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SCHOOL OF CIVIL AND ENVIRONMENTAL ENGINEERING



Estimation of Road user costs of Freight Vehicles in Ethiopia

The case of Addis Ababa – Djibouti Corridor

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Hilina Demeke

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List of Abbreviation

<i>AACCS</i>	<i>Addis Ababa Chamber of Commerce and Sectorial</i>
<i>AADT</i>	<i>Annual Average Daily Traffic</i>
<i>ADT</i>	<i>Average Daily Traffic</i>
<i>ERA</i>	<i>Ethiopia Roads Authority</i>
<i>ESAL</i>	<i>Equivalent Single Axle Load</i>
<i>GDP</i>	<i>Gross Domestic Product</i>
<i>GPS</i>	<i>Global Positioning System</i>
<i>GITEC</i>	<i>Government Information Technology Executive Council</i>
<i>HDM-4</i>	<i>Highway Design and Management Tool</i>
<i>HDM-III</i>	<i>Highway Design and Maintenance Standards Model</i>
<i>IQL</i>	<i>Information Quality Level</i>
<i>LDC</i>	<i>Least Developed Countries</i>
<i>LLDC</i>	<i>Land Locked Developing Countries</i>
<i>MT</i>	<i>Motorized Vehicles</i>
<i>NMT</i>	<i>Non-Motorized Vehicles</i>
<i>PSCE</i>	<i>Passenger Car Equivalence</i>
<i>PSU</i>	<i>Passenger Car Unit</i>
<i>PMS</i>	<i>Pavement Management System</i>
<i>RUC</i>	<i>Road user costs</i>
<i>TEU</i>	<i>Twenty foot Equivalent Unit</i>
<i>USD</i>	<i>United States Dollar</i>
<i>UNCTAD</i>	<i>United Nation Conference on Trade and Development</i>

Abstract

Transport cost covers almost two-third of the total logistics costs and so its determination requires a through consideration. The objective of this thesis was to estimate the road user costs of freight vehicles along the Addis Ababa–Djibouti corridor. Specifically, it was aimed at assessing the existing freight cost determination procedure and suggest a road user costs which could be a reference for determination of freight rates.

The two basic steps in these study were assessment of the existing condition on freight rate determination and estimation of the road user costs by vehicles. The primary data collection method were interview and questionnaire, where data was collected from five transport companies. Data on existing tariff determination procedure, parameters considered for tariff determination, profit margin for the practical use and existing freight rate between the years 2014-2016 were collected. Secondary data were on the input data of HDM-4 and on characteristics of the freight vehicles on the corridor. The determination of road user costs considered two scenarios, fully loaded and empty freight vehicles. For both of the scenarios; a one trip case was taken into account based on the current most common practice. The trip from Addis Ababa- Djibouti was taken to be with empty freight vehicles while the reverse was assumed fully loaded. Road user costs was assumed to comprise the travel time cost and the vehicle operating cost.

Based on the findings, the common vehicles on the corridor have a capacity between 20-40 tonnes. These freight vehicles are owned either by transport companies or association with a ratio of 1:4. About 52.5% of the vehicles are between service years of 1-10 while 21.8% of the vehicles are above 20 years and the rest are in between. The practical tariff setting procedure is far from scientific method but lies on estimation from the previous experience. The profit margin is various within the available companies and ranges from a minimum of 10-15% to a maximum of above 35%. The estimated road used costs was on annual basis and both fully loaded and empty running vehicles' road user costs are at substantially the same. The road user costs has an incremental flow from year to year, projecting to five successive years starting from the analysis period. The section-wise pattern of the road user costs has similarity with the traffic volume.

It could be concluded that the current tariff setting practice is unscientific, and this should call for attention as the transport cost is the main cost component in the logistics system. The majority of the vehicles are owned by associations and less by the transport companies. This may call for

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attention for further revision as it was known that the association are less organized. Future research direction could be on determining road user costs considering both external and internal cost components, and detail analysis on the impact of the current tariffing practice.

Key words: *Freight vehicles, Tariff and Road Users Cost*

CHAPTER ONE

INTRODUCTION

1.1. General

Transport economics is among core areas of concern to provide sustainable development. Most of the activities related to development are accelerated through transport. Projects of transport are to benefit the road users and facilitate the flow of goods and passengers. One the ways of achieving this could be through consideration of the economics of transport which imply the cost of transport.

Freight transport is one of the components of transport which deals with the transport of goods. It is a very dynamic sector of the economy of a country, overall the GDP. Freight transport is directly related to the economics need of the society (kapashkin, 2015).

In Ethiopia the freight transport has been provided in three different ways. These are international road freight operation, interurban domestic freight operation and the urban freight operation. The freight transport is incremental from time to time. The volume of dry cargos in 1999 was 4.8 million tonnes and it rose to 8.5 million of tonnes in 2005. This showed the 9.5% annual growth rates (AACCS, 2009). Because of this growth and other similar reasons, the direction of focus needs be shifted to the economics of the firm.

The Addis Ababa –Djibouti route is the main corridor for the international trade carrying container and bulk transport in Ethiopia. Ethiopia had three main ports of service before the independence of Eritrea in 1993. About 86 % of imports and exports were conducted mainly through the major two ports; Assab and Massawa, while only 14% was through the port of Djibouti (Kifle, et al., 2000). However, the current conditions indicated that almost all the exports and imports are conducted through the port of Djibouti (Asnake, 2006).

1.2. Background of the problem

Transport is very crucial for a country's development. The current level of development of our universe without transport would not have been imaginable. The system comprises passenger transport and freight transport which are maintained via different modes of transport including air, water, rail and road. Stakeholders and researchers have been working on innovation of the firm

from the perspective of safety, efficiency and economical values. The level of this achievement could be seen indirectly as the display of the advancement of a country.

Ethiopia, one of the developing countries, also possess different transport means. The level of quality of the transport system is however, far away from the current global advancement. Especially the freight transport sector of the country is where intensive and coordinated planning and operation is required. The majority of the cross-border freight transport are conducted through Djibouti port. This is one of the many factors which throttle the efficient and economical growth of freight transport system.

One of the main features of freight transport is the economical link with overall economy of a country. One additional burden in freight transport is its relation with transport of goods. The goods could be of import-export or domestic transport. The successful management and flow of goods at both international and domestic levels will not be questioned to be the prerequisite for economic advancement. Transport would be the way for the flow of goods, and thus every activity need to be economically wise. In developing countries, about 15 to 20 percent of the cost of goods is shared by the transport (Aklilu, 2001).

The country is characterized by high transport costs and low quality roads. The increase in road costs also affects the agricultural sector which accounts about 50 % (Bachewe, 2009) of the country's GDP because of limited access to highly potential areas (Tefera & Alemayehu , 1996). The study was initiated by the degree of sensitivity of the transport cost on the overall countries' development while it was less explored by the scientific study.

The other initiative for this study was the need to consider the road condition on fare determination of the road which one determinant factor for the road section. According to the study made by Karim Chatti at Michigan State University in 2013, cost of transport need to consider the road condition such as roughness, surface texture and skid resistance. Especially, heavy trucks are affected by most types of road conditions. Accordingly, an increase by surface texture of 1mm results in an increase in fuel consumption by 1.5% at 88 km/hr. and 2% at 56 km/hr. for heavy trucks (Karim, 2013).

This all indicated that cost freight vehicles need to be considered in more advanced way. It also needs to account the road condition effect in addition to its indirect consideration by fuel consumption. This is the main research gap in our country as there are less study on the area. This study was expected to fill this gap by focusing on the road user costs considering the Addis Ababa – Djibouti corridor as the case area.

1.3. Objective

1.1.1. General Objectives

The main objective of the thesis was to assess the fare rating practice of Ethiopia in order to establish a road user costs that could be inferred.

1.3.2. Specific objectives

- Map out the existing tariff and the perspective setting practice of the freight transport along the Addis Ababa –Djibouti corridor;
- Map out the type of freight vehicles operating on the corridor, and determine truck characteristics under consideration such as type, age and annual km traveled; and
- Estimate the road user costs based on the road and vehicle characteristics using HDM-4 model.

