supply side. The current RUC do not cover externalities imposed by the road user that vary with space and locations. As a result, this sends price signals to the road users that do not include externalities, thus the users only pay according to the charges imposed on them.

Although road users in Namibia pay charges in the form of a fuel levy, vehicle registration and licence fees, CBC, MDC, and abnormal load levies, most of these instruments do not follow the user-pays principle (see Figure 3.4). Namibian roads are characterised by a spacious network serving a small vehicle population, as discussed previously. This poses a challenge to charging pricing that is based on the SRMC of road use. Figure 3.4 raises the question that if Namibia implements the recommended efficient pricing of SRMC pricing for road use, would the approach yield sufficient revenue to cover all the costs and provide for an acceptable return on investment? The opposing view is whether is indeed the aim of the principle to deliver sufficient revenue to cover fixed costs and provide funding for road upgrading and expansion. It should be noted that while the objective of marginal social costs pricing is to reflect the (variable) costs imposed on society, the principle can, under some circumstances, deliver sufficient revenue to cover fixed costs (minimum gross rerun on invested capital and depreciation to invest in capital expansion).

In line with this fundamental concept, the theoretical framework guiding this study was the failure of implementing RUC set at an economically efficient price based on the SRMC principle. Making road pricing a policy strategy that links demand, price, investment revenues, and capital funding has been overlooked for many years. Figure 3.4 presents the scenario of internalising external costs into road pricing. The RA conducted assessments of the road conditions utilising visual systems, including Geographic Information System (GIS) and Road Referencing System (RRS) and other mechanical surveillance measurers to collect data (RA, 2018). Such data were deposited into the RMS. Transport planners use analytical tools such as the HDM-4 model to describe road conditions, identify maintenance and rehabilitation needs, and analyse investment needs.

The rarely explored components of these tools are associated with exploring rich data embedded in the HDM-4 that contain the conditions of the road network and the characteristics of vehicle fleets to estimate the external costs of road use. The HDM-4 has the potential to estimate the negative external costs of road use that are rarely internalised into road pricing. This study attempted to address the said gap by exploring the HDM-4 to estimate the MSC of road use in monetary value (per vehicle kilometre).

The study made the presupposition that the user-pays principle, recommended by the Namibian Transport Policy (MWT, 2017), ought to be implemented and that the SRMC is perceived relevant for road pricing to internalise the MEC into the road price for a true reflection of road use, as discussed in Section 3.6.

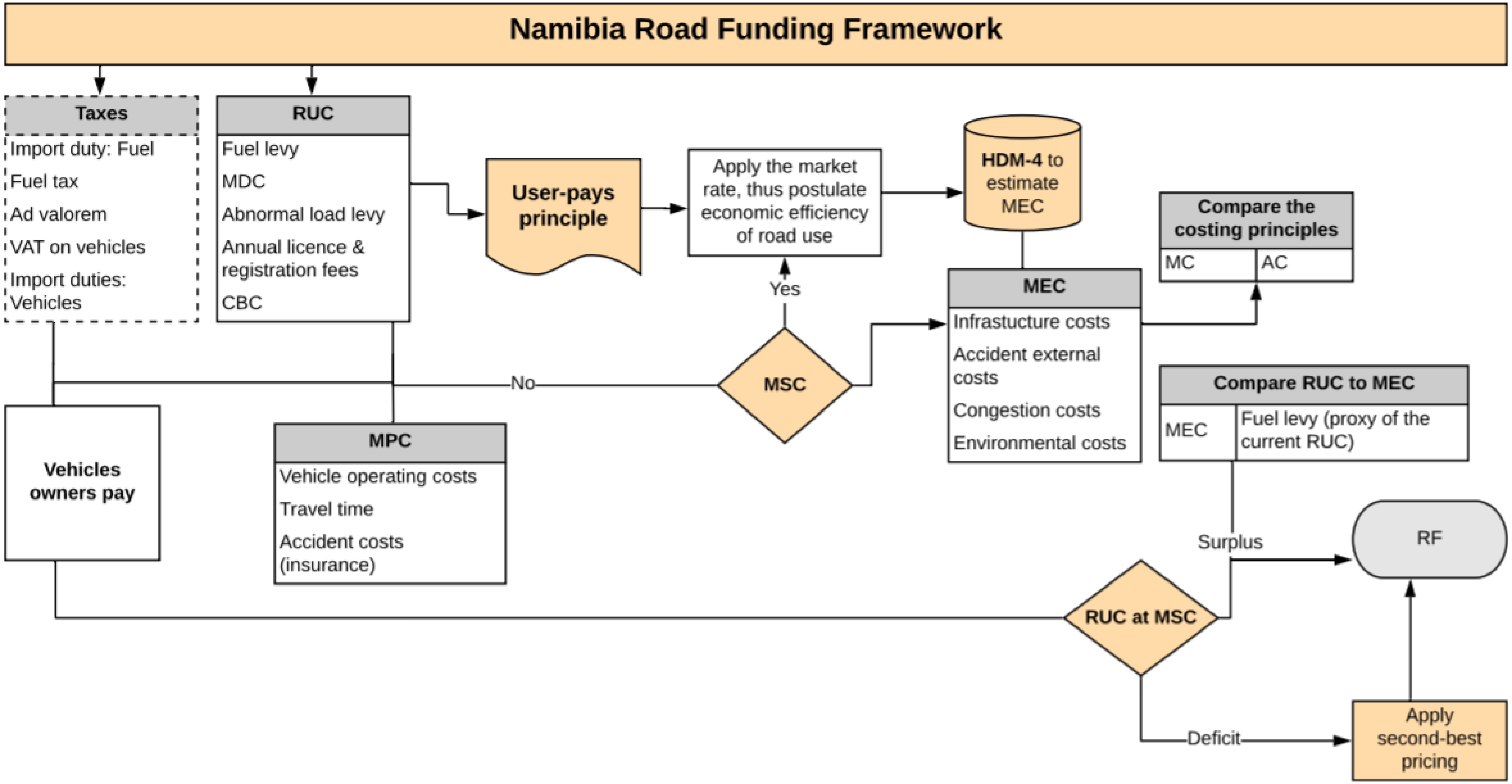


Figure 3.4: Using HDM-4 to internalise the external costs of road use based on the user-pays principle

Source: Author

The estimated MEC are compared to the average costing in order to determine which of the two costing principles yields positive results. Furthermore, in determining what road users are currently paying for road use, the fuel levy was utilised as a proxy of the current instruments and compared to the estimated external costs to assess the impact that the efficiency pricing would have on revenue generation for road use. Would pricing at MSC yield a surplus or deficit? Thus, what is the second-best alternative Namibia could employ in order to bridge or supplement the road sector's financial deficit should the MSC yield a deficit?

3.11 SUMMARY

The contemporary literature on road pricing revealed that RUC set equal to the SRMC could serve as a foundation for charging for road use both on the demand side (sending accurate price signals) and supply side (internalisation of external costs). Road activities abound with externalities that are rarely taken into consideration by road consumers when making decisions for undertaking a journey. The issues of MEC are well documented in the literature, predominately in studies in developed countries. However, research studies on the MEC of road use in developing countries are still in the infancy stage. To the best of the researcher's knowledge, estimating the MSC of road use that covers all four components and assigns monetary value that could possibly be used to inform road pricing and influence policymaking decisions has not been conducted thus far in Namibia.

Overall, the lessons learned from road pricing and funding literature are that every continent seems to have a unique focus on the subject matter. However, transport policies in both developed and developing countries seem to have a common consensus, namely to implement the user-pays system that would foresee consumers of scarce resources paying their fair share of the infrastructure costs and for their use of roads. The literature, however, revealed that charging for road use at efficient pricing is very complex and difficult to implement in practice. This is likely due to the complexity of measuring all components varying in space and time, the resources required to conduct thorough studies, as well as data limitations. The literature, however, recommended that when data permit, the exercise is worth undertaking so as to determine whether pricing at SRMC would yield a surplus or deficit.

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CHAPTER 4:
OVERVIEW OF THE STUDY AREA AND ANALYSIS METHOD

4.1 INTRODUCTION

This chapter provides a trajectory of the methodology applied in this study. This dissertation is structured to address three objectives. Therefore, Chapters 5, 6, and 7 outline a deeper analysis of the methodology as per the objective to be attained.

4.2 METHODOLOGY AND STUDY AREA

The HDM-4 Workspace 2015 version obtained from the RA was used as the basis for the selection of the study area (RA, 2018a). The RMS division of the Namibian RA is responsible for the development and operating of coordinated and integrated support tools or system in order to facilitate the efficient management of the national road network and providing information pertaining to the network (RA, 2019). The RMS comprises several sub-systems, including the Pavement Management System (PMS), the RRS, the Traffic Surveillance System (TSS), the Unsealed Road Management System (URMS), Accident Management System (AMS), and Bridge Management System (BMS). The interdependency and data information associated with each of these sub-systems are presented in Figure 4.1.

The HDM-4 Workspace presented in this study applies all the RMS sub-systems data-collection principles, as well as associated systems such as GIS. Data on all proclaimed road networks were collected through regular visual assessments and mechanical surveillance measurements and deposited in the RMS (RA, 2018b). A well-developed and well-managed RMS often assists management in making accurate decisions when determining the level of funding and to identify and prioritise road projects (Bennett et al., 2007). The RMS division utilises such data to continuously monitor the condition of the road network, analyse the impact of funding scenarios, identify periodic maintenance and rehabilitation needs, and minimise total transportation costs (RA, 2019).

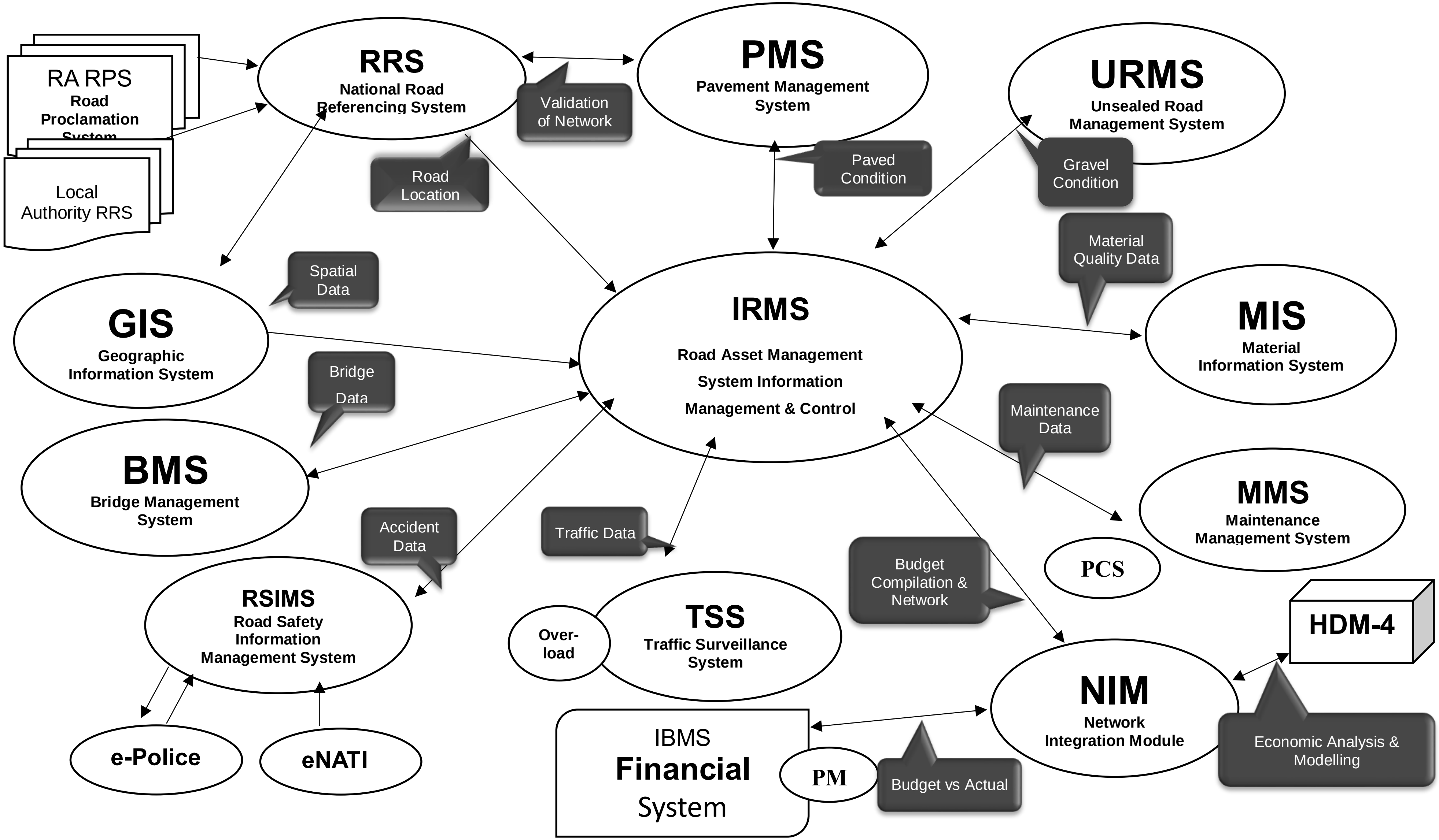

Figure 4.1: Road systems interdependency

Source: Author (Tekie, 2016)

Kerali, Robinson and Paterson (1998) explained the HDM-4's operations and its dependency on core data managers, including:

- the road network manager, who defines the road network or sub-network that forms the basis of the analysis;
- the vehicle fleet manager, who defines the characteristics of the vehicle fleet using the road network to be analysed; and
- HDM-4 configuration, which defines all the default data to be used with the input data, and the user can calibrate default data to the local environment.

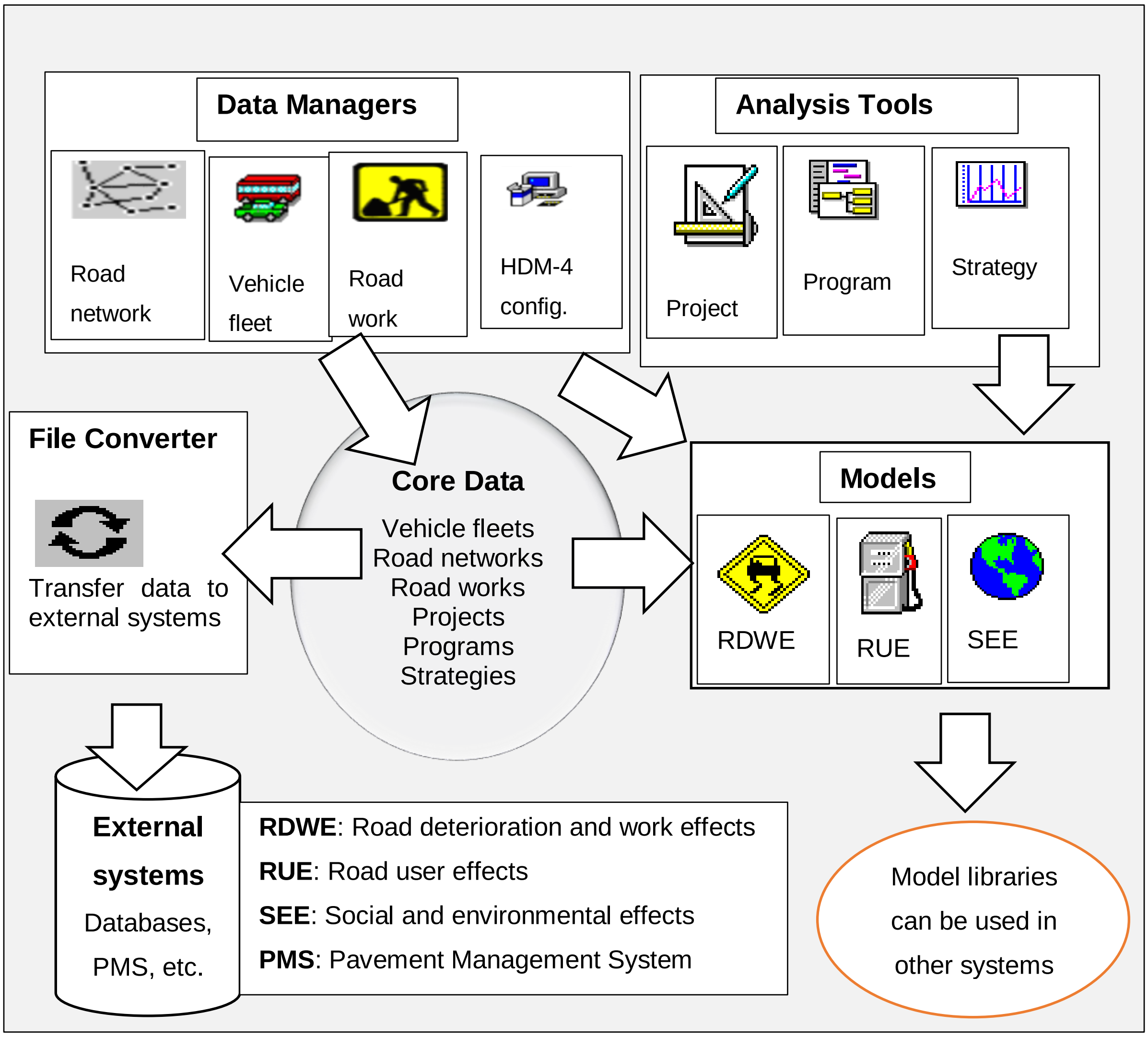

Figure 4.2: HDM-4 system architecture

Source: Henry and Kerali (2000)

The HDM-4 model illustrated in Figure 4.2 has four indispensable components, namely RDWE, RUE, SEE, and the PMS. This model is utilised to predict future pavement conditions and to predict the effects of maintenance treatment on road conditions, to estimate road-user costs as a function of road condition (Harvery, 2012), to estimate the social and environment effects associated with the use of roads, and to forecast the maintenance strategies and investment needs of the road network respectively. This study focuses on the application of the HDM-4 to estimate the MSC of road use. Figure 4.3 presents the HMD-4 lifecycle analysis method.

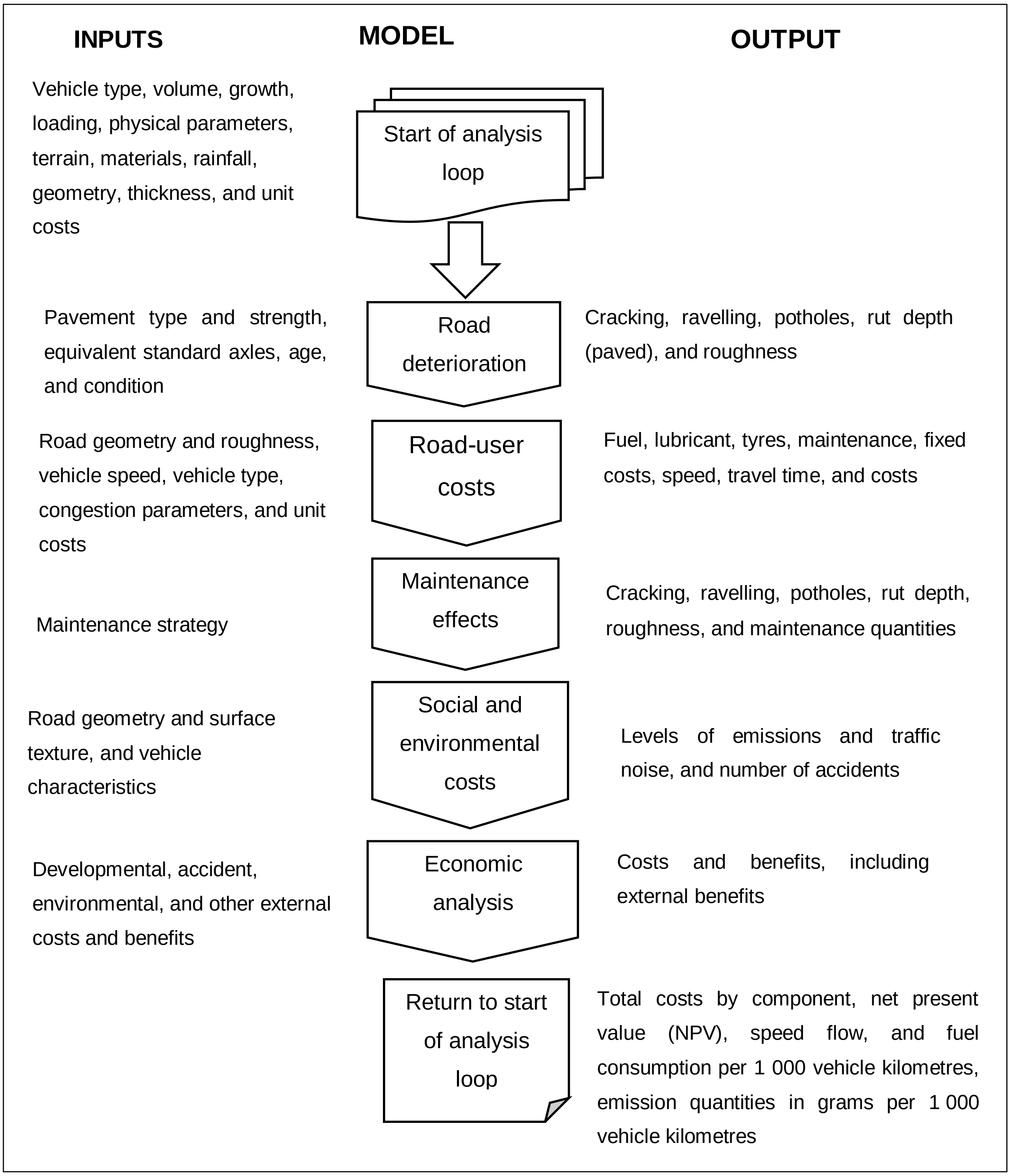

Figure 4.3: HDM-4 lifecycle analysis

Source: Kerali et al. (1998)

Figure 4.3 simulates the underlying operation of the HDM-4. Interacting sets of costs incurred by the roads agency and those incurred by the road users are added over time in discounted present values (Kerali et al., 1998). These costs are determined by predicting the physical quantities of resources consumed and multiplying such quantities by unit costs (Kerali et al., 1998).

4.2.1 Pavement data

The RMS division of the RA in collaboration with several consultants collected the required data using surveys. For instance, a survey can be conducted towards evaluating pavement condition and structure. Pavement evaluations aim to record pavement characteristics that influence pavement performance such as roughness, texture, skid resistance, mechanical or structural properties, surface distress, and geometry (Bennett, De Solminihac & Chamorro, 2006). For instance, pavement condition data collected via visual inspection and classified according to the road condition (very good, good, fair, and poor) can be converted into the HMD-4 model's requirements (Henry & Kerali, 2000).

Pavement evaluation can be functional or structural in nature, depending on which of these characteristics are being surveyed. Function evaluations aim to collect data that provide information about surface conditions that have a direct effect on users' safety and comfort, namely skid resistance, surface texture, and roughness (Bennett et al., 2006). Structural evaluation provides information on the performance of the pavement structure under certain traffic loading and environmental conditions. Pavement evaluations are often performed through manual surveys or by means of specialised equipment and quantified by means of indicators or condition indices (Bennett et al., 2006).

Table 4.1: Pavement data-collection equipment

Pavement characteristic	Equipment class
	Group 1: Precision profiles (Laser or manual)
	Group 2: Other profilometer methods
	Group 3: International Roughness Index (IRI) estimates from correlations
	Group 4: Subjective ratings
Microtexture	Static
	Static
	Dynamic
	Static
	Dynamic
	Falling weight deflectormeter
	Deflection beams
	Dynamic cone penetrometer
	Video distress analysis
	Visual surveys
	Transverse profilers
	GPS
	Inertial navigation units

Source: Bennett et al. (2006)

4.2.2 Traffic data

The collection of traffic data aims to monitor the use and performance of a road network. The principal traffic data categories includes traffic volume, vehicle classification, and truck weight. Furthermore, other traffic characteristics of relevance to this study include vehicle speeds and occupancies. The RMS division operates a traffic counting system. The traffic counts are recorded at a specific point (count station or site) assigned to a certain segment of the national road network. There are approximately 150 base and 200 ad hoc electronic traffic-monitoring stations on selected inks of the national road network (RA, 2018c:43). Since it is not feasible to collect traffic data at every point along the road network, the data collected from the sampled segment of the road network are often extrapolated to represent the entire road (FHWA, 2016). Therefore, information on the AADT growth rate is estimated from the traffic count data. The RMS division can instruct its consultant to conduct traffic count surveys should the RMS data be found to be insufficient (RA, 2014). The software has been designed to work with several data types and quality.

Furthermore, for any missing data, HDM-4 has default data that can be calibrated to the local environment. The data imported into HDM-4 and exported from of the software are organised according to the data objects categorised as road networks, vehicle fleets, maintenance and improvement standards, and HDM-4 configuration (Henry & Kerali, 2000). A workspace obtained from the Namibian RA (see Figure 4.4) was used as the population from which the road sections were sampled.

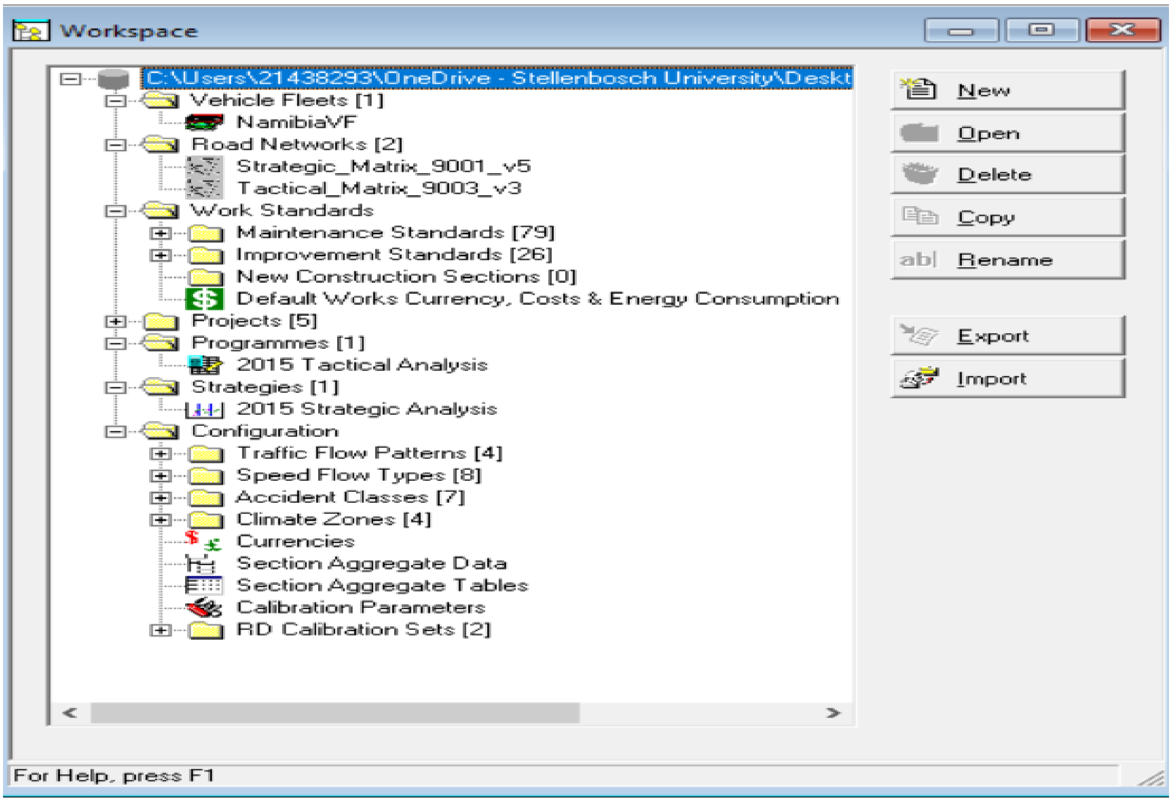

Figure 4.4: HDM-4 Workspace

4.3 DATASET

The full HDM-4 Workspace is available at the Namibian RA (RA, 2018a). This analysis used version 2015 of the workspace, which consists of a full description of the Namibian vehicle fleet and road network data for the national road network. The data provide information on Namibia's vehicle fleet and six representative vehicle characteristics, including basic characteristics and the economic unit costs of each vehicle. Road network data consist of information such as surface classes, pavement type, length, carriage width, speed flow, accident class, climate zone, road classes, and motor vehicles' AADT (RA, 2018a). The HDM-4 Workspace has already been calibrated to the Namibian environment, therefore, in this study, no calibration was carried out. In order to achieve the objectives of the study, the following data were gathered:

- The HDM-4 Workspace (RA, 2018a) and the GIS shapefiles (RA, 2018d) were sourced from the RA division of RMS. The motor vehicle annual growth statistics for the 2012/2013 to 2016/2017 fiscal year were obtained from the RA division of Transport Information and Regulatory Services (RA, 2017).
- Anonymised data on Namibian trade statistics on Chapter 87 and Chapter 27 commodities consisting of income generated from various indirect taxes were obtained from the Department of Customs and Excise of the MoF (2017) and the NSA (2017).

The dataset for the period 2012/2013 to 2015/2016 included customs and excise data (fuel levy), ad valorem taxes, and VAT on vehicle sales and vehicle import duties.

- The RFA provided information on revenue generated from the RUC for the period 2012/2013 to 2016/2017.
- A dataset on revenue generated from the MVA Fund indicates a fuel levy of N$0.503 on a litre of petrol and diesel sold for the period 2012/2013 to 2016/2017 (MVA Fund, 2017).
- The MME provided updated data on fuel composition consisting of the pump prices and wholesale selling of diesel (N$14.08 @ 50 or N$14.13 @ 500[9]) and petrol price less custom and excise duty, NEF fuel levy, RUC, fuel tax, and MVA levy.

4.3.1 Why HDM-4 was the best software for this study

The HDM-4 model of the World Bank is commonly used in developing countries, including Namibia. The model is mainly used for the economic appraisal of road investment needs and maintenance strategies (Henry & Kerali, 2000). The HDM-4 model simulates the behaviour of the roads within the lifecycle by considering the effect on traffic, pavement structure, maintenance operations, and environmental impact over time (Martinez et al., 2018). The software has the ability to estimate savings in road-user costs, as well as to predict the benefit associated with road management, including lower travel times, reduction in accident risk, and fewer environmental effects. The HDM-4 software has the ability to stimulate future change to the road system from present conditions (Bagui & Ghosh, 2015).

HDM-4 consists of a robust framework for road management analysis options to determine the investment needs of paved and unpaved road networks. In order to achieve quality and correct interpretations of the data, as well as the desired reliable results, HDM-4 requires configuration of inputs such as vehicle fleet unit costs, pavement structure, traffic levels and characteristics (type and load), road geometry, road conditions, climate conditions, maintenance operations, accident rates, traffic flow patterns, speed-flow types, etc. Therefore, the model only performs analysis as per the data provided by the user (Martinez et al., 2018). It is therefore crucial for the users of these systems to provide accurate data input as far as possible. Road network performance could be predicted as a function of traffic (volume, loading, and speed), road pavement (type and strength), maintenance and improvement standards, as well as environmental conditions. The researcher believed that HDM-4 was the best software to use as this study intended to explore and build on existing road pricing and funding from multiple perspectives, as well as contributing to the understanding of the RUCS

9 Prices as of 1 January 2019.

in Namibia. The study sought to explore contemporary phenomena within roads agencies by exploring available tools and data that could be used to inform road pricing planning and strategy at the transport policy level. This study can benefit several stakeholders in the road sector, including roads agencies, line ministries, and policymakers.

4.4 DOCUMENTARY ANALYSIS APPROACH

Documentary evidence relevant to the study, including financial reports, business plans, strategic plans, policies, newspaper articles, and published and unpublished articles, were obtained from roads agencies, line ministries, and relevant stakeholders. The documentary analysis approach relies heavily on the RUCS to explore the RUC accrued to the RF managed by the RFA. Figure 4.5 illustrates the RUC instruments and the percentage each instrument contributes to the funds generated from the road users. The researcher assessed to what extent these RUC conform to the user-pays principle. Therefore, the criteria for choosing the RUC included those applicable to the Namibian national road network (see Figure 4.5).

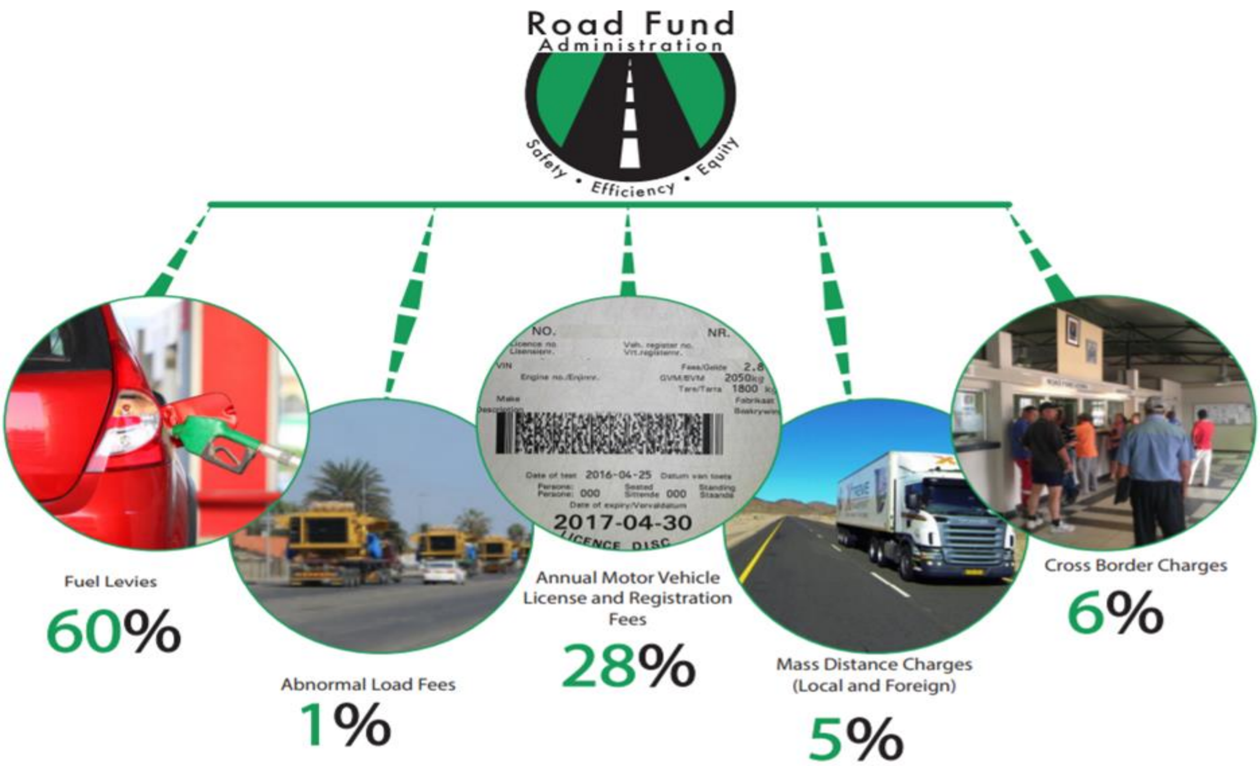

Figure 4.5: Percentage of Road User Charges of revenue

Source: RFA (2018)

4.5 SAMPLE METHOD AND SECTION SELECTION

The idea behind using available tools such as HDM-4 is to sensibly analyse the road sections or other documents that best help the researcher to understand the problem and address the research objectives. One way of sampling is the road network matrix. The matrix is used to assist the researcher in ensuring that the most important factors that affect transportation costs in Namibia form part of the study. According to Henry and Kerali (2000), a typical road network matrix should include the traffic volume or loading, pavement types and conditions, as well as environmental or climatic zones. The following criteria were included in choosing road sections within the Namibian national road network:

- The three main road types (trunk, main, and district roads), the location, and road type (paved and unpaved) are crucial to congestion and accident costs.
- Six representative vehicle classes' (pickups, articulated trucks, buses, heavy trucks, medium cars, and mini-buses) cost per kilometre and revenue heavily depend on vehicle type.
- Traffic volumes influence time period, flow speeds, and congestion and environmental costs, therefore time period is a crucial component.

4.5.1 Case studies

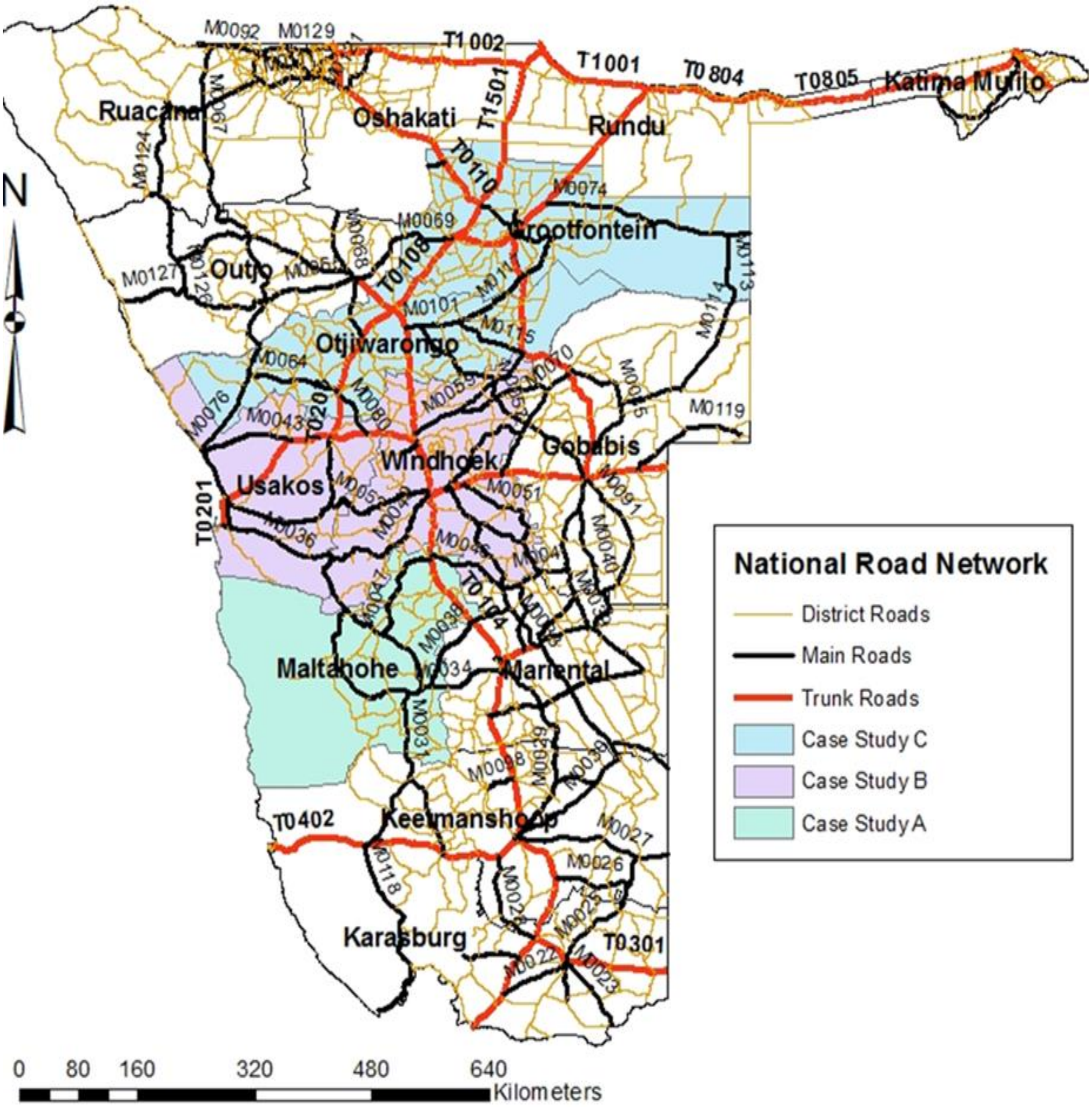

Figure 4.6: Namibian national road network

Source: Author (Based on shapefiles from RA, 2018d)

The Namibian road network parameters consist of three road classes (trunk, main, and district roads) (see Figure 4.6), two surface types (paved and unpaved), three traffic classes (high, medium, and low), three strength classes (strong, medium, and weak), three condition classes (good, fair, and poor), and four climate zones (humid/subtropical-hot, peri-humid/subtropical-hot, semi-arid/subtropical-hot, and sub-humid/subtropical-hot). The road matrix network comprises 274 cells[10] (RA, 2018a).

[10] Data based on the workspace obtained from the RA in 2018.

Box 4.1: Road network matrix

A road network matrix can be modelled using three traffic categories (high, medium, and low), two road categories (paved and unpaved), and three pavement condition levels (good, fair, and poor). It is the researcher's assumption that the environment throughout the study area is similar and a roads agency is responsible for the national road network. The matrix for one road class (for instance, trunk roads) would therefore comprise (3 x 2 x 3 = 18) representative pavement sections.

Source: Henry and Kerali (2000)

Based on the workspace and the data available on the characteristics of the national road network, the sampled sections were categorised as followed: Paved road network into three AADT classes (high, medium, and low); and pavement conditions into three classes (good, fair, and poor). Information on the sampled road section is summarised in Table 4.2.

Table 4.2: Sampled road sections matrix

	Traffic categories		
Paved roads	**High AADT>3000**	**Medium 3000>AADT>1000**	**Low AADT<1000**
Good condition	117.76 km (T0108)		
Fair condition		22.75 km (M0052)	
Poor condition			61.05 km (D0872)

Source: RA (2018a) data adapted from Henry and Kerali (2000)

In order to demonstrate the use of the HDM-4 model and its possibilities to inform the setting of road pricing, this chapter uses three case study scenarios. Three road sections D0872, M0052 and T0108 roads were randomly sampled from the paved roads of the national road network and represent all three road classes, including trunk, main, and district roads (see Table 4.3). To better reflect the candidate road work programme in terms of location and the maintenance strategies applied to a particular section of the case, the study employed tactical analysis. This type of analysis conforms to the SRMC of road use. A description of the road sections sample is provided in Table 4.3.

Table 4.3: Paved road network matrix: A sample of three sections

ID	Section Summary	Length (km)	AADT
T0108 (TBB2HGGZ3)	Trunk: Paved: AMGB: High: Strong: Good: Zone 3	117.76	3114
M0052 (MBB6MPFZ3)	Main: Paved: STGB: Medium: Warning: Fair: Zone 3	22.75	1226
D0872 (DBB5HPPZ1)	District: Paved: STGB: Medium: Warning: Poor: Zone 1	61.05	224

Source: HDM-4 Workspace (RA, 2018a)

Table 4.3 presents the road network matrix outlining the parameters covered by the three hypothetical roads; that is, the three road classes (trunk, main, and district), the paved surface, three traffic classes (high, medium, and low), three condition classes, and two climatic zones. To that effect, the maintenance strategies applied to each candidate road were defined. Table 4.4 outlines the standard maintenance strategy for the three roads and condition classes.

Table 4.4: Maintenance standards for paved roads

Maintenance strategy									
	Trunk roads			Main roads			District roads		
	Good	Fair	Poor	Good	Fair	Poor	Good	Fair	Poor
Minimum maintenance	√	√	√	√	√	√	√	√	√
Rejuvenator	√	√		√	√		√	√	
Single bitumen surface treatment (SBST)	√	√	√	√	√	√	√	√	√
Double bitumen surface treatment (DBST)	√	√	√	√	√	√	√	√	√
SBST with shape correction	√	√	√	√	√	√	√	√	√
DBST with shape correction	√	√	√	√	√	√	√	√	√
Overlay 40	√	√	√						
Light rehabilitation		√	√		√	√		√	√
Medium rehabilitation		√	√		√	√		√	√
Heavy rehabilitation		√	√		√	√		√	√

Source: Author (Ourad, 2016)

Details of the sampled sections and the maintenance strategies applied to each case study are outlined in Table 4.5. Table 4.5 presents descriptions of the three case studies in terms of length (km), carriageway width (m) and the location, number and types of vehicles in the traffic (AADT). The maintenance strategies applied on each sampled case study are also discussed.

Table 4.5: Paved road sections sampled from the national road network

Case study	Description
A: District paved road	Case study A presents a sampled section of a district paved road of the national road network. The road is 61.05 km in length, 6.78 m in width[11], and carries average daily traffic of 224 motor vehicles, including 69 pick-ups, 20 articulated trucks, one bus, 12 heavy trucks, 105 medium cars, and 17 mini-buses. An analysis period of 20 years was used and a discount rate of 12% was applied. The road was assumed to have been newly constructed at the beginning of the period. The maintenance strategy is that the road is subjected to overlay when roughness (IRI) exceeds 5.23, a partial resurfacing if more than 10.61% of the road area suffers structural cracking, or a partial overlay if rutting exceeds 13 mm. The outlined maintenance strategies could apply to a paved road in the Hardap region.
B: Main paved road	Case study B presents a sampled section of a main paved road of the national road network. The road is 22.75 km in length, 13.6 m in width, and carries average daily traffic of 1 226 motor vehicles, including 375 pick-ups, 108 articulated trucks, six buses, 68 heavy trucks, 575 medium cars, and 94 mini-buses. An analysis period of 20 years was used and a discount rate of 12% was applied. The road was assumed to have been newly constructed at the beginning of the period. The maintenance strategy is that the road is subjected to overlay when roughness (IRI) exceeds 4.16 or a partial overlay if rutting exceeds 9.47 mm. The outlined maintenance strategies could apply to a paved road in the Erongo region.
C: Trunk paved road	Case study C presents a sampled section of a trunk paved road of the road network. The road is 117.76 km in length, 7.6 m in width, and carries average daily traffic of 3 114 motor vehicles, including 953 pick-ups, 275 articulated trucks, 15 buses, 172 heavy trucks, 1 461 medium cars and, 238 mini-buses. An analysis period of 20 years was used and a discount rate of 12% was applied. The road was assumed to have been newly constructed at the beginning of the period. The maintenance strategy is that the road is subjected to overlay when roughness (IRI) exceeds 2.22, a partial resurfacing if more than 12.46% of the road area suffers structural cracking, or a partial overlay if rutting exceeds 4.23 mm. The outlined maintenance strategies could apply to a paved road in the Otjozondjupa region.

[11] Carriageway width.

Source: Author

Calculating the marginal and average costs for vehicles using a specific road involves consideration of several influencing factors for each external cost component. Table 4.6 summarises the factors considered for calculating the infrastructure costs, congestion costs, environmental costs, and accident costs.

Table 4.6: Summary of the factors considered for each cost component in calculating the marginal cost and average costs

Influencing factors on cost components	Marginal costs	Average social costs
Infrastructure costs		
Equivalent Standard Axle Loads (ESAL)	√	√
AADT	√	√
Congestion costs		
AADT	√	-
Passenger car space equivalence (PCSE)	√	-
Accident costs		
Accident rates per 100 million	√	√
AADT	√	√
Environmental costs		
GHG	√	√
Carbon dioxide equivalent (CO_2e)	√	√
Fuel consumption	√	√
Key: √ SRMC analysis consists of the additional cost increases per vehicle kilometre. Average cost analysis consists of the average costs the group of users imposes on other users, infrastructure, and the rest of society and the environment.		

Source: Author

4.6 RESEARCH PROCEDURES

A formal letter from the Stellenbosch University requesting data was presented to the roads agencies. Although RFA data are mostly available on the organisation's website, the researcher submitted an official letter for permission to use the data, as well as to create awareness of the study. At the Namibian RA, the researcher received an official letter from the office of the chief executive officer (see Appendix B.1). The researcher then used the approval to interact with several departments for the data required. Recent data not available on websites were obtained from the agencies. A disclaimer form was signed for the workspace obtained from the RMS division of the RA (see Appendix B.2). The data obtained from the Roads Authority were kept in an electronic format and only the research and the supervisor had access to the HDM-4 workspace.

4.7 DATA-ANALYSIS PROCESS

The overarching research aim was to establish the relationship between road network preservation, investment needs, and the RUC imposed on the user in accordance with the user-pays principle. This relationship serves as a motivation to explore the HDM-4 model currently used by the RA to plan for the national road network's investment needs and to extend it further by using the same tools to estimate the external costs of road use that are rarely considered in road pricing determination. Data needed for the type of analysis are project specific and require detailed inventory, condition, and performance data (Flintsch & Bryant, 2009). The HDM-4 has been a support system for transport planners and engineers to project the economic, social, and environmental impact that might occur when making investment decisions (Jain, Aggarwal & Parida, 2005). To achieve the research aim, the research addressed three objectives, which are divided into the following two main categories:

A) Road-user spending, revenue generation, and allocations:

(i) To determine road-user spending on road use;
(ii) To establish the allocation of RUCS funds towards infrastructure preservation and development; and
(iii) To compare the revenue generation and allocation to international standards.