1.4. Significant of the study

The study could be a baseline for understanding the existing tariff setting practice in Ethiopia. On the other hand, the road user costs estimated using HDM-4 could be used as a main inference for stakeholders on tariff determination. Moreover, the results of the study could be used as a kingpin input for further scientific researches by clarifying the extended research needs on transport and economic aspects of the country. It is believed that all road users and the government would understand the tariff setting/ freight rating practices and this could attract special attention for revising the existing practices.

1.5. Limitation of the study

- The study considered only the travel time cost and vehicle operating costs to determine the road user costs; accident costs were not considered.
- HDM-4 extensive data requirement and the cumbersomeness to find all these data. This made the study to take longer time , and it was also mandatory to use default variables
- The road user costs was determined for the one way trip, in both cases assuming one as fully loaded (40 tonnes) and the other trip for empty vehicles.

CHAPTER TWO

LITERATURE REVIEW

2.1. Freight transport

Transport is considered to be the main component for the entire supply and chain system. There are different forms of transport based on the modal usage and the transfer of liability. These are multimodal transport and Intermodal transport. According to the United Nations Convention on International Multimodal Transport of Goods, the definition of multimodal transport is the carriage of goods by at least two different modes of transport on the basis of multimodal transport contract from a place in one country to the destination place in another country (UNCTAD, 2001). On the other hand, intermodal transport is the movement of goods in one or the same unit or road vehicles which uses successively two or more modes of transport without handling the goods themselves in changing modes, but with different contract (UNCTAD, 2001). Research interests have been emerging towards intermodal freight transport due to its importance in supply chain system (Caris, et al., 2008).

2.1.1. Freight Transport in Ethiopia

Road freight transport in Ethiopia could be classified into three sectors (AACCS, 2009).

- i. International road freight operation (import and export);
- ii. Interurban domestic road freight operation; and
- iii. Urban freight operation

International freight transport is mostly for import and export traffic and there is imbalance between the international import and export in Ethiopia. The import accounts 90% of the total import and export commodities. Because of this difference, lower average load factors are available. In addition to this, seasonal traffic flow resulted operators to claim on the operational and management aspect of the scheme (AACCS, 2009).

The Ethiopian logistics system is characterized by its inefficiencies (Debela, 2013) and by having poor road condition and long custom processes (Nathnael, 2015). From studies made so far, it was found that the national transport cost is greater than the price of importing the same cargoes. For instance, for sea transport containerized goods with 20 TEU containers from the ports of Tianjin and Shanghai in China to Djibouti port was USD 1,500 and USD 1315 respectively; while for

domestic inland transport from Djibouti port to Modjo dry port took a freight rate that ranged from 1734 to 1854 USD (Nathnael, 2015). The study also indicated as using different alternatives such as pipeline and railway would be important for improvement. Another study which was conducted on axle load survey found that on Modjo weighbridge station, about 45.3 of the freight vehicles were overloaded. The penalty for such abrogation was also less intensive and more subjective (Beyene, 2015). Table 1 below presents the overloading status of freight vehicles at Modjo.

Table 1: Overloading Status of Freight Vehicles at Modjo (Beyene, 2015)

S.no.	Steering	Non-Steering					Gross Vehicle	Extent of overloading			Overloading frequency	ownership	
		NS1	NS2	NS3	NS4	NS5		<5	5-20	>20		individual	corporate
1	8040	11760	11020	11040	9240	10280	61380		↓		1	↓	
2	7840	9220	10060	10660	11000	9020	57800				1		
3	7880	10340	10180	12080	12740	11020	64240		↓		1		↓
4	8020	13400	9180	9020	11140	12020	62780		↓		1		↓
5	8040	11220	11240	10380	9220	10440	60540	↓			1		↓
6	7840	11020	12220	9080	13460	10240	63860		↓		1	↓	
7	7860	10080	10560	10440	9480	9660	58080	↓			1		↓
8	8000	12820	10380	9660	9620	10380	60860	↓			1		↓

The other feature of the Ethiopian freight transport is trade imbalance between imports and exports. This has resulted from empty running vehicles for the trip from Addis Ababa to Djibouti. Because of this imbalance, the rate of empty running vehicles was estimated to be 46%, and with this, the country has missed USD 300 million for foreign currency (Berhane, 2015). Table 2 below shows the total volume of trucks and empty running vehicles in Addis Ababa-Djibouti corridor.

Table 2: Volume of total trucks and empty running vehicles on Addis Ababa - Djibouti Corridor (Berhane, 2015)

Year	IMPORT		EXPORT		TOTAL		
	Volume Gross Wt. (ton)	Loaded Truck No.	Volume Gross Wt. (ton)	Loaded Truck No.	Empty run- ning trucks No.	Loaded Trucks No.	ER %
2009	7,179,612	265,912	594,236	22,009	243,903	287,920	46
2010	5,804,820	214,993	630,765	23,362	191,632	238,355	45
2011	6,753,250	250,120	631,225	23,379	226,742	273,499	45
2012	8,108,092	300,300	768,903	28,478	271,822	328,778	45
2013	6,842,747	253,435	787,417	29,164	224,271	282,599	44

On the other hand, the efficiency of the freight transport system was found to be improved by implementing a night time delivery (Kebede, 2013).

2.2. Logistic Efficiency in land locked Countries

There are 44 land locked countries in the world (see figure 1), and out of which 31 are in the developing countries, where 15 of them are found in Africa (UNCTAD, 2013). Being landlocked is the major exhibitor of extreme poverty. Its consequences are long international trade with border crossing, cumbersome transit procedures and inadequate infrastructures (UN, 2014). Figure 1 below presents land-locked countries in the world.



Figure 1: Land locked Countries (UNCTAD, 2013)

The burden of being landlocked is visible compared with the nearby developing countries. For the 31 LLDCs' the growth domestic product has been seen to be 43% lower than the close by costal countries. Figure 2 illustrates how the landlocked developing countries has been prohibited from growth (UNCTAD, 2013).

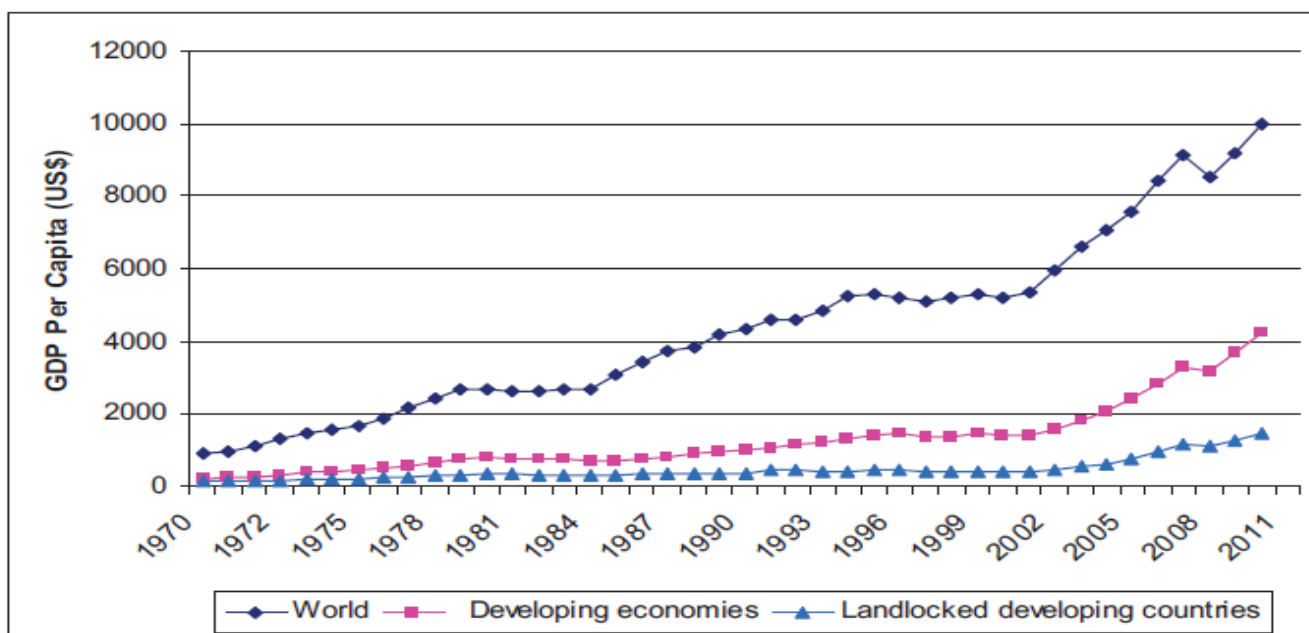


Figure 2: Gross Domestic Product per Capital (US\$) 1970-2011 (Source: UNCTAD)

Landlocked countries have a practice of trading with neighboring countries than more distant countries. In the case of landlocked developing countries, the variation of the export product is very limited to certain product items. The number of products and trade partners were observed to decrease from time to time (UNCTAD, 2013). Table 3 below presents the export volume in the world, Africa and East Africa land locked developing countries.

Table 3: Export Volume (2006-2011): World, Africa and East Africa landlocked developing countries (US\$) million (UNCTAD, 2013)

Exporter	2006	2007	2008	2009	2010	2011
world	12,134,707	14,015,751	16,137,233	12,518,117	15,257,877	18,211,356
Africa	373,284	438,914	561,559	394,888	508,201	590,766
Ethiopia	1,043	1,277	1,602	1,618	2,330	2,615

Uganda	1,188	2,000	2,712	2,995	3,107	2409
Burundi	58	62	54	62	100	122
Rwanda	147	177	268	193	297	417

1.6.

2.3. Transport Economics

The growth rate of the world economy has changed from 1980-2010 by 3.5% per year (Department of Transport and Regional Economics, 2015). Through this period, there was a transition from bipolar to tri-polar considering the emergence of East Asia economy. On the other hand, GDP and the trade growth rate has a varying relation, the trade could be faster or slower than the GDP. (Department of Transport and Regional Economics, 2015). The following figure shows the economic development of the world from 1980 to 2010.

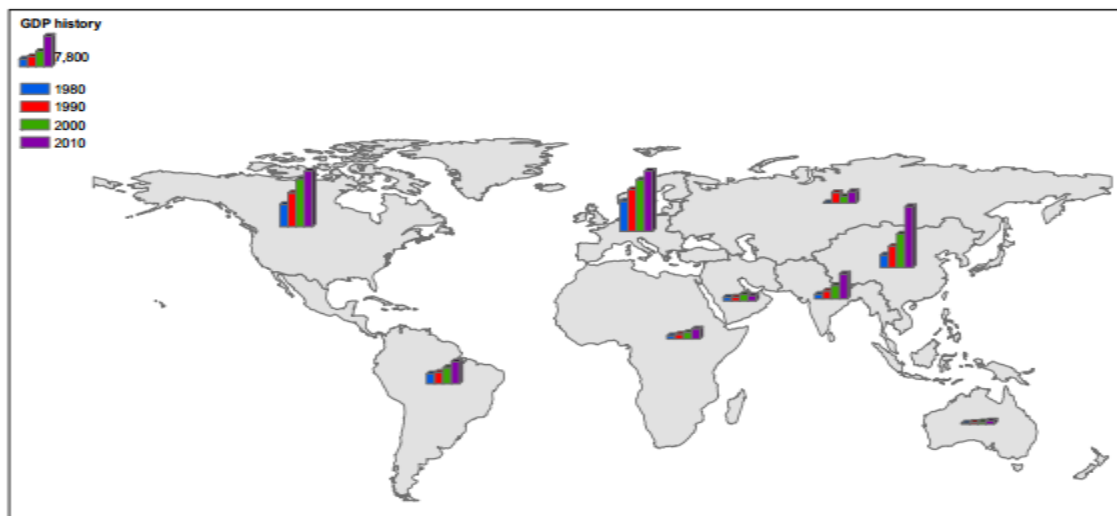


Figure 3: Economic Development from 1980-2010 by world region in GDP (source: World Bank)

2.3.1. The concept of microeconomics

Microeconomics is used to allocate resources among alternatives. Based on the principle of microeconomics, commodities are valued differently from one to another based on the three characteristics; attribute, location and date. The commodities could be tangible and intangible (Hugh & Ray, 2004).

Price and Market

Price is the term used to express the commodity rate of exchange whereas market is the place where certain types of commodities are sold while other types are bought. Market exist due to exchange transaction. There are two market types, forward market and spot market (Hugh & Ray, 2004).

The other important term is an economic agent who represent individuals who are regarded as consumers and who may initially own certain stocks of commodity and has to choose an amount of each commodity. Opportunity cost is the value of alternative forgone by the use of unit of the input (Hugh & Ray, 2004).

2.3.2. Transport Costs

Bases on the research by Paolo Ferrari, there are two properties of freight transport system with which dynamic cost function could be expressed. The first one is the instability of the transport system. The other property is its property to result in cost elasticity that vary over time with asymptotic value that tend to zero as the transport cost decrease (Paolo, 2016). The study was conducted between two territories between which exchanges of good occurs. The transport system behavior was studied for a given period of intervals in which each period possess similar dynamic cost function. Based on the findings, it was concluded that elasticity's are dynamic.

Cost of transport includes both direct cost and indirect cost or external cost (Palma, et al., 2011). Direct cost includes cost of transport operators and overhead cost. While external cost are estimated costs which consider the burden imposed by the transport on the society and the environment. The best examples for external cost factors could be air pollution, congestion, noise and traffic accident (Janic, 2007). The ranking of these external cost components runs from congestion, accident, air pollution and to noise (Palma, et al., 2011).

Different researches have been conducted on determination of pricing of freight vehicles. The study by M. Janic tried to determine the full cost of freight vehicles considering both internal and external costs. The models were developed by identifying different variables and relationships among the variables. Some assumptions were also established on the intermodal network and road network. Internal cost were considered as dependent variable on frequency of vehicle runs, quantity good, load factor, time cost and handling cost (Janic, 2007).

Another research that has been conducted in Greece on estimating the operating cost components for trucks, classified the parameter considered for estimation of cost into two (SDOUKOPOULOS, et al., 2015).

These are:

- a. Cost component comprising the total fixed components; and
- b. Cost component comprising the total variable cost components.

Considering only internal costs, cost components were classified into fixed and variable cost components. Table 4 below shows the listed components under fixed and variable costs.

Table 4: Operating Cost Components (SDOUKOPOULOS, et al., 2015)

Fixed truck operating cost components	Variable truck operating cost components	
Cost of vehicle ownership	Fuel cost	Taxes
Cost of license ownership	Cost for tires	Fines
Road tax	Maintenance cost	Cargo claims
Cargo and vehicle insurance case	Repair cost	subscription
Vehicle parking cost	Tolls	Truck wash
Cost for technical inspection of vehicles	Ferry tickets	Clothing
Cost for legal service	Driver wage	Daily costs
Cost for accounting service	Driver insurance	
Cost for insurance of road freight transport professionals	Driver bonus	

In addition to cost components, characteristics of the truck and the route under consideration were also taken into account. These considerations include origin and destination points, type of truck, age of truck, annual km traveled, length of the freight transport route and truck movement based of the urban and national road.

The tool used to determine the cost was an excel-based calculation. Based on the result, the variable costs has the larger share of the operating cost than fixed cost components (SDOUKOPOULOS, et al., 2015) .

A study which was conducted in Spain, considered the efficient allocation of charges for heavy good vehicles and railways. First, the existing charges by each mode considering short turn marginal costs were identified. Then, additional charges were approximated according to social marginal theory. The charges identified were infrastructure use charge, fuel taxes and minus operation subsidies. External costs were also considered to account for noise, accident, emission and congestion (Vassallo & Perez-Marinez, 2012). The table below represents the practice of some countries with distance base charges.