B) MEC of road use:

(iv) Estimate the MEC of road use;
(v) Establish the financial implications of implementing the RUC-based on MSC; and
(vi) Explore possible second-best RUC.

The analysis of each data approach to address each objective is further elaborated on in Chapters 5, 6, and 7.

4.7.1 Road-user spending, revenue generation, and allocations

The information gathered from the RFA (total revenue generated through the RUCS) and RA (vehicle kilometre travelled) was used to determine what road users are currently spending per kilometre driven on the road infrastructure. Several descriptive statistical analyses were performed to establish the empirical relationship between road revenue generation, road expenditure, and road allocation and relating these to international standards.

4.7.2 Marginal External Costs of road use

This section explores the usage of the HDM-4 model for estimating the MEC of road use for Namibia. Costs relevant for road use for the calculation of marginal costs and average costs include:

- infrastructure costs;
- congestion costs;
- accidents costs; and
- environmental costs.

The analysis approach involved estimating the marginal costs and average costs. Where marginal costs analysis studies the impacts of an additional vehicle per kilometre assuming that the infrastructure capacity is held constant, average costs analysis examines the social costs associated with the road use and assigns the total social costs to the various vehicle types. Both marginal costs and average costs were compared to the revenue, which varies with road use[12].

Table 4.7: Marginal costs versus average costs

Cost components	Marginal costs	Average costs
Infrastructure costs	Mostly wear-and-tear costs associated with increased costs per vehicle per kilometre.	Include all costs related to the upkeep of existing infrastructure.
Congestion costs	Costs imposed by an additional vehicle on other users using the same network.	Not relevant (costs within the group may result in double counting). Costs across different groups are excluded from this calculation.
Accidents costs	Social costs of an additional vehicle per kilometre; mainly the increase/decrease of accident risks associated with an increase in traffic.	Total external costs associated with different groups of vehicle classes.
Environmental costs	Costs of an additional vehicle per kilometre imposed on society.	Total costs for all vehicle classes per kilometre.
Fuel levies	Revenue generated by an extra vehicle per kilometre.	Overall revenue generated from the fuel levies.

Source: Author

In order to establish a link between road investment, maintenance, and pricing, the study employed the direct approach to estimating the costs of road use. The direct approach involves the use of the HDM-4 mostly used by the roads agencies to analyse the economic effects on various maintenance strategies and investment needs of the road network.

A workspace was obtained from the Namibian RA. Estimations were based on case studies representing a paved road sampled from the trunk, main, and districts roads of the national

[12] The fuel levy among the current RUC was found as one of the instruments that varies with road use.

road network. The road sections were assumed to be homogeneous in order to aggregate network capacity into one speed-flow relationship. Each section, mainly inter-urban roads with two lanes (both wide and standard), road width, and aggregate calibration included climate zones, length (km), and AADT. The vehicle fleet comprises six representative vehicle categories: 4x4 sport utility vehicle, articulated truck, bus, heavy truck, medium car, and mini-bus. The output from the HDM-4 include the NPV, fuel consumption per 1 000 vehicle kilometres, emission per vehicle categories, and speed flow, which formed the basis of the calculation. The estimates were based on three case studies representing a section of an individual paved road. The NPV of a certain action formed the foundation of cost inputs into the calculations. Two alternatives were compared, by calculating the difference between two alternative NPV of certain actions. According to Bruzelius (2004), the marginal costs could be determined as thea difference between two alternatives, mainly NPV with an increase in the AADT (AADT plus one) compared to another NPV (AADT).

Table 4.8: Steps and factors that influence the estimation of Marginal External Costs

Externality costs	Descriptions
Marginal Infrastructure Costs (MIC)	The MIC was were calculated from an output of an HDM-4 run, mainly an estimate of the NPV of an action. Considering the outlined maintenance strategy, two cases (do nothing with AADT and do minimum with AADT increased by one additional unit) were compared, and the difference between the NPV of the two cases are were calculated. Therefore, the cost of the marginal user may be determined. The major factor for consideration for estimating the MIC is the ESAL factor (see Table 4.6). In order to obtain the marginal cost of one vehicle, corrections were made to account for the fact that the analysis was based on an increase in one unit a day, and future days, and not just that specific occasion.
Marginal Congestion Costs (MCC)	The estimate of the MCC relies on the speed-flow relationship. An output of an analysis using the HDM-4 model is an estimation of the net time loss of a certain action. Typically, two alternatives are compared in terms of the hourly flows of a given period as a proportion of the AADT. The marginal time loss may be determined as the difference between two actions; one having an increase in the AADT by one additional vehicle in comparison to another. For the purpose of calculation, it was assumed that time loss is valued at N$5 per minute. A correction was made to account for the homogeneous stream in terms of PCSE for all vehicles. Another factor considered was that the analysis was based on an increase of one unit per minutes, thus a need to cater for all minutes in a given year and not just that particular point.
Marginal Accident Costs (MAC)	An output of an analysis using the HDM-4 model provides input data into for calculating the total accident cost per causality, including fatal, injury, and damage- only costs. The major factors considered ion the estimation of the MAC are mainly the accident rate per 100 million per vehicle per kilometre, the road category, and the annual kilometres travelled.
Marginal Environmental Costs (MENVC)	MENVC, as defined in Chapter 6, includes three components; however, the calculation considered only those associated with global warming. In order to allow comparison between the different GHGs, there is a need to make these gasses comparable to each other. Schroten et al. (2019) posit that the way to compare CO_2 emissions with non-CO_2 emissions is to use the global warming potential (GWP). Global warming costs are calculated by multiplying the GHGs emitted by the GWP, to obtain a CO_2e. The main factor of necessity to global warming costs is fuel consumption per 1 000 km. The Namibian environmental levy rate value of N$40 of CO_2 emissions exceeding 120 g/km was used to assign a monetary value per vehicle per kilometre (Republic of Namibia, 2016).

Source: Author

4.8 STUDY LIMITATIONS

Certain limitations are associated with a series of tools or mechanisms that allow transport planners to make better use of the available resources for maintenance and rehabilitating the road network. Limitations associated with the HDM-4 as outlined by Henry and Kerali (2000) include the following:

- HDM-4 is a powerful decision support tool used in road asset management worldwide to estimate the external costs of road use, e.g. emission. However, HDM-4 requires calibrations to the local environment, which were done by the RA. It is unclear for how long a calibrated version of the HDM-4 remains valid and allows external costs estimation reliability.
- Input of unit costs: HDM-4 uses data for new vehicles as input costs. However, Teravaninthorn and Raballad (2009) observed that in most African countries, transport companies mostly purchase second-hand trucks at a price lower than a brand-new truck. They argue that low-priced vehicles would benefit less from the road improvements of the model, which are meant to reduce vehicle maintenance benefits. Thus, it is concluded that the reliability of the model could be subjective to a certain error margin of large fleets of second-hand vehicles that dominate the African road network. Martinez et al. (2018) posit that such a situation could be minimised by means of local surveys to estimate the average price of a second-hand vehicle fleet.
- Low-volume roads: The HDM-4 considers roads with traffic volume of fewer 50 vehicles per day as inappropriate for analysis (Teravaninthorn & Raballad, 2009); the cost-effectiveness approach could therefore be employed.
- Collection of the required data is expensive and time consuming (Bennett et al., 2006; 2007). Feeding data into the software requires conducting several surveys on traffic counts, pavement conditions, etc., which could be time consuming and requires an extensive budget. Therefore, given the time and budget constraints for this study, the researcher acquired a workspace from the Namibian RA.
- The estimated calculations are complex and based on assumptions of certain scenarios. It is therefore crucial for the user of the results to assess the reliability of the results and how the assumptions may influence the outcome. The way to validate the results is to compare them with similar methodology estimates conducted using a similar model. No effort is made in this study to compare HDM-4 results to other methodologies on estimating external costs as outlined in the literature (Bruzelius, 2004; Schroten et al., 2019) (see Chapter 6). However, the adjustments that are compatible with available data were adopted to estimate the external costs of road use in Namibia.

The limitations pointed out above apply to this study. The Namibian road network is expansive and consists of both paved and unpaved roads; however, this research only covered paved road sections sampled from each road category. The research covered paved road sections sampled from all road categories of the national road network, including trunk, main, and district paved roads. This therefore mitigated the limitations by ensuring that the sampled sections represented all road categories and were sampled from different regions, mainly the Haradap, Erongo, and Otjozondjupa regions. Furthermore, the road matrix utilised included the sample road sections used in this study. The RFA allocates funds to both the national road network and local authorities for urban street maintenance. However, the length of urban roads is unknown, thus the study was limited to assessing RUC-generated funds allocated to the RA.

4.9 SUMMARY

This chapter outlined the overarching methodology used in this study. An analytical tool approach (using multiple sources of secondary data) was employed in order to understand the relationship between planning for network investments and determining the level of RUC imposed on road users by drawing recommended practice from the policy level. The researcher utilised available HDM-4 in order to understand to what extent available databases are useful or necessary for decision making, in particular in determining the level of RUC. The chapter also highlighted the limitations of the study.

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CHAPTER 5:
EVALUATION OF NATIONAL ROAD NETWORK FUNDING IN NAMIBIA: THE CURSE OF EFFICIENT ROAD USER CHARGES[13]

5.1 INTRODUCTION

Road infrastructure is critical for economic development, reducing poverty and inequality, creating jobs, and ensuring environmental sustainability (Carter et al., 2017). Investing in new roads and maintaining the existing road network is therefore an important policy for national development. Road infrastructure requires large capital investments coupled with proper financial administration to ensure sufficient financing and funding in order to meet developmental objectives, specifically of developing countries. In most developing countries, infrastructure investment is under-funded, making it difficult for countries to meet strategic developmental goals such as universal access and poverty eradication. Chapter 2 discussed the importance of road infrastructure and the role it plays in economic development.

The search for more sustainable funds therefore prompted many developing countries to establish second-generation road funds in the 1990s (Heggie, 1995a). These second-generation road funds serve as a departure from using the general tax revenue. The main underlying principle that guides the second-generation road funds emphasises that road users (consumers of scarce resources) should pay for their consumption (Freeman, 1982) through RUC (levies or surcharges), separate from general taxation. Revenue generated from the RUC are designated to the RF, managed by the Road Board, with a specific member chosen to represent road users. The establishment of a second-generation road fund is justifiable based on the argument that it could improve the allocation of resources through the implementation of the RUCS (Gwilliam & Shalizi, 1999). Gwilliam and Shalizi (1999) posit that the introduction of RUC directed to a road fund, instead of relying on the consolidation budget, would increase efficient allocations.

The Namibian RF is a second-generation road fund and is supported by earmarked revenue generated from the implemented RUCS. The RFA was established according to the principles of second-generation road funds. Chapter 2 (see Section 2.3.2) of this dissertation provided a detailed discussion of the principles that guide second-generation road funds.

The common problem with second-generation road funds is that they create the impression that all the revenue generated from the RUC should be sufficient to cover the road network

[13] A short version of this chapter was presented at the 2018 Southern African Transport Conference (SATC); see Petrus and Krygsman (2018).

expenditure. The Namibian RF approach differs from those found in other countries in that the legislation states that RUC should fully recover costs to also include or to cover the expenditure incurred when undertaking justified new investments in the road sector (Bruzelius, 2000). The current RUCS, based on the stated principle of economic efficiency, appears to have run into some problems and has proven to generate insufficient revenue to meet the investment needs of the current national road network (Sherbourne, 2017).

The overall contribution of this chapter lies in using administrative statistics and data in order to evaluate the performance of the current RUCS by focusing on how road revenue is generated, allocated, and spent on the national road network. These are compared to international standards. Previous studies conducted in Namibia focused on reforming the road sector (MWTC, 2000; Bruzelius et al., 2000; Runji, 2003; Bruzelius, 2010) and management of funds (Heggie, 1995a). Taking cognisance of the importance of the roads for economic development, research into road funding has received a great deal of attention internationally. Freeman (1982) and Kocaks, Jones and Whibley (2005) are correct in their observation that conclusions reached in RUC studies should be treated with caution. It is important, therefore, that RUC studies and the user-pays principle in particular be complemented with case studies of developing and diverse countries with small vehicle populations such as Namibia. This study focuses on road national policies' performance and funding approaches for Namibia compared to six selected countries to determine the impacts these have on the levels of road expenditure. This chapter contributes to existing knowledge in terms of how much road users in Namibia are currently spending on utilising the national road network.

This chapter sought to bridge the gap between road reform and the implemented RUCS. It serves as a stepping-stone towards efficient pricing by providing information on the performance of the RUCS in terms of revenue generation, allocation, and road expenses for the national road network. The evaluation conducted in this chapter placed Namibia in the larger knowledge on RUCSs, particularly after establishing the RF.

The aim of this chapter is to offer an overview of the Namibian road funding trajectory after the sector reform. The chapter evaluates the revenue generated from RUC, the allocation thereof towards road expenditure by the RFA, and the funding shortfalls experienced by the RA. The chapter also discusses the ignored dilemma facing many developing countries with road funds, namely the inability of RUC to meet expenditure needs. In addition, this chapter sought to determine what Namibian road users are currently spending on road use per kilometre (on average) and to ascertain how much of these funds are allocated back to road infrastructure maintenance, rehabilitation, and new construction. It also sought to analyse the relationship between the RGR and road expenditure in Namibia and relate these to international standards. Towards these goals, Section 5.2 provides a conceptualisation of funding for the road infrastructure. A review of the literature on road funding is presented in Section 5.3, followed by the methodology in Section 5.4. Section 5.5 presents the results, followed by the summary and discussion of the chapter.

5.2 CONCEPTUALISING FUNDING FOR ROAD INFRASTRUCTURE

There is still a grey area that remains unaddressed in making a distinction between road funding and financing. Current studies offer little help in obtaining a definition or distinction between the two. Transport economists sometimes use the two terms interchangeably to cover road investment, which can be related to the road sector. In essence, quality definitions aim to send a clear message for the purpose of analysis and policy. The definitions postulated here are those of economic perspectives. However, before discussing road funding, it is essential to define and clearly distinguish between public infrastructure funding, financing, and charging instruments.

5.2.1 Definitions of road funding and financing

Funding denotes money provided by the government or a road fund to roads authorities based on set agreements and with no expectation of being paid back (Waqar, 2015). Funding can be sourced directly from the road users or indirectly through general rates and taxes that the government imposes on individuals and companies. However, funding for road infrastructure should not be left to the public sector alone, which should look for opportunities to involve both road users and the private sector in order to fund road projects together. In this context, Davies (2016) recommends that the public sector should undertake a radical approach to looking for private sector funding opportunities.

In contrast, **financing** refers to the capital obligations required for infrastructure investment. For example, road infrastructure can be financed by the public sector through surplus recurrent revenues or the private sector through public-private partnerships (PPPs). It is worth noting that when the private sector provides finance for road infrastructure, it ultimately requires a return on investment. Davies (2016) established that finance comes at a price, which is normally above the government cost of finance. Historically, private financing entails transferring project cost risk and expertise and introducing efficiencies. Moreover, it is worth engaging the private sector if risk transfer, expertise, and efficiencies introduced compensate for the higher finance cost. Otherwise, while it is more affordable for the public sector to source financing for infrastructure, it is ultimately required to pay higher returns in the long run.

Therefore, the government should take careful consideration before involving the private sector for infrastructure financing.

Funding for road infrastructure is often generated from the charging instruments in place. **Charging** is therefore a subset of funding, as it refers to the mechanism, type of instruments, levies, and taxes that should be paid. It is critical that sources of funding are in place to support financing. Funding and financing go hand in hand; however, they are fundamentally different. Davies (2016) posits that funding opportunities normally arise where the private sector is already financing an asset.

5.2.2 The Namibian road funding policy framework

Namibia has adopted various initiatives and national policy documents, including plans with direct implications for road funding; namely the NDPs (NPC, 2012; 2017), the White Paper on Transport Policy (MWTC, 1995), the Namibian Transport Master Plan and Master Plan of an International Logistics Hub for SADC Countries (NPC, 2015b), the Windhoek Urban Master Plan (City of Windhoek, 2014), the Road Transport Sustainability Plan (RA, 2015c), and the Namibian Transport Policy (MWT, 2017). All initiatives towards road infrastructure and road safety require funding and place a heavy demand on the current funding sources[14].

Literature on road funding and financial initiatives from different parts of the world illustrates that fuel levies tend to be the main source of road revenue (Kumar, 2002; TRB, 2006). Due to several trends, fuel levies may lose their effectiveness as the main source of income. There is thus a need to implement the recommended user-pays principle for charging road users. The following section discusses various RUC implemented in Namibia and other countries

5.2.3 Road User Charges

These charging instruments are commonly divided into two categories. The first category comprises those that are charged on the road use and that are related to vehicle acquisition, vehicle ownership, and vehicle usage. The second category entails those that are levied on the road beneficiaries and are mainly used in municipal areas for urban access roads and in rural areas for road access (Heggie, 1995b). This study focused on the first category of RUC.

Road users are interested in a well-maintained road network that could reduce their vehicles' operating costs. Therefore, the first step in sourcing road maintenance funding is to ensure that road users pay for the cost of road maintenance (Queiroz, 2009). Experience in various

[14] Current road expenses are funded by the RFA (through RUC) and the government (SRF), complemented by development partners (loans and grants to both the GRN and RFA).

countries indicates that road users are willing to pay for road maintenance and even for further road network expansion provided that the generated revenue is allocated back to improving road networks (Queiroz, 2003). According to Yenny (2002, cited in Queiroz, 2009:2), RUC must be economically efficient, equitable[15], easy to collect, and not easily evaded. Moreover, RUC should be adjusted for inflation. Preferably, RUC instruments should be closely linked to the use of the road network. To that effect, appropriate charges are those charged for road space and the damage that HGVs impose on the roads. Funding for roads should take into consideration the conditions and characteristics of the country under review. It suffices to analyse the current RUC instruments in the Namibian context.

Table 5.1: Revenue streams over the past seven years

RUC (in millions)							
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Fuel levy	852	937	975	1 035	1 105	1 299	1 341
AVLRF and ALF	330	392	410	408	458	586	634
CBC	67	78	86	97	106	122	125
MDC	38	51	63	71	85	85	98
Total revenue	**1 288**	**1 459**	**1 535**	**1 613**	**1 756**	**2 094**	**2 199**

Source: Author (Data from RFA, 2018)

In Namibia, the White Paper on Transport Policy recommends that the full cost for providing the roads be recovered from the road users (MWTC, 1995). To that effect, five charging instruments as per the RFA Act of 1999 were introduced:

(i) **Fuel levy** is one of the common RUC that is widely applied and to some extent varies (proportionately) to the use of the road network. Fuel levies are relatively inexpensive to collect and easy to administer. However, the major shortcoming with a fuel levy is that it does not reflect much of the increased damage imposed on the roads by HGVs. Although HGVs consume more fuel per kilometre than light vehicles, the impact imposed on the road is not proportional with the fuel levy (Queiroz, 2009). A fuel levy should therefore be supplemented by an additional charge that better reflects the cost HGVs impose on the roads. In Namibia, the fuel levy is charged on every litre of diesel and petrol sold and collected by commercial undertakings (Puma, Total, Engen, and Vivo Energy) on behalf of the RFA and deposited directly into the RF's account.

(ii) **MDC or Vehicle Travelling Distance Charges (VTDC)** have been successfully implemented in developed countries, including New Zealand, Sweden, and Norway.

[15] Equity implies that RUC should not have the effect where a certain part of the community is taxed to provide a facility that they largely do not use or that some users subsidise another group. In addition, there must be fair competition between rail/road mode.

It represents the marginal cost of road use. These charges are imposed through sealed hub odometers, on-board devices, GPS, smartphone applications, and in-vehicle telematics. Implementing MDC/VTDC can be costly and requires sophisticated administration. Another shortcoming is that MDC are prone to evasion. For instance, in New Zealand, evasion was recorded as ranging between 10% to 20% (Queiroz, 2009). In 2007, the RFA introduced MDC to ensure that HGV[16] operators pay their fair share towards the maintenance of road infrastructure. MDC are imposed on HGVs (domestic and foreign) with a carrying capacity over 3 500 kg travelling on Namibian roads (see Section 2.3.3.4 of Chapter 2 for fees per vehicle category). The MDC are based on distance travelled within the country, HVG owners are therefore obliged to declare their vehicle odometer readings at the RFA office situated at the border post or nearby town when entering and leaving Namibia. The MDC in Namibia has been faced with implementation challenges, which is the measure's ability to allocate charges to HGVs whose use of the road infrastructure imposes the greatest costs on the road network (Diop et al., 2012). Despite the implementation of MDC, during the financial year 2015/2016, the RFA managed to collected approximately N$59 465 000 and N$25 938 000 from local and foreign HGVs respectively. Prepaid payments can be done directly to the RFA bank account and a permit is issued upon furnishing proof of payment. Evasion is high as the measures are based on self-declaration of distance travelled by the owner[17]. Compliance concerning MDC permits are checked by means of law enforcement in place through the traffic police, roadblocks by the Namibian Police, and through the RA weigh bridge stations across the country. Non-compliance is charged with an amount not exceeding N$4 000 at any of the law enforcement points.

(iii) **CBC** are imposed on foreign-registered motor vehicles (including motor cycles) that utilise the Namibian road network. During 2015/2016, the RFA collected approximately N$122 817 000. The amount was collected by RFA offices located at various Namibian border posts or towns (RFA, 2016).

(iv) **AVLRF** are commonly charged on an annual basis. The fees vary across the different types of vehicles and are easy to administer. The disadvantages of this method are that they are not related to the use of the road. In Namibia, licensing fees are collected by e-NATIS on behalf of the RFA. e-NATIS has approximately 35 offices across the 14 regions of Namibia, 21 testing centres, and three registering

[16] MDC apply to all foreign and domestic vehicle in excess of 3 500 kg that utilise the road infrastructure, as consumption is perceived to increase with vehicle mass.

[17] The system is manual, owners of HGVs must therefore declare the distance travelled.

offices that are directly managed by the RA, while 11 e-NATIS centres are managed by local authorities on a memorandum of agreement with the RA (RA, 2017).

(v) **ALF** are charged on HGVs carrying abnormal loads. Due to their dimensions, abnormal loads cannot be transported without exceeding the mass limitations. Therefore, charges should be imposed on oversized or overloaded vehicles to compensate for the extra damage such vehicles impose on the roads. These fees represent the fixed cost associated with providing the roads (Runji, 2003). Drawbacks associated with abnormal load vehicles involve the increase of the financial burden on road maintenance and that it requires advance payment (charges) for future capital investment for new facilities (Newbery et al., 1988). Another drawback is that such charges can be easily avoided through bribes. In Namibia, the RA issues abnormal load permits and collects payments on behalf of the RFA. During the 2015/2016 financial year, abnormal load charges amounted to N$12 986 000 (RFA, 2016).

Other notable sources of funds include grants and loans offered by development partners, commercial bank loans, and bonds issued by the Infrastructure Finance Corporation. The government acquires grants and loans at favourable interest rates from the development partners (e.g. the RFA16 Loan Stock and the KfW Grant). Given the RFA's revenue flow ability, the RF must keep its eye on the lending market.

> "The RFA through government grantee reached a loan agreement with KfW Development Bank in November 2015 for N$447 million, as per the Road Fund mandate … 'to secure and allocate sufficient funding' (the RFA Act, 18 of 1999 section 3). The loan was made possible through a financial cooperation agreement between the GRN and the Federal Republic of Germany under the Programme Sector Wide Approach Road Transport 2 and 3. This loan was specifically earmarked towards bridging the gap occurred in road rehabilitation particularly for upgrading of Trunk Road 1/6 to a dual carriage freeway (Windhoek to Okahandja)" (RFA, 2018:33).

The earnings accumulated from the fund invested in the diversified local money market instruments redeemed the RFA16 Loan Stock.

(vi) **Road pricing** that exists elsewhere in the world but which has not yet been applied in Namibia, such as:

(i) In most countries, **tolls** are strategically positioned on specific roads, bridges, and tunnels. Tolls are set at a level that is equitable and proportional with road usage. Tolls are, however, an expensive form of raising revenue. It is costly to construct toll plazas, tollbooths, controlled access points, and operating costs. In order to establish tolls, they must comply with the rule of thumb in such a way that traffic volumes on the targeted tolled road should not be less than 10 000 vehicles per day (Bousquet & Queiroz, 1996). When this condition is met, it is likely that administrative costs are kept at a low percentage of the toll revenues.

(ii) **Vignettes** are usually sold for a period of one year or less and can be used during the valid time irrespective of the distance driven and therefore do not address the issue of charging for the use of the road. The drawback of this method is that evasion is likely to be high as verification of vehicles that display vignettes are only done through random checks.

5.3 EMPIRICAL LITERATURE REVIEW ON ROAD FUNDING

Funding for road transport networks has been the subject of ongoing research in recent decades (Freeman, 1982; Jones & Hervik, 1992; Grieco & Jones, 1994; Fon & Heggie, 1999; Gomez & Vassallo, 2014). Studies that investigated the efficient utilisation of resources often focused on economic appraisal of user charges and other taxes levied by the government (see Walter, 1968; Freeman, 1982). Some studies attempted a thorough investigation of road financing systems by focusing on the instruments in place (Queiroz, 2009). Others conducted comparison analyses of road revenue generation, allocation, and expenditure-related ratios (Gomezo & Vassallo, 2014).

In comparison, few studies have focused on sub-Saharan African countries and in particular on Namibia. There are a few traceable papers on the Namibian road sector reform, including Mwase (1987), Bruzelius (2000), Bruzelius et al. (2000), Runji (2003), and Tekie (2005). Mwase (1987) researched funding transport and communication with emphasis on the transformation of the road sector from pre-independent to independent Namibia. In contrast, Bruzelius (2000) and Tekie (2005) explored road management. Runji (2003) discussed in detail the road sector reform process as one moving from dependence on the SRF to one managed and partially funded by the RF. Several studies focused on road funding and financing (Freeman, 1982; Bousquet & Queiroz, 1996; Gomez & Vassallo, 2014); however, the treatment of the road financial system in Namibia is yet to be explored.

The literature on road financing systems has mostly been developed around important yet controversial issues such as earmarking, revenue generation, and expenditure levels with the major focus on maintenance and rehabilitation of the existing roads as a priority versus the development of new roads. The following review follows each of them respectively.

5.3.1 First-generation funds, second-generation funds, earmarking, and commercialisation

Government objectives are multifaceted and state budgets cater for various sectors. For example, due to the growing population, governments may prioritise the social sector over the road sector. Insufficient budget allocation towards the road sector has severe implications for the sector, as it creates a maintenance backlog, which leads to increased transport costs in the long run. On the other hand, road rehabilitation and maintenance seem not to receive priority and promote political agendas as opposed to the development of new roads (Zietlow & Bull, 2002). Interestingly, international agencies support many developing countries with road construction (Orondje et al., 2014). Addressing road maintenance expenses therefore remains a challenge in many developing countries. The search for sustainable funds prompted many developing countries to establish road funds mainly in the 1990s (Heggie, 1995b). The so-called second-generation road funds are funded through RUC instruments. The establishment of a road fund is justifiable based on the argument that it could improve the allocation of resources through the implementation of an RUCS (Gwilliam & Shalizi, 1999). Although second-generation road funds are recommended for sustainable funding of the road sector, they are not necessary or effective in all countries. Experience reveals that countries with good governance manage to maintain their road networks through state budget arrangements. Gwillian and Shalizi (1999) argue that other factors such as poor governance have the potential to make it difficult for a country to maintain the road system even with the establishment of a road fund.

Economists and public finance specialists have criticised the establishment of road funds on the grounds that they constitute earmarking (see Creightney, 1993; De Richercour & Heggie, 1995; Bousquet & Queiroz, 1996; Potter, 1997; Heggie & Vickers, 1998; Calvo, 1998; Gwilliam & Shalizi, 1999; Heggie, 2003; Orondje et al., 2014). Some argue that road funds introduce fiscal inflexibility and fail to address challenges with respect to the internalisation of externalities and do not address the principle of unified budget management. Surprisingly, Gwilliam and Kumar (2003) state that second-generation road funds do not undermine fiscal flexibility, but rather have been an instrument that improves the administration process and output of a road fund in terms of execution capability and the condition of the road network.

Another argument is that the government is best positioned to make decisions on distribution and allocation of revenue and that earmarking taxes for specific sectors is inappropriate. The Asian Development Bank (2015) indicates that first-generation road funds have led to deficiencies in the road sector system with significantly low road maintenance, resource misallocation, and over-investments in projects with low economic returns.

Earmarking of funds is stipulated by the World Bank (1996) as appropriate in a case where there is a high need to protect a certain budget item or in a situation where maintenance planning and implementation have been affected by funding insecurity. Therefore, such cases justify the need for second-generation road funds or better options for the RFA to argue for RUC increments with the aim of strengthening road network maintenance (Queiroz, 2003).

Earmarking of funds should therefore be treated with caution, as each country needs to determine the proportion of taxes and levies to be earmarked for road maintenance and rehabilitation. For instance, Bousquet and Queiroz (1996) used France and the USA as case studies to argue that it is possible for a country to a have good road system with or without the implementation of a second-generation road fund. They demonstrated how both France and the USA managed to have adequate road infrastructure while operating different road funding systems. The USA practises earmarking of the road sector with funds designated to its HTF, whereas in France, with the exception of the motorway tolls, road-related taxes and levies are directed to the general budget.

Therefore, road funds should prevail at all levels concerning resource gathering and expenditure. In addition, users should pay their fair share and administration should see to it that appropriate proportions are allocated towards road expenditure. Finally, sufficient funds should be allocated to roads agencies for the preservation of road networks.

Commercialised road funding implies that revenues should be raised from the RUC and not from general taxes or levies. It also implies that revenues are designated to a road fund and are kept apart from the general funds. This justifies the adjustment of road tariffs on a regular basis with the aim to meet the expected required expenditure. Finally, the revenue generated should finance the maintenance and rehabilitation of the road network and a road fund should not extract further revenue from other sectors.

5.3.2 Maintenance of existing roads versus development of new roads

Inadequate maintenance results in high transport costs and subsequently raises the net costs to the whole economy. Metschies and Rausch (1991) state that the latter has proven (in many African countries) to be a major obstacle to national economic development. Bousquet and Queiroz (1996) agree that insufficient budget allocation to the road sector has implications and constrains economic development. They argue that deteriorated roads have high implications for high vehicle operation, loss of time for road users due to low speed, and high prices.

Vehicle-operating costs increase more than double or triple for each dollar saved on road maintenance (Thriscutt & Mason, 1991). For every additional US dollar roads agencies in developing countries spend on road maintenance, road users save approximately three US dollars (Asian Development Bank, 2003). Insufficient allocation towards road maintenance is often demonstrated by high return to maintenance and rehabilitation (Harral & Faiz, 1988). The backlog of deferred maintenance remains a great concern in many developing countries. Heggie (2003) asserts that in many developing countries, only about a third of the funds required for road maintenance was allocated, which is a main reason for the shortage of funds for maintenance. A properly maintained road benefits not only the users but also contributes to economic development.

Potter (1997) raises the question whether there is a difference between road funds covering road maintenance and rehabilitation only and those that cover capital spending. Potter's (1997) rationale is, for as long as the road funds or roads authorities receive funds from the general budget, they tend to compete with other sectors for budget provision. Countries where road funds pursue a genuine commercial agency approach are likely to achieve efficient means of delivering road maintenance and even cover their capital expenditure. Most developed countries with efficient budgetary systems have proven to satisfy the latter condition. For example, road revenue is significantly higher than road expenditure in most European countries (Bousquet & Queiroz, 1996). However, in many developing countries, recommendations were to reform the road sector and road funds' and agencies' procedures and practices in order to attain efficient road funds financial system.

5.3.3 Road sector funding systems: Cross-country comparison

When reviewing a country's public expenditure, it is helpful to analyse the road financing plan associated with its GDP. This is mainly because other indicators such as comparing one country to another can be very helpful; however, the limitation of this approach lies in the availability of data for both countries (Heggie, 2004). In his cross-comparison between countries with road funds and those without road funds, Heggie (2004) found that countries with road funds spend on average 1.6% of their GDP on their roads. Across the countries under review, the percentage of GDP on road spending ranged from 1.2% in the USA to 2.5%, making Japan the top country among the analysed spending patterns. Figures for maintenance spending have been a challenge, especially in Africa. Heggie (2004) indicates that figures on maintenance spending were below the requirements, with an average of 0.8%. To summarise, maintenance spending figures should be used as a guideline as it is anticipated that some figures might have included rehabilitation costs. When associating maintenance spending to the country's GDP, the rule of thumb implies that the preferred GDP percentage should range between 0.5% and 1.0%, while a range between 1.0% and 2.0% is preferred for total road spending (Heggie, 2004).

5.4 METHODOLOGY

Research is based on underlying philosophical assumptions of what constitutes validity and reliability. In this chapter, document analysis was employed to empirically investigate the Namibian road funding system and compare it to selected developed countries. Towards this goal, a thorough analysis of national road networks was conducted. This chapter presents the Namibian road funding system and outlines the sources of RGR systems, how the revenue is distributed to the approval authorities, and how such revenue is spent on road expenditure. In so doing, the chapter used administrative statistics. According to the African Development Bank, administrative statistics is one of the principal sources of data (Africa Development Bank, World Bank & The Infrastructure Consortium for Africa, 2011:5). Given that the chapter focuses on road funding from the supply side, the institution responsible for road services furnish the administrative records. In contrast, from the demand side (users), national sources such as censuses and surveys provide variable data. In addition, many public and private global databases also provide variable complementary information on road infrastructure.

5.4.1 Data sources

The primary analysis of the Namibian road funding system utilised secondary data for the period 2011 to 2016 in an annual time series. The roads agencies, line ministries, and affiliated public enterprises in the road sub-sector were pragmatically identified. For international comparison, ratio data for the developed countries (the USA, selected countries in the EU, the United Kingdom (UK), Switzerland, Germany, Spain, and France) for the period 2004 to 2009 were extracted from Gomez and Vassallo (2014).

Table 5.2: Selected institutions for data collection

Institution	Data collected	Category
Road Fund Administration (RFA)	Annual reports, policies, newspaper articles, Acts, plans, and strategy documents	Roads agency
Roads Authority (RA)	Annual reports, budgets, plans, policies, research reports, newspaper articles, and statistics on vehicle population	Roads agency
Ministry of Works and Transport (MWT)	Policies and research reports	Line ministry
National Planning Commission (NPC)	Plans and research reports	Affiliated ministry
Ministry of Mines and Energy (MME)	Fuel composition	Affiliated ministry
Ministry of Finance (MoF)	Statistics on revenue generated outside the RUCS	Affiliated ministry
National Statistic Agency (NSA)	Data on national account	Public enterprise
Motor Vehicle Accident (MVA) Fund	Annual reports	Public enterprise

Source: Author

5.4.2 Documentary analysis

Documents related to the topic, including annual reports, budgets, plans, policies, research reports, newspaper articles, and published and unpublished articles, were collected from the institutions listed in Table 5.2. This method was adopted from Heggie and Quick (1990).

Road revenue generated through RUC was utilised to estimate how much road users spent (on average) on the road network and how much of these funds were allocated back to road infrastructure investment. To that effect, three ratios were calculated, namely the (i) RGR ratio, (ii) road expenditure ratio, and (iii) road allocated ratio for Namibia and comparing them to international standards.

Table 5.3: Items covered in the ratio calculation for the Namibia national road network

Concept	Road Expenditure	RGR	Road Allocation
Items covered	***National road network operation expenditure:*** • Maintenance • Construction and rehabilitation • Network planning and consultation • RMS • Road inspection services • Transport information and agents	***Road taxes, levies and charges inside and outside RUCS:*** • Fuel levies • MDC • CBC • Vehicle registration and licences • Abnormal load levies • Vehicle excise duties, vehicle import duties, ad valorem taxes, and VAT on vehicle purchases	***Source of funds:*** • SRF • RF

Source: Author (Gomez & Vassallo, 2014)

Table 5.3 presents the Namibian data used for ratio calculation. The data seek to illustrate the percentage of both road revenue generated from the road users. The analysis of the three ratios was conducted on the Namibia national road network as follows:

- ***Road expenditure*** illustrates the operational expenditure spent on the Namibian national road network managed by the RA.
- ***RGR*** represents all revenue generated through the RUC, taxes, and levies the road users are charged, both directly and indirectly for utilising the Namibian national road network.
- ***Road allocation*** denotes the budget allocated to the RA from various sources including the GRN (including loans and grants) and the RF (RUC) towards national road network management.

5.4.3 International comparison

The comparison aimed to quantify the annual revenues generated through RUC (fuel levy, MDC, vehicle registration and licences, CBC, and abnormal load charges) in Namibia and compare them to the annual national roads level of expenditure. In comparing the Namibian road funding system to selected developed countries, three ratios used by Gomez and Vassallo (2014) were adopted to calculate the Namibian road funding model, namely:

- Expenditure/revenue_ratio $= \frac{RE}{RGR}$ (1)
- Expenditure/GDP_ratio $= \frac{RE}{National\_GDP}$ (2)
- Road Allocation_ratio $= \frac{AR}{RGR}$ (3)

5.5 RESULTS

Road funding sources in Namibia can be divided into two categories, namely (1) allocation from the RF (revenue generated from RUC) and (2) allocation from the SRF (revenue generated from general government taxes). Revenue from the RUC relates to the actual use of the road network by different vehicle types and varies with road use. All revenue generated from RUC accrues to the RF. Revenue allocation from the SRF comprises the national government funds mainly generated from general taxes, which are not associated with the vehicle use of roads and are thus not earmarked for a specific sector.

5.5.1 Namibian road funding and its sources

Namibia generates revenue from various sources such as personal income tax, VAT, company tax, property tax, and trade tax (on goods imported into Namibia), as well as income from the SACU, of which Namibia is a member state. During the 2016 fiscal year, government revenue amounted to N$55 440 billion (MoF, 2016). Income from international trade and transactions, individual tax income, domestic taxes on goods and services, company taxes, and fuel levies contributed 31%, 23%, 19%, 14%, and 5% (see Figure 5.1) respectively to total government revenue (MoF, 2016). The government also collects revenue from other sources such as royalties from minerals (like diamonds and copper), as well as dividends from public enterprises and various administrative fees, fines, permits, and charges. In addition, the government also raises funds by selling T-Bills and bonds to the domestic market and borrowing money from international financial markets.

Filling large voids with external financing entailing account deficits, however, make the economy prone to balance of payment crises, and brings about macroeconomic instability

(Okondjo-Iweala, Pinto & Birdsall, 2018). These challenges drive the government to explore and recognise the importance of the domestic saving rate.

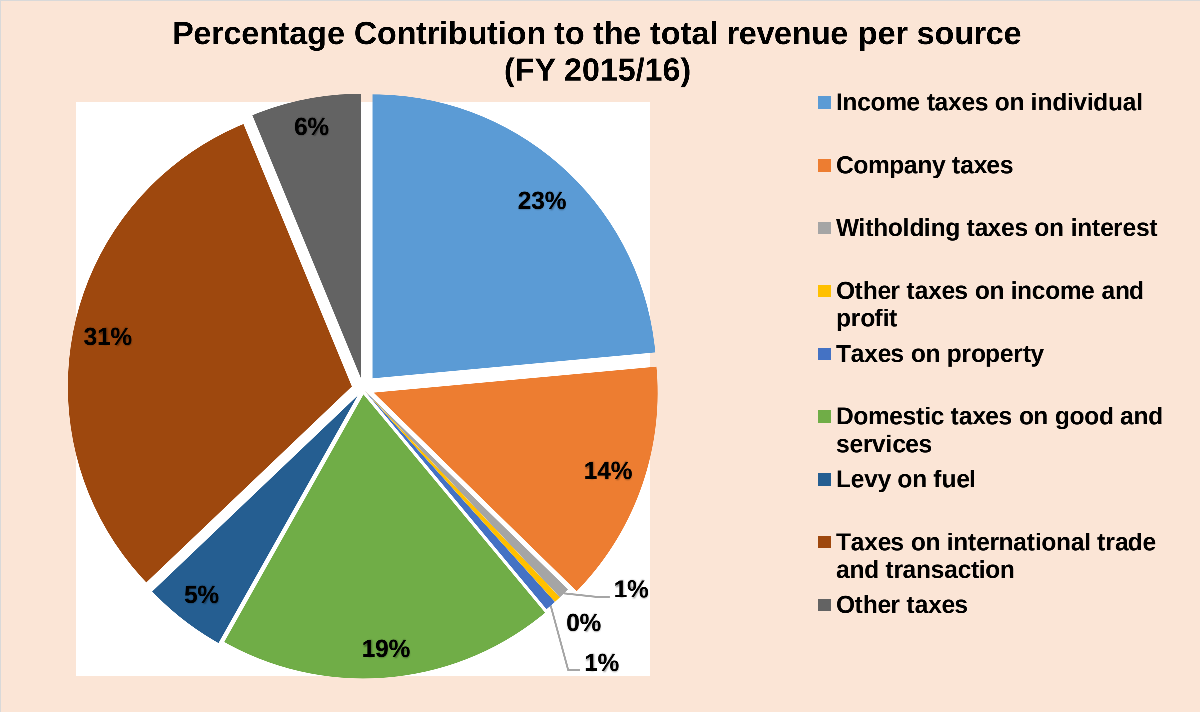

Figure 5.1: Percentage contribution to total revenue per source

Source: Author (Data from MoF, 2016)

All income collected by the national government accrues to the SRF within the MoF. The state budget is allocated to various implementing agencies, including government offices, ministries, or agencies[18]. In addition to the funds allocated from the state budget, municipalities and councils can mobilise funding through various charges such as tariffs and property rates and taxes[19].

Road revenue generation in Namibia can be divided into two categories, namely (1) revenue generated from RUC and (2) revenue generated through the general government taxes. Revenue generated from RUC relates to the actual use of the road network by different vehicle types utilising the roads and varies with the road use. Revenue from general taxes includes national government taxes and tariffs on road-related commodities, which are not associated with the vehicle use of roads, thus they are not earmarked for a specific sector.

[18] Various agencies submit their developmental programmes and projects through the NPC for funding. The NPC analyses and assesses Development Budget submissions from various offices, ministries, or agencies and forwards recommendations for funding to the MoF. The Development Programme's Estimates of Expenditure are then presented in the form of an MTEF, which is a three-year rolling budget. The first year provides accurate figures, followed by estimates for the two consecutive years.

[19] Of all the municipalities, only the City of Windhoek applies parking fees and charges.

Following the establishment of the RF in Namibia in 2000, funding for roads in Namibia has been provided though a combined funding mechanism. Funds generated from the RUC accrue to the RF and is allocated to the approved authorities mandated to manage various road networks. In addition, authorities also receive an annual budget from the national government towards road development projects. Figure 5.2 presented the three stages of the current road funding approaches in Namibia.

The first stage illustrates the receipts of funds for both revenue generated from the RUC and government taxes and tariffs. The roads agencies are responsible for collecting road charges and depositing them to the RF. In contrast, the government through the MoF receives general taxes and levies that accumulate to the SRF. Another agency at this level is the MAV Fund that receives a designated fuel levy charged from the road users.

The second link presents the distribution of funds to various roads agencies and related expenses. The last link focuses on the national road network expenditure. It shows how the funds received from the two sources and allocated to the RA for the fiscal year 2015/2016 were spent.

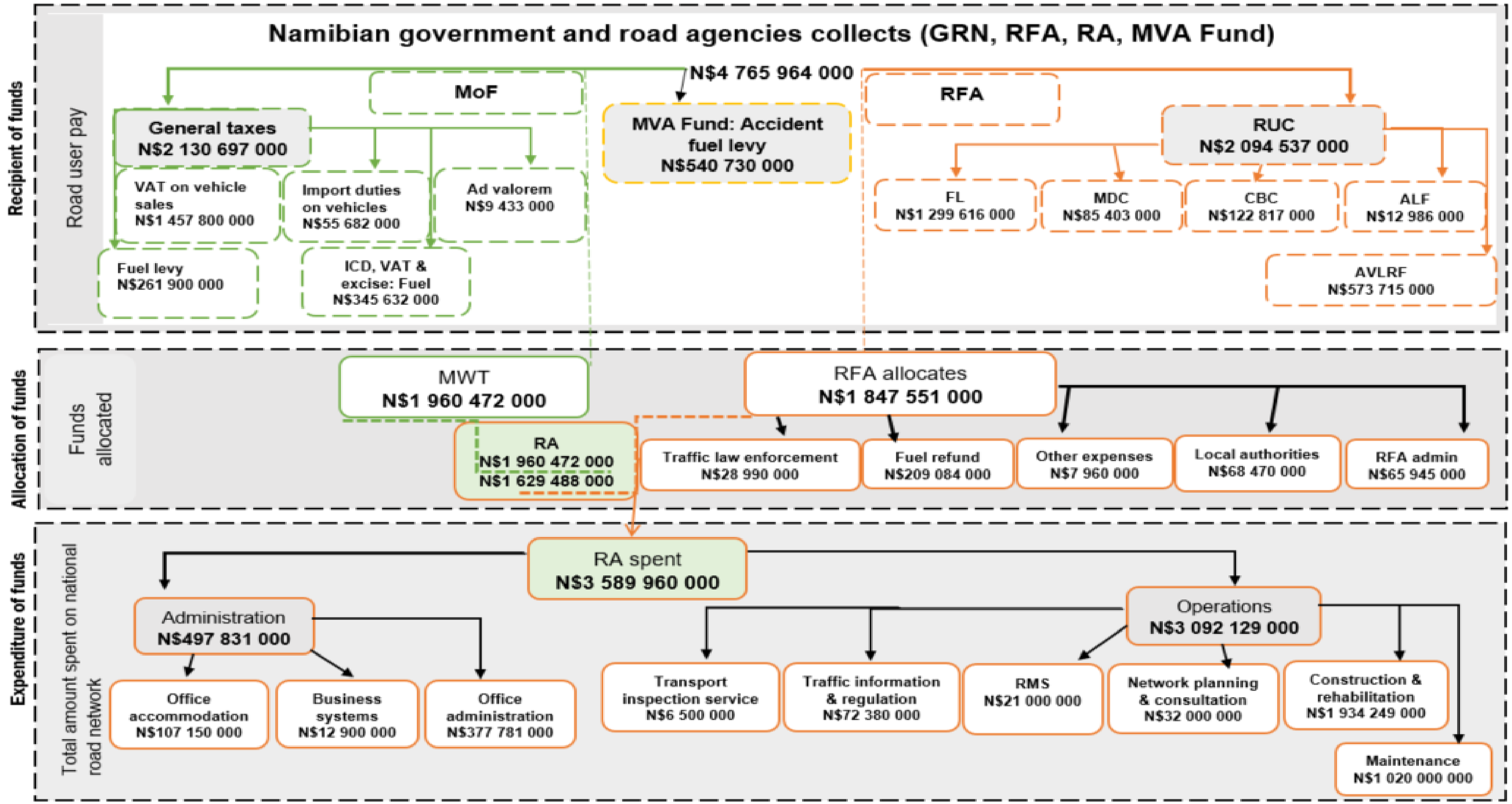

Figure 5.2: Namibia road funding and allocation flowchart approaches[20]

Source: Author (Based on various sources, including RFA, RA, MoF & MVA Fund)

20 RA administration for the 2016 fiscal year amount includes the post-retirement medical aid of N$20 892 000.

5.5.2 Aggregated road-generated revenue for the period 2011 to 2016

The RFA depends mainly on revenue streams generated through the current RUCS to fulfil its mandate. Table 5.4 depicts the aggregated revenue collected from the road users in Namibia. In total, Namibia collected N$4.765 million from road users.

During the 2015/2016 financial year, the RF generated a total revenue of N$2.094 million from the RUC (see Table 5.4). The road funds generated are allocated to the "approved authorities" towards national road network-related maintenance and rehabilitation. In addition, allocation to other expenses includes (i) maintenance of major urban and arterial roads, (ii) traffic-related maintenance of urban roads and streets, (iii) traffic law enforcement and traffic information systems, (iv) the RA, and (v) RFA administrative costs, among others.

Tables 5.4 and 5.5 show that RGR is made up of revenue generated inside and outside the RUC.