Table 5: Some Countries with distance based charges (Vassallo & Perez-Marinez, 2012)

Characteristics of the countries that have already implemented a distance-based charge to heavy goods vehicles in Europe

	Vehicles and network Charged	Price depend on	Revenue usage
Switzerland	Vehicles and network Charged	Maximum Laden Weight emission class	2/3 to railroads 1/3 to canton budget
Austria	HGV over 3.5 tonnes All the interurban	Number of axles	Motorways
Germany	HGVs over 12 tonnes Highway	Number of axles emission class	50% road network 38% railroads 12% inland waterways
Czech Republic	HGV's over 3.5 tonnes highway and some trunk roads	Number of axles emission class	Transport infrastructure

Cost Practices in Addis Ababa

Efficient management of transport system is expressed by (AACCS, 2009)

- Availability
- Utilization level

For cost purpose vehicle should be available for 95% of time and from this available time 80% of it must be spent on paid work. Generally, factors affecting utilization and availability are listed below. (AACCS, 2009).

Factors affecting utilization are

- Delay through bad road;
- Border delay;
- Weight bridge check;
- Custom delay;
- Poor scheduling for loading and unloading;
- Road accident;
- Single driver operation; and
- Congestion.

The Addis Ababa –Djibouti corridor is the main corridor for international road freight in trade Ethiopia. Most of the export and import transport in this corridor with carrying container and bulk transport have cost per ton/km which is similar with other East African countries with direct sea access (AACCS, 2009)

2.4. HDM-4 model

The first model for highway design study was produced by World Bank in 1968. Since the beginning, there were modifications in order to overcome the limitation of the each model. HDM-4 model is one of the models and is the successor of HDM-III model. The first improvement in this transition was the provision of powerful system of analysis for road management and investment alternatives while the second most known advancement was the update of technical relationships of vehicle operating cost and Pavement deterioration, accident cost, traffic congestion cost, energy consumption cost and environmental effects for both rigid and flexible pavements. The general purpose of this model is as a guide for decision in road management system (Kerali, 2000). HDM

utilizes the concept of life-cycle cost analysis considering analysis period of 15-40 years. Within this period, different prediction could be set. There are four known models under HDM-4. These are road deterioration (RD), Road Work Effects (RWE), Road Users Effects (RUE) and Socio economic and Environmental Effects. HDM-4 is derived from large scale field Experiments. (Odoki, 2016). The table below indicates the succession of HDM-4 model.

Table 6: Succession/Advancement of HDM-4 model (kerali, et al., 2000)

No.	Succession of Models	Limitation of the model
1	Highway cost model	Did not consider developing countries conditions
2	Highway Design and Maintenance Standard model (HDM)	Less user friendly
3	HDM-III	Narrower scope of considerations



HDM-4 model

HDM-4 is a multipurpose software having different models that could perform different tasks. One of these tasks is for evaluating road investment projects (Callao, 2008). Different road projects could be checked for economic viability using different economic indicators (Callao, 2008). The analysis has two project scenarios which are project case and without project case. There are three types of analysis under the HDM-4 (Callao, 2008).

These are

1. Strategic analysis;
2. Project analysis; and
3. Program analysis

Strategic analysis

This used to predict medium to long term requirements of an entire road network (Kerali, 2000) and to evaluate the entire network with the aggregate data to provide a micro view to the decision makers (Callao, 2008). The analysis enables to exhibit how any budget constraints could affect the road agency expenditure, the benefits of the society and the road user costs.

Programme analysis

This is used to prioritize the defined road projects into one-year or multi-year program based on the budget constraints. The criteria for the selection could be based on the maintenance, improvement or development standards (Kerali, 2000).

Project analysis

Used for evaluation of one or more road projects based on the economic viability using different economic indicators such as NPV, B/C ratio, IRR. (Kerali, 2000).

Alternatives of the Projects

There are two alternatives for a project appraisal.

1. Without project or Do minimum
2. Project case

Without project or Do minimum case

This represent the current condition with little construction costs but with high maintenance cost and road user costs (Odoki & Kerali, 2000).

With project case

This considers the improvement of the current road condition through new road construction, rehabilitation and maintenance of the existing road. This alternatives possess lower road user costs (Odoki & Kerali, 2000).

2.4.1. Reliability of HDM

The degree the reliability of the model is dependent on the following factors (Kerali, 2000)

- Validity of the underlying HDM relationship;
- Accuracy and adequacy of the input data; and
- Calibration factor used in the analysis.

The level precision of the predicted output could be known by comparing with the observed known values of the output. The correction factors could be drawn from the ratio of the observed and predicted values (Bennett & Paterson, 2000).

2.4.2. HDM-4 calibration

The reliability of the result of HDM-4 model is dependent on two factors (Bennett & Paterson, 2000).

- Data inputs
- Calibration of outputs

There are three levels of calibration (Bennett & Paterson, 2000)

2. Basic calibration;
3. Calibration; and
4. Adaptation.

Basic calibration

- Parameters of RUE can be found from secondary sources.
 - Governmental and industrial publication
 - Operator organization or various RUE reports.
- For road deterioration
 - Climate statistics
 - Road traffic
 - Conditions statistics
 - Geometrical standard
 - Maintenance program and budget

Calibration

This needs the measurement of the local condition with very intensive data requirement. In RUC, the focus is on speed, consumption of tyres, parts and fuel, and fixed costs related to utilization and service life (Bennett & Paterson, 2000).

Adaptation

This comprises two components namely, improved data collection and fundamental research. These require to collect data to even for longer time. Fundamental research is a research on the relationships of HDM-4 to bring alternative relationships (Bennett & Paterson, 2000).

2.4.3. Input data of HDM-4

The general input data includes the parameters that describe the road network and pavement characteristics, road users' data, traffic data and economic data. The degree of the accuracy of the data is dependent on the level of accuracy of the analysis (Odoki, 2016). Base on this, HDM-4 provides four information quality levels depending on the quality of the analysis. These information quality levels are IQL-1, IQL-2, IQL-3 and IQL-4. Among these, the most commonly used information quality level is the IQL-2 which corresponds to fair data sets. Figure 4 illustrates the hierarchy of the data requirement (Bennett & Paterson, 2000).

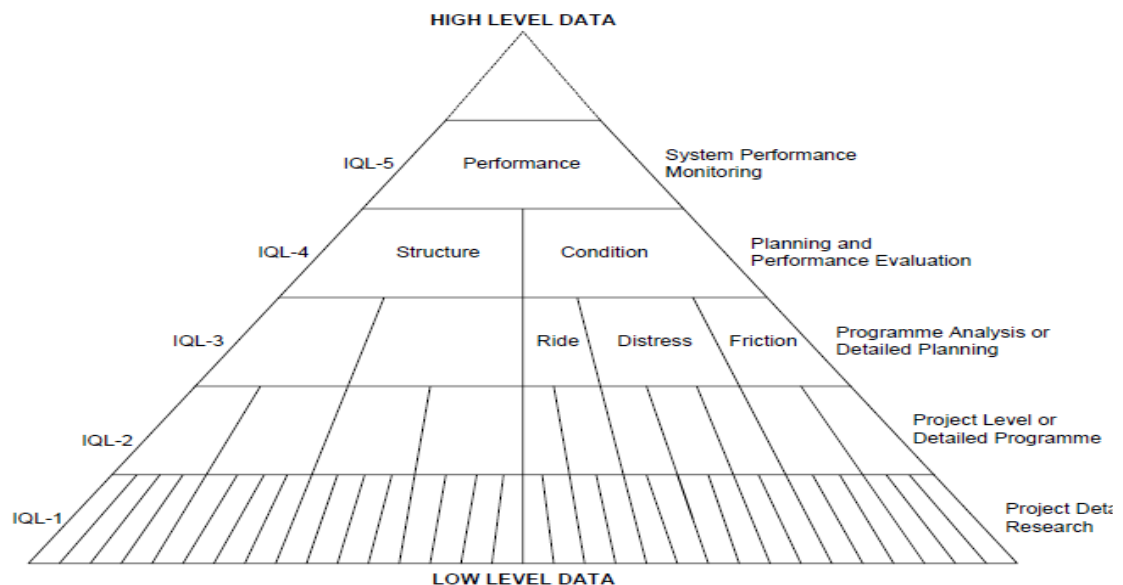


Figure 4: Information Quality Level (Bennett & Paterson, 2000)

2.4.4. Road user costs

HDM-4 considers different parameters to determine road user costs. These parameters are road way and vehicle characteristics, vehicle speed and unit costs. Figure 5 below tabulates the road user costs inputs.