Table 5.4: Aggregated road-generated revenue for the period 2011 to 2016 (in million)

Income stream	2011	2012	2013	2014	2015	2016	Coordinated by
Fuel levy N$1.22/l	852	938	975	1,035	1,106	1,299	RFA
AVLRF	323	383	404	390	475	574	RFA
CBC	67	78	87	97	106	123	RFA
MDC local	30	42	48	52	63	59	RFA
MDC foreign	7	9	16	19	22	26	RFA
ALF	7	8	6	18	13	13	RFA
Total revenue	**1,287**	**1,458**	**1,536**	**1,611**	**1,785**	**2,081**	**RFA**
MVA Fund: Fuel levy N$50.3/l	286	344	390	448	505	541	MVA
Total revenue from RUC	**1,573**	**1,802**	**1,926**	**2,059**	**2,291**	**2,622**	
VAT on vehicle sales	922	1,067	1,294	1,769	1701	1,458	GRN
Import duties: Vehicles	24	54	80	92	120	56	GRN
Fuel levy	104	110	87	52	174	262	GRN
Ad valorem	5	6	37	30	49	9	GRN
Excise duties: Fuel	4	10	15	12	31	50	GRN
VAT on fuel	114	184	198	221	444	292	GRN
Import duties: Fuel	25	576	837	723	2	2	GRN
Revenue from general taxes	**1,194**	**2,007**	**2,548**	**2,887**	**2,521**	**2,079**	
***Total Revenue**	**2,767**	**3,809**	**4,474**	**4,946**	**4,812**	**4,701**	

Source: Author (Based on various sources: RFA, MoF, MVA Fund & RA, 2011-2016)

Table 5.5: Percentage of aggregated road-generated revenue for the period 2011 to 2016

Percentage of income stream	2011	2012	2013	2014	2015	2016	Coordinated by
Fuel levy	31%	25%	22%	21%	23%	28%	RFA
AVLRF	12%	10%	9%	8%	10%	12%	RFA
CBC	2%	2%	2%	2%	2%	3%	RFA
MDC local	1%	1%	1%	1%	1%	1%	RFA
MDC foreign	0.3%	0.2%	0.4%	0.4%	0.5%	0.6%	RFA
ALF	0.3%	0.2%	0.1%	0.4%	0.3%	0.3%	RFA
MVA Fund: Fuel levy*	10%	9%	9%	9%	11%	12%	MVA
VAT on vehicle sales	33%	28%	29%	36%	35%	31%	GRN
Import duties: Vehicles	1%	1%	2%	2%	2%	1%	GRN
Fuel levy	4%	3%	2%	1%	4%	6%	GRN
Ad valorem	0.2%	0.2%	1%	1%	1%	0.2%	GRN
Excise: Fuel	0.1%	0.3	0.3%	0.2%	1%	1%	GRN
VAT on fuel	4%	5%	4%	4%	9%	6%	GRN
Import duties: Fuel	1%	15%	19%	15%	0.04%	0.04%	GRN
Total revenue	100%	100%	100%	100%	100%	100%	
Direct income	**57%**	**47%**	**43%**	**42%**	**48%**	**56%**	**RUC**
Indirect income	**43%**	**53%**	**57%**	**58%**	**52%**	**44%**	**Taxes/tariffs**

Source: Author (various sources RFA; MoF; MVA Fund; and RA, 2011-2016)

The revenue depicted a positive increase between the period 2010/2011 to 2015/2016. However, the RUC were not increased annually, in particular the main contributor, the fuel levy, has not been kept on par with inflation. This significantly contributed to the effect on the economic slowdown on road revenue collected in 2012/2013 and 2014/2015.

In 2015/2016, N$2.081 billion was collected through the RUCS and approximately N$2.079 billion was collected through government taxes and tariffs. The fuel levy formed the highest contributor both to the RF and to the MVA Fund, comprising N$1.299 million (28%) and N$541 million (12%) respectively.

In Namibia, fuel levies are collected by commercial fuel stations, namely Engen Namibia (Pty) Ltd, Total Namibia (Pty) Ltd, Puma Namibia Ltd, and Vivo Energy Namibia (Pty) Ltd on behalf of the RFA and paid directly to the RF. Petrol and diesel in August 2017 were sold at N$10.50 and N$10.33 per litre respectively (MME, 2017). Of the N$10.50 per litre and N$10.33 per litre, the fuel levy charged for road use towards the RFA and MVA Fund are inclusive.

By March 2011, the fuel levy was charged at N$0.99 per litre on petrol and N$1.04 per litre on diesel by April 2011. An increase in the fuel levy of 10% was further recorded by April 2015, thus both petrol and diesel were charged at N$1.14 per litre. In June 2017, an increase of 8% was granted on both petrol and diesel. The fuel levies accruing to the RFA are set at N$1.22 per litre of petrol and diesel.

In contrast, the MVA Fund is able to fulfil its mandate as per the MVA Fund Act (No. 10 of 2007)[21], through which the fuel levy provided by the MME is set at 50.3 Namibian cents per litre petrol and diesel sold (MME, 2017). The fuel levy is the highest contributor toward the revenue stream generated inside the RUCS and contributed approximately N$1 105 591 000 and N$1 299 616 000 during the 2014/2015 and 2015/2016 financial years respectively (RFA, 2016).

5.5.2.1 Revenue streams generated from the Road User Charge System

Road users pay charges and fees for owning and operating a vehicle on the national road network and other roads. The RUC instruments in place include the fuel levy, AVLRF, MDC, CBC, and ALF. The fuel levy dominated the revenue generated from the RUC for the period 2007 to 2017. During the 2016/2017 fiscal year, the fuel levy (N$1.22 per litre for both diesel and petrol) contributed N$1.341 million (61%) to the total RUC revenue, AVLRF and ALF N$634 million (29%), CBC N$125 million (6%), and MDC N$98 million (4%). Figure 5.3 illustrates the trend of revenue generated from the RUC from 2006/2007 to 2016/2017.

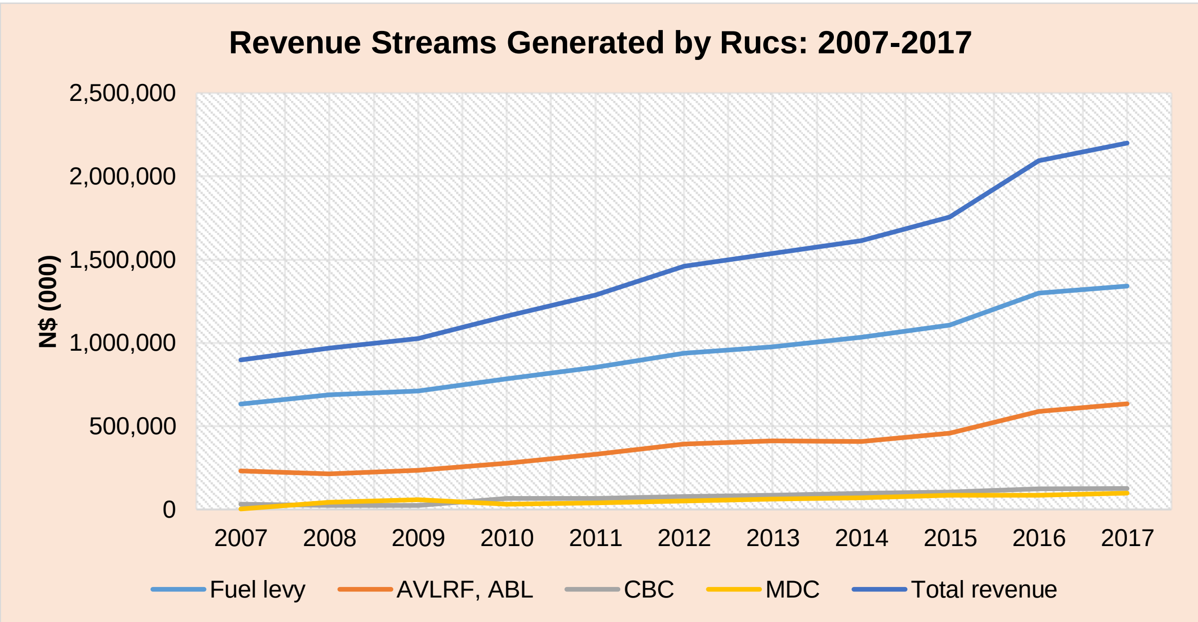

Figure 5.3: Total revenue collected through the Road User Charge System

Source: Author (Data from RFA, 2016)

For the 2007 fiscal year, the RFA generated an amount of N$897 million, which gradually increased to N$2.199 million by 2017. Revenue generated from the RUCS recorded steady

[21] The MVA Fund is mandated to design, promote, and implement crash and injury prevention measures, provide assistance and benefits to persons injured in motor vehicles accidents and to the dependants of those killed in such accidents, and to provide for incidental matters (MFA Fund Act, No. 10 of 2007).

nominal growth of 5% in the 2016/2017 fiscal year. From 2016/2017, the Namibian economy registered a contraction of 0.8% in real value with average inflation recorded at 6.1% (NSA, 2017a). The real RUC revenue generated from charges and fees registered a moderate growth of 5.4% (RA, 2017).

The growth in revenue is deflated to real revenue, using the Namibia Consumer Price Index in order to understand the real revenue growth. Although Figure 5.3 contains information on the revenue growth between the 2006/2007 to 2016/2017 fiscal years, the real growth comparison was only compiled for the 2011/2012 to 2015/2016 financial years (see Figure 5.4). During the 2011 year, the fuel levy (largest contributor to the RUC revenue) was charged at N$0.99 (petrol) and N$1.04 (diesel) and only increased to N$1.14 for both petrol and diesel during the 2015 year. It appears that both the VKT and the vehicle population growth are above the real RUC revenue growth. The RFA stated that RUC, in particular the fuel levy (main contributor), have not been kept on par with inflation.

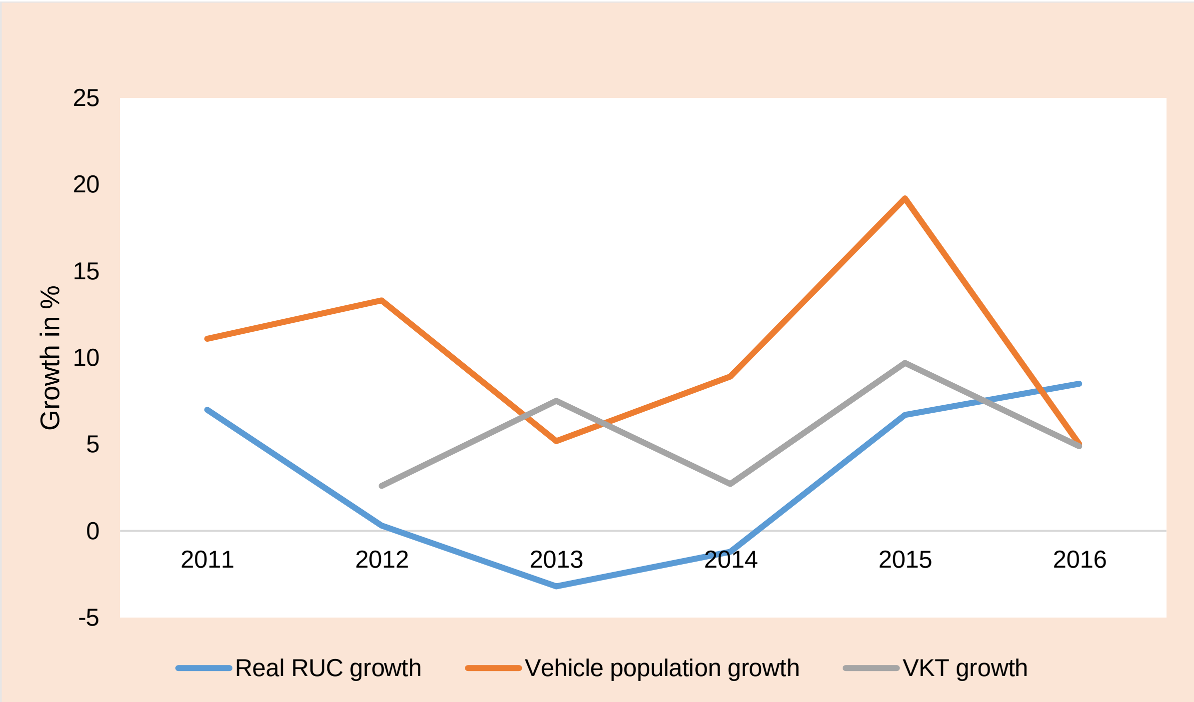

Figure 5.4: Real Road User Charges revenue growth compared to vehicle population and vehicle kilometres travelled

Source: Author's calculation (Using various RA & RFA publications)

The RFA (2015) argues that compensation for inflation since the 2001 to 2015 financial years would have been above N$1.65 per litre as opposed to the N$1.14 per-litre rate charged during the 2015 financial year (RFA, 2015).

5.5.2.2 Revenue allocation to the approved authorities

Approximately 80% of the income collected from the RUC is allocated to the RA towards the national road network maintenance and rehabilitation. In addition, an allocation is also made towards the maintenance of major urban and arterial roads, traffic-related maintenance of urban roads and streets, traffic law enforcement, traffic information systems, and the administration costs associated with the RA and RFA. Figure 5.5 shows the total revenue collected through the RUCS and the allocation thereof to the relevant authorities. During the 2016 fiscal year, the RA received N$1 467 102 000 or 80% from the RFA of the total revenue generated by the RUC. The fuel levy refund constituted the second largest portion of N$209 084 000 (11.4%), local authorities received N$68 470 000 (3.7%), the RFA allocated N$65 945 000 (3.6%) for administration, and the regulatory authorities received N$28 990 000 (1.6%) towards traffic law enforcement (see Figure 5.5).

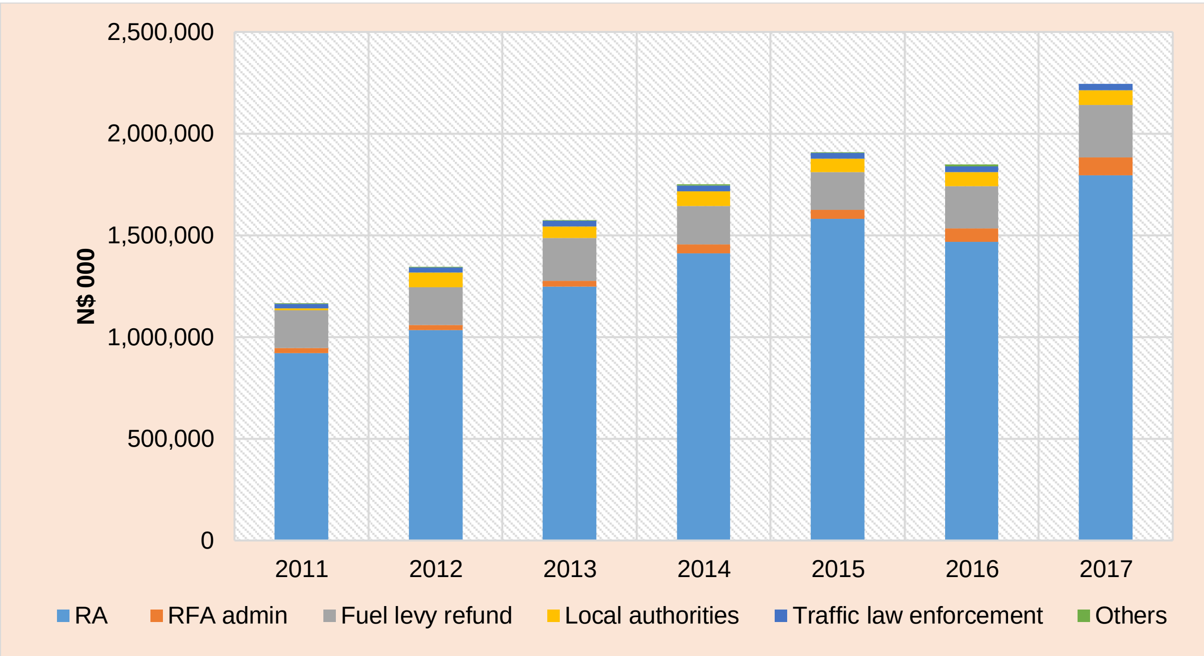

Figure 5.5: Road User Charges revenue allocation for the financial years 2011/2012 to 2016/2017

Source: Author (Based on data from RFA financial reports 2011-2017)

The next section turns to an assessment of the funds allocated to the RA towards the preservation of the national road network.

5.5.2.3 Allocation of funds to the Roads Authority

The RA prepares a five-year budget, guided by key planning documents such as MLTRMP, the NDPs, and the RA Strategic Plan. The MLTRMP outlines the medium-term (2012-2016) and long-term (2016-2030) programmes based on justifiable, economically optimal operation levels for road preservation and development. The RA budget for maintenance and rehabilitation is submitted to the RFA for funding. After a further optimal budget rationale, the RFA accepts and provides the necessary funds. In addition, the RA, through the MWT, submits a budget for new road development to the MoF through the NPC. The government revenue is allocated through a structured budgetary process, which is subject to parliamentary debate and approval. The availability of funds determines the proportion each department receives and the amount the RA receives from the SRF. Figure 5.6 depicts the total contribution from the two funding sources for the period 2012/2013 to 2017/2018.

During the 2012/2013 and 2015/2016 financial years, the government allocated N$1 315 704 000 (52%) and N$1 960 472 000 (55%) respectively of the revenue generated from general taxes. In contrast, the RFA in the same period allocated N$1 239 042 930 (48%) and N$1 629 488 000 (44%) towards national road expenditure from the revenue generated by the RUCS. The budget allocated from both sources to the RA shows that there is a shortfall of the funds required by the RA to meet the demand of national road network expenses and the allocation from the two sources, namely the SRF and the RF.

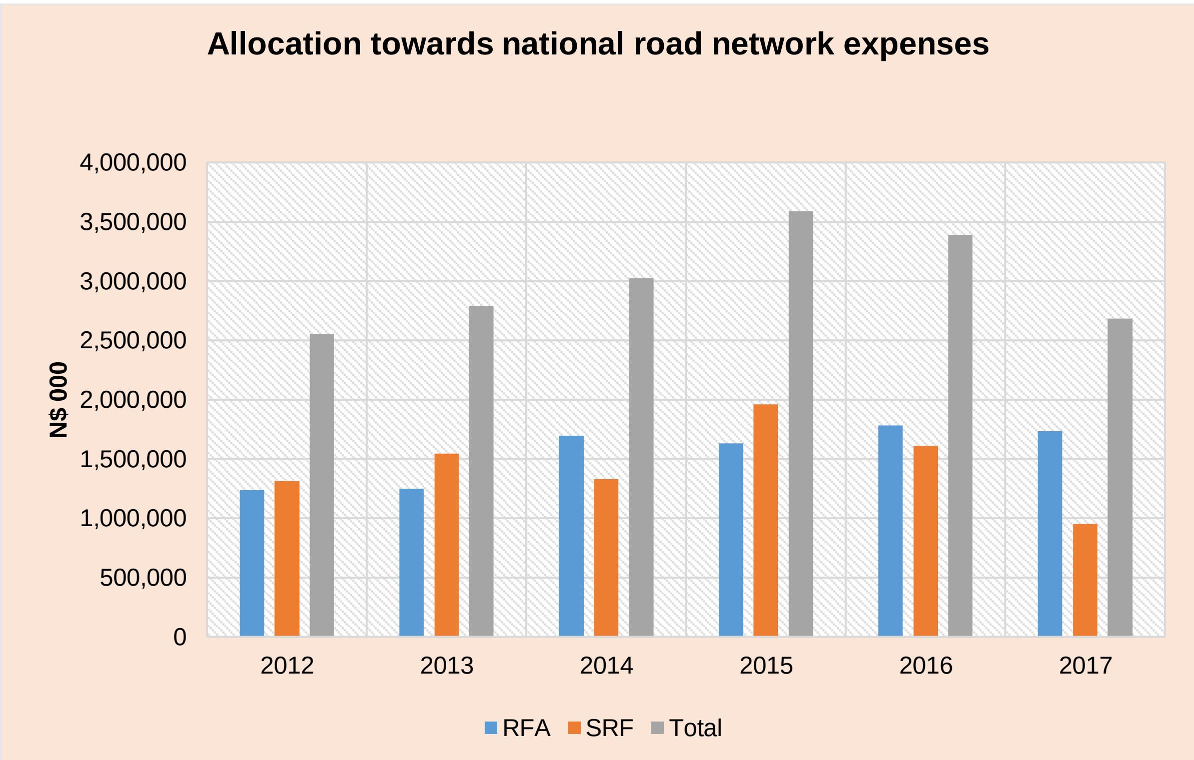

Figure 5.6: Total contribution from the RFA and the SRF towards the national road network

Source: Author (Based on data from RA budgets for the period 2012-2017)

During the 2015/2016 fiscal year, the road sector absorbed approximately 3% of the government's operational budget and approximately 18% of its development budget (NPC, 2015a). The results are in agreement with Heggie and Vickers (1998), who state that the road sector could absorb as much as 10% to 20% of the government's development budget. The percentage share of funding provided by the government towards the development of the national road network is reasonable (18%) compared to international standards (ranging between 10% to 20% of the government development budget). Figure 5.7 presents the RA's budgetary allocation towards national road development (construction) and preservation (maintenance and rehabilitation) projects in real terms, for the period 2011/2012 to 2016/2017.

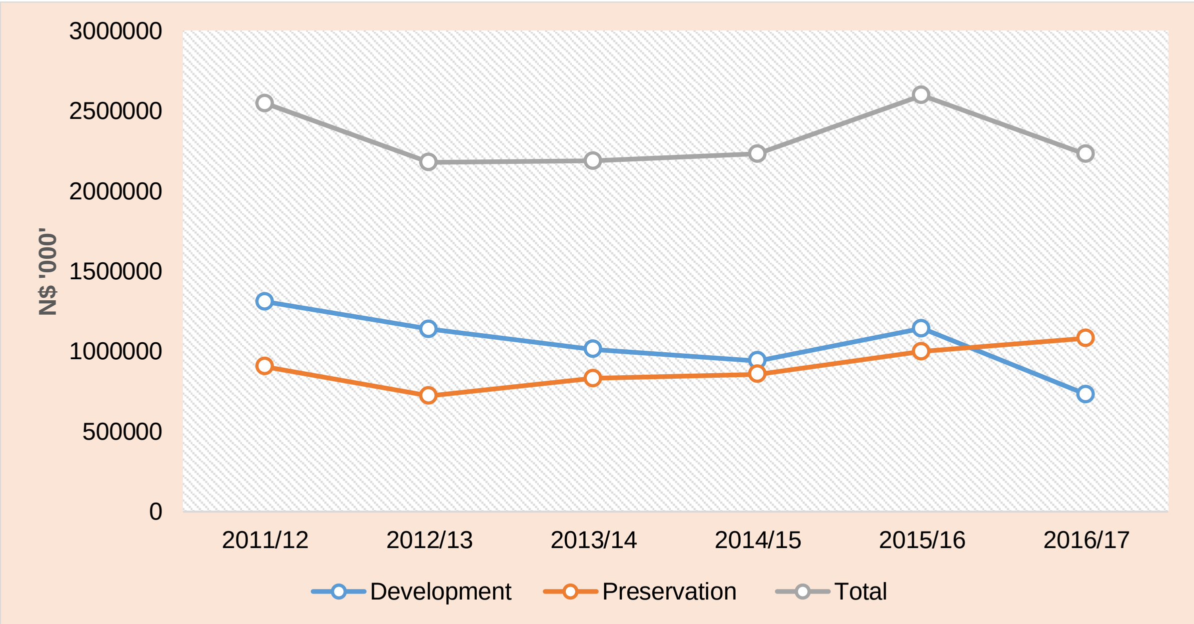

Figure 5.7: National road network expenditure in 2010 prices (N$000)

Source: Author (Data from RA, 2016)

Resources in real amounts made available for construction (development) of new roads and maintenance of existing roads show a flat trend that is proportional to the total budget allocated to the RA towards the national road network. In terms of administration versus the operation budget, the overall RA administration expenses decreased to 48% from 2011/2012 to 2015/2016, corresponding to 15% of the RA's total expenditure (operation and administration) for the national road network budget.

The evaluation demonstrates a fiscal squeeze in the revenue generated from the RUC that resulted in limited resources being available for the preservation of the national road network. The road budget for preservation and development shows a total increase in allocation, although uneven (see Figure 5.7). On average, 80% of the revenue generated from the RUC has been allocated to the RA for the preservation of the national road network. A shortage of funding to meet the required demand cannot be explained as a result of insufficient allocation towards the national road expenses. The RFA can only allocate funds to the road sector, which are generated by RUC or funds acquired through loan arrangements. The road users' base, their travel behaviours, and the level of RUC therefore determine the income generated from the roads, whereas the size of the road network and the standards determine the demand for road funding. Getting the price right is therefore an important policy objective and can have a significant impact on the available resources for road maintenance, rehabilitation, and construction. Although the RFA legislation is clear on the user-pays principle, the theory is yet to be modelled into practice.

5.5.2.4 Namibian aggregated national road expenditure

The budget allocated to the RA aims to fulfil its mandate of managing the national road network. Apart from receiving funds from the RFA, the RA also receives funds from the GRN through its line ministry, the MWT. Figure 5.8 presents the RA budgetary allocation to its various departments and projects.

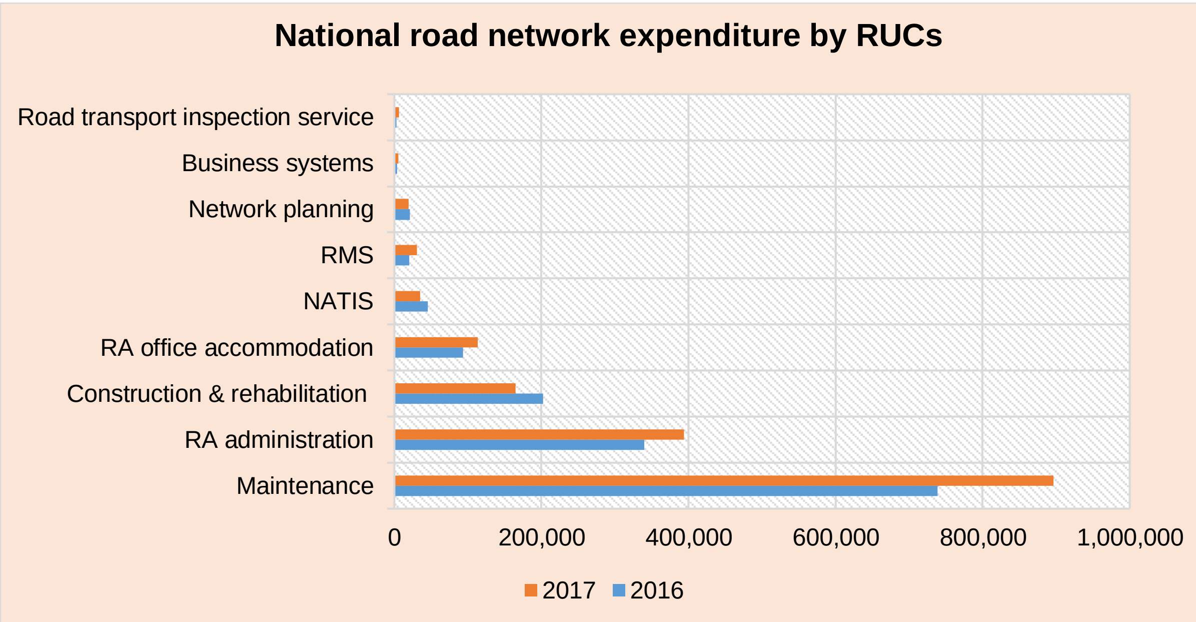

Figure 5.8: National road network expenditure (N$000) during the period 2014/2015 to 2015/2016

Source: Author (Based on data from RA, 2016)

Due to road expenditure demands for road construction and maintenance, the conclusion can be drawn that the RA is faced with a great financial demand for national road preservation. During the 2015/2016 and 2016/2017 financial years, road maintenance received the highest proportion of the revenue of N$739 million and N$897 million respectively (see Figure 5.8).

5.5.3 Existing funding gap

The RA submits a five-year budget proposal to the funding sources, as per the national road expenditure demand for possible funding. The preparation of the budget is guided by planning documents such as the MLTRMP, the NDPs, and the RA's Strategic Plan. The MLTRMP outlines the medium-term (2012-2016) and long-term (2016-2030) identified programmes for road preservation and development. Although the RA received funding from two sources during the period 2012-2016, the results show that the demand for road expenditure required for road preservation exceeded the budget allocated. Figure 5.9 illustrates the funding gap between the budget required by the RA and the budget allocated from the two sources.

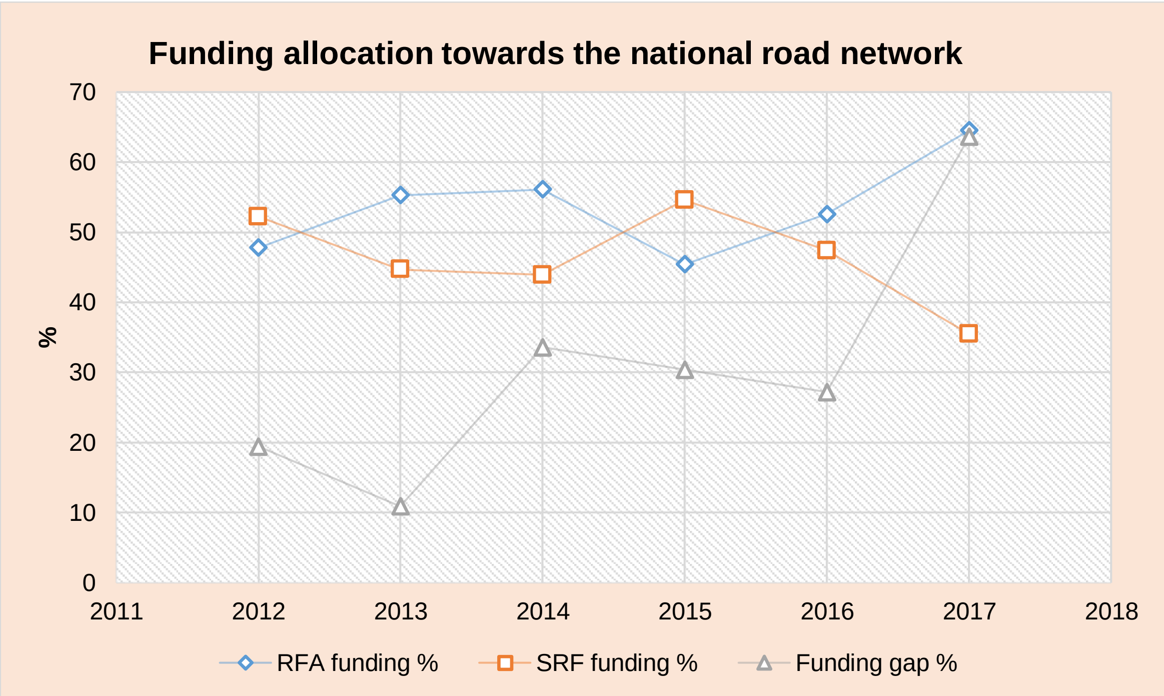

Figure 5.9: Budget allocated towards national road network expenditure from both the State Revenue Fund and the Road Fund Administration for the period 2012/13 to 2016/17

Source: Author (Based on data from RA, 2017)

This gap is in accordance with those observed by the RFA in its annual report, as follows:

- During the 2011/2012 financial year, the RA observed a growing gap between the funds allocated towards development of new roads versus the funds allocated towards maintenance of existing roads (RFA, 2012). In addition, the RFA's business plan for 2011/2012-2015/2016 projected an annual sum of N$1.5 billion; however, approximately 38% of the existing national road network requires rehabilitation and resurfacing work. The RFA requires an approximate additional amount of N$1.4 billion for the business plan period in order to address backlogs in road maintenance and to avoid further deterioration (RFA, 2013).

- During the 2012/2013 financial year, the gap between the revenue generated from the RUC and the actual expenditure resulted in a deficit of N$28 million (RFA, 2013). A further deficit was recorded in the amount allocated to the preservation of the road network. The RA requested N$1.100 million and ended up with an allocation of N$1.030 million (RFA, 2013:5) a deficit of approximately N$70 million is needed in order to fully recover the routine and periodic maintenance.
- During the 2013/2014 fiscal year, N$1.470 billion was allocated to the RA for the preservation of the national road network, of which it was reported that the RA required approximately N$2.844 billion in order to bridge the funding gap (RFA, 2014:3). An overall deficit of N$1.37 billion was recorded in the revenue generated from the RUC.
- The RFA business plan for the 2014/15 financial year projected N$1.780 billion; however, the RUCS only generated approximately N$1.757 billion, which is a shortfall of 1% of its business plan target (RFA, 2015:3). According to the MLTRMP (RA, 2012), the optimal funding was projected at N$2.87 billion. However, the RFA could only allocate N$1.676 billion towards the national road network. This resulted in a funding gap of approximately N$1.194 billion (42%) (RFA, 2015:4).
- During the 2015/2016 financial year, the RUCS generated approximately N$2.1 billion (RFA, 2016:24). The optimal funding requested from the RFA by the RA for the preservation of the national road network and to cover the existing backlog was N$1.756 billion; however, the RFA could only allocate N$1.629 billion, which resulted in an approximate deficit of N$127 million.
- During the 2016/2017 fiscal year, the RFA generated N$2.21 billion through the RUCS and RFA expenditure for the same year stood at N$2.3 billion, of which 81% was spent on road projects (RFA, 2017:7). In contrast, the RA required N$2.115 billion from the RFA, but the RFA could only allocate N$1.781 billion, which resulted in a shortfall of N$334 million (RFA, 2017:7).

In order to close the existing gap observed in the funds generated from the RUCS, there is a need to coordinate efforts in prioritising between the maintenance of existing roads and the development of new roads. In addition, there is room to boost revenue streams generated from the RUC, which currently does not meet the road expenditure demand. Given that the RA's budget did not receive required funds from the two sources, it created a gap between revenue allocated and funds required by the RA to meet the expenditure demand for the national road network. Potential technology leverage, especially for the MDC instrument to mobilise and enhance the RUC revenue, is great.

5.5.4 Road user spending and infrastructure investment

The RA's RMS division, through its traffic surveillance system, collects information on traffic using the Namibian road network (RA, 2015a). Statistics reveal that the total VKT per annum in Namibia was 3.847 million in 2016 (see Table 5.6). In considering the total revenue generated from the RUC of N$2.095 million in 2015/2016, on average, a Namibian vehicle, irrespective of vehicle type, *ceteris paribus*, equals N$0.54 per kilometre of the RUC. At the broader level, the road user spends approximately N$1.24 per kilometre, when considering revenue generated from general taxes (See Appendix C). Although road users have spent approximately N$1.24 per kilometre, only N$0.54 per kilometre could be counted for road preservation. Approximately N$0.70 per kilometre contributed forms part of the consolidated budget.

In contrast, the RA-allocated budget from both sources accrued to N$3.589 billion in 2015/2016, which was invested in the national road network at N$0.93 per kilometre. From the revenue generated inside the RUCS and allocated to the RA, on average N$1.629 billion, N$0.4 per kilometre was invested in the national road network during the financial year 2015/2016. The RA received a fair share of the budget from the SRF through its line ministry towards managing the national road networks. Therefore, more effort should be directed towards exploring available technology to charge road users per kilometre, in order to improve the revenue collected from the RUC.

Table 5.6: Vehicle kilometres travelled for the period 2012-2016, per road category and surface

Roads Categories	2012		2013		2014		2015		2016	
	Length (km)	VKT (mill)	Length (km)	VKT (mill)	Length (km)	VKT (mill)	Length (km)	VKT (mill)	Length (km)	VKT (mill)
Sealed	6,664.31	2,376.22	6,664.31	2,552.16	7,165.18	2,703.85	75,681.10	2,995.58	7,568.10	3,168.89
Gravel	27,709.48	469.59	25,709.48	503.61	25,921.05	485.18	25,675.43	485.49	25,675.43	491.92
Earth	11,459.81	93.82	11,459.81	100.60	11,541.17	91.73	13,022.11	101.91	13,022.11	102.18
Procalaimed only	1,523.63	45.38	1,523.63	58.56	1,445.86	25.25	1,829.16	46.48	1,829.19	46.61
Salt	287.52	42.54	287.52	40.51	304.29	37.56	304.29	37.53	304.29	37.63
Total	**45,644.75**	**3,027.55**	**45,644.75**	**3,255.44**	**46,377.55**	**3,343.57**	**48,399.12**	**3,666.99**	**48,399.12**	**3,847.23**

Source: RA (2017)

To summarise, the RFA allocated a total grant of N$1.629 billion of the revenue generated from the RUC to the RA. In the 2015/2016 financial year, the total expenditure for the national roads network from both the SRF and RF amounted to N$3.589 billion. This amount was invested in national road network infrastructure and operations. A total of N$3.589 billion was invested in preserving the national road network, which includes maintenance, rehabilitation, and development. The amount was spent on 7 284.74 km of road network managed by the RA, used by 371 281 registered vehicles, travelling a distance of 3 847 million km, which resulted in an investment of approximately N$0.93 per kilometre.

Table 5.7 is a summary of what road users contributed to the national road network as per the RUC imposed during the financial year 2015/2016 versus the amount of RGR invested back towards the preservation of the national road network in Namibia.

Table 5.7: Revenue generated from road users for the year 2015/2016

Revenue generated inside the RUCS for the 2015/2016 financial year		**Revenue invested back in the national road network during the 2015/2016 financial year**	
Amount collected from RUC	N$2 094 537 000	Amount invested in national road network preservation	N$1 629 488 000
Total national road network	48 327.53 km	Total national road network	48 327.53 km
Registered motor vehicles in Namibia Foreign vehicles	371 281 266 673	Utilised by the registered motor vehicles Utilised by foreign vehicles	371 281 266 673
Travelled distance	3 847 230 000 km	Travelled distance	3 847 230 000 km
Road user payment	**N$0.54/km**	**Road investment per/km**	**N$0.4/km**

Source: Author

On average, road users spent N$0.54 per kilometre on Namibia's national road network as per the RUC imposed on users (see Table 5.7). In comparison to that is the road investment per kilometre on the amount generated through RUC and invested back towards the road preservation, including maintenance, rehabilitation, and construction, which amounted to N$0.93 per kilometre. The following section explores the Namibian road funding strategies in comparison to the rest of the world.

5.5.5 Namibian road funding compared to the rest of the world

Namibia's road funding framework has been compared to international standards by illustrating the similarities and differences in the national policies and identifying the impact different funding approaches has on different countries' levels of roads expenditure.

5.5.5.1 Road expenditure to revenue ratio

The results of the Namibian national road network for the period 2011 to 2016 compared to the selected developed countries for the period 2004 to 2009 are illustrated in Figure 5.10. The results can be categorised into three different groups. The first group consists of countries with high, followed by the second group consisting of countries with medium, and the third group consisting of countries with low dedication of RGR towards roads expenditure.

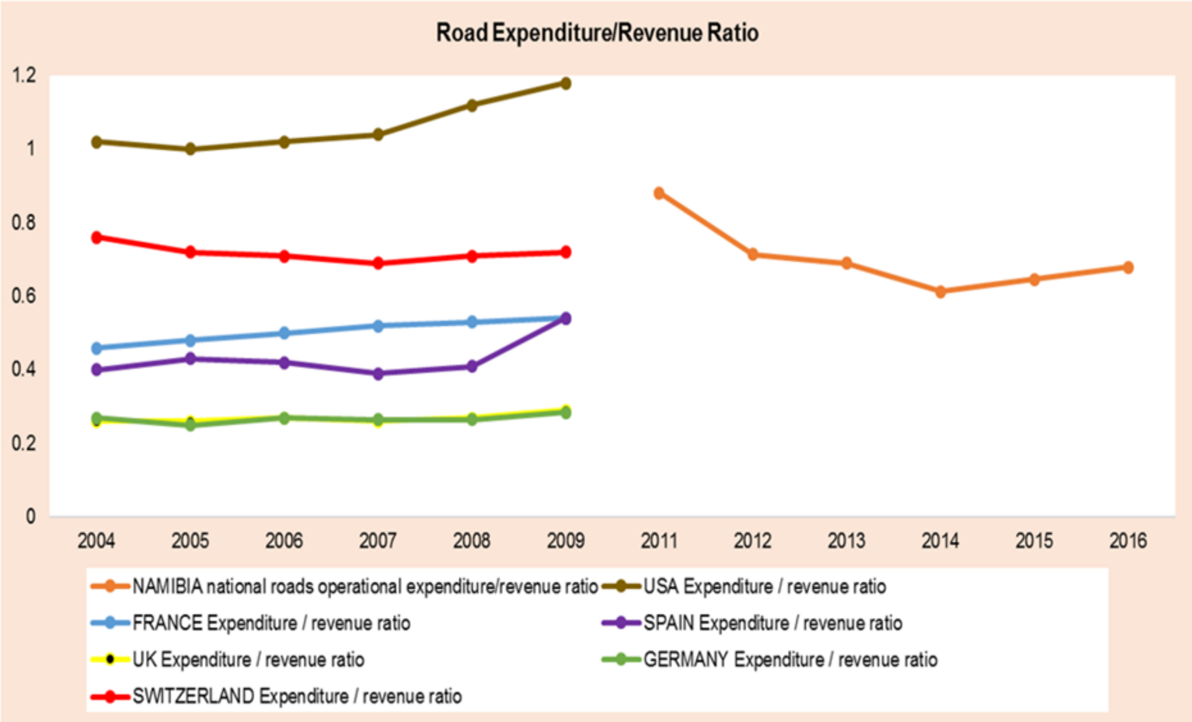

Figure 5.10: Selected countries' road expenditure to revenue ratio

Source: Author's calculations (Based on Gomez & Vassallo, 2014)

Namibia is among the first group of countries with higher dedication revenues of 80% and above towards roads expenditure, together with the USA and Switzerland. The second group comprises France and Spain, which dedicate 40% to 50% towards road expenditure respectively, and the third group includes Germany and the UK, which dedicate 30% or below towards road expenditure. Apart from Namibia, the USA, and Spain, other countries experienced a constant ratio for the period under evaluation (see Figure 5.10).

In their analysis, Gomez and Vassallo (2014) observed features common to the USA and European road funding models. The authors concluded that European road systems subsidise other government objectives and policies, whereas in the USA the roads are subsidised by the public sector. These American trends were observed in Namibia, where the government subsidises the national road network by allocating the annual budget to the RA towards the preservation of the national road network. For the period under evaluation, the RA needed additional funds from the SRF generated through general taxation to fund the national road system. For example, after the 2014/2015 financial year, the expenditure/revenue ratio increased from 0.61 to 0.68 in 2016 (see Figure 5.10). In summary, an observation was made that, regardless of the difference in the road funding models and the countries' characteristics, similar trends were observed between the American and Namibian road funding systems. Both the United State and Namibia has a ring-faced road (highway) fund into which all road-generated income are deposited. Similar to the Namibian Road Fund Administration, the USA

Highway Trust Fund has been frequently under severe fiscal pressures that frequently required the bailout from the government.

5.5.5.2 Road expenditure to gross domestic product ratio

The results show that Namibia has the lowest ratio, with expenditure of approximately 0.25% of its GDP (see Figure 5.11). This is likely attributed to the fact that only the national road network expenditure was considered in the analysis. Namibia recorded an increase in national road expenditure to GDP ratio after 2014. The result is explained by the gap that existed between the road expenditure and the road allocation, which will be further explained under Equation 3 of the RA ratio.

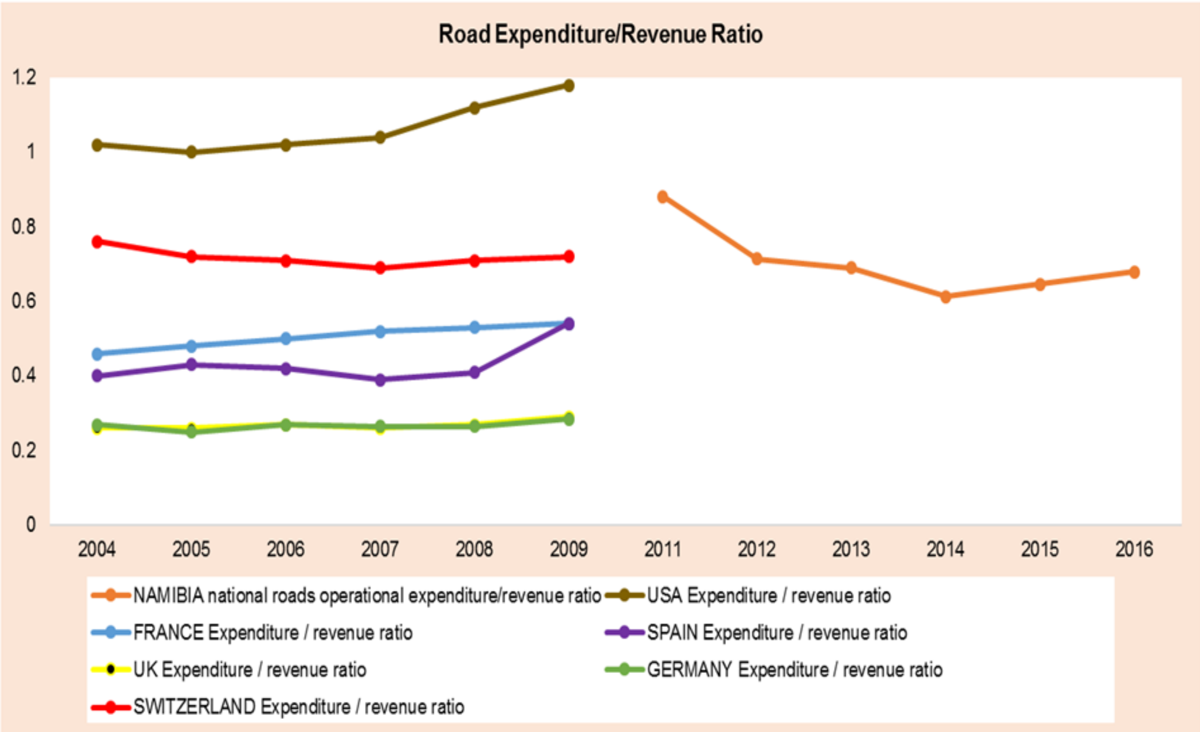

Figure 5.11: Selected countries' road expenditure/gross domestic product ratio

Source: Author's calculations (Based on Gomez & Vassallo, 2014)

Although the countries under evaluation showed different characteristics in terms of size and population densities, different trends were observed in the developed countries. Due to the highest road charges, Switzerland has the highest ratio of approximately 1.4% of its GDP (Gomez & Vassallo, 2014). In addition, the authors assert that other countries exhibited road expenditure to GDP ratios that ranged between 0.5% and 1.0%.

5.5.5.3 Road allocation ratio

The comparison showed that Namibia had the highest road allocation ratio of 0.96 (see Figure 5.12). The RA receives allocation from both the RFA (revenue stream generated through the RUCS), and from the SRF (revenue generated from general taxes and levies). The Namibian road allocation ratio must be considered as the least valuable as urban roads under local authority jurisdictions were not included in the analysis.

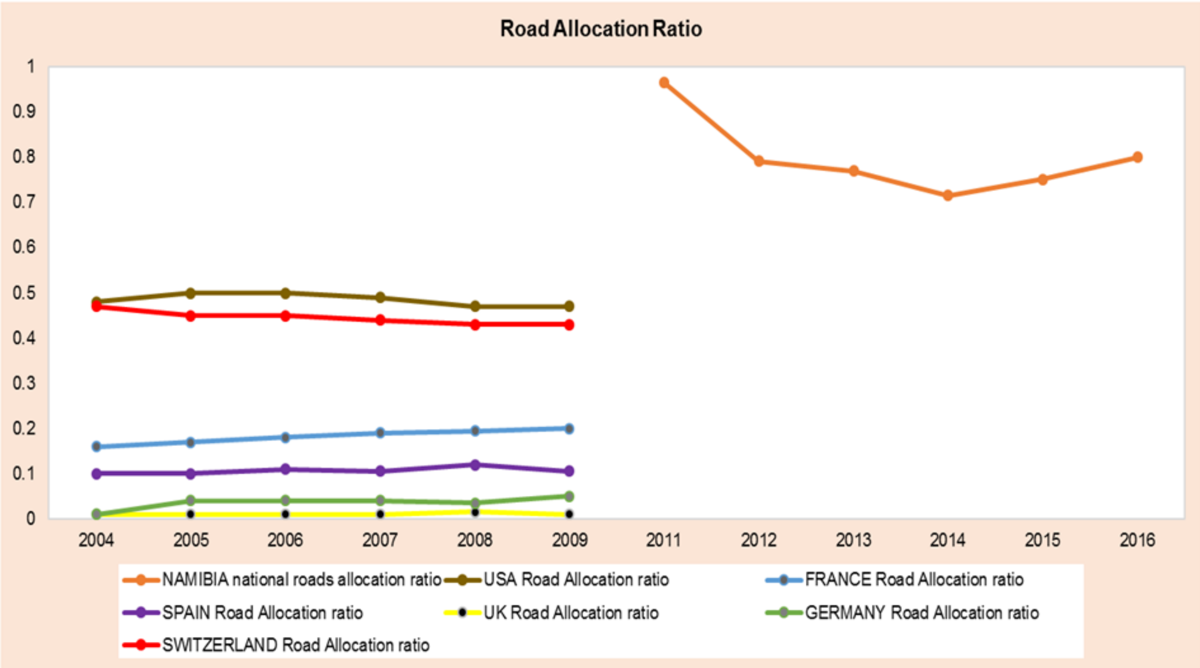

Figure 5.12: Selected countries' road allocation ratio

Source: Author's calculations (Based on Gomez & Vassallo, 2014)

For developed countries, the USA showed a similar trend to Namibia where road systems receive budget allocation at federal and state level. According to Gomez and Vassallo (2014), the USA has the highest ratio of 0.5, followed by Switzerland with an approximate ratio of 0.44, where large amounts of revenue generated from the RUC are allocated back for road purposes. The authors also shed light on countries such as France and Spain, whose dedicated road revenues are generated from private tolls, thus their ratios range between 0.2 and 0.1 respectively. In addition, lower road allocation ratios were experienced in countries such as Germany and the UK. In conclusion, Figure 5.12 shows the proportional relationship between the road allocation ratio and the revenue expenditure to GDP ratio.

5.6 SUMMARY AND DISCUSSION

The primary aim of this chapter was to evaluate Namibian road sector funding approaches with emphasis on the national road network. Towards this goal, the focus was placed on the revenue generation and allocation towards national road expenditure. In addition, the chapter provided an analysis of the relationship between the RGR and the national road network expenditure with emphasis on determining the RGR, road allocation, and road expenditure for Namibia (developing country) compared to the USA and five selected European (developed) countries. Figure 5.13 summarises the Namibian funding approaches to the road sector in terms of revenue generation and allocation towards national road expenditure. The results in this chapter confirmed that given the fact that Namibia established an RF that operates under the so-called second-generation road fund, the road subsector experiences uncertainty in budget allocation towards the preservation of the national road network.

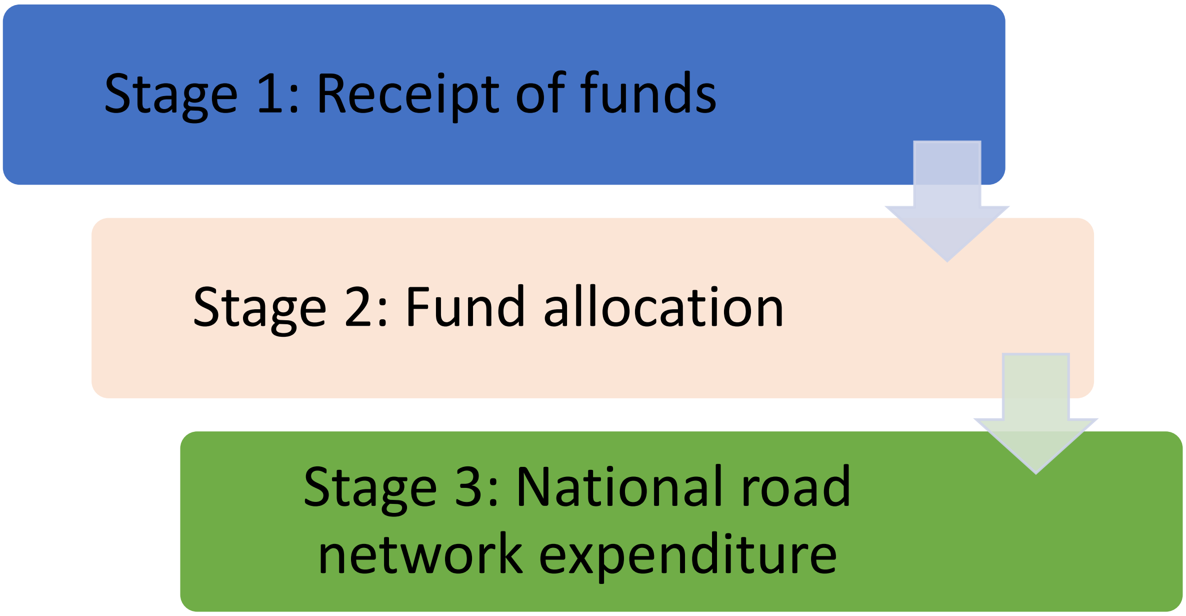

Figure 5.13: Namibian road funding approach

Source: Author's construct

The study confirmed that there are two sources of funds and identified three main stages involved in the current road funding approach in Namibia. The RFA generates revenue from the RUC, which accumulates to the RF and is distributed to appropriate road authorities (Stage 1). Approximately 80% of revenue generated from the RUC (Stage 2) is allocated towards the national road network. Revenue generate from the RUC is allocated towards the preservation of the national road network (Stage 3). The Namibian government subsidises the road sector with annual allocations from the SRF generated though general levies and taxes.

An important finding from the evaluation affirms that funds allocated from both sources between the 2011/2012 and 2016/2017 financial years were not sufficient to meet the demand for required road preservation. Therefore, these results are in agreement with those recorded by Gwilliam and Shalizi (1999), who state that uncertain budget allocation undermines roads authorities' planning and execution of road maintenance. The performance capacity of a roads agency is limited to available resources. During the 2012/2013 and 2015/2016 financial years, the government allocated N$1.315 billion (52%) and N$1.960 billion (55%) respectively of revenue generated from general taxes. In contrast, the RFA in the same period allocated N$1.239 billion (48%) and N$1.629 billion (44%) towards national road expenditure from revenue generated from the RUC. This finding further supports the argument by Zietlow and Bull (2002) that government funds are directed towards financing new developments. This therefore results in a growing gap between optimal allocation towards maintenance of the existing roads and the development of new roads. The need for balance between road construction and road maintenance is essential for sustaining the quality of the existing road network in Namibia.

In addition, during the 2011/2012 to 2016/2017 financial years, the RA received an average allocation of 54% from revenue generated through the RUC, which was subsidised by the government with an allocation of 46% on average for the past six years. The percentage share of funding provided by the government towards the national road network through the general budget is reasonable, given the fact that the country has an RF and that government objectives are multifaceted.

Several issues require special attention with the goal of improving the Namibian funding approach. The RFA funding model has depicted a limited capacity in meeting the increased demand for road expenditure. This study shows that fuel levies were the highest contributor towards the revenue generated through the RUC and contributed approximately N$1 105 591 000 and N$1 299 616 000 during the 2014/2015 and 2015/2016 financial years respectively (RFA, 2016). The finding further supports the argument by the RFA (2013) that the highest contributor is not kept on par with inflation. There is a growing need for more sustainable means of raising funds since the fuel levy as the current highest contributor is not sustainable in the long run. The MDC have the potential to improve revenue growth through the RUC; however, this charging instrument is prone to evasion, as argued by Queiroz (2009). Therefore, an annual increase of the current RUC should be considered as a short-term solution. In the long run, Namibia should also consider introducing toll roads at the PPP level. In addition, automation and new technology to optimise the revenue raised through MDC should be explored.

In this chapter, comparative analysis revealed a growing gap in funds allocated towards road maintenance in Namibia. The Namibian government subsidises the road sector by allocating annual budget to the RA through its line ministry, the MWT, towards the development of new roads. These results show similar trends to that of the USA, where the public sector subsidises the HTF for road infrastructure development. In contrast, in Europe, the road sector subsidises the government towards funding other policies.

In addition, regardless of Namibia having a high road allocation ratio, the RGR ratio has not been able to cover the country's road expenditure needs for the past few years. On average, road users, through revenue generated from the RUC, spent approximately N$0.54 per kilometre. Moreover, investment of the revenue generated from the RUC was N$0.98 per kilometre on average. These results affirmed the fact that Namibia forms parts of the countries with lower levels of RUC, and generates revenue that is not sufficient for the required road expenditure.

An important limitation of this chapter was the use of documentary and administrative data. Therefore, the study's results are only subjected to documentary analysis. While urban and other roads under the local authorities were considered, urban roads were excluded from the analysis due to the limited and unavailability of data and therefore did not form part of the discussion. Thorough analysis was conducted on the national road network with emphasis on allocation and expenditure levels. Revenue allocated towards the preservation of the urban roads under the management of local authorities was not included in the ratio calculations.

This study was further limited by high heterogeneities and characteristics among the countries under evaluation, including population, GDP, road network, developed versus developing, road funding instruments in place, and location on the continent, as noted by Gomez and Vassallo (2014). In contrast, countries within sub-Saharan Africa were considered; however, they were excluded due to the limited data. Therefore, the Namibian national road network was compared to developed countries because of the availability of data. Although there is no correspondence between the analysed data periods for the developed countries and Namibia, general trends were worth observing.

The strength of this research lies in the methodology adopted and the calculation of three ratios, namely RGR, road allocation, and road expenditure for Namibia as a developing country in comparison to the USA and five selected European (developed) countries. This study is necessary for Namibia in that it establishes a balance between charging for road use and national road network expenditure. Thus, the ratio calculated should be considered as a benchmark and serve as a minimum reference value as it is expected that the Namibian figures would have been different if the calculation accounted for the entire road sector.

Future studies should seek to evaluate the best way to raise and improve revenue generated through the RUC in Namibia. While the user-pays principle approach is recommended and acceptable, it leads to insufficient funding. Therefore, there is a need to explore alternative sources of funding. In addition, it is worth investigating whether implementing RUC based on the MSC results in a surplus or deficit. To that effect, implementing RUC for Namibia that are based on the MSC principle is worth attempting.

In conclusion, the evaluation provided novel evidence on the Namibian road sector in comparison to international levels. The evaluation affirmed the fact that Namibia forms parts of the countries with lower levels of RUC, therefore generating revenue that is not sufficient for the required road expenditure. This finding may indicate the dilemma facing many developing countries where revenue from the road users does not cover total road costs due to spare capacity and economy of use. Additional funding sources are therefore required to fund these deficits.

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CHAPTER 6:
THE USE OF THE HDM-4 TO DETERMINE THE MARGINAL EXTERNAL COSTS OF ROAD USE[22]

6.1 INTRODUCTION

Chapter 5 was concerned with unpacking the Namibian road funding and financing system. National policies, legal frameworks, and funding schemes to address the demand for road maintenance, rehabilitation, and construction have been drafted. It is quite clear that Namibia has implemented a seemingly sound institutional framework and has a sound policy on how to secure funding through the road user charges system (RUCS). The RFA Act is clear on maintaining economic efficient pricing. An economic efficient price is one that is set at the short run marginal cost (SRMC) associated with road use. The Namibian White Paper on Transport Policy (MWTC, 1995) and the recent Namibian Transport Policy (MWT, 2017) recommended that road users should pay for the full costs associated with road use. It is not clear, however, whether the current road user charges (RUC) are set to include the external costs generated by road use and impinge on other road users and society. From everyday experience, it is quite clear that there are other costs associated with road use, which are not directly borne by the road users. The price road users pay for a journey may not reflects the true costs of a journey. These are the costs related to infrastructure damage costs, congestion costs, as well as environmental and accidents costs.

An increased interest in transport policies to tackle negative externalities by means of charging instruments have attracted notable studies on estimating the marginal social costs (MSC) of road users over the past two decades. Research conducted on how to measure the MSC and assign monetary value towards efforts of road pricing has predominantly been conducted in developed countries. Remarkable EU studies, which seem to form the fundamental methodology on estimating MSC of transport, include those by Nash (2003b), Nash et al. (2008), and Doll and Essen (2008). In contrast, the concept of estimating the MSC of road use in most developing countries and sub-Saharan Africa in particular is still in the infancy stage. Studies conducted within Southern Africa often focus on estimating the cost of externalities to countries' economies. For instance, the NRSC's (2016) study worked solely on determining the cost of road accidents to the Namibian economy. In South Africa, Olukoga (2004) and Labushagne, De Beer, Roux and Venter (2016) estimated the cost of road/traffic accidents. With regard to environmental costs, Namibia has several reports and strategies that make reference to the Intergovernmental Panel on Climate Change's (IPCC) guidelines for national

[22] A short version of this chapter was presented at the 2019 SATC by Petrus and Krygsman.

GHG inventory (GRN, 2002; 2011; 2016). The IPCC recommended a reduction of CO_2 emissions by 50% by 2040, given the 1990 level as the base. In South Africa, Lotz and Brentz (2017) conducted a study on carbon footprints, which seem to be one of the leading guidelines for practitioners and companies in calculating carbon footprints. Congestion studies focus more on improving urban mobility and reducing the commuting times between cities and suburbs. They seldom calculate a cost for congestion and if they do, it is often on an aggregate national or city level.

The Namibian Transport Policy (MWT, 2017) called for the refinement of the current RUCS in order to assess the feasibility of implementing the user-pays principle, and to ensure full-cost recovery from those who consume the road network for economic justification of road projects and programmes. The user-pays principle aims to hold road users accountable for the costs they impose on the infrastructure, on other drivers using the same facility (in terms of congestion and accidents risks), and on society. The user-pays principle theoretically forms part of the policy documents without further knowledge of the value of such negative externalities to be paid by the users.

This chapter attempts to address the gap between the recommended user-pays principle as a road pricing policy and as a strategy towards its implementation. The fundamental aim of road pricing is mainly based on three pillars, namely (i) the need for demand management, (ii) reducing emissions and accident risks, and (iii) revenue generation. In Namibia, as far as revenue generation from the RUC is concerned, there is evidence that the current RUCS seems to have run into a serious problem and has proven not to generate sufficient revenue to meet the demand for the road network (see Chapter 5).

In terms of revenue generation, the fuel levy is Namibia's largest contributor to the revenue generated among other RUC but is projected to lose it prowess and seems to be under intense pressure across the globe with emerging new-generation, fuel-efficient vehicles. When it comes to the fuel levy, there is a high chance of less productivity, especially with the new powertrain technologies and fuel-efficient vehicles, for example the introduction of hybrid and electric vehicles that use less or no fuel at all (Van Rensburg & Krygsman, 2015; Krygsman, 2018; Van Rensburg & Krygsman, 2019). Although there are other RUC instruments in place, their revenue reliance cannot be compared to that of the fuel levy, especially in the Namibian context. In this chapter, the researcher also follows the argument by Nash and Matthews (2005) that consumers of the road infrastructure should be held liable for their consumption of road use, and thus be made to pay in proportion to the costs they impose on the road infrastructure, other users, and society. Despite the progress made in estimating the MEC of road use elsewhere, in sub-Saharan Africa and Southern Africa in particular, comprehensive studies incorporating all-important components of MEC are rare. This holds true for the Namibian case as well with regard to evidence of any of the important four components of the MEC of road use. In light of these views, the case studies presented in this study provide such evidence and evaluate results by comparing the marginal costs and average costs.

This chapter seeks to examine efficient RUC for Namibia based on the principle of MSC. The importance of studying efficient RUC for Namibia cannot be overemphasised as roads contribute to the nation's economic development, job creation, and reducing poverty and inequality in Namibia (NPC, 2017). Efficient road pricing is therefore crucial to generating revenue for road infrastructure development and financing. The formal contribution lies in demonstrating that the HDM-4 model of the World Bank can be used to estimate the marginal costs of road use for a specific road section or network. Bruzelius (2004) posits that HDM-4 can be utilised to determine the marginal costs of a specific road or "as an average level of aggregation". Apart from demonstrating the ability of the HDM-4 to estimate the MEC of road use, it is hoped that this chapter's findings will provide important information and guidance that could be valuable to researchers, planners, and governments in road infrastructure development and financing, as well as policymakers and roads agencies who seek to internalise the MEC of road use in road-use tariffs.

This chapter focuses on the estimation of the MEC of road use with particular emphasis on marginal infrastructure damage, marginal accident, marginal congestion, and marginal environmental costs using the available secondary data. Although previous literature provides methodology and estimates of MEC, these estimates do not reflect the Namibian context (Proost et al., 2002; Bruzelius, 2004; Preiss & Klotz, 2008; CE Delft, INFRAS & Fraunhofer ISI, 2011; Technical University of Dresden, 2012; Korzhenevych et al., 2014) and cannot serve as input for decision makers and planners to make relevant decisions at the tactical or strategic level in Namibia. The main objective of this chapter is to demystify MEC estimations and help roads agencies to grasp the concept, as well as to internalise externalities into road pricing. This chapter therefore aims to explore the following objectives:

- To explore the possibility of estimating the MEC of road use in Namibia; and
- To compare MEC (efficient) to average cost (cost recovery) pricing.

The chapter is organised as follows: The next section provides the theoretical framework, followed by the literature review. Section 6.4 discusses the methodology used to estimate MEC. Section 6.5 discusses the results of marginal externality estimates in comparison with the average costs of road use. Section 6.6 provides the conclusions.

6.2 THEORETICAL FRAMEWORK AND LITERATURE REVIEW

Literature on efficient RUC and road pricing with a particular focus on the Namibian road sector is lacking, and this study intends to fill this gap. Dierks (1992) conducted a study focusing on the technical aspects of appropriate low-volume roads in Namibia. Although Dierks' (1992) study conducted investigations that led to cost- and quantity-optimised systems based on VOC, the study excluded the MEC associated with road use. Both the Namibian White Paper on Transport Policy (MWTC, 1995) and the Namibian Transport Policy (MWT, 2017) discussed the user-pays principle as a point of departure, with no further implementation strategies on the MSC of road use.

6.2.1 Marginal External Costs theory

In order to maximise net economic benefits, road pricing should be set equal to the SRMC of road use (Nash & Matthews, 2005; Litman, 2019). The road price is reflected as short run because charges only consider the use of existing roads without any consideration of how the expansion or new road investment should be funded. The economic theory of MSC indicates that the use of roads comprises two cost components, namely MPC and MEC (see Figure 6.1). The former comprises VOC, insurance, other ownership costs, and travel time costs. MEC consist of the costs that road users do not necessarily consider when undertaking a journey. These entail damage imposed on the road infrastructure, accident risks, congestion, and environmental costs imposed on society (Van Essen et al., 2019). Setting the price equal to MSC ensures that, in addition to MPC, users also cover their external costs of road use. Although the MSC concept entails the two components, the researcher's focus in this study is on estimating the MEC.

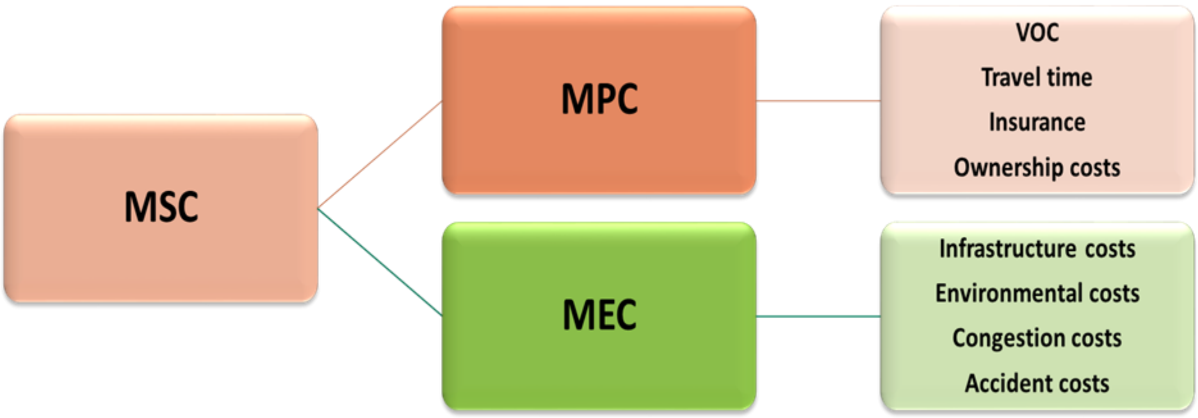

Figure 6.1: Economic theory of the Marginal Social Cost of road use

Source: Author's construct

6.2.2 An illustration of Short-Run Marginal Costs charging

Economic realities and the use of roads demonstrate several unpaid actions; in particular the negative externalities associated with road use. What is not yet known is to what extent these externalities are relevant for the Namibian policy framework. Rothengatter (2000) explains how these interactions work. Externalities occur through an unplanned interaction among agents, who mostly work outside the market (thus no market price), and they negatively affect the efficiency of the market economy. This is illustrated in the model modified by Glaister and Graham (2003). They estimated the cost of a specific vehicle class, at a particular time of the day, measuring the total costs each user per vehicle kilometre using the following equation:

$$G = P + r_v\left(\frac{1}{S}\right) + r_{wW} + C + \cdots \qquad 1$$

P is cost, r_v is value in vehicle time multiplied by per vehicle kilometres plus time value (waiting) x average waiting time + charges + (…) any other relevant costs.

Figure 6.2 presents the general costs per vehicle kilometre. The horizontal axis illustrates the flow of vehicle class per hour and the vertical axis presents the costs per vehicle. For any road type and network section, MSC and MPC as presented in Figure 6.2 can be estimated. The MPC line represents the marginal cost the vehicle owner may incur for undertaking an extra trip and the MSC line includes external costs imposed on other users and society. On the vertical axis, the distance between point x_{i0} and x_i presents the cost difference between MPC and MSC (see Figure 6.2). If vehicle owners can plan their journey (route) and strive to minimise their private costs as much as possible, then, as illustrated in Figure 6.2, equilibrium is reached at x_{i0} where MPC intersect with the demand curve; however, this equilibrium is referred to as suboptimal. For instance, the motorist could pay N$0.50 as MPC per additional kilometre travelled. However, when travelling the vehicle owner also imposes external costs of approximately N$0.05 on other users and society. This implies the marginal social cost of a journey costs N$0.55 per kilometre travelled.

At equilibrium, x_{i0}, there is a welfare loss, mostly referred to as "deadweight loss[23]" as illustrated by triangle area B. The deadweight loss can be improved or minimised by charging users at equilibrium x_i, where the SRMC intersects with the demand curve. However, in order to move road users from, x_{i0} to x_i , a charge needs to be introduced. The introduced charge

[23] Deadweight loss is a cost to society as a whole that is generated by an economically inefficient allocation of resources within the market (Agarwal, 2019). When supply and demand do not balance by market forces, consumers may opt not to acquire the good or services as they assess that the price charge is not worth the utility of goods or services offered. Thus, when the overall exchange of goods and services for money reduces, the efficiency of overall resource allocation drops, and therefore society's welfare decreases subsequently.

leads to a decrease in number of users from, x_{io} to x_i and it simultaneously increases cost from, p_0 to p_1.

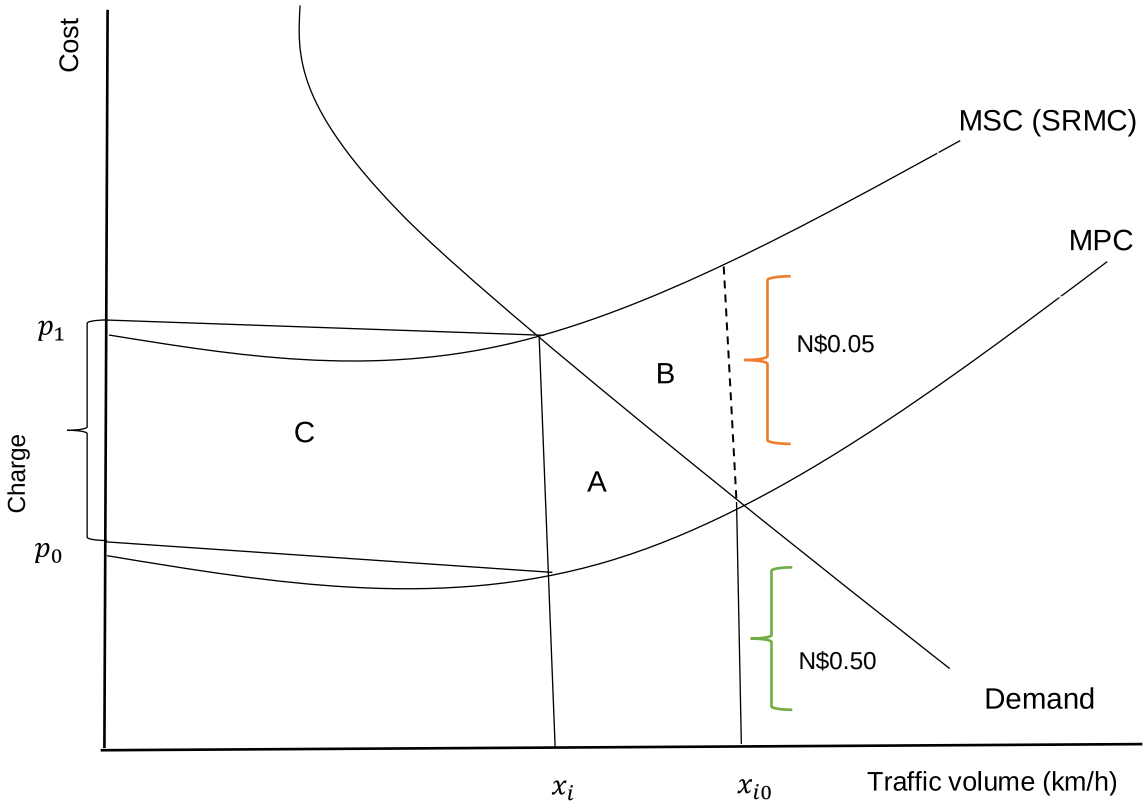

Figure 6.2: The principle of Short-Run Marginal Cost pricing

Source: Author (Rothengatter, 2015:406)

The optimum charge is therefore the difference between MSC and MPC at equilibrium x_i. Revenue generated by introducing the charge is illustrated by rectangle C in Figure 6.2. Given the two equilibriums, it is theoretically possible to integrate all other externalities, for instance accident costs and environmental costs, into the estimated MSC. The total MEC can be illustrated (adapted from Sansom et al., 2000:21) as follows:

MEC = MIC + MENVC + MAC + MCC …………………………………………………………… 2

MEC represent Marginal External Costs, MIC represent Marginal Infrastructure Costs, MENVC represent Marginal Environmental Costs, MAC represent Marginal Accident Costs, and MCC represent Marginal Congestion Costs. The danger of this equation is that double counting can easily occur, in particular with MCC (where perpetrators and victims happen to belong to the same club[24]) if optimal adjustments are not properly conducted (Rothengatter, 2015).

Given the above illustration, it is theoretically easy to demonstrate the principle of SRMC; however, it is widely accepted that the textbook theoretical model is far from practical. Whenever impractical implementation of SRMC perseveres, Rothengatter (2003) proposes a deviation from the SRMC principle in order to implement the best alternative that suits a particular environment. For instance, the SRMC can be modified by adding a mark-up to the average costs or by constructing multi-part tariffs to capture different external costs (Rothengatter, 2015). Such charges or tariffs permit aberration from the first-best pricing to the second-best pricing principles.

6.2.3 Challenges of implementing Short-Run Marginal Costs

The criticisms of implementing MSC are well established in the literature, with Rothengatter (2003) as a chief critic. Implementing the principle of MSC for road use is quite a challenging exercise, it is time consuming, and it requires an extensive budget (Link et al., 2016). The MEC are situation based and location specific, which makes it difficult for practical use (Shepherd, 2003). Several shortcomings of the SRMC principle are outlined by Rothengatter (2003). He makes numerous arguments why the textbook approach might face challenges, including the following:

- Measuring the SRMC of road use is very complex in practice;
- The SRMC tend to ignore equity;
- Efficient pricing at SRMC relies on present infrastructure and ignores the capital costs required for network expansion;
- Financial and institutional matters are ignored. The concept is objected on the ground that it rarely covers total costs; and
- The concept ignores price distortion elsewhere in the economy.

Nash (2003a) made a counter-argument on financial issues that this depends on the aggregation level at which costs are compared to the revenue generated. For marginal costs to recover total costs typically implies a big increase in RUC or taxation coupled with a reduction in other modes such as rail and public transport charges. At the aggregate level, the reverse applies.

[24] Rothengatter (2015) explains that secondary effects from the road congestion externalities turn out to be external to the individual driver but internal to the group of road users utilising the same network. He therefore argues that as a group, road users are somewhat paying a sum of external congestion costs, although not at the desired social optimal point.

MEC are situation based and location specific. Thus, estimating MEC requires a thorough study that analyses a range of circumstances such as time of day, location of the road, as well as geographical region. There is often substantial variation in measuring the marginal costs of different types of vehicles using the road network and MEC differ per vehicle category. Creightney (1993) posits that an assumption for a single marginal cost curve can be made (ignoring the difference in vehicle category) or calculated using the MEC per vehicle category. This has led to many policymakers abandoning such exercises and type of road pricing policy (Creightney, 1993). Therefore, it may be realistic to make estimations based on the best available data to estimate the MEC of road use. In a more realistic approach, case studies on a specific section of the network could give a better understanding of the cost variations from one circumstance to another. Despite the difficulty in implementing the MSC principle, road pricing should aim to attain economic efficiency in road-use tariffs as only efficient pricing will bring about gains in terms of economic development.

Setting the price equal to SRMC does not guarantee fiscal neutrality, or an increase in revenue generated from RUC. Road use charges set at SRMC could in fact lead to a revenue deficit or surplus (Proost & Van Dender, 2003; Heggie, 1995). The literature therefore suggests using SRMC as a point of departure in order to determine whether RUC set at SRMC could lead to a deficit or surplus (Walter, 1968). Kahn (1988) outlines the principal challenge of setting the price at SRMC, in that in networks defined by low demand and excess capacity, SRMC pricing is likely not to cover the fixed costs (return on capital investment) that the roads agency ought to recoup from road users. In the case of high demand, SRMC pricing is likely to generate revenue surpluses.

6.3 LITERATURE ON ESTIMATING THE MARGINAL EXTERNAL COSTS OF ROAD USE

The literature presents estimations of the MEC (accident cost, air pollution, congestion, and road damage) of road use at the country level or for a particular road network. This section provides an overview of some studies that have been conducted on MEC (Blauwens et al., 2012; Ghadi et al., 2018; Gavanas et al., 2017; Pretro & Konecny, 2017).

6.3.1 Accident costs

Korzhenevych et al. (2014) define external accident costs as those social costs of traffic accidents that do not form part of risks covered by insurance premiums. The principal accident costs include medical costs, production losses, material damage, administrative costs, and proxies to estimate the pain, grief, and suffering caused by traffic accidents in monetary value

(Korzhenevych et al., 2014). Traditionally, accident costs rely on two methodologies, namely the human cost approach, and the value of statistical life (willingness to pay) to determine the costs. The human capital approach involves observation of present and future expenditure (see Figure 6.3) as a result of accidents and includes medical and hospital costs, legal and administrative costs, and property damage (Ghadi et al., 2018).

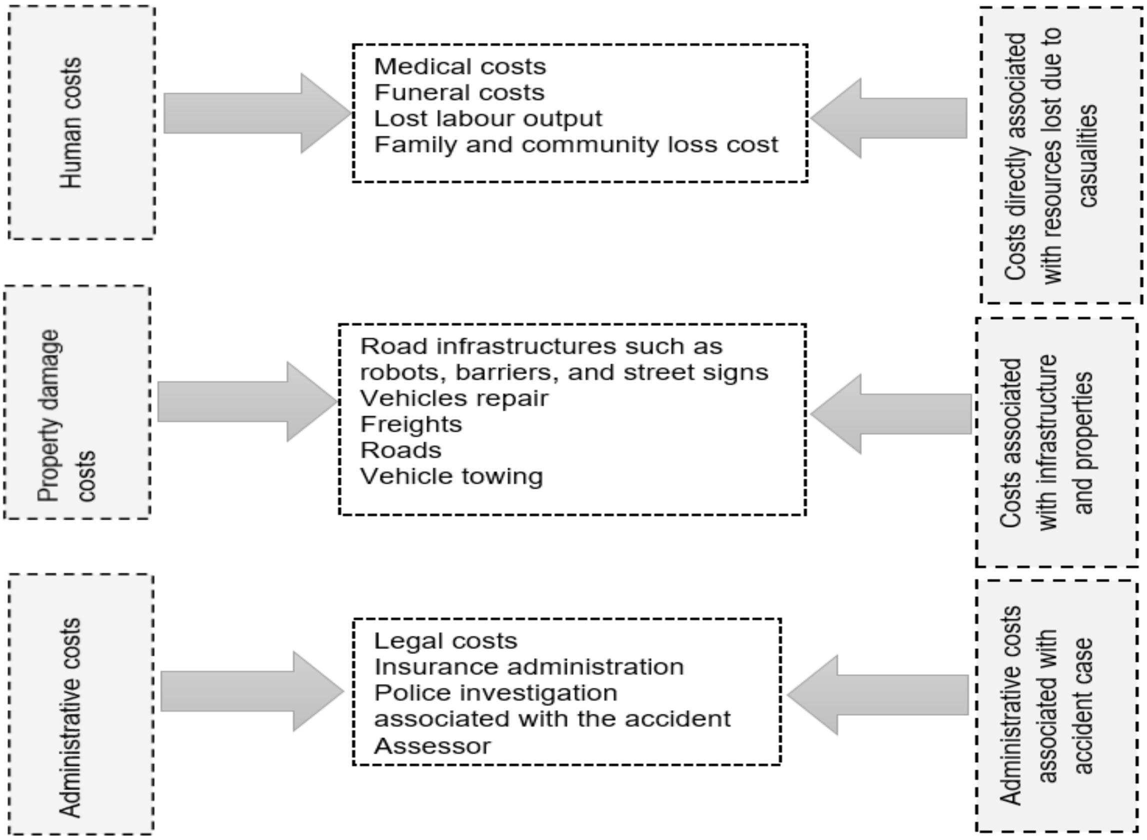

Figure 6.3: Classification of accident cost components by the human capital approach

Source: Author

Willingness to pay includes risk values such as loss of productivity to the economy due to premature death and thus the willingness to pay in order to reduce accident risks. Ghadi et al. (2018) used the human capital approach to estimate the total and unit costs of traffic accidents for Jordan for the period 2011-2013. The study findings estimated that the total costs of accidents amounted to US$543 917 509, US$532 458 743, and US$414 026 545 for the years 2011, 2012, and 2013 respectively. These costs constituted approximately 2.5%, 2.3%, and 2.25% respectively of the country's total GDP (Ghadi et al., 2018:133). Mofadal and Kanitpong (2016) studied traffic accident costs in Sudan for 2010 and 2011 using the gross loss of output approach. The study evaluated and compared the significance and impacts of economic loss caused by road traffic accidents employing key parameters such as severity level, vehicle type, discount rates, and medical and insurance information in Sudan. The total cost of the accidents was estimated at US$391 million and US$413 million, constituting 0.57% and 0.62%

of the GDP for the year 2010 and 2011 respectively. In Namibia, the cost of vehicle accidents to the Namibian economy was estimated at N$512.97 million. In 2015, the average cost of vehicle accidents in Namibia was estimated at N$19 047 and approximately N$1 604 per registered motor vehicle (NSRC, 2016).

6.3.2 Congestion costs

Road congestion implies the costs that motor vehicles impose on other vehicles using the same network, at the point where traffic flow approaches the highest network capacity (Goodwin, 2004). Congestion builds up when an additional vehicle joins the network and potentially reduces the speed of all the other vehicles, thereby causing journey delays and higher fuel consumption. It is therefore essential to calculate the time lost for all the vehicles on the road section due to the additional costs of an additional vehicle. Congestion costs are highly influenced by marginal time costs. Marginal external time costs are calculated by the difference in journey time caused by an additional vehicle on a specific network multiplied by the estimated value of the journey time (Blauwens et al., 2012). A methodological caveat is the need to estimate the marginal external congestion costs after the congestion charges have been determined (Link et al., 2016). These allow the roads agencies to internalise MCC into road tariffs.

Another methodology used in the literature is the speed-flow relationship used to estimate changes in journey time. The speed-flow relationship is typically characterised as a relationship between travel speed, traffic volumes, and the number of vehicles (traffic density) occupying a given space of a road (FHWA, 2008). Figure 6.4 illustrates scenarios of speed-flow relationships.

At low-volume traffic, motor vehicles are likely to have an insignificant impact on one another; the speed limit per vehicle per kilometre is only limited by speed regulation and the road geometry. As the traffic volume increases, vehicles' freedom to manoeuvre between lanes or overtake another vehicle becomes very restricted. This results in decreasing travel speed that is indirectly proportional to the traffic volume on the network (as traffic volume increases, they are likely to lower other vehicles' travel speed). When traffic density reaches the maximum point, also called jam density, speed starts to decrease due to the additional vehicles in the traffic stream (FHWA, 2008).

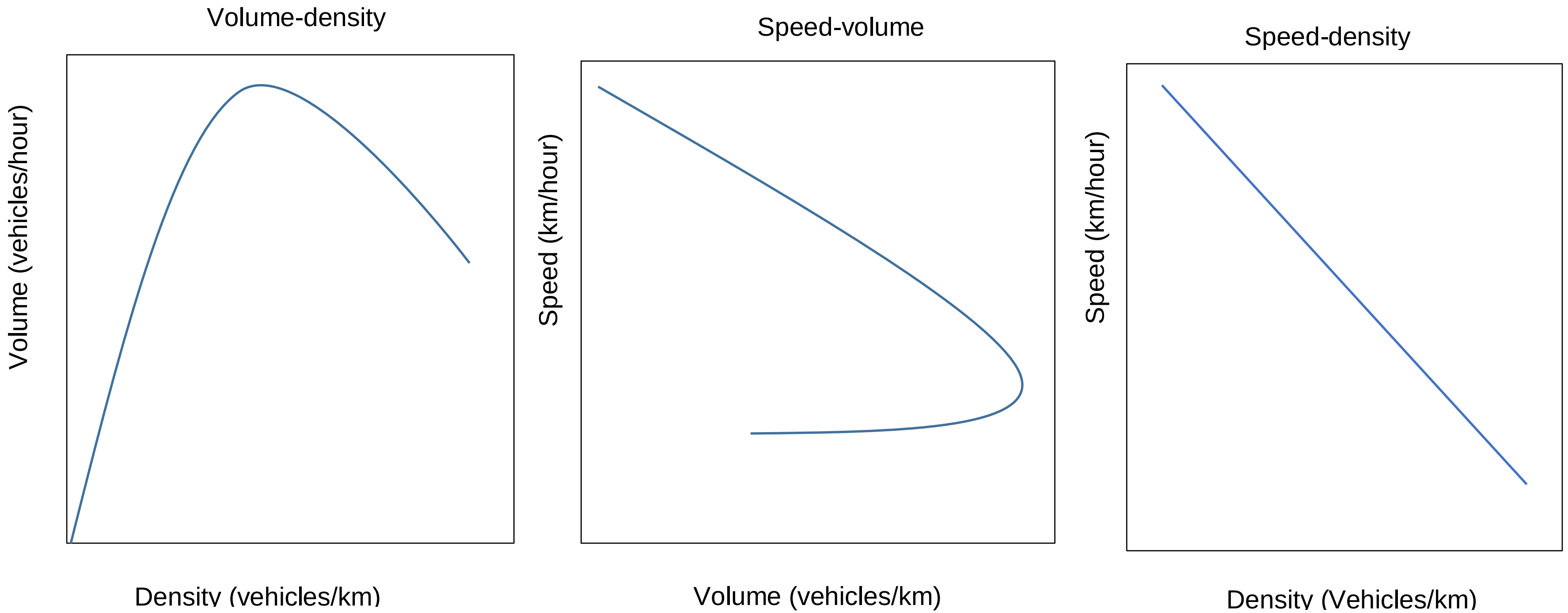

Figure 6.4: Fundamental traffic-flow relationship

Source: FHWA (2008:9)

Gavanas et al. (2017) used the speed-flow function to assess congestion costs in Thessaloniki, Greece. Using floating car data, the study utilised the following equations to estimate marginal and total social costs for congestion along a specific street (Tsimiki Street):

MCC congestion $= F.C. + V.O.T.\frac{S+395.791}{395.791\,S}$ $,(When\ S = 25.72)$.............. 3

Total social costs congestion $= 1.275.e^{x3.204+X}.\left(F.C. + V.O.T.\frac{1+X}{395.791}\right)$.................... 4

F.C. represents fixed cost, V.O.T. represents the value of time, and S represents speed. The finding of their study is summarised in Table 6.1, which presents the difference in marginal and total social costs due to congestion between the values that correspond with the average hourly speed during a workday and the 85 percentile hourly speed of a workday.

Table 6.1: Marginal and total social costs of congestion along Tsimiski Street

Speed (km/h)	*Flow (PCU/h[25])*	*MSC (€/passenger.km)*	*MSC (€/passenger car.km)*	*TSC (€/km)*
Daily average hourly 29.6	1425	0.496	0.513	731.025
85 percentile hourly 32.4	923	0.456	0.473	436.579

Source: Gavanas et al. (2017)

Blauwens et al. (2012) employed the speed-flow relationship approach to illustrate an estimated congestion tax on a (2 by 3) road carriage lane. The study employed the following equation:

V $= 105 - 0.005833\,x,\ (if\ x \leq 1200)$ 5

$V\ =\ 98 - 0.025(x - 1200),\ (if\ x > 1200\ and < 2000)$ 6

V represents speed flow (km/h) and X represents vehicles per hour, per lane, PCU, and one minute has a value of €0.1. Their results indicate that the congestion levy increases with the traffic flow. For example, when traffic flow is 200 cars per hour, the optimal levy amounted to €0.0065 per kilometre. In the case of heavy traffic of 2 000 cars per hour per lane, the congestion levy rises to €0.04927 per kilometre. Gronau (1994) used a speed-flow function to estimate the MCC in Accra, Ghana, with an average count of 1.16 private cars equivalent. The results indicate MCC of ¢0.13-0.29 per private-car equivalent per kilometre (Gronau, 1994).

[25] PCU implies private car unit per hour.

6.3.3 Environmental costs

Environmental costs mostly consist of the three main components of air pollution, global warming, and noise.

6.3.3.1 Air pollution

Air pollution from vehicles consists of carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons (HC), particulate matters (PM2.5), and sulphur dioxide (SO_2), which are the main contributors to air pollution (Link et al., 2016). CO causes a reduction of oxygen in the bloodstream, which results in difficulties in breathing and negative cardiovascular effects (Parry, Walls & Harrington, 2007).

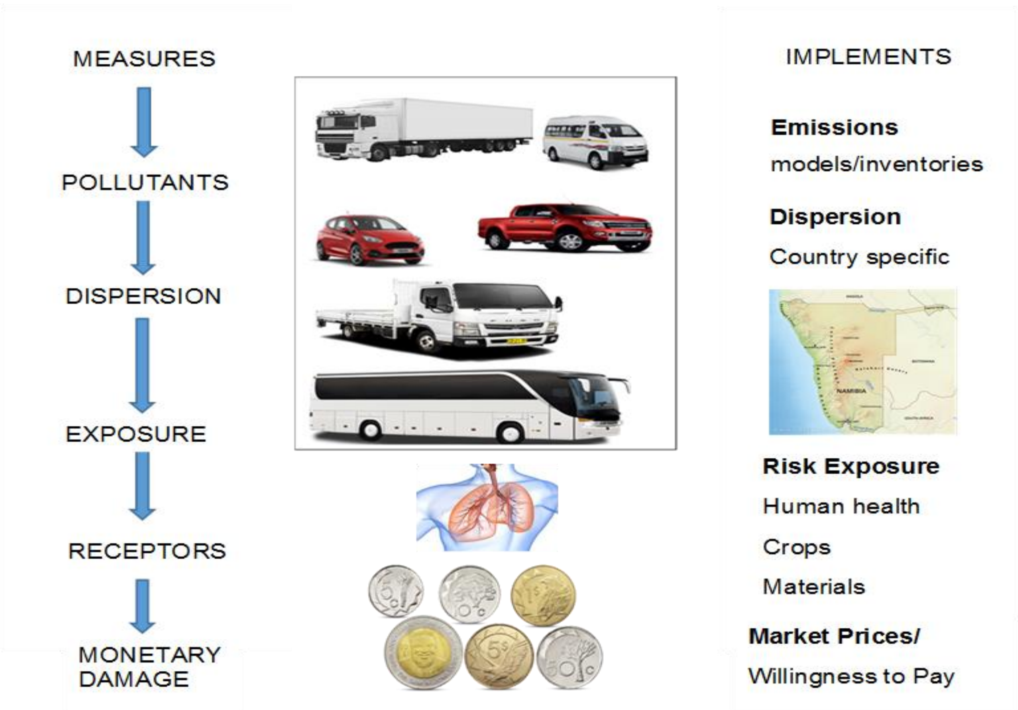

Figure 6.5: The steps of an impact pathway analysis on air pollution

Source: Author (Based on European Commission, 1998, and Bickel et al., 2005)

HC and NOx are the main components of smog. They react in sunlight and result in ozone layers. HC and NOx have greater effects on children and cause asthma-related diseases and affect visibility. PM2.5 have an effect on lung tissue, and particulate exposure has been related to mortality effects (Douglas et al., 1993). The costs category includes damage to materials and buildings, health costs, crop damage, and ecosystem damage. The common approach to air pollution is mainly the impact pathway (bottom-up) analysis, which models the emissions, their dispersion, and risk exposure, and then monetises the value obtained. The impact pathway study conducts a detailed assessment of human health and the environment using five steps (see Figure 6.5).

These steps involve determining the emission factors such as dispersion parameters that lead to exposure that influences human health and the environment. Such impacts were quantified into monetary values by way of willingness to pay. In the estimation processes, technology type per vehicles, the dose-responses functions used to quantify the physical impacts, and the value of statistical life are used to assess the value of death risk or illness caused by air pollution.

6.3.3.2 Global warming

Motor vehicles emit pollutants that can affect the global climate. GHGs such as carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) are the main causes of climate change. Estimating climate change costs is a complex task due to the global and long-term character and risk pattern involved (Link et al., 2016). Climate change impacts include sea level rise, health impacts, ecosystem and biodiversity impacts, extreme weather events, and catastrophic events or major climates discontinuities (Link et al., 2016).

An environmental impact study conducted by Condurat, Nicuta and Andrei (2017) on road transport traffic, performed with COPERT 4 software, aimed to quantify the energy consumption and CO_2 emissions produced by road traffic. Their results indicated passenger cars as the highest carbon monoxide (CO) contributors, with approximately 72.18% to the total emissions. CO is one of the contributors to high ozone concentration, which could lead to global warming. Condurat et al.'s (2017) study also indicated that vehicle engines produce approximately 47.43% of CO_2. For the NOx emissions, the study findings indicated heavy vehicles as the main pollutant, producing 41.77% as compared to 18.91% produced by passenger cars (Condurat et al., 2017).

The standard approach to estimating global warming costs involves three major steps: (i) convert individual gasses to CO_2e (carbon dioxide equivalent); (ii) multiplying the amount of CO_2e emitted by the cost factor, and (iii) multiplying it by the GWP[26] of the associated gas. The *Intended national determined contributions (INDC)* report covers three direct gases, namely CO_2, CH_4, and N_2O. The report uses the IPCC's 2006 guidelines and software and adopted the GWP, mainly CO_2 (1), CH_4 (21), and N_2O (310). Namibia contributes less than 0.1% to global emissions (National Determined Contributions Partnership Support Unit, 2017), and the country's CO_2e emission outlook indicates a 63% contribution to CO_2, 21% of CH_4,

[26] According to the Kyoto Protocol, the GWP for CH_4 is 23, for N_2O it is 300, and 1 for CO_2.

and 16% of N_2O. The Ministry of Environment conducted a study titled "the National Greenhouse Gases (GHG) Inventory Report". The report indicated that there has been an increase in CO_2e emissions over a 10-year period from road transportation. In 2000, the CO_2e emitted amounted to 1 334 GHGs' CO_2e in comparison to 20 163 GHGs' CO_2e in 2012 (GRN, 2016:36).

6.3.3.3 Noise

Noise costs involve disturbances, annoyance, and health impacts. Disturbance and annoyance are related to individual experiences associated with traffic noise. Health impacts are associated with long-term exposure to noise and could result in health effects such as hypertension and myocardial infraction (Link et al., 2016). The methodology explored in the literature to estimate marginal noise costs is similar to the impact pathway approach to estimating air pollution costs.