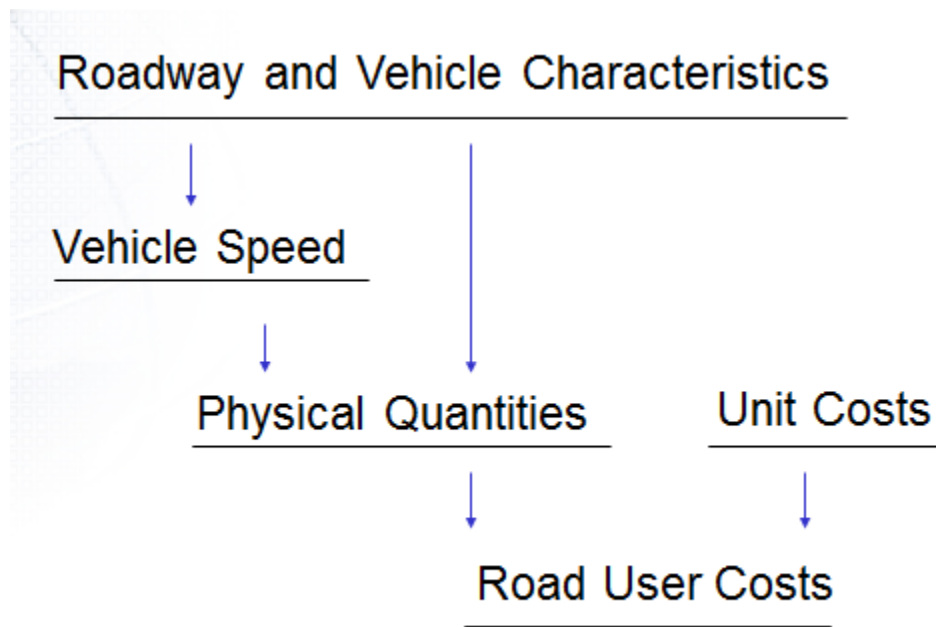


Figure 5: Factors of road user costs

Road user costs model is used to determine the road user costs of the road using different relation for the speed, travel times, vehicle operating cost and emission (Transport Sector Board, 2010). One of the components of Road user costs, the vehicle operating cost, is determined by multiplying the vehicle resources by the unit cost. The road user costs is determined on per annum basis for each vehicle types and for each traffic flow period (Odoki, 2016).

Road infrastructure comprises three types of costs, namely construction cost, maintenance cost and road user costs. Among these, road user costs takes the majority of the proportion (Federal Republic of Germany, 2009).

The general definition of road user costs is the cost incurred by the traveling public and the vehicle operators. The components of the road user costs include the vehicle operating cost, travel time cost, accident costs and cost of discomfort. For developing countries, there is a lack of acceptance method to determine the accident cost and the cost of discomfort, and these values are not included in the existing road appraisal methods (Odoki & Kerali, 2000). The annual road user costs for each vehicle type is the result of the multiplication of the cost per vehicle type of the vehicle by the total traffic volume of the corresponding vehicle (Odoki & Kerali, 2000). Road user costs are computed by multiplying the unit costs with predicted physical quantities of resource consumption (Kerali, 2000).

Travel time cost

These values are the factor of average vehicle speed, travel distance and unit cost per hour of road user's time (Odoki & Kerali, 2000).

2.5. Sensitivity Analysis of HDM-4

Used to check the impact of varying a parameter on the outcome. In HDM-4, sensitivity analysis is quantified by impact elasticity. Impact elasticity refers to the ratio between the percentages changes of the outcome and the input parameter. The impact is divided into high, moderate, low and negligible. The ranges goes from the more sensitive to the less sensitive one. Table 7 below represents the sensitivity analysis criteria of HDM-4.

Table 7: HDM-4 Sensitivity Analysis (Kerali, 2000)

Impact	Sensitivity Class	Impact elasticity
High	S- I	>0.5
Moderate	S- II	0.2-0.5
Low	S- III	0.050-0.20
Negligible	S- IV	<0.05

CHAPTER THREE

METHODOLOGY

3.1. Study area

The study area was the current active international road corridor of Ethiopia, Addis Ababa- Djibouti Corridor. The road user costs analysis on this corridor starts from the Addis Ababa and ends at Galafi with a total of 725 km was covered. Major cities traversed by the road are Addis Ababa, Bishoftu, Adama, Awash, Mille, Semera, Serdo and Galafi. There is an altitude drop from 2,300m above sea level of Addis Ababa to 918m above sea level of Galafi while the temperature elevates from 20°C to 31°C from the start to the end location of the study area.

3.2. Study Design

The design of the study was more of focused on applied research type in which the pertinent aspect in the current tariff determination procedures were assessed. In addition, an inferable solution was forwarded at the end which could be used as the display of the shortcomings of the existing practice. Descriptive type of study was conducted for the illustration of the existing tariff setting practice on the corridor.

3.3. Methodology

In order to achieve the required objective and to provide solution for the listed problem, a proper methodology is very vital. This research has implemented different methodologies. HDM-4 was the main analyzing tool. Before going to the detail of the data collection, pilot study was conducted to have a general overview of the way functioning of the firm, focusing on the corridor. The main overview was on transport owners, vehicle characteristics, existence of any monopoly and on data quality and availability (especially with transport operators) of the system.

The following tasks were included:

- Gathering data on existing tariff setting practice.
- Analyzing data on existing tariff setting practice.
- Gathering data on vehicle operating cost components and road network.
- Organizing the data as HDM-4 model input format.

- Analyzing the data using HDM-4 model.
- Estimation of the road users cost for the freight vehicles on the corridor

3.3.1. Data collection and analysis

Data Collection.

For the current work, both primary and secondary data has been collected. In the following section the data collection methods have been clearly annotated.

Primary Data

The main primary data collection methods were interview and questionnaire. The interview and the questionnaire were conducted with the transport companies. Out of ten freight transport companies, where the list was taken from transport authority, five were contacted. The selection of these companies was by the degree of organization and on willingness of data provision. This data collection was targeted on understanding of the tariff setting methods and criteria, the related problems and the profit margin.

Secondary Data

Most of the data was acquired through secondary data collection method. The source and the data types are elaborated on Table 8 below.

Table 8: Secondary data and sources

No.	Data type	Source
1.	Traffic Data	ERA
2.	Road Condition Survey Data	ERA
3	Engineering reports of the road Sec-	ERA
4	Freight Vehicles Owners data	Transport Authority
5	Vehicles basic characteristic	Transport Companies
6	Financial Cost units	WT Consult and ERA
7	Climate Data	Metrology Agency

Road network data

This data include the altitude, geometry and characteristics of the road segment. Road network can be defined as the system of links, sections and nodes (Kerali, 2000). The information quality level (IQL) for this study was assumed to be IQL-2 in which more detailed information were required. Since HDM-4 considers the developing countries scenarios, majority of the default values were appropriate. Therefore, the data collection was focused on gathering data that were helpful on determining the default values. The condition survey data conducted by the Ethiopian Roads Authority in 2016 was the main input to determine the road condition descriptors such as the number of pot-holes, total area of cracking, raveled area, roughness index, texture depth, edge break and mean rut depth.

ERA road Condition surveying method

A road condition survey was reported by the Ethiopian Roads Authority in 2016. The materials and devices used were GPS, Hawkeye 1000 profiler, Benkelman Beam, Camera, Straight edge, Condition manuals, Laptops and computers and condition manuals. The experts were senior highway engineers and Condition Surveyors.

Hawkeye 1000 Profiler was used to measure the roughness while the deflection was measured by Benkelman Beam. The other distresses such as the surface cracking, rutting, pothole, raveling, edge break and texture were measured using ERA PMS Condition survey manual.

Vehicle Fleet Data

Vehicle fleet data was used to represent the traffic mix on the road network. There are sets of representative vehicles for which certain basic characteristics were defined (Kerali, 2000). The basic characteristic defined for representative vehicles should reflect the characteristics of the true vehicles on the road network. Based on HDM-4 model guide, vehicles can be defined in terms of categories, class and types (Kerali, 2000).

Categories

There are two categories of vehicles, motorized and non-motorized vehicles. For the purpose of this study, only motorized vehicles were considered.

Class

The class includes vehicles with similar physical, utilization and performance characteristics. Under the category of motorized vehicles, there are motorcycles, cars and utilities and trucks and buses while the non-motorized vehicles comprise animal cart, bicycle, pedestrian and rickshaw.

Types

There are 16 default types of representative vehicles. The representative vehicles for the study were selected based on ERA traffic count classification. The types of vehicles were included in the class and. It was tried to relate the default values of the vehicle classification used in HDM-4 model with ERA traffic count vehicle classification. All vehicle types and their characteristics were inserted on the HDM-4 model. However, the road user costs estimation was focused on the freight vehicles on the corridor. From the pilot study conducted, it was known that the dominant type of vehicles are with a capacity of 20 – 40 tonnes, which corresponds to vehicles under the classification of truck and trailers. The road user costs estimation, therefore was for truck and trailers. Table 9 below illustrates the vehicle classification of Ethiopian Roads Authority.

Table 9: Vehicles Classification of the Ethiopian Roads Authority (Source: ERA, 2016)

Classification	Description
Passenger Vehicles	
Car	Cars and Taxis
Land Rovers	Land Rovers, Jeeps, Station Wagons, Land Cruiser etc.
Small/Buses	Small Buses up to 27 Passenger seats
Large Buses	Large Buses over 27 Passenger Seats
Freight vehicles	
Small Truck	Small Trucks of 3.5 tons load
Medium Truck	Medium Sized trucks of 3.6 to 7.5 tons load
Heavy Truck	Trucks and Tankers of 7.6 to 12 ton load
Truck – Trailer	Truck Trailers and Tankers Trailer above 12 tons load

The vehicle fleet data for each vehicle types includes the basic characteristics of the vehicles and different cost units. The basic characteristics of the vehicles include the physical characteristics of the vehicles, the utilization and the tyre types used. The cost unit are classified as financial cost and economic cost. Table 10 illustrates vehicle fleet data requirements.

Table 10: Vehicle Fleet Data (kerali, McMullen, & Odoki, 2000)

Utilization		Physical Characteristics	Tyres
Annual Km (km)		Passenger Car Space Equivalent	Tyre Type
Working Hours (hrs.)		No. of Wheels	Base no. of recaps
Average Life (years)		No. of axels	Retread Cost (%)
Private Use (%)		Loading	
Passengers (persons)		ESAL	
Working Related Passenger Trip (%)		Operating Cost	
Economic and Financial Unit Cost components			
Vehicle Resources		Time Value	
Cost of new vehicle	Crew Wages (per hour)	Passenger Working Time (per hour)	
Replacement of tyre	Annual Overhead	Passenger Non-working Time (per	
Fuel (per litre)	Annual Interest (%)	Cargo (per time)	
Lubricating oil (per litre)	Maintenance Labour cost (per hour)		

Since the study focused on freight vehicles, the collection of the vehicle fleet data concerned only on the target vehicles. The vehicle fleet data for the other vehicles were taken from the default values and other study such as (Gebru, 2016). The rationale behind this was the vehicle characteristics data of one vehicle does not affect the operating cost of the other vehicle.

Collection of vehicle fleet data for freight vehicles

The basic characteristics data of the freight vehicles were taken from cross boarder freight vehicles owning transport companies. Out of 10 freight transport companies, where the list was taken from transport authority, five were contacted. The collection of the data was specific to different model type of the vehicles.

Table 11: Truck Trailer fleet characteristics

Characteristics		Economic Unit cost		Financial unit cost	
New Vehicle		3655000		4300000	
Replacement of tyre		13345		15700	
Fuel		12.92		15.2	
Lubricating Oil		62.23		73.21	
Maintenance Labor (per hour)		43.19		50.82	
Crew wages(per hour)		75.37		88.67	
Annual Overhead(birr)		19348.7		22763.23	
Annual Interest		12%		12%	
Loading					
Operating Weight(tonnes)	Empty		18		
	With cargo(fully loaded)		58		
ESALF	11.45				
Utilization				Time Value	
Annual km(km)	95000	Private use	0%	Passenger Working time	16
Working hours(hrs.)	1152	Passengers	2	Passenger non-working time	1
Average life(years)	10	Work related trips	100%	Cargo(per hour)	1.467

Data Analysis

The main analysis tools used were HDM-4 model and Microsoft excel. HDM-4 was used for estimation of annual road user costs while the Microsoft excel was used for the descriptive analysis on existing tariff setting methods.

HDM-4 Analysis

There are four types of models in HDM-4 model. These are:

1. Road Deterioration Model;
2. Road Works Effect;
3. Road User Effects; and
4. Social and Environmental Effects.

Among these four models, the one that was implemented in this analysis was Road User Effects.

Road User Effects

The analysis under road user effects are:

- Motorized Transport (MT) speed, operating cost and travel time;
- Non-motorized Transport (NMT) speed and operating and travel time costs; and
- Road Safety.

Road user costs consists of:

- Motorized transport vehicle operating and travel time cost; and
- Non-motorized transport (NMT) operating and time cost.

MT vehicles were the focus of this study, and thus road user costs were taken as the sum of vehicle operating costs and travel time cost of MT vehicles. Accident costs were not considered, as the costs of accident are not recorded in acceptable way in developing countries like Ethiopia.