Table 6.2: Impact pathway approach to noise

Step	Description
Noise emissions	The changed levels of noise are measured in terms of change in time, location, frequency, level, and source of noise.
Noise dispersion	The differences in exposure to noise are estimated according to geographical locations, and measured in decibel (dB) (A) and noise level indicators (L_{den} andL_{night}). The results are presented in noise maps.
Exposure response functions	These functions present a relationship between dB levels and the negative impacts of noise. Each impact has one or more endpoint. Using the information about the number of cases of each endpoint, the overall change in noise impact is calculated.
Economic valuation	An economic value for a unit of each endpoint of the exposure-response functions is calculated by transferring estimates either from existing valuation studies or by conducting a new original study using environmental valuation techniques.
Overall assessments	The economic value of each unit of endpoint is multiplied by the corresponding impact and aggregated over all endpoints from exposure-response functions.

Source: Korzhenevych et al. (2014:49)

6.3.4 Infrastructure damage

The marginal infrastructure damage (MIC) of road use associated with an additional vehicle utilising a specific network comprise three components, namely road damage externality, road wear, and damage (Bruzelius, 2004). Road damage externality implies the increased costs imposed on other vehicles because of an additional vehicle that joins the network. Road wear and damage are conditions that cause roads authorities to take action (routine and periodic maintenance) to remedy the wear and damage at an earlier stage than the case would have been without an extra vehicle.

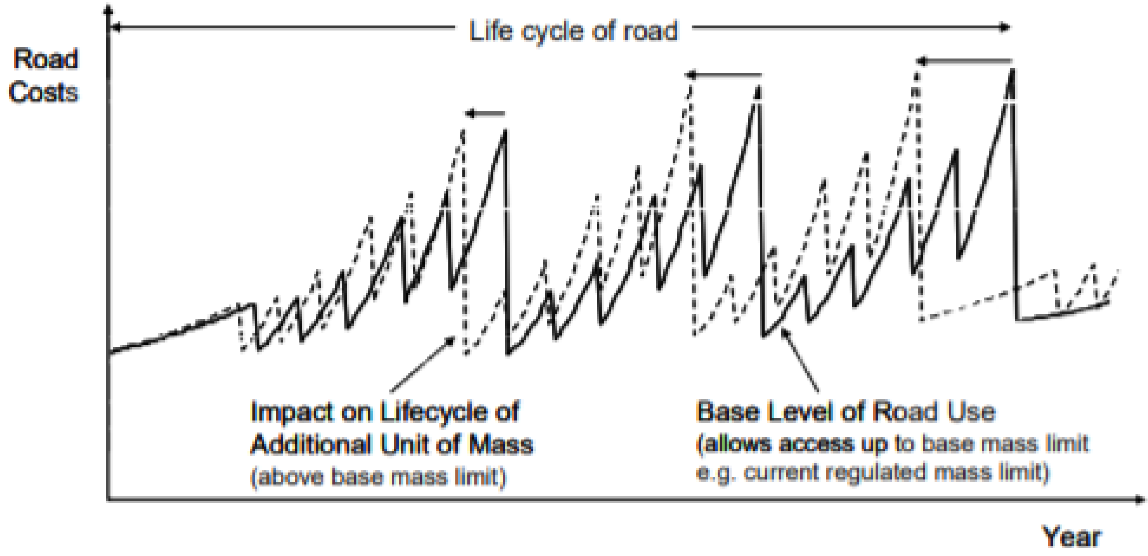

Figure 6.6: The impact of additional unit of mass to the road network

Source: National Transport Commission (NTC, 2009:33)

Figure 6.6 illustrates the impact of additional mass loads on the road surface that call for earlier maintenance action in order to ensure that the network maintenance standard is kept at a certain level. The repercussion of a vehicle driving on a deteriorated road is felt because of increased vehicle operation costs, and lower speeds that subsequently result in longer journeys and less comfort. The structure and capacity of the road are directly linked to its foundation and pavement type, which is expressed as a number of Equivalent Single Axle Load (ESAL). South Africa uses 80 kN axle as the standard axle load (Department of Transport, 1991). The amount of damage caused by heavy vehicles is associated with axle load to the fourth power (Blauwens et al., 2012). The Department of Transport (1996) explains that the cumulative damage effect caused by different vehicles moving across roads is defined by the number equivalent 80 kN single axle loads (E80) The structure design of the road requires an estimate of the cumulative equivalent traffic expressed as the number of E80 axles over its design life.

Box 6.1: An illustration of Equivalent Standard Axle Loads

If one chooses 8.2 tonnes as a standard axle load, then an axle load of G tonnes may be expressed in ESAL by inscribing the load G in the expression of $(G/8.2)^4$. For instance, an axle load of 10 tonnes is equivalent to $(10/8.2)^4$ = 2.21 ESAL. A passenger car with an axle load of about 600 kg corresponds to no more that $(0.6/8.2)^4$= 0.000029 ESAL.

Source: Blauwens et al. (2012)

MIC have been estimated using four main approaches. First is the direct approach that mostly uses the HDM-4 and yield estimates in the form of a NPV (Bruzelius, 2004). The second is the indirect method that is based on David Newbery's fundamental theorem, which focuses on the effect of road damage and periodic maintenance in the form of overlay (Newbery, 1988). The club approach is the third, and it is often based on equity and is not compatible with the marginal cost principle (Bruzelius, 2004). The fourth is the econometric approach, which often estimates marginal costs after the cost function is built on the microeconomic production theory.

Bruzelius' (2004) study was based on the direct method to estimate the MIC of a sampled section of the Swedish national road network. The study utilised the HDM-4 to estimate the NPV of a defined action. Bruzelius (2004) made an illustration of a 9m wide road carrying average daily traffic of 6 000 vehicles, namely 4 860 cars, 300 pick-ups, 360 large trucks, 360 small trucks, and 120 buses. A maintenance strategy applied included an overlay if IRI exceeds 5.0, a partial overlay if rutting exceeds 22 mm or a partial resurfacing if more than 10% of the road area suffers structure cracking.

The costs of the marginal user were determined by calculating the difference between two NPV alternatives; one with an increased AADT by one unit (with a case) compared to a do-nothing case. A run was performed with HDM-4 for the identified road in South Sweden. The results indicated that the road damage externality was found more important than the wear and damage (see Table 6.3). Bruzelius (2004) concluded that marginal-based pricing presents a more promising chance to recover costs associated with road damage externality than with wear and damage for the period of 50 years in Sweden. His results of the estimated MIC of road use per vehicle class calculated with HDM-4 output are presented in Table 6.3.

Table 6.3: Marginal Infrastructure Costs (SEK per/km)

Vehicle	Wear and damage	Road damage externality	Total
Bus	0.001635	0.516679	0.518314
Truck	0.015533	0.741432	0.756965
Light truck	0.000204	0.134756	0.134961
Car	0.000177	0.026454	0.026630
Pick-up	0.000000	0.064340	0.064340

Source: Bruzelius (2004:25)

Gronau (1991; 1992, cited in Gronau, 1994) studied the contribution of road damage to road-use costs in sub-Saharan Africa, Ghana (1991), and Zimbabwe (1992) in particular and how MSC should be recovered. He particularly focused on the interurban road deterioration in the least developed countries for the 1987 fiscal year and utilised Newberry's theorem. Gronau (1991 & 1992, cited in Gronau, 1994) outlined that estimates for road damage externality reflecting the loading and associated increased returns to scale to reflect the production of loading services. He determined the impact that an additional vehicle has on road roughness over time. An alternative case was then to increase the level of roughness and determine the impact on VOC, *ceteris paribus*. His assumption of road damage externalities that are load related rather than traffic responsive for paved roads in Ghana was estimated at ₵0.9 per ESAL kilometre (Gronau, 1991, cited in Gronau, 1994); in correspondence, in Zimbabwe it is estimated at ₵7.1 per ESAL kilometre (Gronau, 1992, cited in Gronau, 1994). Assigning external costs to heavy vehicles' road damage externalities yielded in the range of ₵1.53 to ₵3.87 per vehicle kilometre in Ghana and 5.33 US cents per vehicle kilometre for Zimbabwe.

In Namibia, studies on the road management system (RMS) focus on the use of the HDM-4 model, for planning, especially for budgeting purposes to motivate more funding for the network needs (Tekie, 2015).

6.4 METHODOLOGY

This study employed the direct method of estimating the external costs of road use. This method best allows researchers to make use of RMS data and the HDM-4 in order to estimate the external costs of road use. As discussed by Bruzelius (2004), the HDM-4 model is mostly used in developing countries in order to analyse the economic effect of several maintenance policies and network investment needs. The Namibian RA uses the HDM-4 for the same purpose. In this chapter, the use of HDM-4 is extended to estimating the external costs of road use, which could be further utilised by road planners and policymakers as an input to determine road pricing.

6.4.1 Dataset

The analysis in this chapter, as described in Chapter 4, is based on the dataset obtained from the Namibian RA (see Section 4.4). Using case studies, this chapter intends to make comparisons between two road pricing rules, namely average costs and marginal costs, in order to establish which of the two could yield the best results for Namibia. Marginal cost pricing presents the efficiency case, while average cost pricing implies a practical long-term alternative. The next section explains the difference between the two pricing approaches.

6.4.2 Average costs

Average costs imply the total costs of the external components divided by a measure of outputs such as vehicle kilometres (Commission of European Communities, 1998). The average external costs were calculated by taking the total external costs imposed by a certain vehicle category (for instance, articulated trucks) divided by the group AADT per road section.

For instance, the average infrastructure costs of road use were calculated by taking the NPV of maintenance costs divided by the AADT for all the vehicle types per road section. Cost allocation was done by using the apportionment formula that considers the size and weight of a vehicle. However, various factors could potentially influence the value calculated (see Chapter 4, Section 4.7.2). In this study, average external costs per vehicle class are presented in N$ or Namibian cents per kilometre. While average costs deliver reasonable results, the pricing approach does not necessary produce results that accurately reflect the impact an additional vehicle has on road costs, and the results may underestimate the true impacts of different vehicle classes (NTC, 2009). From an equity point of view, average cost pricing presents results that indicate whether vehicle categories pay their way according to the costs they impose when using the road network.

6.4.2.1 Average infrastructure external costs

This study adopted the methodology from Bruzelius (2004), namely using the direct method in order to estimate the infrastructure external costs of road use. As described in Section 6.3.4, the output of the HDM-4 model analysis is the NPV of a certain action. At this point, the analysis was structured to exclude other external costs such as accident costs. The estimate of infrastructure external costs for three sampled paved roads to reflect the average infrastructure external costs of each vehicle category. The maintenance strategy applies as defined in Chapter 4 (see Tables 4.5 and 4.8 for a full description).

6.4.2.2 Average accident external costs

The main input in the HDM-4[27] includes the average accident category costs (in thousand Namibian dollars), including fatal (N$1 440 380), injury (N$224 230), and damage only (N$496 260). The RA's accident costs as presented in the *Economic evaluation manual* (2014:8) were utilised as a base and projected to 2015 for the HDM-4 analysis (see Figure 6.7).

[27] The HDM-4 Workspace was last updated in 2015.

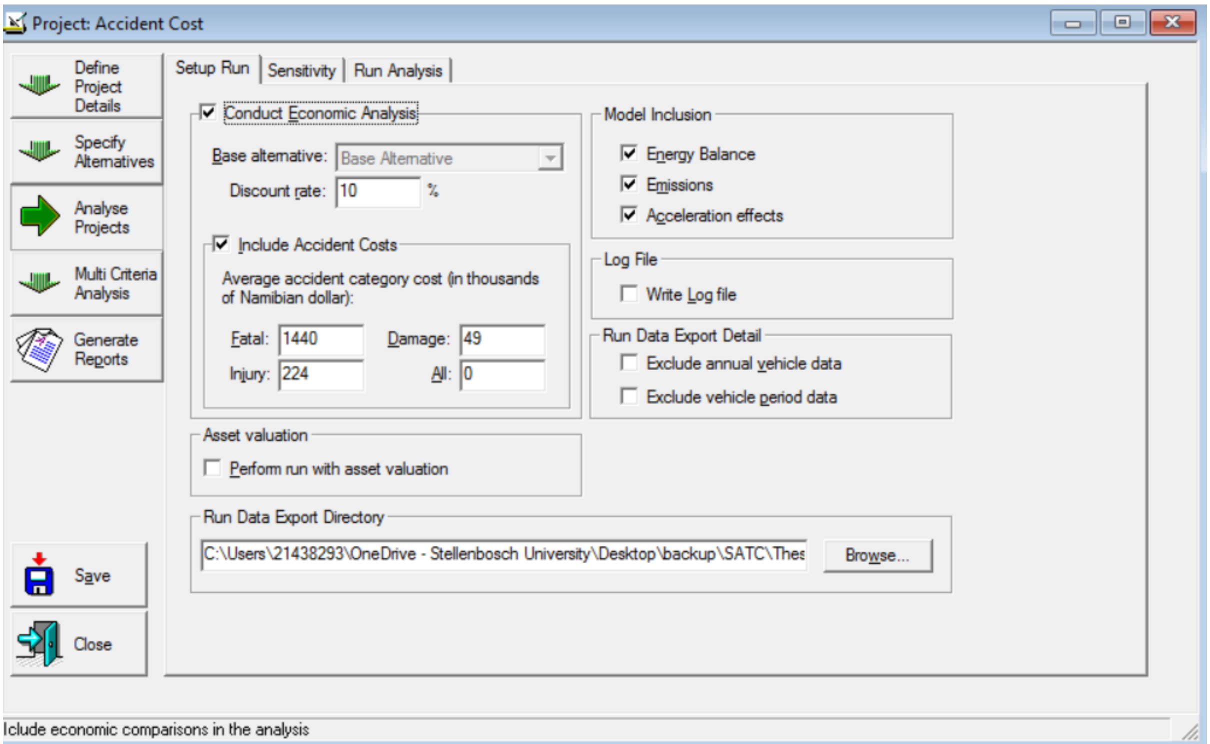

Figure 6.7: Average accident costs categories

Source: Author

To calculate the average external costs per road section, the road-user accident costs were obtained from the HDM-4 run. To determine the average external accident costs, road-user accident cost per road section is divided by the traffic volume on each sampled section. To determine the average accident external costs per kilometre, the determined average accident cost is divided by section length (kilometre) and per day. Then the average costs per vehicle per kilometre are determined.

6.4.2.3 Average environmental external costs

For environmental externalities (mainly climate change), average external costs and MEC are equal. Schroten et al. (2019:67) argue that "an additional kg of CO_2 emitted results in the same external costs as the average kg CO_2 emitted, since the quantity of CO_2 emitted occupy the whole atmosphere". Their argument applies to this study. The estimation of average global warming/climate change in this study adopted Schroten et al.'s (2019) methodology. The GHG emissions per vehicle category were obtained from HDM-4 run and the steps as outlined under marginal environmental external costs were applied.

6.4.3 Marginal External Costs

MEC refer to the additional costs arising due to an additional vehicle on the road network and which are not directly borne by the user in question (Sansom et al., 2001). The estimation of MEC therefore needs to be established using a case study representing different inter-urban road categories (trunk road, main road, and district road) of the national road network.

Road pricing at the price equal to SRMC of road use has, however, been criticised in the literature to be a more theoretical construct with difficulty in implementation, with special reference made concerning the state of technologies and legislation (Milne, Niskanen & Verhoef, 2000). Marginal pricing set at SRMC, although yielding efficient pricing, is difficult to achieve in practice, therefore average costs pricing is often applied as second best. The former attempts to analyse the impact that each vehicle class has on road costs.

Marginal cost pricing assessment could present results that can be utilised for the internalisation of external costs into road pricing in order to achieve economic efficiency of road use. Three road sections (D0872, M0052 & T0108) were sampled from the paved road of the national road network (see Section 4.3 in Chapter 4). To better reflect the candidate work programme in terms of location and time of a particular section, the researcher conducted tactical analysis in the HDM-4 model.

6.4.3.1 Marginal Infrastructure Costs

As described in Section 6.3.4, the marginal user costs were determined by calculating the difference between two NPV alternatives; one with an increased AADT by one unit compared to a do-nothing case with AADT.

The calculations of MIC involve the following steps:

1) Determine the NPV of each option: (i) NPV with a do-nothing case to AADT, and (ii) add an additional vehicle (ADDT plus one).
2) Determine the difference between the two NPV alternatives and divide by the AADT for the candidate road in order to obtain the costs per vehicle.
3) Obtain the costs per vehicle per kilometre by dividing the answer in Step 2 with the length of the sampled road (for instance 117.76 km) and multiply by ESAL factor for each vehicle (see Appendix D, Table 6A.1).
4) In order to determine the costs per vehicle per kilometre per day, a correction is made for the answer obtained in Step 3 to account for all the days in a year.

6.4.3.2 Marginal Congestion Costs

The quantification of congestion on the inter-urban (national) roads was estimated by means of parameters derived from the characteristics of the road network as per the HDM-4 Workspace obtained from the RA. Schroten et al. (2019) argue that it is unrealistic to assume that all locations where congestion occurs can be identified and measured. Hence, MCC estimates need to be established using a case study that represents the homogenous traffic conditions on the sampled inter-urban roads of the national road network and different levels of traffic under normal traffic and congested periods[28]. For Period 1, the HDM-4 run comprises an action of adding one vehicle to the existing traffic flow on each sampled road. The total annual road congestion costs per sampled road could be calculated by adopting a delayed cost approach (which is basically a speed-flow relationship) (Schroten et al., 2019) and building on the values of delayed costs per vehicle kilometre for the candidate road simulating circumstances of a congested network.

The simulated circumstances could represent a trunk-paved (T0108) road and level of capacity occupancy (free-flow speed, and congested/peak). The HDM-4 values must be altered with additional input values to simulate[29] different levels of capacity occupancy in order to estimate the road congestion external costs that could reflect the scenarios under evaluation. The analysis in this section employed output generated from the HDM-4 run, thus estimating the net time loss. The available information on inter-urban roads consists of road network characteristics, including average speed, PCU coefficient, and traffic flow. Motor vehicle hourly traffic by period (in PCSE per hour) was obtained from the HDM-4 run. For congestion external costs, two major scenarios were considered. The first scenario entailed a free-flow case representing the real situation as per the available data, and this is the scenario that could be compared to other external costs. This scenario applied to all three case studies. The second scenario simulated cases of peak conditions. This allowed the researcher to simulate a congested scenario on the sampled T0108I road. The second scenario only applied to Case Study C (trunk-paved road). Since the principal objective is to estimate the MCC that an additional vehicle imposes on other vehicles traveling on the same road, the following steps were employed:

1) Extract the speed flow for every vehicle class from the HDM-4 run and determine the difference in flow speed between the two AADT options; increase by one vehicle compared to a do-nothing case.

[28] Period 1 represents the free-flow (off-peak) period of the day and Period 2 represents the peak period. This allows accounting for the fact that trip purposes are not the same during each period of the day and therefore that the value of time and demand for the road use vary.

[29] The simulation of the different levels of occupancy was only applied to the paved trunk road and it was assumed that the sampled section represents the congested spot on the hypothetical road.

2) Multiply the speed difference obtained in Step 1 with each AADT accordingly.
3) Make a correction in order to account for the homogeneous stream in terms of the PCSE for all vehicle classes and for each action.
4) Determine the aggregate flow per hour during free-flow traffic for each action.
5) A correction is made to account for all minutes in a year and not just for that particular point, thus dividing the aggregate flow during Period 1 with the hours (8 760) in a year to obtain the flow per hour.
6) Given that the vehicle travelled on each sampled road (for instance 117.76 km of a trunk-paved road), determine the flow per kilometre by dividing the answer obtained in Step 5 for each action by 117.76 km (see Column 2 in Table 6.4).
7) The time difference between the two actions is presented in Column 3. This step determines the additional time coupled with an additional vehicle joining the 117.76 km stretch of the trunk-paved road.
8) To determine the time loss due to an additional vehicle on the sampled road, the additional driving time in Column 4 is therefore multiplied by the number of vehicles affected (3 114) by the delay of an additional vehicle (AADT+1) imposed on other vehicles (see Column 4)
9) Since there is no monetary value imposed on congestion delay in Namibia, for the calculation purpose in this chapter, the researcher made an assumption that time loss is valued at N$5 per hour (N$0.08333 per minute). Therefore, the congestion levy presented in Table 6.4 (see Column 5) could be determined by multiplying the answer in Column 4 by 0.08333 minute. Thus, at the price of N$0.08333 per minute, the time loss of 0.05766 may be valued at N$0.0048 per kilometre.

Table 6.4: Calculating a congestion levy based on a speed-flow relationship

(1) Vehicle per hour per lane	(2) Diving time / km (minutes)	(3) Time difference (minutes)	(4) Time loss caused by an additional vehicle (min.)	(5) Levy: N$/km
3114	0.057661			
3115	0.05768			

Source: Author

6.4.3.3 Marginal Accident Costs

Accident statistics available were obtained from the *Economic manual* of the RA (2014) (see Appendix D, Table D.3). HDM-4 gives the option to include or exclude accident costs. In order to calculate the marginal accident external costs, the two HDM-4 alternatives were run and thus determined the different accident costs between the two options. The HDM-4 Workspace obtained from the RA contains accident classes with configured accident rates (in number per 100 million vehicle kilometres).

The following steps were considered in estimating the MAC:

1) Determine the VKT per year on a wide two-lane road: 117.76 km x 3114 AADT x 365 days.
2) Obtain annual accident rate per casualties on the road section (117.76) km.
3) Calculate total accident costs (VKT x (AADT/100 million) x accident costs (Step 2).
4) Determine the accident costs per casualties (fatal, injury, and damage only).
5) Determine the costs per vehicle class.

6.4.3.4 Marginal Environmental Costs

The HDM-4 run provides emissions by vehicle type by quantities in grams per 1 000 vehicle kilometres (see Appendix D, Figure 6A.3). For the GWP, GHG is given in CO_2e. The calculation of the CO_2e includes a total of CO_2 times 1, N_2O times 310, and CH_4 times 21. These emission factors are extracted from the IPCC's *Assessment report WG1* (Foster et al., 2007; Republic of Namibia, 2016a). The impact on global warming from the emission of particles and other formations of secondary pollutants are not covered in the calculation. To calculate the environmental external costs, the researcher adopted the methodology used by Schroten et al. (2019).

Steps followed:

1) Obtain the gases from the HDM-4 run obtained from two options (see Appendix D, Figure A6.4).
2) Determine the total emission per vehicle class (by adding CO_2 + CH_4 + N_2O).
3) Convert the grams into tonnes.
4) Convert the individual GHG into to CO_2e by multiplying the GHG by GWP.
5) Multiply the CO_2e with fuel consumption per vehicle (obtained from the HDM-4 run output (see Appendix D, Table D.4).
6) To determine the environmental (climate change) external costs, the GHG emission per vehicle is then multiplied by environmental levy (see Chapter 4, Table 4.8) per vehicle. To reach the environmental external costs per vehicle, the climate change costs are divided by the kilometres travelled by each vehicle type on each sample road.

6.5 RESULTS

This section presents the results of the HDM-4 analysis for the three paved road case studies. In order to demonstrate the use of the HDM-4 and its possibilities to inform the setting of road pricing, this chapter used three case study scenarios.

6.5.1 Case Study A: District Paved Road

Figure 6.8 presents a contextualised sampled road (D0872) from the district paved road of the national road network. Chapter 4 of this dissertation presented the full description of the road section for this case study (see Section 4.5).

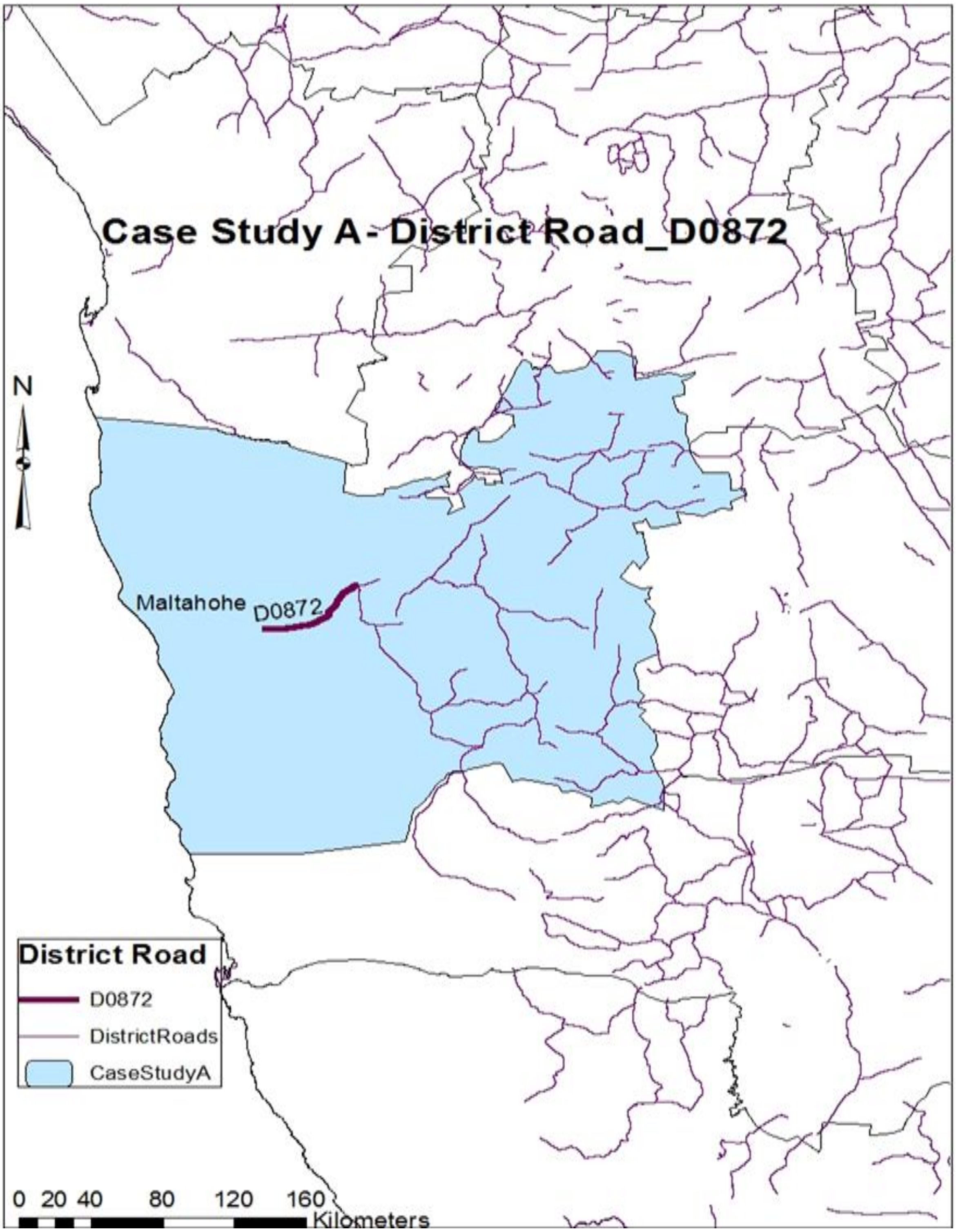

Figure 6.8: Study area

Source: Author (Shapefiles from RA, 2018)

The estimation of the external costs for vehicles using the district paved road (DO872) yielded results for different vehicle classes that differed slightly in terms of cost components. The analysis presents a variation in costs between heavy vehicles and light vehicles. When comparing average costs to marginal costs, the vehicle cost contribution follows the same pattern, although it differs percentage wise. Figure 6.9 shows heavy vehicles as a higher external cost contributor both to marginal and average costing. Table 6.5 contains average and marginal costs for all six representative vehicles in cents per kilometre.

The results indicate that heavy vehicles contributed by far the highest infrastructure external costs per vehicle (see Figure 6.9). When applying average costing, articulated trucks contribute approximately 56%, followed by heavy trucks with 26%, and buses with 18%.

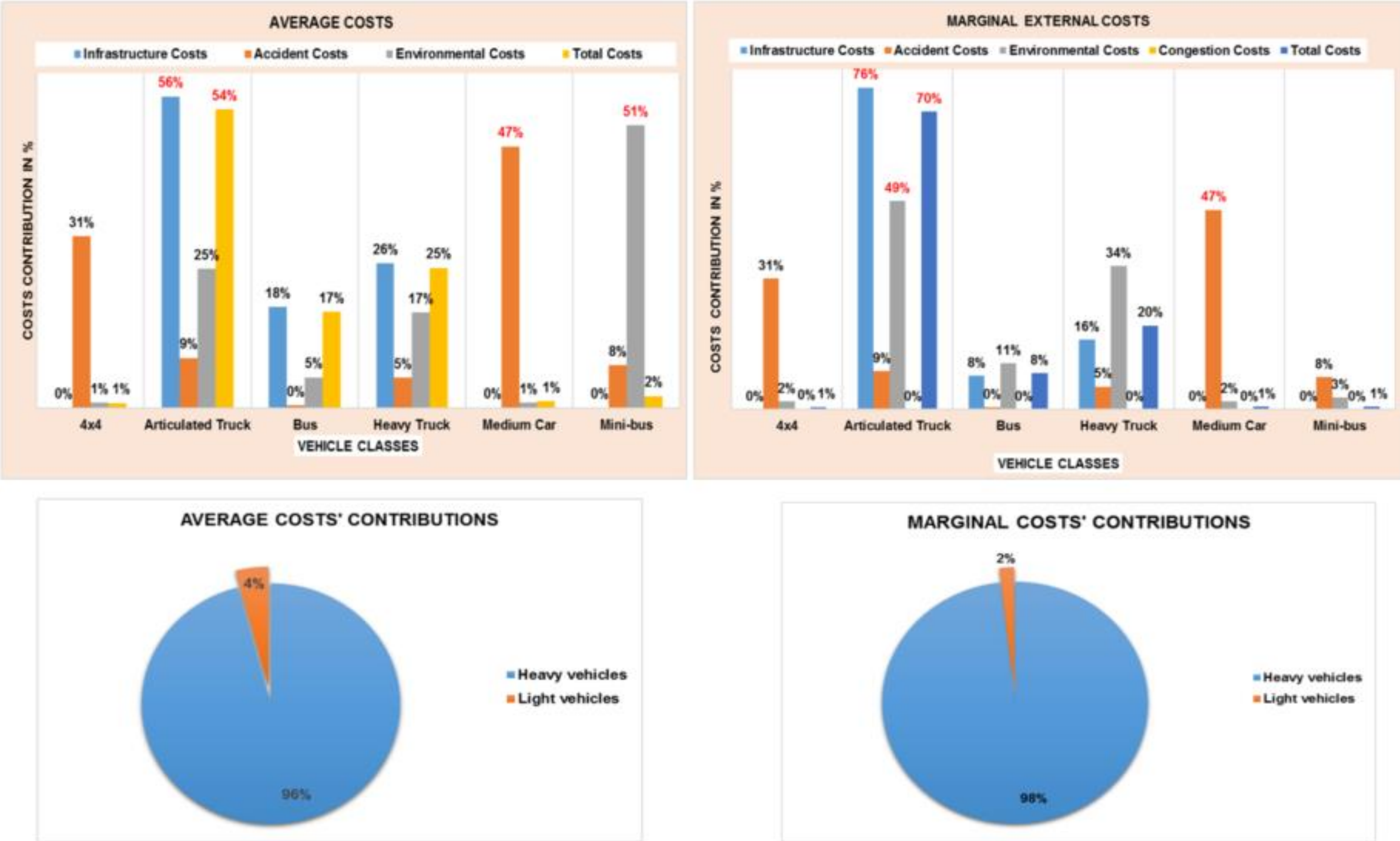

Figure 6.9: Average cost and Marginal External Costs analysis (contribution in percentage, Case Study A: District paved road)

Source: Author

When compared to marginal costing, the results follow the same pattern with a contribution ranging from 76% for articulated trucks, 16% for heavy trucks, to 8% for buses. In terms of accidents' external costs both at average and marginal costing, light vehicles contributed the most as compared to heavy vehicles; the former costs contribute as much as 47% for medium cars to as low as 8% for mini-buses on an average and marginal cost basis. Heavy vehicles' contribution to accident costs varied between 9%, 5%, and close to 0% for articulated trucks, heavy trucks, and buses respectively. When comparing marginal costs and average costs, the accident external costs are similar. These results are consistent with Fridell et al. (2011), who highlighted that marginal accident external cost results are usually similar or higher than the average accident external costs.

For environmental external costs, the marginal costs are the same as average costs. This observation was also made by Schroten et al. (2019), who reason that the average and marginal emissions per kilometre per vehicle are equal. Environmental external cost results indicate commercial vehicles to be the highest contributors, with mini-buses contributing approximately 51%, articulated trucks 25%, heavy trucks 17%, and 5% for buses. On the contrary, heavy vehicles contributed the most on a marginal costing basis, namely 49%, 34%, and 11% for articulated trucks, heavy trucks, and buses respectively. All light vehicles contributed approximately 1% on an average costing basis and approximately 2% on a marginal costing basis. In terms of congestion costs, the results indicate no congestion on the sampled district paved road.

Overall, the results for the district paved road indicate that heavy vehicles contributed by far the highest external costs per vehicle, both on an average cost basis, contributing approximately 96%, and approximately 98% on a marginal costing basis. Light vehicles contributed as low as 2% on an average costs basis and 4% on a marginal costing basis.

6.5.2 Case Study B: Main Paved Road

Figure 6.10 illustrates the estimation of the external costs for vehicles using the main paved road (M0052) analysed as per the full description in Chapter 4.

For instance, as recorded in Case Study A, heavy vehicles make the highest contribution to road infrastructure and environmental costs. Similarly, light vehicles contributed the most in terms of accident costs.

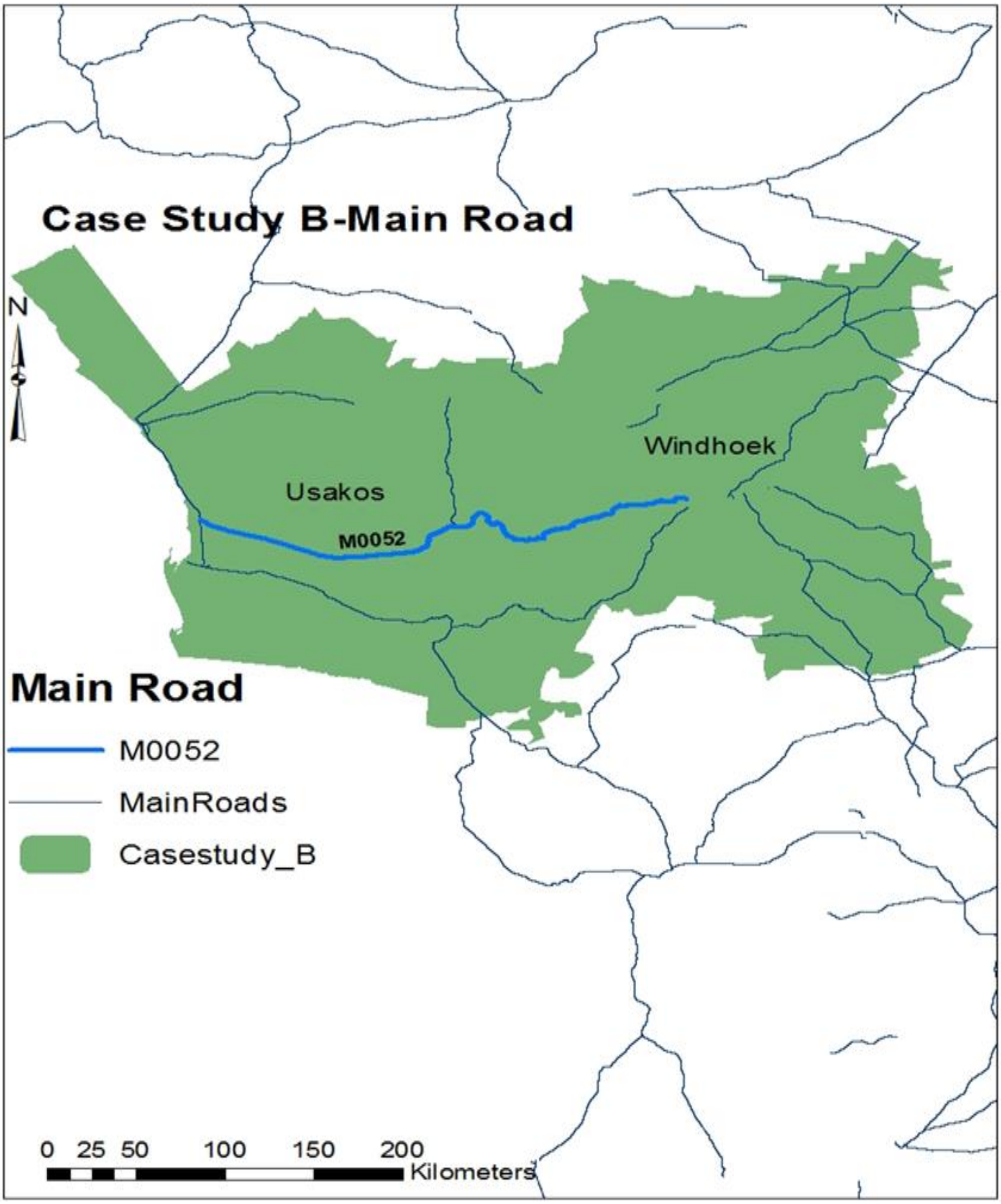

Figure 6.10: Main paved road

Source: Author (Shapefiles from RA, 2018)

Table 6.6 contains the average and marginal costs for all six representative vehicles in cents per kilometre. Looking at Figure 6.11, heavy vehicles cause overall external costs of approximately 97% both on average and marginal costing bases. The light vehicles' overall external costs contribute approximately 3%, which is over 32% lower than the external costs heavy vehicles impose on other users, infrastructure, and society. On the sampled main paved

(M0052) road, heavy vehicles cause higher infrastructure external costs on average, ranging from as high as 70% to as low as 12% for articulated trucks and buses respectively. The marginal costs on the main paved road ranged between 63% to 12% for articulated trucks and buses respectively.

The highest environmental external costs of road use on the sampled main paved road are caused by commercial vehicles, ranging from 38% by articulated trucks, 27% by mini-buses, 24% by heavy trucks, to 8% by buses. The environmental external costs for light vehicles on the sampled inter-urban road is even lower, with 4x4 vehicles and medium cars contributing only approximately 1%.

The results indicated accident external costs to be highly caused by light vehicles in terms of both average and marginal costing. The pickups or 4x4 vehicles contribute approximately 48% to external accident costs on average cost and about 31% on marginal cost bases. Other light vehicles, including medium cars and mini-buses, contribute approximately 48% and 6% to marginal costing respectively. The literature review indicated that light vehicles often result in higher accident costs as they drive relatively fewer kilometres with a lower occupancy rate (Schroten et al., 2019). In terms of congestion costs, the results for the main paved road shared similar findings as those of district paved roads with close to zero congestion, with all vehicles contributing approximately 0% to congestion costs.

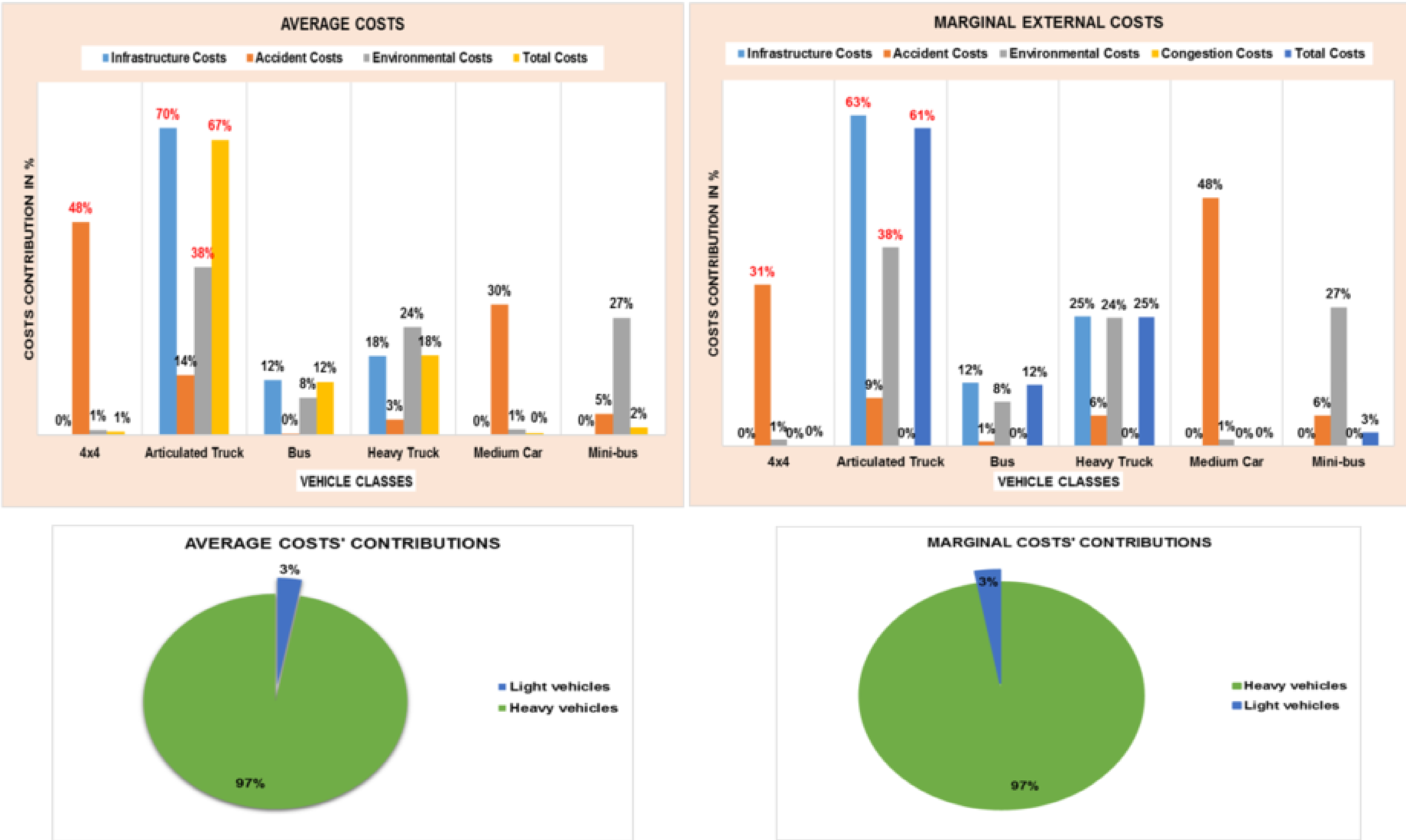

Figure 6.11: Average cost and Marginal External Costs analysis (contribution in percentage, Case Study B: Main paved road)

Source: Author

6.5.3 Case Study B: Trunk Paved Road

Figure 6.12 demonstrates the estimation of the external costs for vehicles using the trunk paved road (T0108) analysed as per the description in Chapter 4.

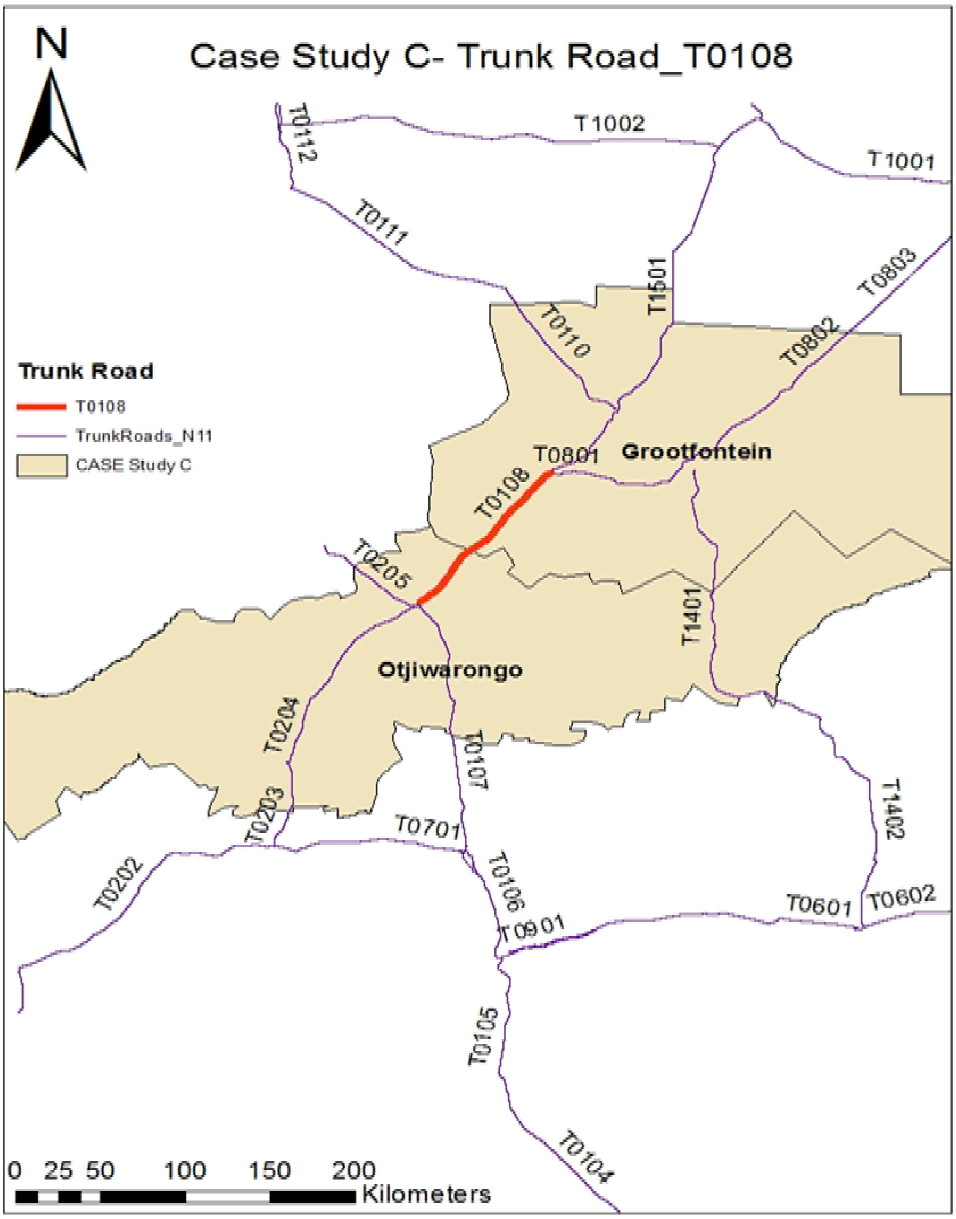

Figure 6.12: Trunk paved road

Source: Author (Shapefiles from RA, 2018)

The estimation of the MEC and average external costs for the sampled trunk paved road use yielded results that differ slightly from those obtained for Case Studies A and B in terms of the cost components and for each vehicle class.

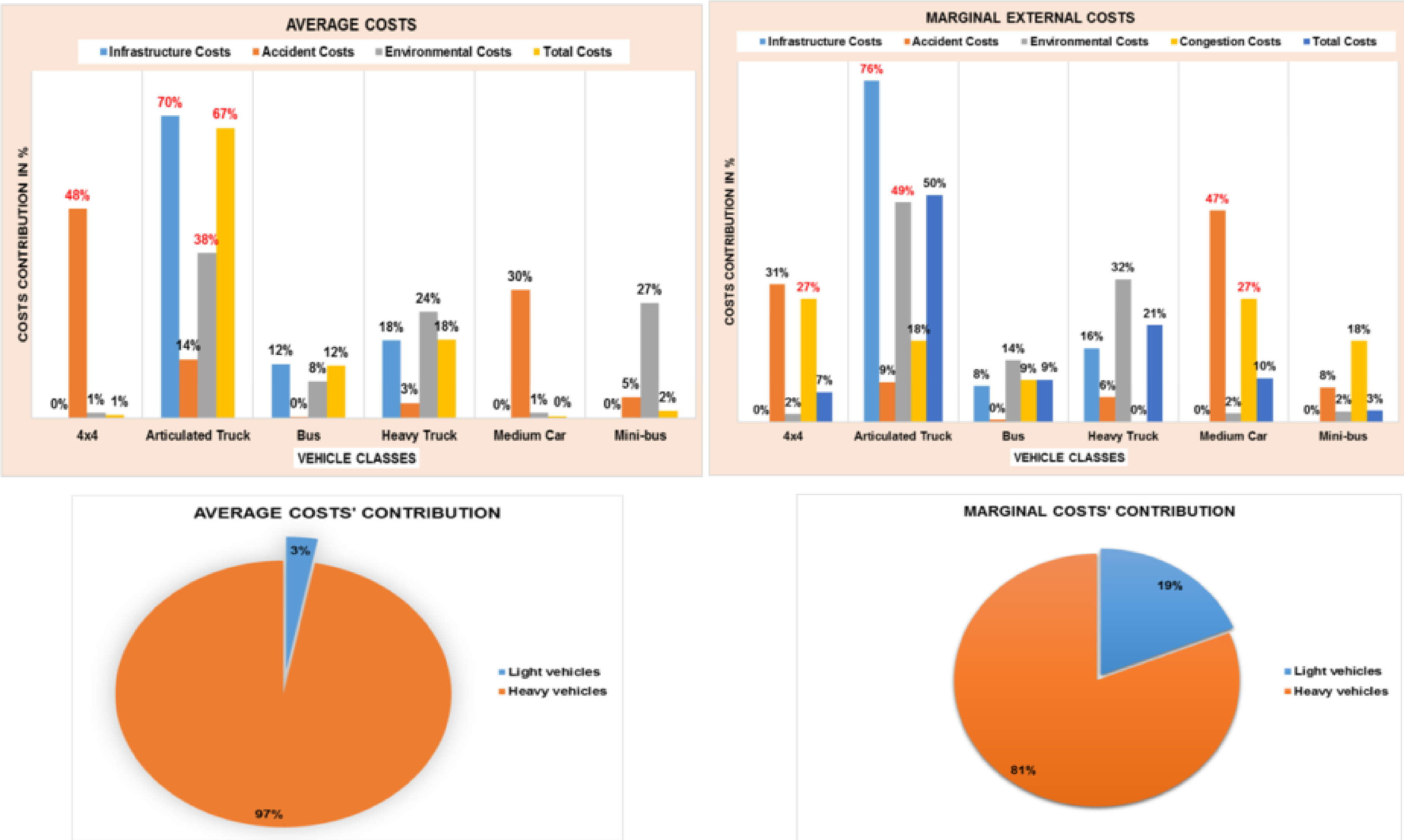

Figure 6.13: Average cost and Marginal External Costs analysis (contribution in percentage, Case Study C: Trunk paved road)

Source: Author

Similar to Case Studies A and B, Case Study C's analysis presents a variation in costs between heavy vehicles and light vehicles. Table 6.7 contains the average and marginal costs for all six representative vehicles in cents per kilometre. Figure 6.13 shows that heavy vehicles cause high infrastructure external costs and environmental external costs on a marginal costing basis. Marginal infrastructure costs range from as high as 76% for articulated trucks, 16% for heavy trucks, and to as low as 8% for buses. The average infrastructure external costs caused by heavy vehicle range between 70% for articulated trucks to approximately 12% for buses.

In terms of marginal costs, light vehicles contribute the most to external accident and external congestion costs as compared to heavy vehicles. The light vehicles contribute to external accidents costs from as high as 47% for medium cars to as low as 8% for mini-buses. Heavy vehicles' contribution to external accident costs varies between 9%, 6%, and close to 0% for articulated trucks, heavy trucks, and buses respectively. The average accident costs of light vehicles are around 48% for 4x4 vehicles, 30% for medium cars, and 5% for mini-buses.

In terms of congestion external costs, light vehicles contribute the most to congestion on the T0108 trunk paved road by contributing approximately 27% by pick-up (4x4) vehicles and medium cars. Heavy vehicles contribute to congestion when using the T0108 trunk paved road with 18% for articulated trucks and 0% by heavy trucks.

For marginal costing, the results present heavy vehicles as higher contributors to environmental external costs, with costs ranging between 49% by articulated trucks, 32% by heavy trucks, and 14% by buses. All light vehicles contribute approximately 2% to environmental external costs when utilising the T0108 trunk paved road. Currently, one could argue that marginal average costs are to a certain extent internalised into the current road pricing with road users paying 50.30 Namibian cents per litre as an accident levy. Environmental external costs (global warming) present yet another case for consideration.

The MENVC levy is highly influenced by fuel consumption; the more the distance driven, the higher the chances of such vehicles to emit emissions. Other researchers (including Link et al., 2016; Petrus & Krygsman, 2019) concur that global warming costs are better internalised into a fuel levy. Petrus and Krygsman (2019) share the same views concerning the marginal infrastructure costs. They argue that heavy vehicles impose the highest cost on the infrastructure in terms of wear and tear. The internalisation of such costs therefore calls for revamping the current manually operated system of MDC. The analysis presented a huge disparity between heavy vehicles and light vehicles. Overall, the MEC in Figure 6.13 present heavy vehicles as higher external cost contributors with approximately 81%. The light vehicles contribute approximately 19% of external costs when utilising the T0108 road.

Table 6.5: Average cost and Marginal External Costs analysis (cents/km, Case Study A: D0872 road)

	Average costs				Marginal costs				
Vehicle categories	Infrastructure costs	Accident costs	Environmental costs	Total costs	Infrastructure costs	Accident costs	Environmental costs	Congestion costs	Total costs
4x4	0.180	1.846	0.081	**2.107**	0.0001	0.0428	0.081	0.0000	**0.1239**
Articulated truck	128.324	0.535	2.1945	**131.0535**	13.6595	0.0124	2.1945	0.0000	**15.8664**
Bus	41.570	0.027	0.4829	**42.0799**	1.4334	0.0006	0.4829	0.0000	**1.9169**
Heavy truck	59.643	0.321	1.5085	**61.4725**	2.9508	0.0074	1.5085	0.0000	**4.4667**
Medium car	0.000	2.808	0.0813	**2.8893**	0.0000	0.0652	0.0813	0.0000	**0.1465**
Mini-bus	0.181	0.455	0.1229	**0.7589**	0.0000	0.0105	0.1229	0.0000	**0.1334**

Source: Own calculation

Table 6.6: Average cost and Marginal External Costs analysis (cents/km, Case Study B: M0052 road)

	Average costs				Marginal costs				
Vehicle categories	Infrastructure costs	Accident costs	Environmental costs	Total costs	Infrastructure costs	Accident costs	Environmental costs	Congestion costs	Total costs
4x4	0.0508	0.6963	0.0741	**0.8212**	0.0005	0.0037	0.0741	0.0000	**0.0783**
Articulated truck	65.3169	0.1958	2.3385	**67.8512**	36.101	0.0011	2.3385	0.0000	**38.4406**
Bus	11.6946	0.0044	0.5219	**12.2209**	6.8543	0.0001	0.5219	0.0000	**7.3763**
Heavy truck	16.7792	0.0504	1.5067	**18.3363**	14.1103	0.0007	1.5067	0.0000	**15.6177**
Medium car	0.0000	0.4264	0.078	**0.5044**	0.0000	0.0057	0.078	0.0000	**0.0837**
Mini-bus	0.0508	0.0697	1.6359	**1.7564**	0.0001	0.0007	1.6359	0.0000	**1.6367**

Source: Own calculation

Table 6.7: Average costs and Marginal External Costs analysis (cents/km, Case Study C: T0108 road)

	Average costs				Marginal costs				
Vehicle categories	Infrastructure costs	Accident costs	Environmental costs	Total costs	Infrastructure costs	Accident costs	Environmental costs	Congestion costs	Total costs
4x4	0.0286	108.805	0.0859	**108.9195**	0.0000	0.5943	0.0859	0.0044	**0.6846**
Articulated truck	20.3299	31.397	2.3712	**54.0981**	2.6627	0.1715	2.3712	0.0065	**5.2119**
Bus	6.5857	1.7126	0.6678	**8.9661**	0.2794	0.0094	0.6678	0.0025	**0.9591**
Heavy truck	9.4491	1.9637	1.5413	**12.9541**	0.5752	0.1073	1.5413	0.0000	**2.2238**
Medium car	0.0000	166.804	0.0891	**166.893**	0.0000	0.9111	0.0891	0.0044	**1.0046**
Mini-bus	0.0286	32.3104	0.1142	**32.4532**	0.0000	0.1484	0.1142	0.0035	**0.2661**

Source: Own calculation

Table 6.8: Marginal Congestion Cost for the trunk paved road (cents/km, Case Study C: T0108 road)

Vehicle class	Free-flow	Congested (peak hours)
4x4	0.0044	0.0709
Articulated truck	0.0065	0.1169
Bus	0.0025	0.1205
Heavy truck	0.0000	0.1276
Medium car	0.0044	0.6024
Mini-bus	0.0035	0.0850

Source: Own calculation

6.5.4 Comparison of average cost pricing to marginal cost pricing

The results for both average costs and marginal costs in Tables 6.5 to 6.7 are expressed in Namibian cents per vehicle per kilometre. For all case studies representing the trunk, main, and district roads (see Tables 6.5 to 6.7), average costing yielded results that are higher than the marginal costing of road use.

6.5.4.1 Infrastructure external costs

In Case Study A (D0872 road), heavy vehicles, including articulated trucks, heavy trucks, and buses, on average costing, would pay 128.32, 59.64, and 41.60 Namibian cents per kilometre respectively for infrastructure external costs. In contrast, in terms of the marginal costing basis, these vehicles would only pay 13.66, 3.00, and 1.43 Namibian cents per kilometre respectively (see Table 6.5), which is 9.4 times lower than articulated trucks would pay on an average costing basis, 20 times lower for heavy trucks, and approximately 29 times lower for buses.

The same pattern applies for Case study B (M0052) road where heavy vehicles for infrastructure external costs would pay approximately 65.32, 16.78, and 11.6 Namibian cents per kilometre for articulated trucks, heavy trucks, and buses respectively (see Table 6.6). Considering marginal costs, the same vehicles would, for infrastructure external costs, only pay 36.10, 14.11, and 6.85 Namibian cents per kilometre respectively. The difference between D0872 and M0052 roads is that the marginal costing for M0052 road is almost two times lower for all heavy vehicle classes under evaluation.

The infrastructure external costs for T0108 road present results that are similar to those of D0872 and M0052 roads, with heavy vehicles causing higher external costs of road use and closer to zero for light vehicles. The heavy vehicles, including articulated trucks, heavy trucks, and buses, cause approximately 20.33, 9.45, and 6.59 Namibian cents per kilometre respectively on an average costing basis (see Table 6.7), and approximately 2.66, 0.28, and 0.58 Namibian cents per kilometre respectively (see Table 6.7) on a marginal costing basis.

These results are in line with Andreson and Thompson's (2014) results that the marginal infrastructure cost for heavy vehicles were substantially higher than for light vehicles.

As a point of reference, Bruzelius (2004) estimated marginal infrastructure cost at SEK0.518 (Swedish krona) per vehicle kilometres for buses (roughly N$0.82), SEK0.757 per vehicle kilometres for trucks (roughly N$1.20), and SEK0.135 for light trucks and heavy vehicles per vehicle kilometre (roughly N$0.21) respectively. Bruzelius' (2004) results are in accord with those presented in this study as they indicate that heavy vehicles impose the highest infrastructure external costs as compared to light vehicles. Light vehicles' marginal infrastructure costs range from SEK0.027 (roughly N$0.043) to SEK0.064 (roughly N$0.10) per vehicle kilometre for cars and pick-ups respectively. Although these results are not comparable in terms of the environment in which the analysis was conducted, *ceteris paribus*, given the exchange rate, one would expect Namibian estimates to be higher.

6.5.4.2 Accident external costs

Accident external costs are highly caused by light vehicles. Considering Tables 6.5 to 6.7, light vehicles cause the highest accident external costs in all case studies analysed on both average costing and marginal costing bases. Light vehicles using the D0872 road caused average external costs of around 1.85, 2.81, and 0.46 Namibian cents per kilometre for 4x4 vehicles, medium cars, and mini-buses respectively (see Table 6.5). In terms of marginal costing, the accident external costs for the same vehicles are close to zero, estimated at N$0.04, N$0.06, and N$0.01 per kilometre respectively (see Table 6.5). In comparison to heavy vehicles using a stretch of 61.05 km D0872 road, articulated trucks cause external costs of approximately N$0.54 per kilometre, N$0.32 per kilometre by heavy trucks, and N$0.03 per kilometre by buses. The same vehicles, on a marginal costing basis, cause accident external costs between zero cents per kilometre for buses to approximately N$0.01 per kilometre for articulated trucks.

The results for Case Study B of the M0052 road network show that on average costing, light vehicles cause external costs of N$0.69, N$0.43, and N$0.07 per kilometre by 4x4 vehicles, medium cars, and mini-buses respectively (see Table 6.6). The marginal accident cost on a 22.75 km stretch of M0052 road are closer to zero, ranging between N$0.004 per kilometre for 4x4 vehicles and N$0.006 per kilometre with mini-buses, which cause approximately zero external accident costs on the main paved road. In contrast, heavy vehicles' accident external costs are insignificant or relatively zero, with articulated trucks causing the highest costs of approximately N$0.20 per kilometre, N$0.05 per kilometre for heavy trucks, and approximately N$0 per kilometre for buses (see Table 6.6). On a marginal costing basis, these costs are relatively zero, ranging between N$0 per kilometre for buses and approximately N$0.001 per kilometre for articulated and heavy trucks.

Finally, the results for external accident costs on the T0108 road are quite significant, with 4x4 vehicles causing approximately 108.81 Namibian cents per kilometre, 166.80 Namibian cents per kilometre by medium cars, and approximately 32.31 Namibian cents per kilometre by mini-buses (see Table 6.7). On a marginal costing basis, light vehicles cause less accident external costs when compared to average costs. Medium cars cause the highest accident external costs of approximately N$0.91 per kilometre, N$0.59 per kilometre by 4x4 vehicles, and approximately N$0.15 per kilometre by mini-buses (see Table 6.7). In comparison to light vehicles, heavy vehicles' accident external costs on T0108 road are quite relevant as compared to D0872 and M0052 roads. On an average costing basis, articulated trucks cause approximately 31.40 Namibian cents per kilometre, approximately 1.96 Namibian cents per kilometre by heavy trucks, and approximately 1.71 Namibian cents per kilometre by buses using the T0108 road. On a marginal costing basis, the articulated trucks cause approximately N$0.17 per kilometre, N$0.11 per kilometre by heavy trucks, and approximately N$0.009 per kilometre by buses (see Table 6.7).

6.5.4.3 Environmental external costs

The results for Case Study A show environmental external costs that are quite similar for both average costs and marginal costs. The environmental external costs for heavy vehicles range from N$0.48 per kilometre for buses to N$02.19 per kilometre for articulated trucks and N$01.51 per kilometre for heavy vehicles. For light vehicles, the environmental external costs range from a low N$0.08 per kilometre for 4x4 vehicles and medium cars to a high N$0.12 per kilometre for mini-buses (see Table 6.5).

Case Study B's results present that heavy vehicles cause higher environmental external costs of road use as compared to light vehicles using a 22.75 km stretch of M0052 road. The heavy vehicles' environmental external costs vary from a low N$0.52 per kilometre for buses, approximately 1.51 Namibian cents per kilometre for heavy vehicles, to a high 2.34 Namibian cents per kilometre for articulated trucks. The light vehicles' utilising the M0052 road cause approximately N$0.074 by 4x4 vehicles, N$0.078 by medium cars, and approximately 1.64 Namibian cents per kilometre by mini-buses (see Table 6.6).

Finally, Case Study C's results, illustrated in Table 6.7, show similar results as those presented for Case Studies A and B where heavy vehicles caused higher environmental external costs of road use. The articulated trucks cause approximately 2.37 Namibian cents per kilometre, approximately 1.54 Namibian cents by heavy trucks, and approximately N$0.67 per kilometre by buses. Light vehicles cause approximately N$0.11 by mini-buses, and approximately N$0.09 by medium cars and 4x4 vehicles when using a 117.76 km stretch of the T0108 road. The environmental external costs illustrated in Tables 6.5 to 6.7 are most important in the case of commercial and public vehicles. Sen, Tiwari and Upadhyay (2010) found similar results and recommended that emissions could be reduced by opting for vehicles with improved technology or by utilising an alternative mode.

6.5.4.4 Congestion external costs

Overall, congestion external costs seem not to be a major factor on the national road network as the results in Tables 6.6 to 6.7 show that congestion is mostly not significant on D0872 and M0052 roads, with less traceable cases on T0108 roads. Table 6.7 indicates that light vehicles cause relatively high congestion external costs on the 117.76 km T0108 road as compared to heavy vehicles using the same road. The former causes approximately N$0.004 per kilometre by medium cars and 4x4 vehicles and approximately N$0.0035 per kilometre by mini-buses. Heavy vehicles utilising the T0108 road cause approximately N$0.0065 per kilometre by articulated trucks, approximately N$0.0025 per kilometre by buses, and zero cents per kilometre by heavy trucks.

The case, however, is different for analyses conducted in other countries. For instance, a study by Sansom et al. (2001) in Great Britain indicated that the MCC alone far exceeded the revenue generated per vehicle per kilometre for all representative vehicles. In India, Sen et al. (2010) found that congestion is the most important cost among other external costs in Delhi resulting from excessive use of motor vehicles in peak periods of the day.

Table 6.8 presents estimates for marginal external congestion costs on the T0108 road of the national road network at both the free-flow and peak periods. As presented earlier in the analysis, the Namibian national roads do not experience congestion with a traceable case on the trunk roads. As explained in Section 6.4.3.2, an alteration was done on the traffic using the 117.76 km stretch of the T0108 road in order to simulate a congested road scenario. To that effect, an increase of 10 times of the existing AADT per vehicle class was applied. As presented in Table 6.8, the marginal external congestion cost is quite significant in a simulated congested scenario. These results demonstrate that there will be a need to curb the congestion on T0108 road should the traffic volume grow to 31 141 vehicles per day.

Theoretically, marginal cost pricing reflects the additional unit costs imposed by additional vehicles per kilometre on a specific road under study. Externalities such as accidents, congestion, and infrastructure costs depend on traffic density. For instance, an additional car in free-flow traffic would cause marginal external congestion costs that are significantly lower than the average external congestion costs (Schroten et al., 2019). Moreover, when an additional car joins traffic flow at the point where road capacity is at its peak, the MCC could be significantly higher (see Table 6.8). Since reforming the road pricing policy is not an overnight exercise, it is worth recommending that an investigation towards extending distance travelling to all vehicles and charges per kilometre driven should be logged. Current efforts by the RFA to launch an investigation into the possibilities of toll roads in Namibia are worth noting. Although such a call was based from the revenue generation point of view, the study could be coupled with demand management for road use in the near future.

Overall, the MEC results for Namibia indicate slightly higher accident costs associated with light vehicles as compared to heavy vehicles, whereas marginal infrastructure presented higher costs for heavy vehicles as compared to light vehicles. Walter (1968) argues that in the long run this could lead to resource wastage as, in the case of low demand, roads would be underutilised, however it could yield surplus above the required resource under high demand. Although the analysis only covered three sections of the paved roads, the methodology could be applied to the whole network. The MEC of the road use for all the sampled cases appear below the average cost of road use. Suppose that MEC are justified from the efficient point, and average cost to justify the cost recovery; if the average social cost recovery applies, the minimum costs are likely to be recovered. If it is assumed that the RUC are set at SRMC, the results confirm an argument by Kahn (1988) that in a case of uncongested roads (low traffic), SRMC would never cover fixed costs; that is, mainly to cover the capital cost of new investments.

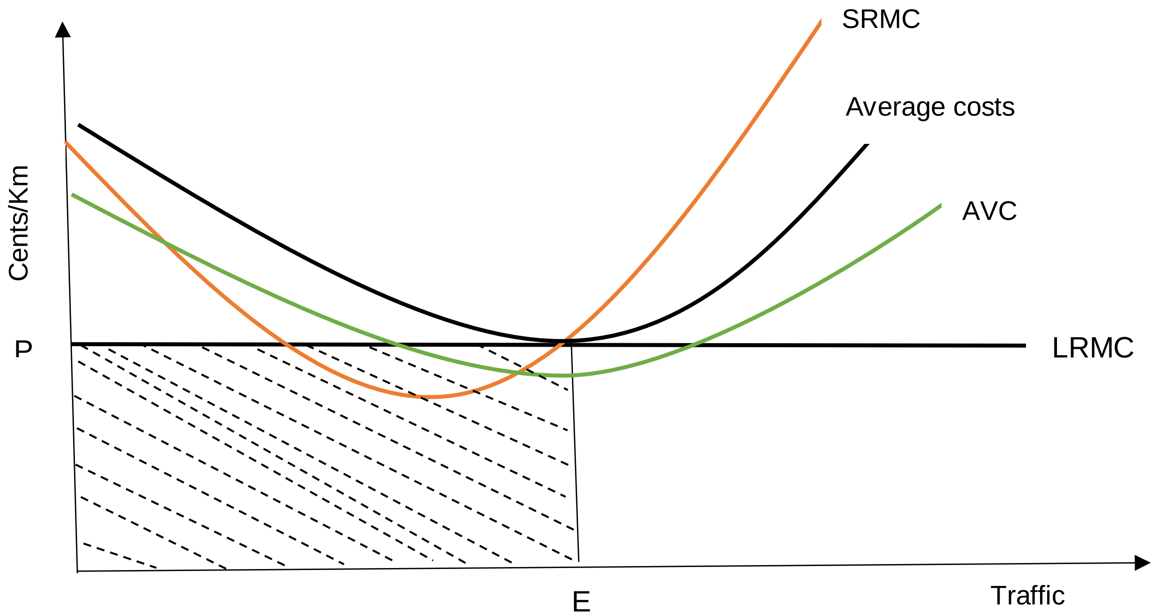

Figure 6.14: Short-Run Marginal Cost on national road network (cents/km)

Source: Author (based on Kahn 1988:74)

Figure 6.14 demonstrates that the SRMC under low traffic demand could never exceed the average costs. The SRMC could be lower or equal to the average cost. Moreover, the opposite applies if the demand of road use tends to be higher and roads are congested, then SRMC could exceed average costs.

On the uncongested Namibian network, applying RUC based on SRMC would likely yield results that fall under the shaded area (see Figure 6.14), depending on the traffic volume on a specific road section. Applying marginal costing to achieve economically efficient yields MSC that are less than the average social costs and likely to generate revenue per kilometre that is less than on average basis per kilometre. In this case, the results seem to favour charging for social costs on an average basis as opposed to charging on a marginal basis.

Suppose the charging policy follows cost recovery, an additional revenue per kilometre will offset externalities cost per kilometre. Without the externalities costs being internalised on the marginal basis, the sector may be better off charging for social costs on an average basis. The challenge is that average costs do not cover externalities costs on the marginal basis. Suppose the authorities considered charging at average costs as they offer revenue generation advantages as compared to marginal basis approach. Marginal costing as charges could be potentially affected by several factors. For instance, road users could decide to make use of vehicles that contribute less to externalities in terms of environmental external costs and consider undertaking a journey only when the benefits of doing so outweigh journey costs. The question is then what would happen if agency measures of reducing externalities do not yield economic benefits or road users decide to drive anyway. In fact, pursuing the average costs may be a better option as they would yield better revenue; however, it would not be based on the efficiency principle. It appears that low-volume traffic may force roads agencies not to pursue the efficiency approach.

To summarise, generally the optimum charge for road use is one at SRMC. For an efficient first-best approach, no other pricing or taxes are required. However, when shortfalls exist, two-part tariffs or mark-up may apply to enable the agency to maintain the network and make worthwhile investments. Walter (1968) also came to a similar conclusion and emphasised that such taxes should not infringe on road users, nor on any marginal-related principles. Notwithstanding, efficiency pricing always necessitates setting RUC at SRMC, although average costs would under no circumstances be consistent with the efficiency of road pricing and SRMC would never cover fixed costs in a low-demand environment.

6.6 SUMMARY

This chapter demystified the MEC estimation for road use in Namibia. The HDM-4 model plays a crucial role in the economic valuation of road infrastructure and subsequently the road pricing. The RA relies on the HDM-4 for network investment and maintenance strategies. The HDM-4, however, seems to be more popular for funding motivation and maintenance strategies, with very little investigation done on utilising the same model for influencing the present and future prices of road use. The results indicated that it is possible to use the HDM-4 model to estimate the MEC of road use depending on the available data and quality and that the model specifications and calibrations are accurate. This chapter demonstrated the applicability of HDM-4 to case studies (D0872, M0052 & T0108) roads of the national road network. The case studies' results suggest that for external costs of road use, heavy vehicles constitute approximately 97% of both average costs and the marginal costs of road use, with the exception of accident external costs, where light vehicles showed a slightly higher cost. Of all the external cost components, infrastructure costs, environmental costs, and accidents costs appear to be more important than congestion costs, which turned out to be less significant in Namibia. As the results confirm, road users in Namibia certainly impose social costs when using the road network. It is therefore fair to argue that those utilising the road infrastructure should bear external costs associated with their use of the road. Ideally, as stipulated in the RFA Act (No. 18 of 1999), road pricing should be based on the user-pays principle. Furthermore, reforming the current RUC should be considered the most effective and efficient instrument that could reduce global warming costs and accident risks, and raise revenue for infrastructure maintenance and development.

There is, however, growing interest among policymakers and transport planners in Namibia in the internalisation of the negative externalities of road use into road pricing. Although there are yet more ground to cover towards implementing the user-pays principle, in particular with respect to the MSC concept, from the efficient road pricing the principle offers theoretical realisation of optimal road pricing. The setback with the implementation of efficient road pricing could be associated with the literature's emphasis on the gap between the textbook MSC principle and its actual implementation. Moreover, awareness of pricing holding road users to account for their negative externalities is growing in the Namibian transport sector, which is expressed in available policy frameworks, including the latest Namibia Transport Policy. For instance, in terms of efforts towards infrastructure damage, the RFA's measures include automation of the travelling distance charges (MDC), which are reported to suffer evasion due to manual record keeping. Given that the major factor that influences MENVC (global warming) is fuel consumption, Link et al. (2016) share a similar conclusion that global warming costs are better internalised into the fuel levy as a direct proportion with the carbon content of fuel.

The quantification presented in this chapter forms the basis of MEC estimation that roads agencies could explore to internalise externalities into road pricing, and to ensure that those who consume the scarce resource bears the cost of maintaining and, where possible, the development of new facilities. The MSC pricing as a first-best pricing approach seems not to be a desirable pricing for the Namibian national road network as it is likely to lead to a financial deficit.

It is worth noting that the MEC estimated in this study may be underestimated due to the paucity of data and assumptions underlying the congestion costs. For instance, for calculating congestion costs on the D0872 and M005 roads, no significant congestion was traced on those roads. This could be coupled with the traffic volume associated with the sampled roads. Modifications were made to the traffic data for the T0108 road to simulate a scenario of a congested road during a peak period. Furthermore, for the environment costs, only emissions related to global warming were taken into account. Therefore, the MEC calculations presented in this study only hold for the specific situations under evaluation. Using the three case studies (D0872, M0052 & T0108) road, the researcher estimated the best possible MEC associated with the Namibian national road network.

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CHAPTER 7:
REFORMING THE ROAD USER CHARGE SYSTEM IN NAMIBIA: LESSONS FROM AUSTRALIA AND NEW ZEALAND

Transferring the MSC principle from a textbook theory to practice involves various complications. For instance, MSC have been perceived as an overarching goal for promoting economically efficient pricing; however, planners and decision makers responsible for implementing practical pricing systems are faced with several constraints, including the need to take into consideration other policy objectives such as revenue generation, equity, sustainability, demand management, etc. Moreover, there is a significant need for the applicability of prevailing technology to RUC, as well as the acceptability of charging instruments by road users. The literature deliberated on a few cases where road pricing measures have been implemented in practice, although the objectives motivating the move have not always in line with the efficiency principles (Milne et al., 2000:81).

7.1 INTRODUCTION

Chapter 6 discussed the principle of MSC and issues surrounding the concept. The discussion of the theoretical concept demonstrated that charging road users at an efficient price, the SRMC, could be a nightmare in the Namibian case. The efficient price is centred on the desire to promote both the efficient use of road capacity and ensuring that road consumers also pay the MEC of road use. This thinking plays a principal role in the Namibian Transport Policy, which seeks to align the RUC and taxes to the user-pays principle (MWT, 2017). In most developing countries, particularly in sub-Saharan Africa, governments and roads agencies are faced with fiscal revenue shortfalls; improving cost recovery is therefore more critical as opposed to improving demand management (Heggie, 1995). Challenges associated with the Namibian roads include an expansive network that serves a small vehicle population, as discussed in Chapter 5.

The current RUC lean heavily on broader fiscal policies of revenue generation and have little connection to setting costs of road use at an efficient price. According to first-best efficient pricing, reflecting the MSC should be optimal when the MSC vary according to kilometres driven, driving time, location, chosen route, vehicle technology, vehicle operation conditions, and drivers' driving behaviour (Mline et al., 2000:58). RUC set to reflect efficient pricing factors are likely to ensure optimal results in both short-run and long-run scenarios. Meanwhile the gap between costs and actual charges has been growing wider, in that the user charges have little or no connection to transportation activity defined by optimal user charges. Chapter 6 discussed and estimated SRMC pricing as the recommended theoretical concept aimed at fulfilling the efficient pricing of road use. While different aspects of pricing instruments have been explored within the current RUC, the pricing model is silent on marginal cost pricing issues. In the past years, there has been a growing literature gap regarding the efficient pricing theory and the possibilities of the practical implementation of the pricing theory (Milne et al., 2000). Another area of concern that dominates the literature is that of the possibility of the available technologies to translate the theory into practice. To the best of the researcher's knowledge of road pricing, particularly the efficient price aspect, the literature remains inadequate even though road transport in Africa is the dominant mode of transport that accounts for 80% of freight and approximately 90% of passenger traffic on the continent (Economic Commission for Africa, 2009). Research on road pricing in Africa has grown over the past decade (for instance, see Mudenda, 2017), but does not centre on charging vehicles for the distance travelled on particular types of roads as a focus that could advance the challenge of internalising the MEC of road use in Africa.

The implementation of the first-best pricing approach to marginal costs in Namibia poses pervasive challenges to roads agencies and the government. Externalities associated with the use of the road network involve different actors and take different forms, yet require roads agencies and governments to make complex arrangements. The agencies' challenges involve funding capacity to acquire smart technologies that could better record actual road usage, as well as institutional, legal, and political constraints.

The Namibian Transport Policy calls for the refinement of the RUCS to reach its potential (MWT, 2017). The policy posits that the level of the current RUC instruments needs to be determined according to the economic principle outlined in the RFA Act of 1999. Chapter 6 estimated the MEC of road use and raised the need to address the issue of lack of finance with the second-best price rules.

There are two principal areas of consideration when discussing RUC, namely the institutional framework in charge of the RUC decision making (Rothengatter, 2003) and the factors to consider when determining the RUC (Creightney, 1993). In Namibia, the fuel levy as the main component of the RUC clashes with the fuel price determination, which is regulated by the Petroleum Product and Energy Department of the MME (MWT, 2017). Chapter 2 of this dissertation illustrated road sector governance. Generally, the MoF is responsible for deciding the level of taxation – subject to parliament approval.

Transport economists often focus on how to set RUC and raise revenue in the most efficient manner, described by charging road users at the SRMC (Walter, 1968; Hau, 1992; Nash, 2015). In so doing, the RUC are set at the right level; that is, set at the SRMC of the journey per kilometre, which serve to influence road users' decisions on undertaking a journey. Users would thus only undertake a journey if the benefits gained from a journey are set to outweigh the costs associated with the journey per kilometre. However, due to challenges associated with implementing the efficient principle of RUC, the government and the agencies are often forced to consider several options. RUC play a crucial role in raising revenue, managing demands, reducing accidents and environmental risks, and achieving transport policy goals. Creightney (1993) argues that embarking upon broader policy views often means that RUC do not conform to strict efficiency criteria.

The motivation of this research was to determine to what extent current road users conform with or deviate from the optimal level of SRMC; thus to examine the extent to which revenue covers the costs of road use as per the users' consumption. The government's interest presented in the Namibian Transport Policy to reform the current RUC in order to accommodate the negative externalities that arise from road use (MWT, 2017) encouraged the researcher to investigate whether estimating the MSC of road use yields results in terms of road pricing for Namibia. This study dwells on what RUC set at the SRMC have to offer when compared to offsetting fuel levies as a form of RUC.

Previous literature provided useful information concerning the growing gap in road funding and financing. Creightney (1993) indicates that the identified gap has been influenced by several factors, including the absence of clear RUC (as per road use), inefficient user-pays policies (with references to equity, heavy vehicles, and the fuel levy), and the nature of tax in place. While the RA uses the HDM-4 to strategise on maintenance expenditure and motivate investment required for the national road network, the use of the HDM-4 to influence present and future road pricing remains a grey area in the authorities' domain. Bruzelius (2004) made an important argument that if road authorities perceived the HDM-4 as the relevant tool for planning, then why not use the same tools to factor in the marginal costs of road use in order to influence present and future road pricing. Of the few studies that focused on estimating the MEC for road users, many were conducted in the Western world (Nash, 2003; Schreyer et al., 2004; Nash et al., 2008; Doll & Essen, 2008) or sub-Saharan Africa (conglomeration of Sub-Saharan Africa Transport Program [SSATP] country reports), of which few of these reports include Namibia (SSATP, 2007; Teravanithorn & Raballand, 2009; Runji, 2015). This research goes beyond the estimation of the marginal externalities of road use to explore the possibility of setting the RUC at the SRMC to possibly address the funding challenges in Namibia. This is a unique action report using data from the RMS division of the Namibian RA. The results could easily be synchronised to influence present and future road pricing. It is anticipated that the estimation will provide guidance for planners, policymakers, researchers, and others involved in the transportation sector in order to draw evidence-based solutions to the challenges faced by the road sector. This research therefore aimed to achieve the following objectives:

1) To determine the implications of implementing SRMC-based RUC in Namibia; and
2) To explore the second-best RUC based on the prevailing circumstances in Namibia.

The rest of this chapter is structured as follows: Section 7.2 provides a conceptualisation of the current RUC and existing model. Section 7.3 is a literature review on second-best alternatives, while Section 7.4 discusses the research methodology. Section 7.5 examines the current Namibian road pricing, Section 7.6 examines alternative pricing for Namibia, and Section 7.7 compares Namibia's road financing to those of Australia and New Zealand. The chapter concludes with a discussion and a summary.

7.2 CONCEPTUALISATION OF ROAD PRICING BASED ON EFFICIENT PRICING

Road externalities arise whenever one road user makes another user or society worse off, yet does not bear the costs associated with such costs imposed on others. As the case may be with road users not taking into consideration the costs they impose on others, the implications of not factoring external costs into road pricing also apply to the supply side. The current RUC do not cover externalities imposed by road users (Van Essen et al., 2019), which vary with space and location. As a result, this sends price signals to the road users that do not include externalities, thus the users only pay according to the charges imposed on them. Namibian roads are characterised by a spacious network that serves a small vehicle population. This poses a challenge to charging prices that are based on the marginal costs of road use. Figure 7.1 illustrates the application of efficient pricing in the Namibian content by posing the question: if Namibia implements the recommended efficient pricing of SRMC pricing for road use, would the approach yield sufficient revenue to cover all the costs and provide for an acceptable return on investment? The opposing view is whether is indeed the aim of the principle to deliver sufficient revenue to cover fixed costs and provide funding for road upgrading and expansion. It should be noted that while the objective of marginal social costs pricing is to reflect the (variable) costs imposed on society, the principle can, under some circumstances, deliver sufficient revenue to cover fixed costs (minimum gross rerun on invested capital and depreciation to invest in capital expansion).

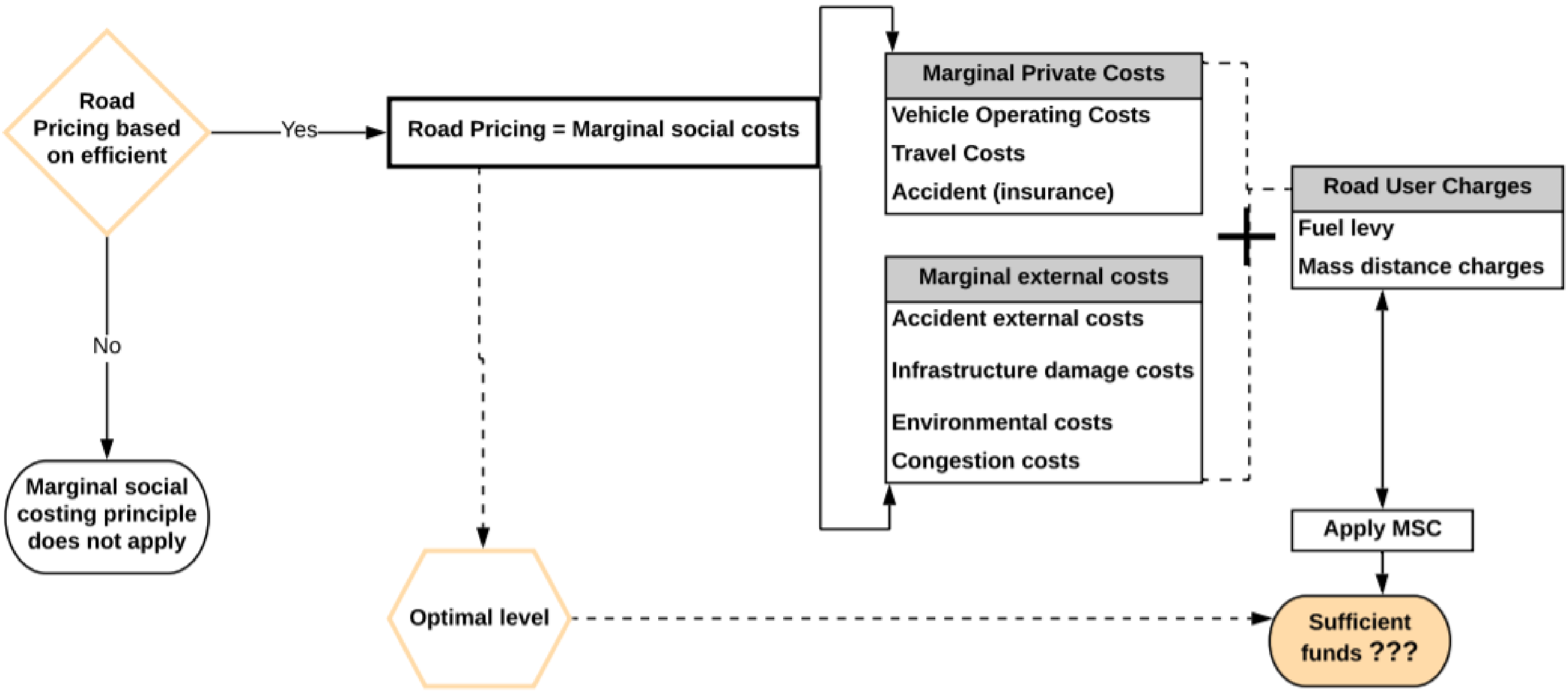

Figure 7.1: Conceptual framework

Source: Author

7.3 DEVIATION FROM SHORT-RUN MARGINAL COSTING

Rothengatter (2003) points out the possible alternatives and deviations to the textbook approach, which seem inapplicable in practice. Extensions to the SRMC may be summarised as follows:

1) SRMC with mark-up and Ramsey pricing; and
2) Multi-part tariffs.

7.3.1 Mark-up and Ramsey Pricing

The two extensions of pure SRMC are applied with the aim of achieving reasonable revenue for the road infrastructure. The SRMC mark-up is applied in an increased proportional approach in a way that the total revenue meets the total cost (Rothengatter, 2003). Ramsey pricing, on the other hand, implies a modification of the SRMC values per the budget constraints and joint demand elasticities. For instance, mark-up prices apply in a situation where different users using the same facilities at the same time pay different prices. Such application is often practised in the rail and airline industry where inelastic demand (business traveller) and elastic demand (leisure travellers) pay different prices. Rothengatter (2003) posits that both the SRMC mark-up and the Ramsey pricing scheme when applied could guarantee adequate revenue to cover total costs; however, the two schemes cannot guarantee generous incentives with respect to network characteristics and motor vehicle technology. Green and Pardina (1999) state three main reasons why Ramsey pricing could face public objection:

1) Generally, Ramsey pricing is applicable where markets are equally monopolistic or competitive; otherwise the regulators would limit Ramsey pricing to a selected group of services that fall within similar degrees of competition. In the transport sector, authorities often cluster services within similar degrees of competition, for instance business travellers and leisure travellers, and price flexibility within each service cluster.
2) Ramsey pricing, although it might be economically efficient, might not be consistent with government objectives of providing affordable services to the poor. Moreover, Ramsey pricing might not correspond with political sustainability. Therefore, whenever pursuing Ramsey pricing, restrictions on specific cluster services should be in place and where applicable, incentives should be clearly stipulated and regulated accordingly.

3) Ramsey pricing often translates into acts of price discrimination (Berg, 1998) by users of the particular service who perceive it as unfair for operators to impose a higher mark-up above marginal cost on one group of users over another group of users.

Therefore, these reasons may place further limits on authorities' ability to implement Ramsey pricing. Given the above critical factors, considerations to adopt Ramsey pricing need to be evaluated in the context of other pricing mechanisms and welfare-maximising objectives.

7.3.2 Multi-part tariffs

Multi-part tariffs describe a situation where agencies charge distinct prices for different components of a service. Multi-part tariffs consist of both fixed and variable elements and consumers pay both a connection fee and a price. Andreson and Thompson (2014) state that products or services financed by this combined approach have the advantage of the effect of pricing network use at marginal costs, which may result in efficient use of the network whilst the fixed network access fee covers the long-run cost of developing and maintaining the network. The general principle is that the unit price can be set at marginal cost, which is efficient as long as the connection fee (fixed element) can raise sufficient revenue without deterring some consumers from buying the product/service (Green & Pardina, 1999).

Advanced applications of a multi-part tariff can be traced in utility services such as electricity, where the user pays a monthly subscription for access and a usage fee for daily consumption of electricity. In the road sector, multi-part pricing can be associated with a situation where road users pay a fixed component included in the AVLRF, which intends to give infinite access to motor vehicles to utilise the road. Such cost components are often designed to achieve cost recovery with charges paid once off, monthly, quarterly, or annually (Berg, 1998); whereas variable components involve charges approximate to the road usage, such as fuel levies. These components can be flexibly adjusted and synchronised with the costs and the network demand characteristics (Rothengatter, 2003). Generally, fixed components intend to achieve the cost recovery target, whereas variable components focus on the additional costs of a trip priced at the marginal cost of road use (Sansom et al., 2001). With a two-part tariff, roads agencies could charge users according to marginal costs in terms of road usage, and a fixed element for road accessibility in terms of registration and licence fees, which could lead to revenue generation depending on the traffic volume of a particular road. Multi-part pricing differs from linear tariff charging, where roads agencies may charge a single price for the road network.

Multi-part tariffs can be appropriate for transport prices for three main reasons as outlined by Rothengatter (2003), namely:

- In order to generate appropriate incentives for infrastructure needs and user technology choices, multi-part tariffs should include information on such characteristics and functions.
- Tariffs can be set to best suit the situations of different user groups.
- Tariffs can be constructed in a way that the results are pareto superior to linear tariffs to suit favourable cost recovery.

Box 7.1: An example of a multi-part tariff

Suppose there are two consumer groups, A and B, with demand functions Da and Db. Under a linear tariff (p1), which combines the marginal costs (m), with mark-up, the demand is qa and qb and the total demand is q. Fixed costs are assumed to be recovered through payments a+b+c. After introduction of a two-part tariff p2 = (a+b+c/qa) +m. Given a self-selection set {p1,p2}, B will still prefer linear tariff p1. A, however, will choose the two-part tariff that encourages A to increase demand to qa*. With this, the consumer's surplus increases by d. If the technology is concave, a further scale effect occurs: marginal cost will decrease instead of remaining constant, as shown in the graph, and will increase welfare gain d.

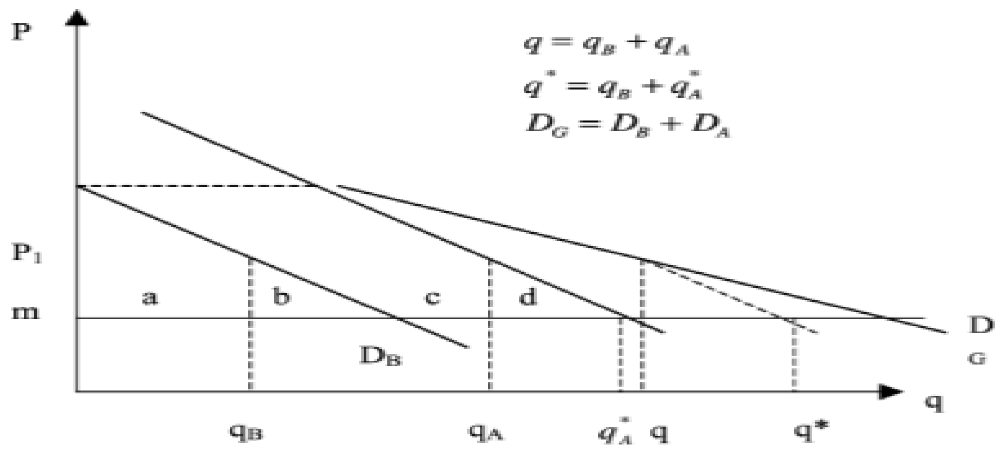

Figure 7.2: Superiority of the two-part tariff

Source: Rothengatter (2003)

In a perfect market, for transport investments (perfectly divisible) a clear rule for the network extension could be developed. Then the savings of marginal users should exceed or at least be equal to the increase of the MIC. It is an illusion to believe that first-best or optimal pricing in a part of transport infrastructure would improve the situation in the whole transport sector (Verhoef et al., 1996; Rothengatter, 2003).

Faulhaber and Baumol (1988:594) allude to Ramsey pricing as a great example that derives from the literature and that has received great attention from government agencies. The principle deviates from marginal pricing while offering “second best pareto optimal prices” that maximise welfare on the condition that roads agencies generate sufficient revenue through charges to cover their total costs. The concept is therefore associated with high charges to users, whose demand for the service is relatively inelastic.

7.4 FINANCIAL AND MANAGEMENT ISSUES

Rothengatter (2003) explains the three main reasons for failure with respect to dynamic financial and management issues. He affirms that once the technology of transport is concave, marginal costs are likely to follow an inverse pattern with the traffic activity, and then fall below the average costs. At this point in time, the network is more likely to generate insufficient revenue. For some of these reasons, roads agencies are often constrained by budgetary considerations and cost recovery requirements. In order to meet the financial need of the defined road networks, Clough, Guria and Yeabsley (2008) suggest roads to be provided under sub-optimal second- or third-best approaches, by means of Ramsey pricing and PAYGO principles, while accommodating some external effects of road use if possible. The literature suggests three ways to close the gap between infrastructure costs and revenue, as discussed below.

7.4.1 Adding external congestion costs, accidents costs, and environment costs

This entails charging for the external cost elements, which are excluded from RUC. In order to align the user decision with the use of the road, which includes the MSC, the charge must be introduced to cover the difference between marginal costs and average costs (see Appendix E, Box E.1).

7.4.2 Cross-subsidisation from road to rail or from urban to non-urban areas

Congestion externalities often occur in urban areas. Therefore, urban areas have a great advantage in terms of generating revenue through a congestion levy. In light of this view, several authors focused on promoting cross-subsidisation (Liu & Nie, 2011; Gwilliam, 2001). Surpluses from road charging must be directed to rail freight transportation or urban car traffic to public transport. Cross-subsiding has several shortcomings. Rothengatter (2003) argues that the fact that the road is congested while rail has free capacity should not form a base argument for cross-subsidising. While both modes offer services, their services might differ significantly in that directing users to an inefficient alternative should not precede welfare enhancing.

7.4.3 Financing by the general budget

The benefits of RUC surpass general taxation for several reasons. General taxes could easily distort taxpayer behaviour, whereas charges do not. Generally, charges are designed based on the services offered to users. Users thus ought to pay for the services they consume. On the contrary, taxes are based on the values (income, sale of property, etc.) and therefore not on the quantity consumed. Bird and Slack (2017) argue that taxes can be easily altered to change the behaviour of the tax obligation as opposed to the services that these taxes fund. When users do not pay the full costs of road use, Bird and Slack (2017) suggest that taxpayers must make up the difference although taxes could distort behaviour and impose deadweight losses. User charges are also preferred over general taxes because they send the correct signal to the consumers regarding the correct prices they ought to pay. When charges are set to cover the MSC of providing the services, users only consume the services up to the point where benefits received from the service are at par with the price they pay for the service. Bird and Slack (2017) posit that suppliers that are financed at full-cost pricing have an incentive to embrace the most effective and efficient way of providing services up to the point that consumers are willing to pay for them.