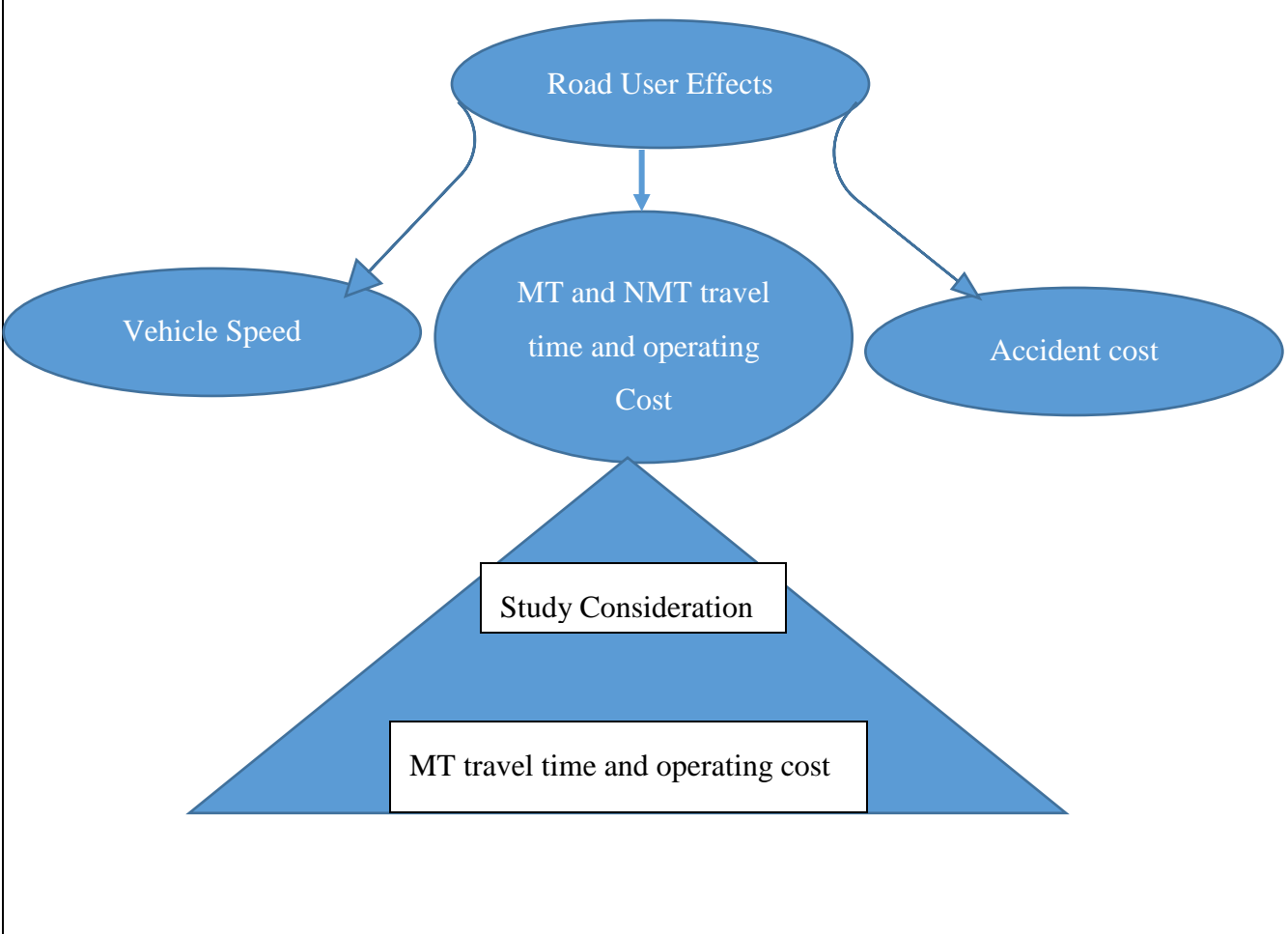


Figure 6: HDM-4: Analysis and Study Consideration

For the purpose of the HDM-4 analysis, the corridor has been divided into seven sections. The classification was based on ERA traffic counting road section division. The traffic data has been adjusted for seasonal variation considering only the start of the analysis year traffic data. Table 11 below illustrates the seven sections.

Table 12: Road Network Sections

Section Name	Section ID	Distance(km)
Section-1:	Akaki – Bishoftu	56.0
Section-2 :	Bishoftu –Adama	51.0
Section-3 :	Adama – Awash	125.0
Section 4:	Awash- Mille	308.0
Section 5 :	Mille – Semera	73.0
Section 6:	Semera – Serdo	37.1
Section 7	Serdo – Galafi	74.1

Traffic analysis

Seasonal adjustment factor

ERA traffic count is conducted for three cycles per the counting years. Therefore, it needs to adjust the traffic count for different seasonal variation of the year. This was conducted through the computation of the seasonal adjustment factor which is the average value of the seasonal coefficient factors of the different traffic count cycles. The seasonal coefficient factor was computed as the ratio of AADT of a given year to Average Daily Traffic (ADT) of each cycle in that year. These seasonal coefficient factors were averaged to compute the seasonal adjustment factor for the specific year. The adjusted AADT for seasonal variation will be then the product of AADT of a given year and the averaged seasonal adjustment factor of that year.

In this study, the 2016 traffic count data was used as the analysis start year traffic data. The adjustment of seasonal variation thus considered the year's three cycles and the overall AADT for the section considered.

Composition of Vehicles

The composition of traffic of the different vehicle types for the different road section in each year were computed as the percentage of the total adjusted AADT of that specific year. The composition of vehicles were computed for the start of the analysis year.

Choice of commodities

Import cargo types were the concern for the study. It was needed therefore to select items that were most prominent. There were four cargo types targeted in this study. The choice is based on frequency of import and on requirement of special cost. Special costs in the transport could be cost of precaution for dangerous goods, costs related to car washing after transport for goods having soiling nature and other related costs. These four cargoes were:

- Wheat;
- Fertilizer;
- Reinforcement bar;
- Container.

These cargoes are almost always fully loaded on the vehicles for the import trip (from Djibouti to Addis Ababa). Wheat and fertilizer are loaded as package while containers are used for variety of commodities. There is a rare practice of loading wheat and fertilizer in containers.

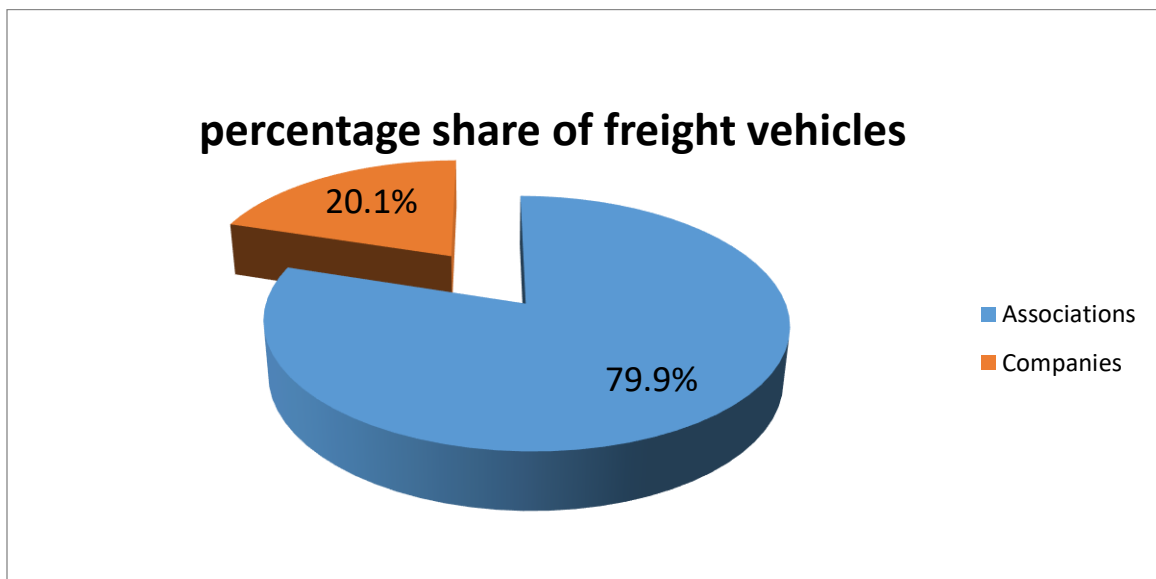
CHAPTER FOUR

RESULTS

4.1. Common freight vehicle types

Generally freight vehicles on the corridor have a capacity between 20-40 tonnes. The owners of these freight vehicles are either associations or transport companies. The associations are organized from independent vehicles owners having a memorandum of conduct. These associations facilitate and act as intermediary between importers or the government and the vehicles owners. For this bridge activity, the associations share 2-3% commission. However, the transporters (the vehicle owners) can provide the service by themselves with a duty of the same or a lesser commission for the association. On the other hand, transport companies are companies that own freight vehicles in which the management, operational and marketing activities are controlled by the company itself. The composition of dry cargo freight vehicles on the corridor for the associations and transport companies is shown in Figure 7 below.

Figure 7: Percentage share of freight vehicles (source: Transport Authority)



As figure 7 elaborates, the majority (about 80%) of the freight vehicles on the corridor are facilitated through associations while only 20 % of the freight vehicles correspond to transport companies.

From the pilot study conducted on transport operators on both associations and transport companies, the structure of the association has been found to be less organized than the transport companies. For the sake of accuracy, the estimation of road user costs considered only the transport companies' data.

The dry cargo freight vehicles are arranged into three levels. The classification criteria is based on the age and capacity of the vehicles. All of the transport companies are under level 1-A while the associations corresponds to all of the three levels

Table 13: Capacity and Age of freight vehicles on the corridor (source: Transport Authority)

Vehicle class		Capacity(tonnes)	Age(years)
Level 1	A	30– 40	0-10
	B	20-29.9	
Level 2	A	30 – 40	10-20
	B	20-29.9	
Level 3	A	30-40	>20
	B	20-29.9	

Figure 8 illustrates the proportion of freight vehicle for different levels of organization.