User charges also give a chance to politicians to easily assess service managers' performance. However, citizens have limited access with respect to assessing politician performance concerning their taxes. The literature discusses financing road revenue deficits by the general budget as a seemingly comfortable solution (Schiavo-Campo, 2007); however, this is only found to be welfare enhancing if the welfare loss for taxpayers is lower than the benefits that users obtain from subsidisation (Rothengatter, 2003).

7.5 CLOSING THE GAP BETWEEN INFRASTRUCTURE COSTS AND REVENUE

The principal cause of the gap between the current RUC and the marginal costs mainly lean on two major factors, namely externalities and non-optimal taxes (Runhaar, 2001).

7.5.1 Externalities

Transport activities produce several externalities, positive or negative, which may have unintended consequences for parties not directly involved in decision-making processes or who do not make use of facilities (Runhaar, 2001). The use of a road network may result in too high or too low externalities. Drivers often take into account their private cost of road use and hardly consider any negative externalities that arise from their use of the network. Negative externalities and associated external costs are illustrated in Figure 7.3. Externalities affect victims outside the system. For instance, society suffers air pollution, noise, and global warming. Other drivers using the same network suffer congestion (time delay) and accident risks (see Chapter 6 for a detailed discussion). Runhaar (2001) argues that all these victims have no obligation to decongest the network, clear the air, or prevent the noise. In addition, even if they had to, the process requires negotiation, which often yields undesirable results because of the cost involved.

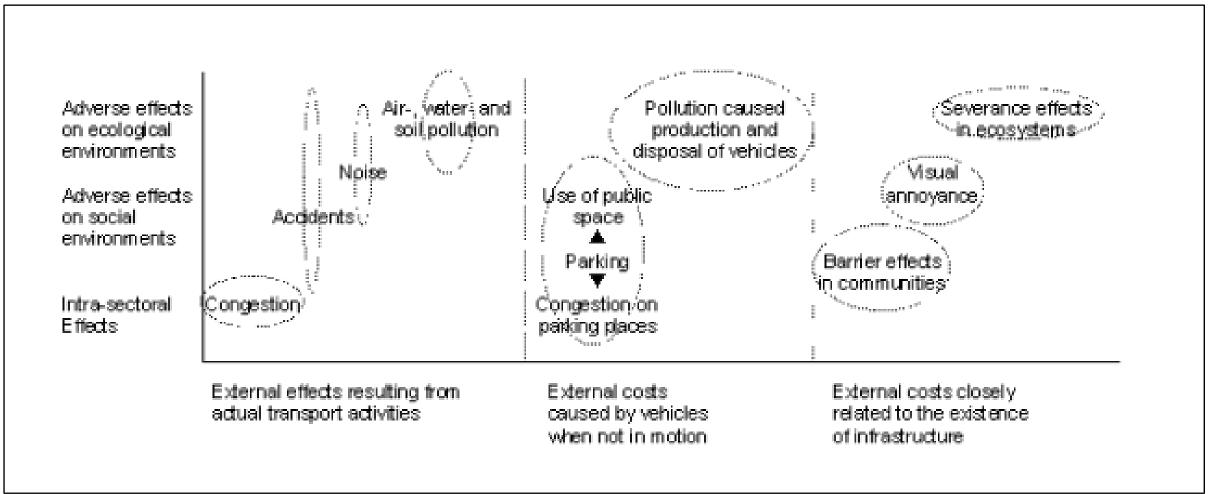

Figure 7.3: Classification of external costs of road transport

Source: Verhoef (1996:15)

7.5.2 Non-optimal taxes

Transportation taxes that are generally designed with the principal objective of raising revenues as opposed to correcting externalities contribute to the deviation between transport prices and marginal costs. General taxes are not related to external costs or transportation facilities.

7.5.3 Pricing as a policy instrument

Prices play a crucial role in the transportation sector as they provide information to both the roads agency (supplier) and the road users (demand) regarding resource scarcity. Basic economic principles imply that prices are likely to increase proportionally with demand. Due to scarcity, in the short-run the service is provided to consumers with the highest willingness to pay for the desired service or product. Thus, in a competitive market, prices will increase up to the point where the marginal cost of demand equals the supply of the service or product.

When the service is supplied in excess of the demand, the opposite occurs. Transport economists argue, however, that scarcity does not apply to transport prices (Runhaar, 2001).

The scarcity rationale for the transportation sector follows the queuing approach, thus willingness to wait; however, this approach comes with extra costs, including time costs. Therefore, time delays could be avoided if pricing plays a role, as users who value their time more will be more willing to pay to avoid spending excess time on a journey. In the transport sector, willingness to pay is tied to the value placed on time (Runhaar, 2001). Generally, shorter travel times are associated with reliable arrival times, thus accompanied by lower transport costs and higher willingness to pay. In the case of congestion, transport prices are likely to increase with travel costs; however, reliability in arrival time decreases, which may result in lead-time costs[30].

7.6 METHODOLOGY

As explained in the methodology chapter of this study (see Chapter 4), this research adopted a case study design. The data sources utilised in this research included desktop research, secondary data and documentary review, and the HDM-4 Workspace obtained from the RA. To achieve the research aim outlined in Section 7.1, this chapter divided the two objectives into two groups. The first task tackles the implications of setting RUC at SRMC in Namibia, and the second task explores the second-best RUC for Namibia by leaning on some lessons learned from New Zealand and Australia.

In order to determine the implications of implementing the SRMC pricing as RUC in Namibia, this chapter uses the estimated MEC obtained in Chapter 6 and compares the MEC to the fuel levy (as a proxy of the current RUC instruments) estimated on the same sampled sections of the road network. The implication focus is solely on pricing (comparing external costs to the fuel levy) and thus no attempt is made to quantify potential efficiency gains when road use is charged at efficient pricing.

7.6.1 Fuel levies and data sources

The fuel levy charged per litre of petrol and diesel is the only instrument among other RUC that could be related to the variable costs (per litre) of road use. It was on this basis that the researcher opted to estimate the fuel levy income generated from vehicle representatives using the sampled section of the road and compare such to the marginal costs per vehicle per kilometre estimates from the same portion of the road section. Motor vehicle owners and road users pay in total 186.3 Namibian cents fuel levy per litre, of which 136 Namibian cents fuel

[30] Cost that arises when products are not delivered on time, such as loss of sales or productivity lost due to productivity delays (Runhaar, 2001).

levy per litre (price at 1 April 2019) are RUC toward the RFA and 50.3 Namibian cents fuel levy per litre towards the MVA Fund (Republic of Namibia, 2019). The fuel levies were calculated based on the fuel consumption per 1 000 vehicle kilometres for each representative vehicle. The fuel consumption of each vehicle was obtained from HDM-4 data (see Appendix E)[31]. The calculation of the fuel levy income generated per vehicle per kilometre of the sampled section includes the RFA and MVA Fund fuel levy rates, the fuel consumption per 1 000 vehicle per kilometre, the road section length (km), and the vehicle classes (AADT).

The income generated from the fuel levies per vehicle kilometre was then compared to the MSC; this hypothetical case was made merely to determine the gap between the revenue generated from the fuel levies as a road user charge and that generated from MSC charged from the same vehicle travelling on the same road section.

7.6.2 The second task: Explore the second-best Road User Charges for Namibia

This task aims to explore the second-best RUC based on prevailing circumstances in Namibia. The section applies secondary data, including annual reports, research reports (published and unpublished), policies on transportation, newspaper articles, and documents that deal with RUC mainly from the RFA, the MWT, the MoF, the RA, and the MVA Fund. The desktop research was applied to New Zealand and Australia.

7.6.3 Desktop research

This entailed desktop research on road pricing literature available, including the RUC instruments applied by Australia and New Zealand. The criteria considered for choosing New Zealand and Australia included a country that has an expansive road network and a relative vehicle population, as well as interventions in place to fund the road network. Therefore, the desktop research section established what is known about road pricing with a particular focus on inter-urban roads or national road networks and informed the researcher on designing a RUC framework that could possibly inform planners and decision makers on the options for consideration for an MSC basis for the Namibian national road network.

7.7 RESULTS

In this study, demand costs for road use, as well as the price interaction at the macroeconomic level that could provide insight into price fluctuation, did not fall within the scope of this study, thus the results obtained cannot be interpreted to reflect the magnitude of price changes.

[31] The amount of levy imposed on petrol and diesel on every litre sold is 136 Namibian cents, therefore no differentiation is made between the two.

7.7.1 Comparison of estimated Marginal Social Costs to fuel levy revenue

The comparison of the marginal costs of road use with revenues presented a larger differentiation in charges than the current fuel levy could offer. The results for all paved road sections (T0108, M0052, & D0872) yielded revenue generated per vehicle per kilometre that far exceeded the MEC of road use for both heavy and light vehicles. This implies that charging for MEC on these sampled sections of the national road network is worse off in comparison to the fuel levy as an instrument for charging for road use. These results are in line with Heggie's (1995) findings, which emphasised that most developing countries' roads do not experience persistent congestion; setting prices equal to SRMC therefore has a high chance of resulting in financial deficits, which is the case with Namibia.

7.7.1.1 Case Study A: D0872 Road

Marginal costs for all vehicle classes yielded charges per kilometre that are below the current fuel levy generated from the same portion of the road. Table 7.1 indicates the revenue generated from the fuel levy and marginal cost pricing bases. Charging external costs for all vehicle classes on D0872 road is relatively low as compared to fuel levies as a charging instrument.

Table 7.1[32]: Case Study A: Comparison of marginal costs and fuel levy (cents-veh-km)

Vehicle Classes	4x4	Articulated Truck	Bus	Heavy Truck	Medium Car	Mini-Bus
Marginal Costs:						
MIC	0.000	13.660	1.433	2.951	0.000	0.000
MAC	0.043	0.012	0.001	0.007	0.065	0.011
MENVC	0.081	2.195	0.483	1.509	0.081	0.123
MCC	0.000	0.000	0.000	0.000	0.000	0.000
Sub-Total Costs	**0.124**	**15.867**	**1.917**	**4.467**	**0.146**	**0.134**
Revenue:						
RFA Levy[33]	15.286	74.305	39.168	61.6216	15.194	18.692
Accident Levy[34]	5.654	27.482	14.486	22.791	5.620	6.913
Sub-Total Costs	**20.940**	**101.787**	**53.654**	**84.413**	**20.814**	**25.605**
Difference (Cost - Revenue)	-20.816	-85.920	-51.737	-79.946	-20.668	-25.471

Source: Own calculation

*Note: Costs were only based on the estimated marginal costs of road use and excluded VOC. Revenue was only based on fuel levies, and other RUC were not considered.

The total external costs ranged from a low 0.12 Namibian cents per kilometre for 4x4 vehicles to a high 15.87 Namibian cents per kilometre for articulated trucks. When compared to the

32 See Appendix 7 for detailed calculations and steps followed to determine the amount generated per vehicle kilometre.

33 The analysis used the fuel levy as applicable from April 2019. The RUC fuel levy for both petrol and diesel was set at 136 Namibian cents per litre.

34 The analysis used the fuel levy as applicable from April 2019. The MVA Fund (accident) levy for both petrol and diesel was set at N$0.503 per litre.

fuel levy, the gap ranged between 20.82 Namibian cents per kilometre for 4x4 vehicles to 85.92 Namibian cents per kilometre for articulated vehicles. The results indicate that marginal cost pricing is likely to generate less revenue as compared to the fuel levy; however, the finding does not imply that the fuel levy is excessive. As a matter of fact, the latter has been below inflation for the past decade (see Chapter 1). For heavy vehicles, the MIC cost of 13.66 Namibian cents per kilometre, 1.43 Namibian cents per kilometre, and 2.95 Namibian cents per kilometre for articulated trucks, buses, and heavy trucks respectively are far below the fuel levy. MAC on the district road for all vehicles present results that are low compared to the accident levy per vehicle kilometre. The light vehicles, including 4x4s, medium cars, and mini-buses, would pay N$0.04, N$0.07, and N$0.01 per kilometre respectively for external accidents when travelling on a district paved road as opposed to the accident levy at 5.65, 5.62, and 6.91 Namibian cents per kilometre respectively for the same vehicles.

7.7.1.2 Case Study B: M0052 Road

The results of the analysis of motor vehicles (4x4s, articulated trucks, buses, heavy trucks, medium cars, and mini-buses) using the M0052 road of the national road network are presented in Table 7.2. The results relate to all vehicle classes of the same group travelling on the same section of the road. As is the case on the district road, the fuel levy exceeds the marginal cost charges per vehicle kilometre by a greater margin.

Table 7.2: Case Study B: Comparison of marginal costs and revenues (cents-veh-km)

Vehicle Classes	4x4	Articulated Truck	Bus	Heavy Truck	Medium Car	Mini-Bus
Marginal Costs:						
MIC	0.001	36.101	6.854	14.110	0.000	0.000
MAC	0.004	0.001	0.000	0.001	0.006	0.001
MENVC	0.074	2.339	0.522	1.507	0.078	1.636
MCC	0.000	0.000	0.000	0.000	0.000	0.000
Sub-Total Costs	**0.079**	**38.441**	**7.376**	**15.618**	**0.084**	**1.637**
Revenue:						
RFA Levy	14.374	75.409	35.617	60.544	14.646	17.922
Accident Levy	0.558	2.918	1.378	2.343	0.567	0.693
Sub-total Costs	**14.932**	**78.327**	**36.995**	**62.887**	**15.213**	**18.615**
Difference (Cost - Revenue)	-14.853	-39.886	-29.619	-47.269	-15.129	-16.978

Source: Own calculation

On average, the revenue generated from the articulated trucks (78.33 Namibian cents per kilometre) exceeded more than double (38.44 Namibian cents per kilometre) the MEC charges. For heavy trucks, the revenue generated from the fuel levy (62.89 Namibian cents per kilometre) exceeded marginal cost charges (15.62 Namibian cents) by approximately four times. For light vehicles, the gap between revenue and costs is wider, with marginal cost almost 1% of the revenue, ranging between 14.93 Namibian cents per kilometre, 15.21 Namibian cents per kilometre, and 18.62 Namibian cents per kilometre for 4x4s, medium cars, and mini-buses respectively. In terms of MIC, the heavy vehicle charges exceeded that of the light vehicles; however, this does not imply that the heavy vehicles are paying their fair share of costs imposed on using the road network. Significant MAC were recorded for light vehicles as compared to the heavy vehicles (see Table 7.2). Congestion on the main road is not significant or closer to zero.

7.7.1.3 Case Study C: T0108 Road

The analysis of the six representative vehicles travelling on T0108 road yielded results that are not very different from those obtained from M0052 and D0872 roads (see Table 7.3). At least there was a trace of congestion on the trunk road, although not very high. MCC for light vehicles were approximated at N$0.004 per kilometre for medium cars, mini-buses, and 4x4 vehicles. Moreover, articulated trucks and buses also contributed to congestion costs on the trunk road, ranging between N$0.0065 for articulated trucks and N$0.0025 for buses.

Table 7.3: Case Study C: Comparison of marginal costs and revenues (cents-veh-km)

Vehicle Classes	4x4	Articulated Truck	Bus	Heavy Truck	Medium Car	Mini-Bus
Marginal Costs:						
MIC	0.000	2.663	0.279	0.575	0.000	0.000
MAC	0.594	0.172	0.009	0.107	0.911	0.148
MENVC	0.086	2.371	0.668	1.541	0.089	0.114
MCC	0.004	0.007	0.002	0.000	0.004	0.004
Sub-Total Costs	**0.684**	**5.209**	**0.958**	**2.223**	**1.004**	**0.265**
Revenue:						
RFA Levy	16.021	78.645	41.729	63.422	16.223	16.223
Accident Levy	6.199	30.429	16.146	24.539	6.277	6.277
Sub-Total Costs	**22.220**	**109.074**	**57.875**	**87.961**	**22.500**	**22.500**
Difference (Cost - Revenue)	-21.536	-103.865	-56.917	-85.738	-21.496	-22.235

Source: Own calculations

MIC and MENVC presented a case for charging heavy vehicles for the cost they impose on the infrastructure and environment when making use of the road network. The MIC for heavy vehicles range between N$0.28 per kilometre, N$0.58 per kilometre, and N$02.66 per kilometre for buses, heavy trucks, and articulated trucks respectively. The MENVC for heavy vehicle range between N$0.67 per kilometre, N$01.54 per kilometre, and N$02.37 per kilometre for buses, heavy trucks, and articulated trucks respectively.

The overall results for the marginal charges analysis presented similar trends across the three road types, with a substantial margin between MEC and the fuel levy. The results could be related to the representatives of vehicles and traffic on each road network. For instance, in terms of the MIC, the highest cost of N$02.66 per vehicle kilometre (see Table 7.3) is associated with heavy vehicles. This could be explained by the relatively high proportion of damage that heavy vehicles impose on infrastructure when using the trunk road.

7.7.2 The implications of implementing Short-Run Marginal Costs-based Road User Charges in Namibia

Tables 7.1, 7.2, and 7.3 indicate the discrepancies between the costs incurred and revenue generated from the sampled paved roads of the Namibian national road network. Table 7.4 shows the roads agency cost (see Column E) incurred to preserve the stretch of 117.76 km trunk road of the national road network. The MEC per vehicle per kilometre on the same road are set out in Table 7.4 in Column F (MIC), Column G (MAC), Column H (MENVC), and Column I (MCC). The vehicle operation costs per vehicle per kilometre are illustrated in Column A. Fuel levy charges and MDC per vehicle kilometre are presented in Column K (RFA fuel levy), Column L (MVA Fund accident levy), and Column P (travelling/MDC).

The results shows that RUC based on marginal pricing in Namibia would result in substantial financial deficits. Given the costs versus revenue on the sampled trunk road, the financial deficit is approximated at N$5 million. It should be noted that only charges that stand to vary with road use were taken as a proxy (fuel levy and MDC) for efficient RUC in addition to the estimated external costs of road use. Therefore, this figure could be lower when other costs, including ownership costs charged on an annual basis to grant access to utilise the road network, are included. As per the literature, in order to bridge the funding gap that arises from setting RUC at SRMC as an alternative to the first-best pricing, the second-best pricing must be employed.

The departure point would then be on strategies to finance such a deficit. The traditional way has been to increase the RUC on annual basis in order to increase revenue or raise general taxes that could subsequently increase budget votes for the road sector. The literature also referred to generating revenue from those who benefit from the provision of roads, mainly property owners such as residential streets, businesses, and rural access roads (Bird, 2001; Bird & Slack, 2002). This study, however, focused on inter-urban roads that primarily provide services to traffic and not to beneficiaries to a large extent. The literature provides several debates on other options such as reducing the maintenance and investment expenditure in order to reduce road deficits. Faiz and Harral (1988) oppose that idea by arguing that it is not economically efficient. They further argue that reducing road expenditure increases user costs. For every dollar saved on maintenance, VOC increase by $2 to $3 (Heggie, 1995). To summarise, these results postulate that for countries with expansive road networks and small vehicle populations, road charges priced at SRMC are likely to result in greater deficits. As per the literature, the second-best alternative of charging some services priced below average costs and others above (Heggie & Fon, 1991) could yield results for Namibia in terms of revenue generation.

Table 7.4: Roads agency costs and efficient Road User Charges simulation on a trunk road (N$ at 2019 prices)

Vehicle Type	**Vehicle Characteristics**			**HDM-4 Projection**	**RAC (HDM-4) (N$)**	**MEC (N$ cents)**				**Total MEC per veh/km (N$ cents)**	**RFA Fuel Levy (cents)**	**MVA Fuel Levy (cents)**	**Total Levy (cents)**	**External Costs + RUC [Fuel levy] (Cents)**	**Total Annual Revenue Generate from 117.76 km (N$)**	**MDC Charges 117.76 km (N$)**
	(A)	(B)	(C)	(D)	(E)	(F)	(G)	(H)	(I)	(J)	(K)	(L)	(M)	(N)	(O)	(P)
	VOC (c/km)	PCSE	ESAL (mill)	AADT	HDM-4 Results	MIC	MAC	MEC	MCC	Total	N$ 136	N$ 0.503	N$ 186.3			
4x4	5.029	1.00	0.02	1024	2,062,451.61	0	0.594	0.086	0.004	0.684	16.021	6.199	22.22	27.933	12,006.27	
Articulated Truck	19.146	2.20	7.10	371	747,235.89	2.663	0.172	2.371	0.007	5.213	78.645	30.429	109.074	133.433	57,352.71	1,716,898.96
Bus	12.92	1.70	2.30	20	40,282.26	0.279	0.009	0.663	0.002	0.953	41.729	16.146	57.875	71.748	30,839.01	14,355.20
Heavy Truck	18.412	1.80	3.30	232	467,274.19	0.575	0.107	1.541	0	2.223	63.422	24.539	87.961	108.596	46,677.17	199,000.32
Medium Car	4.958	1.00	0.00	1569	3,160,143.15	0	0.911	0.089	0.004	1.004	16.223	6.277	22.5	28.462	12,233.65	
Mini-Bus	15.64	1.20	0.01	256	515,612.90	0	0.148	0.114	0.004	0.266	16.223	6.277	22.5	38.14	16,393.49	
Totals				3472	**6,993,000.00**	3.517	1.941	4.864	0.021	10.343	232.263	89.867	322.13	408.312	**175,502.30**	**1,930,254.48**

Total RAC = N$6 993 000.00; Total Revenue = N$1 930 254.00

Source: Author

7.7.3 Success and major issues associated with the Namibian Road User Charge System

Currently, the RFA Act of 1999 outlines who should pay RUC, the charging instruments available, the basis of charges (ownership, mass/load, and distance), and refund mechanisms that govern the Namibian RUCS. The institutional arrangements and their mandate (including the collection and distribution of the revenue) were discussed in Chapter 5. One noteworthy achievement is the current RUCS-recorded link between the RUC and the revenue that accrues to the RF and therefore a strong link between revenue generated from the roads and allocated back as an investment into the road network (see Section 5.5 of Chapter 5).

It suffices to say that the current RUC in Namibia were designed to amplify the two-tariff approach consisting of both flat charges (vehicle registration and licence fees) and a combination of variable charges (proxy), including fuel levies and travelling distance charges (MDC). What is not clear is whether these charges were exploited at market price to reflect the marginal costs of travelling on the road network or whether the application of a two-part tariff was optimal. Efficient pricing requires pricing road services at travellers' marginal costs (Andreson & Thompson, 2014). Given the low marginal costs (see Chapter 6) associated with the Namibian road network, an optimal two-part tariff designed on a combination of a flat fee and a variable fee that would internalise the MEC of road use could be a solution to Namibia's road funding challenges. These could bring about sustainability in road funding mechanisms.

7.7.4 Key observations regarding the Road User Charge System in Namibia

The recommended user-pays principle has not been fully implemented, although it, to an extent, had some influence on shaping RUC instruments. The current instruments to an extent mimic a two-part tariff approach where road users pay a flat charge for road network accessibility and a quasi-user charge based on fuel consumption in the form of a fuel levy. There is, however, no close link between the RUC and actual patterns of road use in time and location. For instance, a driver travelling 500 km on the main corridors or in Windhoek's central business district would pay the same charges in fuel levies as a driver covering the same distance on rarely used district roads. Another interesting observation highlighted in recent literature and applicable to Namibia is that owners of fuel-efficient vehicles pay a smaller fuel levy for their use of the road as compared to users with older cars (De Percy, 2018). Furthermore, heavy vehicles pay access fees and usage in terms of MDC (travelling), and there is no direct link between the damage they cause and the cost of road maintenance.

The variable-related levies apply to both petrol- and diesel-powered vehicles paying fuel levies, including the RFA's RUC and the MVA Fund's levy. The variable charges applicable to diesel-vehicles using fuel other than petrol consist of fuel taxes and levies, as well as travel distance charges on HGVs only. The travelling MDC are imposed according to the Road Traffic and Transport Act (No. 22 of 1999), which also contains other regulations pertaining to vehicle taxation. In order to fully implement the user-pays principle, the RUC should be charged based on road use and not vehicle ownership. Other concerns that need to be addressed include the following:

- Under the current RUCS, road fees and charges are collected by various agencies, while the accountability for these funds lies with the RFA, which results in an opaque and complex system that disconnects funds generated and transferred to the RF. For instance, there have been debates and proposals for eNATIS (Electronic National Traffic Information System) to be housed under the RFA as opposed to the status quo (under the RA); however, the challenge observed is that eNATIS executes other duties that are not associated with vehicle registration and licence fees (MWT, 2017).
- The power of the RFA to execute the adjustment of the levies is a concern.

Following these arguments, it appears that two things are needed on the transport policy front. Firstly, the RUC must be modified by focusing on encouraging users to make efficient use of the existing network. Planning and pricing are the key instruments to improve the efficient use of the road network in Namibia. Secondly, investing in alternative modes such as rail could reduce road damage when heavy freight is efficiently transported by rail. Chief among the challenges are the prioritisation and funding of road projects (maintenance versus development), as well as lobbying for political support towards an appropriate road pricing system that speaks to the usage pattern so as to facilitate network efficiency while maximising user satisfaction.

Road authorities should be subjected to price oversight and independent pricing determinations as applied to other monopoly sectors, including water, electricity, and telecommunication. The current two-part tariff does not provide price signals to the users that can be adjusted to their behaviours. Charging road users according to the MSC has not yet been applied in practice as road pricing in Namibia, although road users are required to pay for their full consumption of the road network according to the RFA Act and the Namibian Transport Policy. While the current system of collecting revenue is based on the available instruments, the system has loopholes when it comes to fuel-efficient vehicles and electronic vehicles. According to the Transport Information and Regulatory Service department of the RA, no electrical vehicles have been registered in Namibia thus far (RA, 2019). The identified challenge in this study is that marginal cost pricing could only reap benefits and prove useful to an economical network with substantial traffic.

7.8 NAMIBIA IN COMPARISON TO NEW ZEALAND AND AUSTRALIA: LESSONS FROM SUCCESSFUL ROAD USER CHARGE INSTRUMENTS FOR ROAD PRICING

7.8.1 Why Australia and New Zealand?

The *Global competitiveness report* rankings on road connectivity index and quality of roads (Schwab, 2018) inform the comparison decisions made in this chapter. Furthermore, recent research conducted in the Asia-Pacific region on RUC (Clough et al., 2008; Infrastructure Partnerships Australia, 2014; Kirk & Levinson, 2016; De Percy, 2018) gave more reasons for this chapter to draw a comparison on RUC instruments implemented to maintain expansive road networks. Both Australia and New Zealand offer notable experience for their PAYGO systems of road cost recovery (Clough et al., 2008). According to the World Atlas (2019), Namibia ranked 34th of the world's largest countries with an area in square kilometres approximated at 824 000 km². Australia is at the top of the comparison, ranked in 6th position with approximately 7.7 million km², whereas New Zealand ranked in 75th position with an area of 265 000 km², which is four times smaller than Namibia. Table 7.5 provides road indicators that informed the comparison between the countries under discussion. In terms of the quality of the roads, Namibian roads outperformed Australia and New Zealand with a value of 5.1, 4.8, and 4.7 (out of 7) respectively. In terms of the score out of 100 in comparison to the 2017 *Global competitiveness report*, both Namibia and New Zealand depicted an increase, while Australia recorded a decrease (See Table 7.5). Namibia ranked 10th out of 140 in terms of the road connectivity index, while Australia and New Zealand ranked 16th and 56th out of 140 countries in the world respectively.

Table 7.5: Road quality and connectivity for the year 2018/2019

	Quality of roads 1-7 (best)			Road connectivity index 0-100 (best)	
Countries	**Value out of 7**	**Score[35] (out of 100)**	**Rank/140**	**Score (out of 100)**	**Rank/140**
Namibia	5.1	68.2 ↑	28	92.8	10
Australia	4.8	62.8 ↓	35	90.0	16
New Zealand	4.7	61.3 ↑	39	70.1	56

Source: Author (*Global competitiveness report* [Schwab, 2018])

7.8.1.1 Australia

Australia has much in common with Namibia in terms of large landmass, a highly dispersed population, and the experience of remote and rural roads with low traffic levels (Fraser, 2011). As experienced in Namibia (see results in Chapter 5), insufficient funds and lack of available

[35] Scores are on a 0 to 100 scale, where 100 represents the optimal situation or frontier. The arrows indicate the direction of the change in scores from the previous edition (Schwab, 2018).

revenue from traditional source of funding (public), especially for low-traffic roads, have also been experienced in Australia. The Australian diesel fuel excise has been in place since the 1950s. It was introduced with the principal aim of contributing to road costs. Vehicle registration fees have also been in place before the introduction of the heavy vehicle road user charge in 1992.

Infrastructure Partnerships Australia (2014) describes this charging instrument approach for road networks as opaque and blunt as it presents a limited relationship between network access and user charges. The explanation described the collection and distribution of charging to be inefficient, unfair, and unsustainable. The Australian Chamber of Commerce and Industry (2015) argues that users should be held accountable for at least a portion of the costs associated with the provision of the road network. Road pricing is believed to offer a platform of road use as part of the integrated transport system, to bring about environmental benefits and to possibly reduce congestion. Taking cognisance of these benefits, among others, the Council of Australian Government (COAG) believes that reforming the RUC offers opportunities to enhance the current system and make it more fair, sustainable, and efficient (Fraser, 2011). This is likely to bring about efficiency in asset use, which is a situation that called forth a reform as the described approach was found undesirable. Infrastructure Partnerships Australia (2014) developed RUC reform principles as presented in Table 7.6.

Table 7.6: Principles for Australian road pricing reforms

Categories	Descriptions
Objectives	The RUC reform scheme should provide: • A mechanism to sustainably fund additions to the transport network; • A mechanism to sustainably fund maintenance of the network; • A fairer allocation of costs of benefits in the transport market; • Funding stream security; and • An opportunity to improve network performance.
Scope and pricing	Road prices should be set so that the total revenue generated by direct charging matches the current total revenue collected from road users. Any future scheme should be structured in a way that does not discourage private sector investment to address Australia's land transport infrastructure deficit.
Revenue allocation	Revenue generated through the scheme should be re-invested in the construction, maintenance, and operation of infrastructure to facilitate mobility, including public transport.
Implementation	A new RUCS should balance simplicity against the need to achieve complex reform objectives. If a scheme ultimately seeks to balance a range of objectives, then clear articulation and relative priority must be considered and priced accordingly. Potential impacts of new charging arrangements should be tested through pilot trials.
Privacy	Protecting the privacy of road users should be a central consideration in the design of the scheme.
Technology	Technology should be driven by scheme design, with final solutions to be developed through trials and competitive processes, including the flexibility to be delivered using a variety of technology solutions and allowing the market to determine the best approach.

Source: Infrastructure Partnerships Australia (2014:40)

The RUCS in Australia underwent a reform a decade ago. The initial charges applied to HGVs were set through a cost recovery pricing model and based on historical cost (Australian Government, 2013). These user charges under discussion take the form of fixed annual registration charges and fuel taxes. The system managed by the NTC is referred to as the PAYGO model. Introduced in 1992, the hybrid model aimed to ensure that HGVs pay their share of marginal costs associated with the wear and tear of the road network resulting from their use of the network, as well as contributing to common costs that benefit all road users, including street lighting, rest bays, and signage (Australian Government, 2013).

Along with addressing road infrastructure financing and investment decision making, the Australian government invested in good transportation policies, in particular road transportation shaped to deliver better information and incentives from both the demand and supply side. With a great focus on HGVs, COAG agreed to undertake a comprehensive long-term road reform in 2007. The reform effort leaned heavily on the importance of infrastructure pricing and a case for change from the cost recovery pricing to a more direct form of charging (marginal cost pricing) that takes into account space and time. However, the COAG took cognisance of the dynamics associated with implementing marginal cost pricing options and identified the costs of the required technology and business system support as an impediment to the desired pricing option. Eventually, in 2012, informed by a feasibility study, the reform took a broader scope to capture the calculation of prices, collection of charges, and the possibility of linking the use of revenue generated from road use to the provision of road infrastructure (Australian Government, 2013). From the supply side, the reform incorporated all processes related to the planning, funding, construction, and maintenance of the road network.

Box 7.2: Australian cost-allocation approach

As technologies evolve, more countries consider different charging and transport pricing reforms. The NTC uses the average road expenditure for the current budget year and the past two years in order to estimate the annual cost of road service provision. The NTC gathers data, including overall road network expenditure including capital and maintenance at all levels of government, to fully recover such costs within the period spent (Productivity Commission, 2006). This Australian cost-allocation approach comprises three broader categories:

- Cost allocation is based on the average level of road expenditure over three years minus 39% deducted as amenity costs.
- Costs are allocated to different vehicle classes as per road use as much as possible.
- The residual costs are allocated to different vehicle classes by using a broad measure of road use in terms of VKT.

Source: Road User Charges Review Group (RUCRG, 2009:29)

The Australian cost-allocation model aimed at recovering road expenditure associated with each vehicle class through a hybrid model of fuel excise and fixed annual charges. Revenue generated from access charges and diesel fuel charges are deducted from the road expenditure allocated to vehicle classes. The remaining expenditure thus forms the basis for setting the MDC, which, combined with the access charge, are wrapped up in the vehicle registration charges (Clough et al., 2008). The preferred charging model of the NTC has been that of mass-distance-location-based pricing, thus the NTC clearly indicated its motive of moving from the highly averaging charging system to a more accurate approach that reflects the costs of road use.

Persistent efforts for accurate measures towards the use of the road network prompted the NTC to conduct a feasibility study on incremental pricing for heavy vehicles, which was completed in 2011 and implemented in 2014. The incremental pricing allows operators to carry additional mass above the national regulated limits on specific roads by paying extra road wear-and-tear costs to the councils or agencies of that specific road (NTC, 2009). The COAG introduced this initiative towards increasing productivity within the road sector and with the possibility of expanding its target on road spending (Fraser, 2011). This initiative serves as an important milestone for Australia towards developing a comprehensive mass-distance-location-based charging scheme. The full implementation of the scheme is projected to replace the existing registration and fuel charges with the mass-distance-location-based charge on road users based on the vehicle's mass as it travels the distance and location (RUCRG, 2009).

Clough et al. (2008) propose that the common costs of each vehicle class should be estimated and Ramsey pricing should be employed to allocate costs to different vehicle classes in inverse proportion to the price elasticity of such vehicle types. In so doing, the roads agencies could recover costs with the least distortion of road use. In 2007, the NTC proposed an incremental pricing method that could be used to set charges to vehicles that exceed the regulated mass limit on each network. To determine the incremental pricing, the NTC compared PAYGO and lifecycle cost approaches to determine incremental costs and thus proposed a trial base of this approach. This approach, however, was criticised by the Austroads Pavement Technology Review Panel (APTRP, 2007), arguing that the trial approach may provide wrong incentives and possibly result in lighter charges for HGVs that create the greatest damage. To that effect, the NTC in its 2008 national incremental policy took broader initiatives, including migrating towards the preferred direct pricing of heavy and light vehicles to replace the former charging model. Notable initiatives include research and data collection that could inform setting direct pricing, developing tentative technology for a collection system, and investigating the reform of road management to facilitate the proposed direct pricing (Clough et al., 2008).

Australia's road pricing regime can provide important lessons for Namibia when reforming its RUCS. While applying trials on the commercial (heavy) vehicles, the reform could concurrently consider introducing future direct charges for light vehicles. The overall lesson from the Australian road pricing regime is that road pricing should be established based on charges that are linked to network use. This requires a multi-approach to investigate advanced direct charging mechanisms feasible for the Namibian environment.

7.8.1.2 New Zealand

The discussion of and emphasis on the potential of RUC to generate revenue prompted governments and roads agencies into action, and adoption across the globe has been based on the desire to reduce externalities. New Zealand employed the PAYGO approach as a cost-allocation model on road use attributed to different expenditure per vehicle categories as a base for setting RUC.

Cost differentiations are based on traffic, including damage to road pavement mainly attributed to HGVs and to surface markings attributed to light vehicles (Clough et al., 2008).

Clough et al. (2008) describe New Zealand's road cost-allocation model as follows:

- Total annual expenditure for the national road programme (both local and state highways) separates them into different vehicle class categories based on gross vehicle weight or axle loadings.
- Deducts from annual expenditure the fixed revenues from local government rates and licence fees; thereby offsetting them against fixed cost components across all work categories.
- Allocates the residual costs across revenue bases to reflect the number of vehicles and to forecast the VKT by each vehicle class, attribute strength and wear costs to heavy vehicles, and then allocate the remaining costs to all vehicles, mostly light vehicles, which will be collected through a combination of RUC and fuel taxes.

Box 7.3: Technology innovation in road pricing reforms: The New Zealand experience

In the 1970s, New Zealand introduced a variable mass-distance based charging system. The RUC apply to all heavy vehicles with a gross vehicle mass over 3.5 tonnes and all light vehicles powered by diesel or any other untaxed fuel (Kirk & Levinson, 2016). The road users are required to purchase a licence in a set of 1 000 km increments to use the network. All vehicles subscribed under the scheme must be fitted with distance recorders for reliable recordkeeping of distance travelled. All vehicles must display a paper-based licence on the inside of the vehicle's windscreen. In 2008, the New Zealand government undertook a review of the RUC and made recommendations, including the need to improve the revenue-collection approach. Issues associated with the traditional approach include evasion and tampering with odometers and hudometers. Moreover, compliance costs were found to have a significant impact on users because of the need to purchase paper licenses.

The review received interest from both public and private entities. The EROAD company approached the New Zealand government with a proposal to develop an electronic road user charging system (eRUCS). In 2009, the government approved a cellular-based vehicle tracking and fleet management system that enables users to purchase RUC licenses online. Road users expend an amount of $80 per month plus an additional $5 transaction fee for licence payments. The benefits reaped from the system are twofold; firstly, the vendor generates revenue from the vehicle tracking and fleet management, and secondly, the electronic payment approach has reduced the amount of paper administration the government associated with licence transactions. The eRUCS attracted approximately 15% of HGV users in 2011 – an increase from less than 1% at the inception of the system in September 2009.

Source: Infrastructure Partnerships Australia (2014:67)

The principal advantage of this New Zealand system lies in its ability to allocate charges to vehicles according to their overall use of the network and maintenance incurred by the authorities due to the use of roads. It is a charging approach that added weight to the New Zealand RUC. For the past decade, the developed world has been marching toward the use of technology and envisaged charging users based on weight, distance travelled, time, and location associated with a journey. While recommended and utilised in countries such as the Netherlands, the USA, Sweden, and Australia (RUCRG, 2009), it is quite a process to install the appropriate technologies in vehicles, which takes even longer for light vehicles, and mostly depends on the incentives in place.

Technology such as GPS or cellular-based systems could potentially serve as a platform for Namibian MDC. Moreover, such technology could further inform the reformed RUCS in setting road pricing on time and location; for instance, rate differentials for particular road types and different sections of the road, while serving other objectives such as managing safety issues.

7.9 PROPOSED ROAD PRICING FRAMEWORK FOR THE NAMIBIAN NATIONAL ROAD NETWORK

From the international experience discussed in this study and the Namibian RUCS, a reform of the current charging system could bring about charges closer to the accurate use of the road network. A trial of potential technologies could be a solution to the current HGV (travelling) MDC in Namibia. The trial could be done on a voluntary basis and the RFA could offer incentives to drivers willing to participate in the trial. The idea as outlined in the Namibian Transport Policy is to ensure that HGVs pay their fair share of using the road network. The results in Section 7.5 of this chapter demonstrate that HGVs impose greater costs on the road infrastructure and incur greater environmental costs as compared to light vehicles. Reforming the RUC could assist the RFA to ensure that these crucial external costs form part of the RUC. Dealing with the issue of equity, an investigation to introduce toll roads could be lodged possibly in one of the appropriate national corridors or other roads to ensure that light vehicles also pay for the congestion they impose on other users. This view is supported by industry and user representatives at various forums held by the RA toward the formulation of the Namibian Transport Policy: “The representative supports the investigation of toll roads on PPP basis as an addition to the current charging instrument in place” (MWT, 2017:10).

Therefore, the review could examine potential options of road pricing toward revenue generation as a principal objective while also contributing to reducing environmental risks, as discussed below.

Light vehicles (weight ≤3500 kg): Enhance charges for light vehicles, to bring about a system that will bring various improvements to the current status quo. In combination with current charges, consideration of tolls road on a PPP basis is an alternative that is worth exploring.

Heavy vehicles (weight ≥3500 kg): In combination with flat charges, introduce technology considerations toward location, time, distance-based charges for HGVs, and possibly introducing a CO_2 tax to be charged via fuel levy, could serve as alternative. Currently, both options of charging for light and heavy vehicles recognise the current charging system and its sound principles; however, there is room for improvement.

Integrating the aptitude to use technology-based distance measurements could offer further efficiency improvements within the system. Better RUC will be designed to charge vehicles per kilometre driven based on factors such as VKT, amount of emissions, vehicle mass, accident costs, congestion, and the type of road used, for instance standard design to withstand heavy vehicles (Atkinson, 2019). Therefore, the most efficient way to address externalities is by incorporating costs associated with network access into road pricing.

Figure 7.4 provides a framework for possible charging mechanisms for private vehicles and commercial vehicles. This framework could serve as a solution to the road financing in Namibia and could be applied by following the two-part tariff approach recommended in the literature (Rothengatter, 2003; Andreson & Thompson, 2014), namely a charging part that could cover the marginal costs of using the road network and another part (flat charges) that could cover the capital costs. In addition, a financial transfer could subsidise the road sector for the first three to five years of the RUC reform trajectory.

It is worth noting that designing a pricing scheme could be very complex and policymakers must ensure that they consider every possible technology that could send price signals to change road-user behaviours. International experience (Infrastructure Partnerships Australia, 2014) has shown that RUCS reform when pricing models are designed in consideration of the following elements may offer a solution to the Namibian road sector:

1. The time of day the road user accesses the network;
2. Distance travelled (space consumed);
3. Location (urban, trunk, main, and district roads);
4. Associated externalities (for instance, climate, air pollution, congestion, noise, accidents, etc.); and
5. Vehicle model/characteristics (hybrids, safety design, etc.).

The roads agencies and policymakers should consider these elements when reforming the Namibian RUCS in order to economically recover the full costs of road expenditure from those who make use of the network in an equitable manner. Each or a combination of these elements could be considered to deliver a rational price on road usage while addressing specific objectives such as revenue generation and/or reducing externalities. In addition to the current instruments, the reformed RUCS could explore tolling charging schemes. A toll system could be installed to collect road-user fees for accessing a section of roads in an identified network of the Namibian roads. Tolls could be established at a section or network where the demand for the road service could be found to be inelastic. This could be in urban areas or national corridors; on whichever road considerations for estimating economic cost or incidence of the charge should be a priority. Each section or network identified could be priced by applying price differentiation as service costs differ at various locations. The revenue generated could primarily be spent on maintaining the particular corridor. Revenue that is invested back into a particular road where it is generated appears as an improvement evident to the motorists and surrounding community. A tolling system may have merit within the Namibian context in terms of increasing the generation of funds for the road sector.

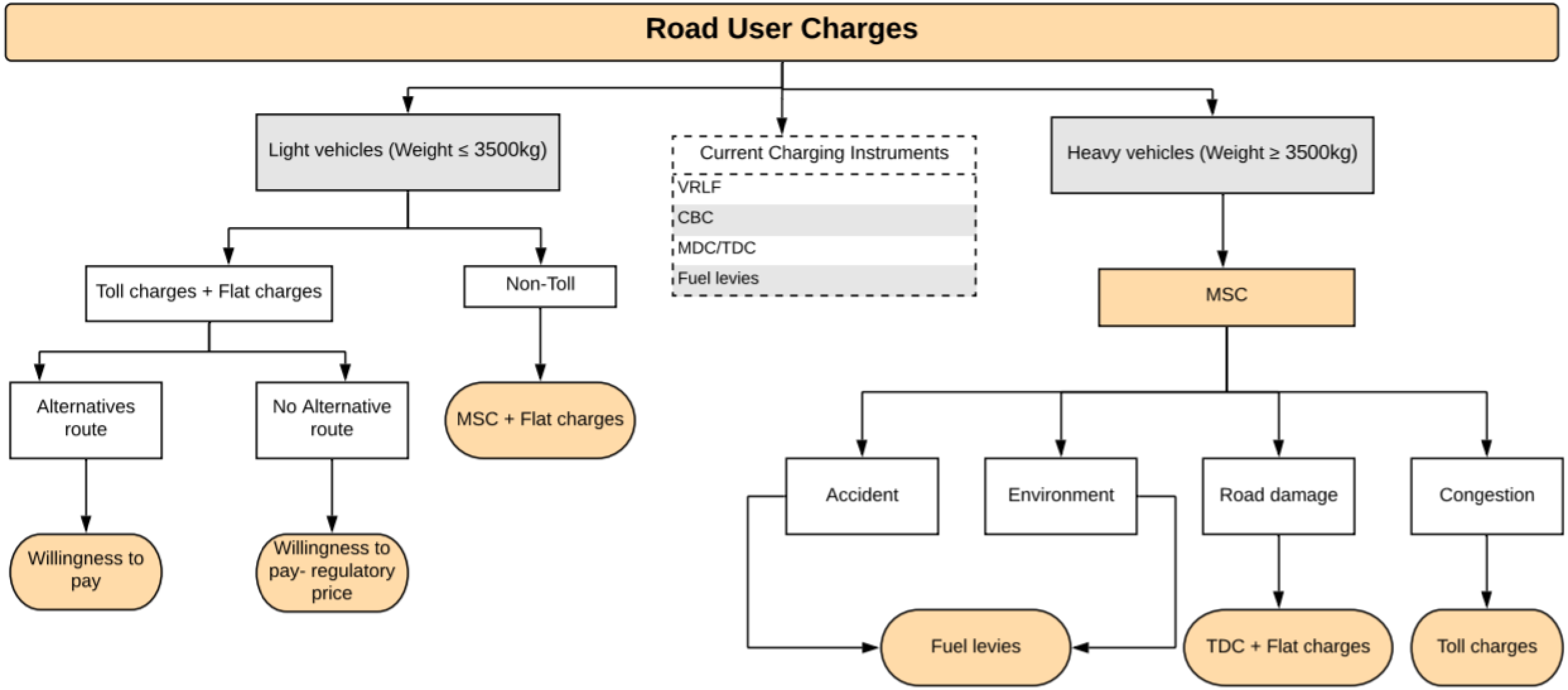

Figure 7.4: Proposed framework for a Namibian Road User Charge System

Source: Author

Figure 7.5 presents hypothetical corridor pricing that could be considered for a reformed RUCS pricing regime. In this hypothetical trunk road, four or more sections could be sampled based on location boundaries, strategic road interception, and estimated AADT based on vehicle types. The charges could be based on a per-kilometre basis or accessed sections in a journey.

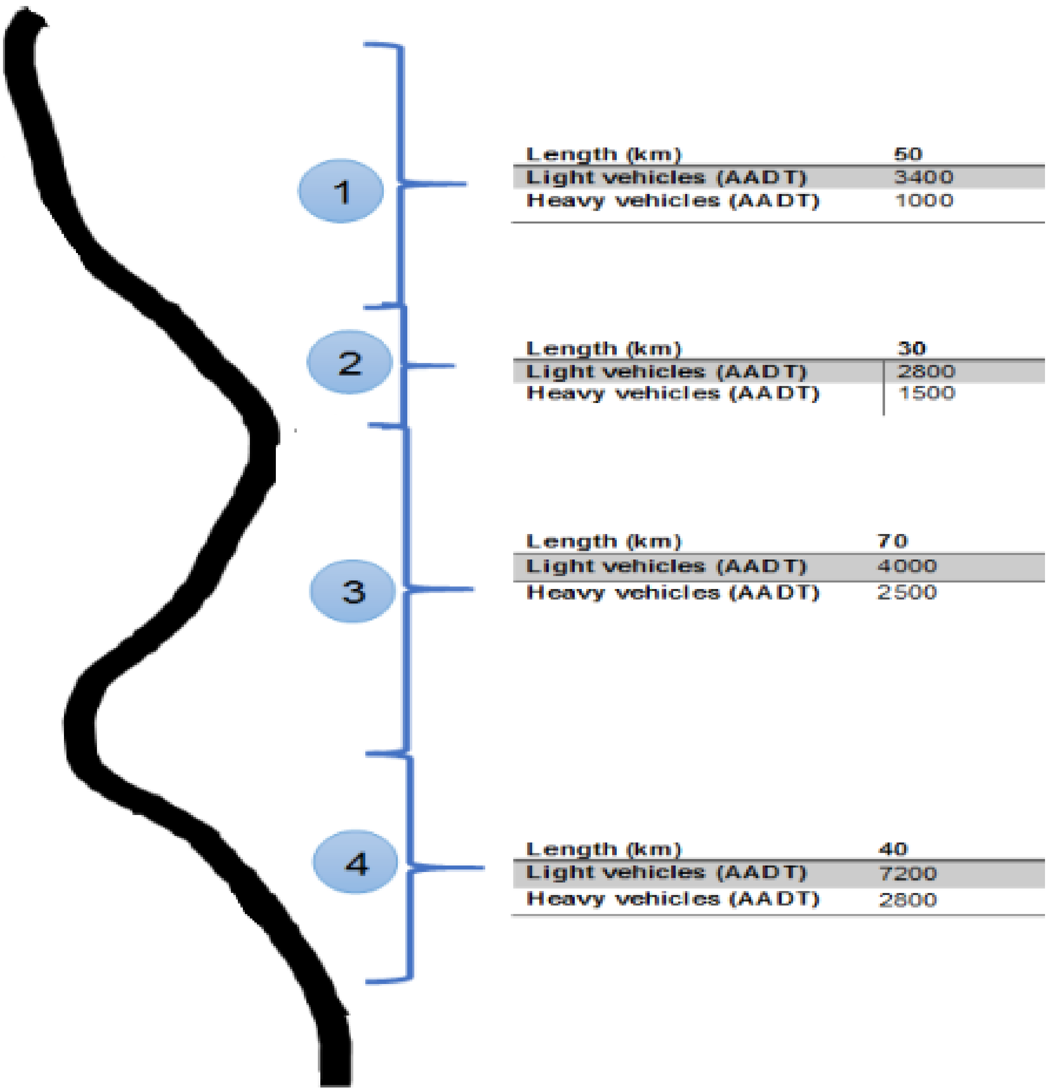

Figure 7.5: National road network hypothetical toll stations

Source: Author

In the Namibian context, the RFA has called for the investigation of the feasibility of tolling of roads in the country. Experience from the literature indicates that equity considerations in terms of price for local residents and commuters should be resolved. Moreover, there must be an alternative route as an option for motorists. One caveat with the Namibian road network discussed in Chapter 5 is that it is associated with sparse roads with few users. The literature, however, discussed that administrative costs are likely to be kept low when the traffic volume on a toll-targeted road section is 10 000 or more vehicle per day (See Section 5.2.2.1).

7.10 SUMMARY

This chapter aimed to review the RUCS towards funding the Namibian national road network by drawing lessons from Australia and New Zealand. The Namibian effort towards financing the road network both in terms of road pricing and institutional arrangement are thus highly praiseworthy in its own context. Moreover, there is still room for improvement, in particular in consideration of a system (RUCS) that has the capacity of raising the needed revenues whilst providing additional benefits such as reducing environmental and society externalities, more efficient use of the transportation infrastructure, and sending pricing signals to the road users.

There is a need to review the current RUCS and possibly conduct a feasibility study on introducing road pricing that varies with distance, space, and time of network access. Indeed, there are lessons to learn from the developed world, in particular countries such as Australia and New Zealand that are faced with an expansive road network, yet have an advanced road sector in terms of road pricing. This chapter concludes by calling for the reform of the RUCS in Namibia. Moreover, there is a need to determine the optimal level of the two-part tariff charge approach. Furthermore, the identification of sections of the network for tolling could establish the viability of toll roads in Namibia. Finally, there is a need to conduct a trial in order to establish the relevant technologies applicable to revamp the MDC that seek to internalise the external costs of road users in Namibia.

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CHAPTER 8:
ROAD FUNDING AND FINANCING: LESSONS LEARNT AND THE WAY FORWARD

8.1 ROAD FUNDING: THE INTERNATIONAL DILEMMA

Many countries are faced with a shortage of resources for the maintenance of their road networks – a situation that has led to an ever-increasing backlog of deferred maintenance, especially in developing countries. For many decades roads have been funded from the consolidated budget and had to compete with equally important sectors such as the education and health sectors. The danger of funding roads from the consolidated budget is that for various political reasons the government is likely to pump funding into developing new roads as opposed to maintaining existing roads. Many governments, especially in Africa, resolved to rescue the road sector by establishing second-generation road funds in order to commercialise the road sector and bringing it to the market place. Towards that, governments have put together several policies, legal frameworks, and charging instruments to bring about road pricing that is justifiable on the grounds of economically efficient pricing. The user-pays principle seems to have taken centre stage of these policies as the best option and as an act that governs the roads agencies toward economic efficiency in funding roads. Second-generation road funds or governments have decided on how to charge the road users, and thus established appropriate RUC instruments. This intention of making those who use the roads pay for their usage was intended to solve the challenge faced by many developing countries on how to fund their roads. Somewhat implicit in implementing these second-generation road funds is the confidence that the RF, based on the user-pays principle, will deliver sufficient funds for the road sector.

As discussed in Chapters 1 and 6, economic efficiency implies that road prices are set equal to the SRMC. In so doing, the agencies must ensure that road users, as the consumers of the scarce resource (roads), pay for their use of roads. The issue of setting RUC equal to the SRMC is that under circumstances of low demand and excess capacity, the efficient prices do not cover capital investments that must be earned by the roads agencies, as rightly explained by Kahn (1988). For instance, in a developed country with more users, the demand for road services is likely to be higher. The literature explains that when internalising external costs, congestion charges alone could generate significant revenue. In addition, most of these countries fall under the high-income category, which could be interpreted based on affordability and the willingness to pay for their road consumption. In contrast, most developing countries are faced with small vehicle populations, expansive road networks, and most of these countries are categorised as low to medium income with a low Gini coefficient. This implies that if charges are set higher, the poor majority who may be trying to make ends meet could be affected negatively by high tariffs.

Setting RUC at an economically efficient price varies across the globe and is a complex exercise, which is also time consuming and requires a large budget. Among charging instruments for road use, the fuel levy is quite sensitive to many national objectives. For instance, the major issue has been setting the fuel levy on par with inflation. This challenge has been more acute in developing countries, where the fuel levy has been the highest contributor to the revenue generated from RUC. Therefore, year in year out, roads agencies are faced with a funding gap, which puts immense pressure on the government fiscus. The argument in the literature and transportation policies has been in support of efficient charges and that users should pay for their consumption when using a road network. This concept, however, seems not to have been properly understood by many planners. Therefore, on the journey towards implementation of this principle, there is a need for researches to be more scientific about how road agencies should set RUC or tariffs. Roads agencies need to use the tools at their disposal, including the HDM-4 currently used for maintenance strategies and determining road network investment needs.

8.2 NAMIBIA: COUNTRY PROFILE

Namibia is situated within the southern region of the African continent. According to the World Bank (2016), Namibia is categorised as an upper-middle income country, with a GDP established at US$10.3 billion and a per capita income of US$4 140 (N$55 114). The country has a total land area of approximately 825 614 km² (a population density of approximately 2.6 person per km²). Namibia has a relatively large national road network of approximately 48 399 km that serves a vehicle population of approximately 371 281 registered motor vehicles (RA, 2016), about 266 673 foreign vehicles and a population of 2.3 million inhabitants (NSA, 2017). Approximately 52% of its inhabitants reside in the rural areas of Namibia's 14 regions. This presents a need for better transport connectivity and improved welfare of the citizens. The implication of funding an extensive road network that serves few users is that the network requires more funds to maintain the existing network; not to mention the development of new roads to ensure connectivity and better services to its citizens. In Namibia, the potential for a self-funded road sector is not yet being fully exploited. Among other constraints to insufficient revenue generated from the RUCS is the inability of RUC to meet the national road network expenses. Namibia established a second-generation road fund supported by earmarked revenue generated from the implemented RUCS. The common problem with the second-generation road funds is that they create the impression that all the revenue generated from the RUC should be sufficient to cover the full expenditure of the road network.

8.3 INTERNATIONAL EXPERIENCE WITH ROAD FUNDING AND ROAD TARIFFS

There is a common understanding in both developed and developing countries on charging for road use. The argument across the globe is to ensure that the users of roads should fund the maintenance and provision of the required infrastructure. However, because continents and countries are unique, the application of charges differs per continent and per countries, although similarities can be traced. For instance, each country charges a tax or levy on fuel sold per litre. In addition to the fuel levy are other taxes and charges (see Chapter 5).

The theoretical economic principle that governs setting RUC is the user-pays principle, which is justifiable by holding accountable users of the network to pay the full costs of road provision and use. The price set at the SRMC aims to internalise the negative external costs imposed by the user at the point of using the network. Attempts to estimate these values has seen the European Commission committing resources and funding several studies to develop methodologies (see Chapter 3, Section 3.2.1). Due the complexity and limitations associated with setting tariffs or charges at the SRMC of road use (see Chapter 6), most roads agencies and governments have, however, opted to deviate from the so-called first-best road pricing and resolved to set tariffs at the second-best road pricing. The latter, when followed, allows the agencies to price road services by recovering costs from the users while minimising market distortions (see Chapter 7).

8.4 RESEARCH FOCUS

This dissertation sought to address three objectives, which examined the issues surrounding the funding and financing of the national road network in Namibia. The research aimed to investigate funding and financing of the national road network in Namibia. The research focused on the RUCS and how the charging instruments have been utilised to generate funds and what charging principles and planning tools the roads agencies use to inform the setting of road pricing. The following chapters addressed the research objectives:

8.4.1 Chapter 5

In this chapter, the researcher evaluated the relationship between the RGR and its allocation towards national road network expenditure and related these to international standards. This chapter addressed the first objective.

8.4.2 Chapter 6

In Chapter 6, the researcher determined the methodology to estimate the road-use cost based on the efficiency principle of SRMC and compared the marginal costing of road use to the average cost pricing of road use. This chapter laid the foundation for the second objective by estimating the MEC of road use, which were further utilised to determine the implications of implementing the theoretical economic principle of user charging.

8.4.3 Chapter 7

In Chapter 7, the financial implications of implementing MSC as a charging principle for road use were determined. The estimated MEC were compared to the fuel levy (as a proxy of the current charging instruments) per vehicle per kilometre on D0872, M0052 and T0108 roads. The researcher explored the possible second-best RUC based on the circumstance surrounding the Namibian road pricing towards addressing the funding challenges. To that effect, the researcher examined the government's efforts towards road pricing and compared Namibian road pricing to Australia and New Zealand in order to draw possible lessons. This chapter addressed the second and third objectives.

To achieve the objectives, the research used secondary data and explored the HDM-4 model, to estimate the MEC of road use. Other secondary information sourced from roads agencies and relevant line ministries included financial reports, Acts, organisations' websites, published articles, budget speeches and documents, strategies, development plans, newspaper articles, and policy documents, which were found relevant to further support the analysis. These tools provided an in-depth understanding of the road pricing, revenue generation, allocation, and expenditure of the national road network. For instance, the study used the HDM-4 model to estimate the MEC of road use, which have mostly been overlooked by several studies in developing countries and in sub-Saharan African, particularly Namibia, which makes the investigation conducted by this study more fact-finding than previous studies.

Furthermore, previous studies focused on examining pricing for urban roads (Ferrai, 2010; Hau, 1992; Cavallaro, Giaretta & Nocera, 2018) towards reducing urban congestion and environmental risks. Other studies focused on pricing the national road network using experimental models (De Borger & Proost, 2012; De Palma & Lindsey, 2011). This study focused on the Namibian national road network managed by the RA and used data used from this authority for maintenance plans and investment needs, which provided base estimates for calculating the MSC of road use that could easily be integrated into setting road pricing.

Apart from providing a methodological base for estimating the marginal costs of road use in Namibia, the study also initiated a new dimension to the debate and the controversial topic of efficient pricing in developing countries, particularly in Namibia as a country with an expansive road network and few users. This study thus contributes to the existing body of knowledge relating the supply side of funding an expansive road network with few users (a small vehicle population). This is different from previous studies, which mostly examined the issue of expansive networks but with a reasonable number of users that could possibly fund the road network, depending on the policies and charging instruments employed. This study provides possible benefits that roads agencies could reap by utilising the available tools (such as HDM-4); not only for making informed decisions towards price setting that covers the externalities of road use but they also present possibilities for a system that could potentially send clear signals to the users of the total price they ought to pay when using the road network.

8.5 RESEARCH FINDINGS

8.5.1 Evaluation of National Road Network Funding in Namibia: The Curse of Efficient Road User Charges

The road funding discussed in Chapter 5 confirmed that Namibia finances its national road network from two main funding sources. These sources are (i) revenue generated through the RUCS, which accrues to the RFA and (ii) revenue generated from general tax, which forms part of the SRF.

In addressing the first objective, the VKT on the national road network for the year 2015/2016 and revenue generated from the RUC amounting to N$2.095 million for the fiscal year 2015/2016 were used to determine road-user spending per kilometre on national road network, *ceteris paribus*. The results indicated that users spend N$0.54 per kilometre on RUC, which accrues to the RFA. At the broader level, when considering revenue generated from other taxes, approximately N$0.70 was spent per kilometre. Therefore, the total spending per kilometre on the national road network amounted to N$1.24 for the financial year 2015/2016. This implies that during 2015/2016, the allocation from the SRF outweighed the revenue generated from the RUC.

The RFA presents high transparency in allocating RGR towards the preservation of the road network. This places Namibia among countries with a high dedication of 80% and above towards road expenditure, together with the USA and Switzerland when compared to international standards (see Figure 5.10). While revenue generated from the road users is largely allocated back to the preservation of the road network (0.96 ratio), the researcher argues that the road sector should not rely so heavily on government subsidies, but must seek other means of financing itself. This research supports previous literature that pricing roads at an economically efficient price could be a solution to road funding in Namibia.

8.5.2 The Use of the HDM-4 to Determine the Marginal External Costs of Road Use

Chapter 6 explored estimating the external costs of road use for Namibia using the HDM-4 model and discussed issues surrounding implementing the MSC concept. The chapter used the HDM-4 Workspace obtained from the RA and sampled three case studies from the national road network representing each road category (district [D0872], main [M0052], and trunk [T0108]) to demonstrate the applicability of the HDM-4 model to estimate the MEC of road use. The results indicated that heavy vehicles imposed the highest costs in terms of infrastructure damage and environmental costs when using the network. Overall, light vehicles contribute the most to congestion and accident costs. When average costing is applied as a pricing approach, the results indicate that heavy vehicles impose approximately 96% of the costs and light vehicle impose approximately 4% when traveling on D0872 road. The results yielded similar results as for heavy vehicles, with approximately 97% and approximately 3% for light vehicles when travelling on M0052 and T0108 roads. When applying marginal costing, the results indicated that heavy vehicles impose approximately 98% of costs and approximately 2% by light vehicles when traveling on D0872 road. On the M0052 road, the results indicated approximately 97% and 3% imposed by heavy and light vehicles respectively. The results for T0108 road indicate that heavy vehicles impose approximately 81% and approximately 19% by light vehicles. The variation that appears when charging per marginal costs is associated with congestion costs. On D0872 and M0052 roads, the congestion is not quite significant and the light vehicles' cost contributions were thus found to be low. However, on T0108 road, the results presented a traceable percentage of congestion imposed by light vehicles, thus increasing the cost contribution from 2% (D0872 road) and 3% (M0052 road) to approximately 19% on T0108 road.

The results of this chapter could allow roads agencies to take stock of the progress made towards implementing the user-pays principle and identify options for further internalisation of road transport external costs. Based on the findings, road users impose some negative externalities when using the road network and it would make economic sense to internalise such costs into the RUC.

One possible reason why roads agencies do not pursue MSC pricing is attributed to the fact that measuring marginal externality costs varies with time and space, which makes it a challenging exercise that is time consuming and requires an extensive budget. While marginal cost pricing is desirable, this research confirmed that it leads to financial deficits given the fact that most Namibian roads are defined as low demand yet exhibit excess capacity. The existing MDC attempted to solve the challenges associated with charging heavy vehicles according to distance travelled; however, the current MDC is a blunt instrument that does not adjust charges according to weight, time, and location. The marginal pricing approach in the Namibian context (expansive road network serving few users) might not necessarily raise the revenue required for the investment and maintenance of the road network. Therefore, there is a need for an alternative approach to marginal pricing.

8.6 REFORMING THE ROAD USER CHARGE SYSTEM IN NAMIBIA: LESSONS FROM AUSTRALIA AND NEW ZEALAND

The findings presented in Chapter 7 addressed the second and third objectives. The fuel levy and MDC were used as a proxy to determine the revenue generated from the three sampled cases per vehicle per kilometre. The MEC estimated in Chapter 6 represented the cost imposed on each sampled road per vehicle kilometre. A comparison of the marginal cost pricing with the current RUC findings confirmed that the revenue generated from the fuel levy exceeded the MEC of road use per vehicle per kilometre (see Tables 7.1, 7.2, and 7.3). The researcher contributed to the ongoing debate (see, for instance, Van Rensburg & Krygsman, 2016; Krygsman, 2018) by arguing that the fuel levy may not be regarded as a reliable source in the long run, especially with fuel-efficient, hybrid, and electric-powered vehicles (Van Rensburg & Krygsman, 2015).

The findings on the hypothetical trunk road demonstrated the implications of setting charges at the efficient price (SRMC) in Namibia. Section 7.2.2 (see Table 7.4) indicated that it costs the RA approximately N$6 million to preserve the 117.76 km stretch of trunk road; however, RUC set at SRMC could only generate a total revenue of approximately N$1 million. In order to fund the Namibian low-volume roads, roads agencies should seek an alternative to the first-best road price, the so-called second-best pricing.

Towards addressing the third objective and exploring the second-best pricing approach for Namibia, the study assessed the current Namibian RUCS regarding reforming the current system in order to internalise MEC where possible. Taking cognisance of the efforts made towards implementing the recommended user-pays principle, the researcher designed an RUC framework that could form the basis for the roads agencies to launch investigations towards reforming the current charging system (see Figure 7.4). Moreover, the research leaned on countries such as Australia and New Zealand, which are described by expansive land space similar to Namibia and which have successfully reviewed their RUCS, particularly their unique approach towards distance charging bases for heavy vehicles. There is a lesson for exploring some charging mechanisms that foresee being sustainable in the long run in terms of revenue generation whilst reducing externalities. Reforming the current system with the focus on distinguishing suitable charges for light and heavy vehicles to account for their use of the road network per vehicle per kilometre according to time and location is a lesson that Namibia can learn from Australia and New Zealand.

Given the findings presented in this study, it is evident that the Namibian road sector is faced by the dilemma of an expansive road network to be funded by a small vehicle population. Interventions should be directed at exploring long-run sustainable revenue-generation alternatives from the current highest contributor, namely the fuel levy. Collaborating efforts from both the public and private sectors could be another step towards road financing solutions.

8.7 IMPLICATIONS FOR A ROAD FUNDING POLICY

The results of this study demonstrated that it is possible for roads agencies to utilise tools such as the HDM-4, which is currently used only for planning, to be extended to estimating the costs of road use per vehicle per road categories. This would further inform transport planners and policymakers on setting charges that are closer to the road use. As discussed in Chapter 7, this study laid the foundation for reforming the current RUCS to consider internalising the negative externalities of road use. By internalising the external costs of road use, roads agencies could generate more revenue while at the same time reducing air pollution, putting in place safety measures, and managing demand. A holistic policy approach would help the roads agencies and the government to set prices that send the right signals to road users, thus road users would only consider taking journeys when necessary.

8.8 OPPORTUNITIES FOR FUTURE RESEARCH

This research investigated the revenue generated from the RUCS and allocated to roads agencies. Although the RFA allocates funds to the local authorities, there are no records of the network length of urban roads maintained. The estimates of amounts spent by users per kilometre were limited to kilometres travelled on the national road network. It is recommended that the RMS be extended to local authorities for planning for investment needs and maintenance strategies. This would enable future studies to conduct in-depth research that includes urban road networks.

The RMS's supporting systems and tools utilised to facilitate the efficient management of the national road network in order to provide information pertaining to the network need to be explored further to provide details on users' willingness to pay for safety, time savings, and reduced VOC.

Road funding and financing pathways require a system that is kept on par with market trends and evolving technology. This requires further studies on sustainable charging mechanisms for each vehicle class, be it light or heavy, used for private or commercial purposes. Furthermore, integrated transportation is necessary to ensure that users have a variety of options for moving goods or traveling from one place to another.

Another area of research could be attributed to privacy and human rights. The literature has expressed concern with regards to the privacy and human rights issues (Glaister & Graham, 2004) associated with recording and tracing vehicle movements. In order to conduct a successful RUCS reform, research should be conducted to obtain public views on using technologies and devices that record individuals and their travelling information.

Equity is another concern that deserves analysis in terms of the effect that the envisaged RUCS reform could have on different classes of road users. Experiences from the literature indicated that RUC might be a disadvantage to users. A detailed study on the macroeconomic assessment impact that transport prices would have on the whole economy is needed. In the same vein, a detailed study on the optimal level of RUC and revenue projection from each instrument given traffic demand by 2025 can be undertaken. To that effect, the roads agencies should strive to collect data on travel demands for the whole network, VOC, motorists' value of time, traffic speeds, elasticity of travel demand, and a thorough analysis of external costs of road use covering all components.

8.9 RECOMMENDATIONS

This dissertation recommends necessary interventions for the enhancement of road pricing that could subsequently lead to an improvement of funding and financing of the road network. Efforts should be directed at reviewing the current RUCS in particular to make a distinction between light and heavy vehicles, as well as available technologies that could be utilised to charge users per kilometre. There are benefits to revisiting the current approach to road pricing. The following points are of specific concern for further research:

- Roads agencies should explore utilising the HDM-4 model, to estimate the values of external costs on a marginal basis that would be of great benefit in internalising the external costs of road use when setting charges.
- Priority areas should be directed towards investigating possible charging instruments that could yield positive results in terms of revenue generation and reducing road

externalities by charging users on kilometres driven based on distance driven, amount of pollution emitted, motor vehicle weight, congestion, and the type of road used.

- Introducing the possibility of vehicle owners utilising on-board distance measurement units presents a better alternative to odometer readings. It will, however, be unwise to discard the current system that is well understood by users in pursuit of improvements based on untested substitutes.
- Roads agencies, the RFA in particular, should consider available technologies towards automation of (travelling) MDC. The RFA should offer incentives for drivers to voluntarily participate in a trial that could indicate the feasibility of opted technologies under Namibia's specific operating conditions. Automating MDC, using technology to log kilometres travelled, and charging vehicles on accurate distance could possibly result in collecting greater revenue from hybrid and electric vehicles in the near future.
- Examples of reforming RUC, in particular utilising several experimental trials on implementing charges on kilometres driven by heavy vehicles, should be studied from other countries, including New Zealand, Australia, the USA, Germany, and the Netherlands.
- Further investigation into the feasibility of tolls could be conducted and trials could be carried out on a PPP basis.
- Namibia needs a minimum provision of infrastructure independent of actual use patterns because this is essential. This implies that in the short run, the government should continue to support the road sector from consolidated revenue, as is the case while reforming the current RUCS.

The overall message from this study is to ensure adequate funding that will enable the roads agencies to preserve the great asset (roads) that would continuously place Namibia on the map for having a quality road network ranked number one in sub-Saharan Africa and 28th out of 140 by the *Global competitiveness report* (Schwab, 2018).

Road pricing often does not take externalities into account and this is a huge oversight associated with developing countries. Moreover, it is a fact that there are negative externalities associated with the use of the road network that both supply and demand of roads should take cognisance of when planning for network investment or when planning for a journey. Failure to price the value of time spent on a congested road, accident and environmental risks, as well as damage imposed on infrastructure when using the road network result in false signals to the users of the network, which may lead to more damage to the network as drivers might end up making unnecessary trips. For an expansive road network, Namibia could draw examples and lessons from Australia and New Zealand. As discussed earlier, both Australia and New Zealand underwent RUCS reforms towards implementing charges by distance and weight that could replace the fuel levy, given the fast-moving market of hybrid and electric vehicles. Therefore, it is wise to put in place charging mechanisms with the ability to charge users according to their overall use of the network. Both Australia and New Zealand's reforms yielded great RUCS reforms with successful results in terms of road pricing.

Lastly, consultation with users and educating them on well-maintained roads, as well as great transparency of the revenue generated from road use and its allocation, would serve as a basic motivation for users to do their part and willingly welcome reforms.

8.10 CONCLUSION

Road funding and financing constraints are attributable to the policies and institutional frameworks in place. Furthermore, roads agencies are not subjected to rigorous market discipline. Road expenditure is financed depending on the employed mechanisms, mostly RUCS supported by general tax revenue, as is the case in Namibia. This study showed that insufficient funding for road networks is governed by several aspects, including lack of clear road pricing that could send signals to both supply and demand, as well as the huge disparities that appear between land space and the number of users to fund an expansive network. The findings suggest that in addition to promoting institutional arrangements for the road sector, getting the price right could be a solution to road funding and financing.

With respect to road pricing for a national road network, setting the "right" price equal to economically efficient SRMC is one of the major challenges that face roads agencies. Several shortcomings associated with implementing the theoretical pricing concept of MSC are thoroughly deliberated in the literature, including the complexities of undertaking such an exercise. Gathering necessary data is quite time consuming and requires an extensive budget. MEC are situation based and location specific, which makes it difficult to translate the concept into practical use. This study demonstrated the importance of the HDM-4, in estimating the externalities costs of road use. The MEC estimated for Namibia could form the basis for internalising external costs of road use into road pricing. Moreover, the objectives of reducing road externalities could easily be achieved when the value associated with such externalities per vehicle per kilometre is known.

This study compared the efforts made by the government of Namibia, in particular the RFA, to charge users for their use of the road network towards implementing the user-pays principle according to international standards. The Namibian government has put in place noteworthy institutional arrangements that seem to serve as a benchmark for other countries in sub-Saharan Africa. For the past two decades, the roads agencies made progress towards road pricing, funding, and financing. There is, however, much room for improvement, especially when it comes to implementing the user-pays principle. The RUC framework designed in this study could therefore be a starting point to lodging an investigation towards reforming the current system.

Lessons learned from the current RUCS indicate that efforts towards the implementation of the user-pays principle and revisiting the achievement of the goals and targets of the RUCS could yield results. This requires the efficient pricing and internalisation of MEC to be accounted in the Transportation Policy, pricing, strategy, and investment needs. The biggest shortcoming of all remains the translation of policies and strategies into actual action in a timely manner within a constrained budget, which will require political and user advocacy. There is therefore a need to gather the necessary data, which could methodologically be translated into calculating the external costs of road use and the application of HDM-4 to inform road pricing.

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APPENDICES

Appendix A: Fees applicable to different vehicle classes

TABLE A:Cross-Border Charges (Entry Fees) for foreign-registered vehicles

(From 1 May 2019)

Type	Description (Petrol & diesel driven)	Entry Fee N$
1	Motor cycles, motor tricycle, motor quadru-cycle, caravans, & light trailers drawn by Type 2 vehicles.	196.00
2	Motor cars, single and double 242.00 cab goods vehicles (bakkies), 2x4 and 4x4 goods vehicles (bakkies), minibuses (less than 25 passengers).	308.00
3	Light goods vehicles/delivery vehicles (GVM<3,500 kg)	644.00
Heavy vehicles: single units		
4	Bus with 2 axles (carrying capacity of 25 or more passengers)	727.00
5	Bus with 3 axles (carrying capacity of 25 or more passengers)	923.00
6	Single unit truck with 2 axles	727.00
7	Single unit truck with 3 axles	923.00
Heavy vehicles: Traction unit as part of a combination vehicle		
8	Truck tractor with 2 axles	727.00
9	Truck tractor with 3 axles	923.00
10	Truck tractor with 4 or more axles	1763.00
Heavy trailers as part of a combination vehicle		
11	Trailer with 1 axles	476.00
12	Trailer with 2 axles	727.00
13	Trailer with 3 axles	923.00
14	Trailer with 4 axles	1244.00
15	Trailer with 4 or more axles	1510.00
Construction vehicles		
16	Tyre dozer, grader motor, front-end loaders, excavators, self-propelled vibratory rollers	2561.00
17	Any other vehicle not listed	489.00
Regular User Permits		**434.00**

Appendix B.1: Letter of approval

SAFE ROADS TO PROSPERITY

Private Bag 12030
Ausspannplatz
WINDHOEK
Namibia

Our Ref: 2/1/5/5

Enquiries: C Kasika
Telephone: 061-284 7174
Fax: 061-284 7652
E-mail: kasikac@ra.org.na

7 December 2017

Ms Helvi Petrus
21438293@sun.ac.za
+27792115011

Dear Ms Petrus

RE: LETTER OF APPROVAL FOR MS HELVI PETRUS TO CONDUCT A RESEARCH STUDY AT ROADS AUTHORITY.

Your letter requesting to conduct research study with Roads Authority (RA) refers.

Kindly be informed that your request has been granted to conduct research on Roads Authority, as per your topic **"Marginal Social Road User Cost, Road User Charges (RUC) and the extent to how RUCs are used to fund road maintenance and rehabilitation.**

However, you are cautioned that any collected information should be treated with uppermost confidentiality and solely be used for study purposes.

Yours Sincerely,

....
C Nyati
Senior Manager: Human Resources

HUMAN RESOURCES
2017 -12- 08
Private Bag 12030
Ausspannplatz, Namibia
Tel: +264-61-0847038 · Fax: +264-61-2847147
www.ra.org.na

Appendix B.2: Data usage disclaimer

Serving the road user

Data Usage Disclaimer Roads Authority

The Roads Authority of Namibia, a statutory body established by an Act of Parliament, Act 17 of 1999, is the sole and exclusive entity responsible for managing the national road network with a view to achieving a safe and efficient road sector. Road inventory and condition data are compiled as part of the management process of the road network.

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2. No licence to modify, publish, transmit, transfer, create any derivative work therefrom, sell, distribute, commercially use, or in any other way exploit, in whole or in part, data, information, spatial attributes and reports without the written permission of the RA, is given.

3. This data, information and spatial maps about the status and condition of the road network in Namibia are provided free of charge to relevant stakeholders and third parties subject to the following disclaimer.

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RMS Manager

S. Tekie

Signature

Receiver Details

HELVI N. PETRUS

Stellenbosch University

Signature :

Appendix C: Spending per kilometre (given the budget and VKT per year)

$$Road\ users\ spend\ on\ average = \frac{\text{Revenue generate from RUCS}}{\text{VKT per year}}$$

$$Investment\ on\ national\ road\ network = \frac{\text{Budget funded by RFA}}{\text{VVKT per year}}$$

*At the broader level = comprises total revenue generated inside and outside the RUCS, as well as budget allocated to the RA from both sources.

Appendix D: Estimating the Marginal External Costs of road use: A worked example

This annex depends on a case study sampled from the trunk paved road of the national road network using the road pricing and policies developed in Chapter 6 to estimate the MEC of road use in order to ensure that the external costs of road use are considered when setting or determining RUC. Illustrations made here reflect Case Study C: Trunk road.

Table D.1: 2020 work program optimised by year

HDM-4

HIGHWAY DEVELOPMENT & MANAGEMENT

Economic Indicators Summary

Study Name: **Tactical Analysis**
Run Date: **08-03-2019**
Currency: **NAM$ (millions)**
Discount Rate: **12.00%**

Year	Section	Class	Length (Km	Surface Classes	AADT	Work Desprition	NPV@AADT	NPV@AADT+ an additional vehicle
	D0872km 0.410-61.460 (DBB5HPPZ1)	District	61.05	Bituminous	224	40mm Overlay @ 5.23 IRI	35863689	36035865
	M0052km 0.000-22.750 (MBB6MPFZ3)	Main	22.75	Bituminous	1226	40mm Overlay @ 4.16 IRI	55331404.5	55351103.5
	T0108km 0.000-117.760 (TBB2HGGZ3)	Trunk	117.76	Bituminous	3114	40mm Overlay @ 2.22 IRI	5976883996	5977783948
	T1501km 120.000-134.900 (TUU1VGFMMZ4)	Trunk	14.9	Unsealed	997	Regravelling	184271626	184225962
	M0023km 0.200-100.870 (MUU1MGFTNZ2)	Main	100.67	Unsealed	47	Regravelling	159597116	161276315
	D381km 0.000-18.290 (DUU2LGPTNZ2)	District	18.29	Unsealed	2	Regravelling	-712160.81	-345986.75

Box D.1: Methods for estimating the Marginal External Costs

HDM-4 analysis

Requires a calibrated workspace to the local environment and updated data inputs. Define a series of maintenance strategies (see Table D.1) in order to define the optimal NPV. It is crucial to ensure that the value of ESAL is assigned to each vehicle representative. Run an analysis twice: full traffic as measured and with an additional vehicle (this is merely to measure the impact an additional vehicle has on the infrastructure, on other network users in terms of congestion and accidents, and on the environment). In principle, the marginal cost of an additional vehicle could be determined by the difference between the NPV of the two actions (see Table D.1).

Steps for each component of MEC:

(i) MIC:

Determine the difference between the NPV (see Box D.1) as obtained from the HDM-4 run. Determine the marginal cost of users by taking into account the sampled road section length, the ESAL, and AADT per vehicle representative. Table D.2 presents the average roughness of each sampled case.

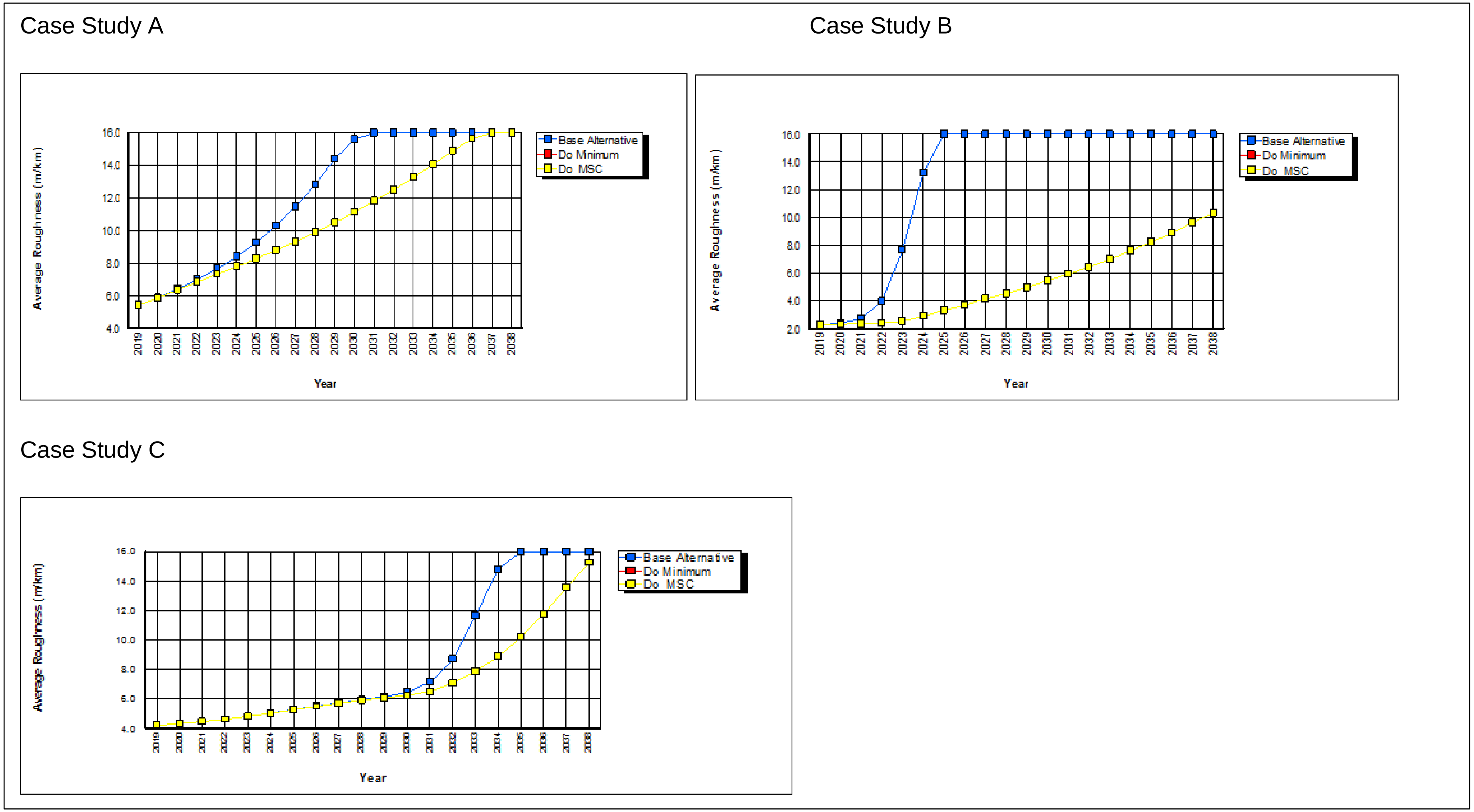

Figure D.1: Average roughness by year

Source: Author

Table D.2: HDM-4 net present value for the International Roughness Index = 2.22 m/km (2019)

Vehicle classes	AADT	ESAL	ESAL % of marginal cost-veh/km-day	Aggregate cost per veh/day	Marginal cost per veh-km (N$)
4x4	954	0.02	0%	1.05636E-05	2.113E-07
Articulated truck	275	7.1	56%	0.003750076	0.026626
Bus	15	2.3	18%	0.001214813	0.002794
Heavy truck	172	3.3	26%	0.001742993	0.005752
Medium car	1461	0	0%	0	0.000000
Mini-bus	238	0.01	0%	5.2818E-06	5.28E-08
Total	**3115**	**12.73**	**100%**	**0.006724**	**0.085593**

Source: HDM-4 Output (Own calculation)

(ii) MCC

From the HDM-4 output, estimate the net time loss of defined actions (see Box D.1); that is the free speed-flow difference. Determine the time loss, considering the 21.48 PCSE, 117.76 length (km), and the time value per hour (an assumption of N$5 per hour).

Table D.3: Calculating a congestion levy based on speed-flow relationship

(1) Vehicles per hour per lane	(2) Flow per hour	(3) Diving time /km (minutes)	(4) Time difference (minutes)	(5) Time loss cause to an additional vehicle (min)	(6) Levy per N$/km
3 114	6.790191	0.057661			
3 115	6.792371	0.05768			

Source: Author's calculation (Blauwens et al., 2012:410)

(iii) MAC

Estimate the accident costs per casualty, including fatal, injury, and damage-only costs. Determine the annual accident costs taking into account the accident rates (in number per 100 million vehicle kilometres) for the wide two-lane road for paved trunk and paved main roads, as well as a standard two-lane road for main district road as obtained from the HDM-4 run. Estimate the accident costs per casualties by multiplying the total accident cost with the accident rate per 100 million for each.

Table D.4: Components of accident costs (2011 value and price)

Cost per casualty: N$				
	Accident rates	Costs base year 2011		
	Fatal	1 023 650		
	Injury	159 350		
	Damage only	35 270		
Vehicle classes	**Fatal cost per veh.**	**Injury cost per veh.**	**Damage cost per veh.**	**Total marginal costs per veh-km**
4x4	0.00094	0.00055	0.00445	0.00594
Articulated truck	0.00027	0.00016	0.00128	0.00171
Bus	0.00001	0.00001	0.00007	0.00009
Heavy truck	0.00017	0.00010	0.00080	0.00107
Medium car	0.00145	0.00084	0.00682	0.00911
Mini-bus	0.00024	0.00014	0.00111	0.00148
Total	**0.00309**	**0.00179**	**0.01454**	**0.01942**

Source: Accident rates, RA (2018), accident costs per vehicle (author's calculation)

(iv) MENVC

Table D.5: Emissions by vehicle type in quantities (in grams per 1 000 veh-km)

H D M - 4	Emissions by Vehicle Type									
HIGHWAY DEVELOPMENT & MANAGEMENT				Study Name:	2019-3038 Tactical Analysis					
				Run Date:	09-03-2019					
Quantities in grams per 1000 vehicle-kilometres										
Vehicle Classes	HC	CO	Nox	Par	CO2	SO2	Lead PB	GWP		
4x4	1064.93	1065.51	3796	213.1	280016	911.75	0	Carbon dioxide	C02	1
Articulated truck	7102.94	6529.78	24454	1306	1571212	5132.18	0	Methane	Ch4	21
Bus	3267.7	3224.13	11580	644.8	835917	2723.09	0	Nitrous dioxide	N2O	310
Heavy truck	6622.05	5694.96	22210	1139	1263071	4138.78	0			
Medium car	305.89	1933.5	2034.5	14.33	289784	92.33	37.18			
Mini-buses	305.7	2021.37	2139.2	15.51	328237	104.45	42.07			

Source: Author's calculations

Table D.6: Marginal Environmental Costs per vehicle kilometres travelled on 117.76 km paved trunk road

Vehicle classes	Fuel consumption per 1 000 veh-km	HC4	Nox	CO_2	CO_2e	Costs per veh-km
4x4	0.12324	8.024E-08	2.860E-07	2.110E-05	2.146E-05	0.000859
Articulated truck	0.60496	2.627E-06	9.044E-06	5.811E-04	5.928E-04	0.023712
Bus	0.32099	6.413E-07	2.272E-06	1.640E-04	1.670E-04	0.006678
Heavy truck	0.48786	1.975E-06	6.624E-06	3.767E-04	3.853E-04	0.015413
Medium car	0.12479	2.334E-08	1.552E-07	2.211E-05	2.229E-05	0.000891
Mini-buses	0.14118	2.639E-08	1.846E-07	2.833E-05	2.854E-05	0.001142
Total	**1.80302**	**5.373E-06**	**1.857E-05**	**1.193E-03**	**1.217E-03**	**0.048695**

Source: Author's calculations

Table D.7 presents the marginal and average social costs of road transport in Namibia (cents per kilometre) for each vehicle class (light or heavy) per road category (district, main, and trunk).

Table D.7: Average costs and Marginal Social Cost of road transport in Namibia: 2019 (cents/km)

	MEC						Average costs					
Roads	**District**		**Main**		**Trunk**		**District**		**Main**		**Trunk**	
Costs components	**Light vehicles**	**Heavy vehicles**	**Light vehicles**	**Heavy vehicles**	**Light vehicles**	**Heavy vehicles**	**Light vehicles**	**Heavy vehicles**	**Light vehicles**	**Heavy vehicles**	**Light vehicles**	**Heavy vehicles**
Infrastructure	0.000	18.044	0.001	86.282	0.000	3.517	0.361	229.537	0.102	64.574	0.057	36.365
Accidents	0.119	0.020	0.010	0.002	1.654	0.288	5.109	0.883	1.192	0.251	307.919	35.073
Environmental	0.285	4.186	1.788	4.367	0.289	4.580	4.634	4.186	1.788	4.367	0.289	4.580
Congestion	0.000	0.000	0.000	0.000	0.012	0.004	-	-	-	-	-	-
Total	**0.369**	**22.244**	**6.373**	**91.441**	**1.955**	**9.850**	**10.104**	**234.606**	**3.082**	**69.192**	**308.266**	**76.018**

Source: Own calculation

Appendix E: Fuel levy estimation

In order to compare the estimated marginal costs to income generated from each sampled candidate road, the fuel levy generated from each vehicle travelling on the sampled road was estimated. The following steps were utilised to estimate the fuel levy income:

1. Obtain the fuel consumption per 1 000 vehicle kilometres of all vehicle classes from the HDM-4 output.
2. Obtain the current fuel levy per litre of petrol and diesel paid by road users as outlined in the *Government Gazette*.
3. Determine the annual AADT of each vehicle class.
4. Determine the total income generated from vehicle classes utilising the sampled road section per year.
5. Determine the RFA and MVA Fund income generated per vehicle kilometre.

Fuel Levy Estimation

$$\text{RFA fuel levy Income per veh/km} = \frac{\text{Total income per year (step 4)}}{\text{Road length (km)}} \div \text{Annual AADT}$$

Where Total income = Annual AADT x fuel consumption rate per vehicle kilometre

Road Length= Kilometres travelled (distance)

Annual AADT = AADT per vehicle class on a sampled road x 365 days

To determine the fuel levy paid by each vehicle class per kilometre:

$$\boldsymbol{RFA\ Fuel\ levy\ per-veh/km} = \frac{Length\ (km)}{1000\ \text{veh}-\text{km}} \times \text{Fuel consumption}\left(\text{litre per }1000-\frac{\text{veh}}{\text{km}}\right) \times \text{RFA Fuel levy per litre}$$

For instance, calculating the income generated from a 4x4 vehicle, the following steps were followed similarly as illustrated above:

- Fuel consumption per 1 000 vehicle kilometre (obtained from the HMD-4 run output): 112.
- VKT: 25 185 annual AADT.
- The district paved road: 61.05 km length.

- The fuel levy comprises 136 Namibian cents that accrue to RFA and 50.3 Namibian cents towards the MVA Fund.

$$\text{RFA fuel levy Income per veh/km} = \frac{\text{Total income per year (step 4)}}{\text{Road length (km)}} \div \text{ Annual AADT}$$

= (235 035.16/61.05) ÷ 25 185.00

= N$ 0.15286

Box E.1: An example of marginal costs in the presence of increased return to scale

The economics of roads rely on the fundamental fact that the LRAC curve is downward-sloping due to the high fixed costs of constructing roads. Due to the falling LRAC, marginal costs not only fall but must be below the LRAC. At this point, the usual efficiency rule to price road services at marginal costs will not generate sufficient revenue to cover the costs of the road network. In Figure 7.4 demand curve (D) also represents the marginal revenue (curve and the average revenue curve). When the efficient pricing rule applies (P=MC), in order to obtain the efficient amount of road use, revenue generated will be equal to rectangle $0q_1$ab; whereas the total costs of providing q_1 units of road service is the rectangle $0q_1$cd. This implies that when applying the efficient pricing rule in the presence of increasing return to scale, the total costs exceed the revenue generated and the marginal cost pricing thus results in a decifit. The desirable marginal cost pricing rule, taken from a competitive market context, will not work as revenue generated will be insufficient to cover the road costs in the long run.

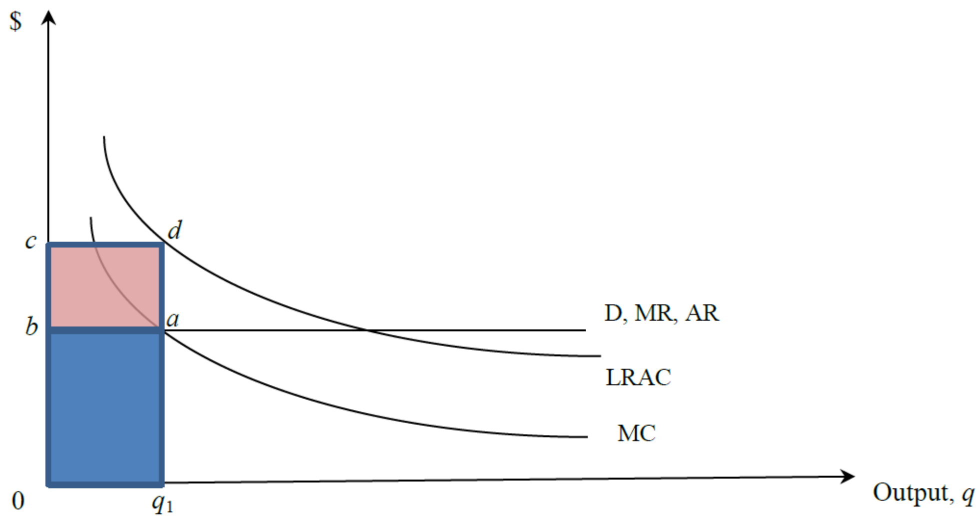

Figure E.1: Marginal cost pricing in the presence of increasing return to scale

Source: Andreson and Thompson (2014:17)

Given the situation presented in Box E.1, Andreson and Thompson (2014) state that the solution would be to subsidise the road from the general revenue or to implement a two-part tariff. A two-part tariff could be a solution that could generate revenue that meets the network investment needs. Under a two-part tariff scheme, road users are required to pay two fees. Andreson and Thompson (2014) posit that under a two-part tariff approach, road users must pay two fees: one fee for subscription equal to one road user's share of the deficit *abcd* (see Box E.1) and another variable fee charged per trip. They indicate that the two-part tariff can be thought of as a linear price, $P = a + bq$, where the price (*p*) represents the flat fee (*a*) plus a variable fee (*bq*), which depends on elements *b* and *q*, where *q* represents the number of trips made and *b* represents the per-trip charge (see Box E.1).