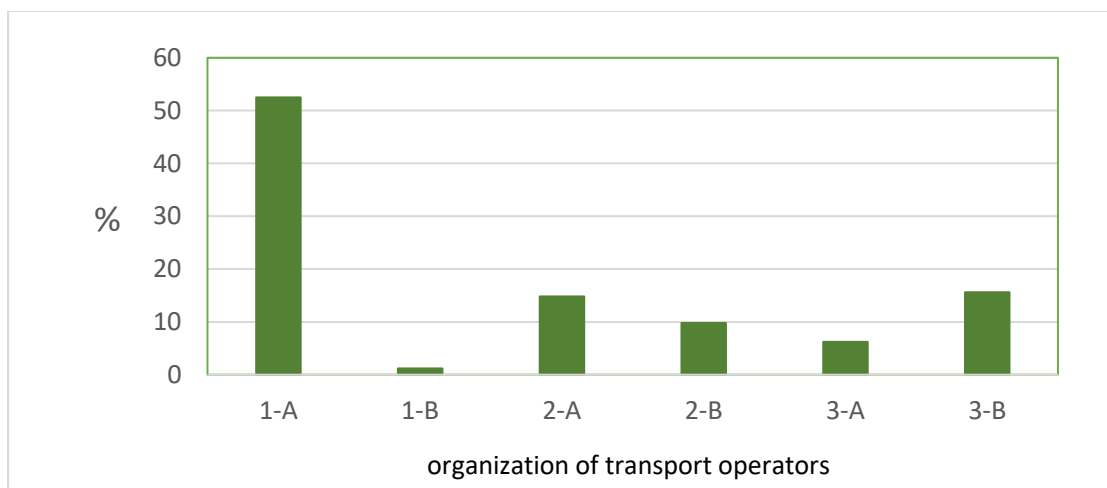


Figure 8: Organization of Freight vehicles (Source: Transport Authority)

4.2. Tariff setting practice

Through the interviews and questionnaires conducted with transport operators, the existing tariff setting practice has found to be practiced into two ways. The first one is through negotiation. In this case, importers or the government determine the tariff and request for the service. The provision of the service lies on the acquiescence of the transport operators. The second practice is through a tender prepared by the transport operators as per requisite of the service.

4.2.1. Preparation of tender for tariff

Based on the interview conducted, the tender for the tariff is prepared based on the techniques shown in the Figure 9 below.

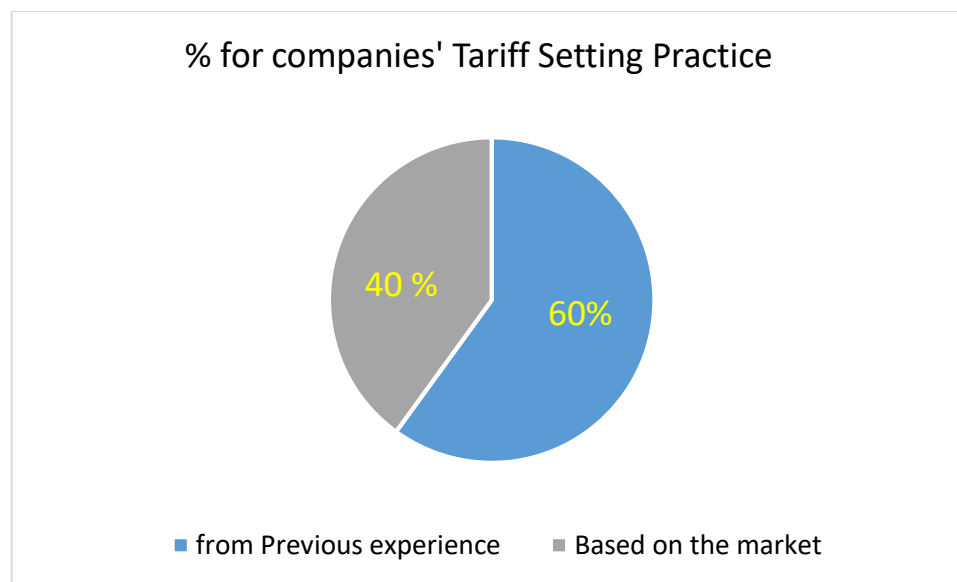


Figure 9: Tariff Setting Practice (source: transport companies, 2017)

From the list of companies for which the interview was conducted, 60% of them set tariff for tender based on the previous experience. These companies determine the tariff through a break-even analysis though all of the input parameters for the analysis are estimated from the previously determined cost. The determined cost is then exposed to the market condition. The other 40% of companies estimate the tariff based on the market price without any prior break-even analysis. Through the questionnaire, it was also tried to assess if there is any scientific practice to determine the tariff, but no company found to have such practice.

4.2.2. Cost parameters for tariff determination.

The cost parameters used for the determination of tariff are classified as variable and fixed cost parameters. From the commonly used cost parameters, Figure 10 and Figure 11 show the parameters that are used by the companies under none, rare and usual basis. Note that this figure corresponds for the transport companies performing break even analysis.

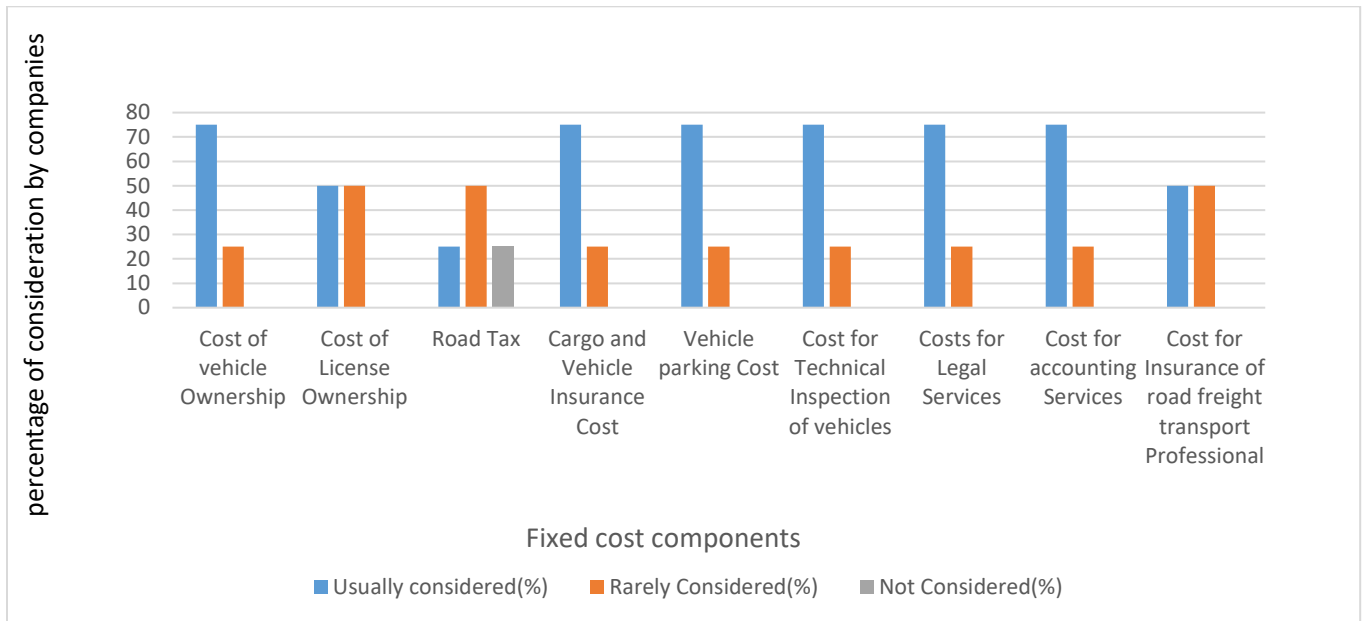


Figure 10: Percentage of companies considering fixed cost parameters

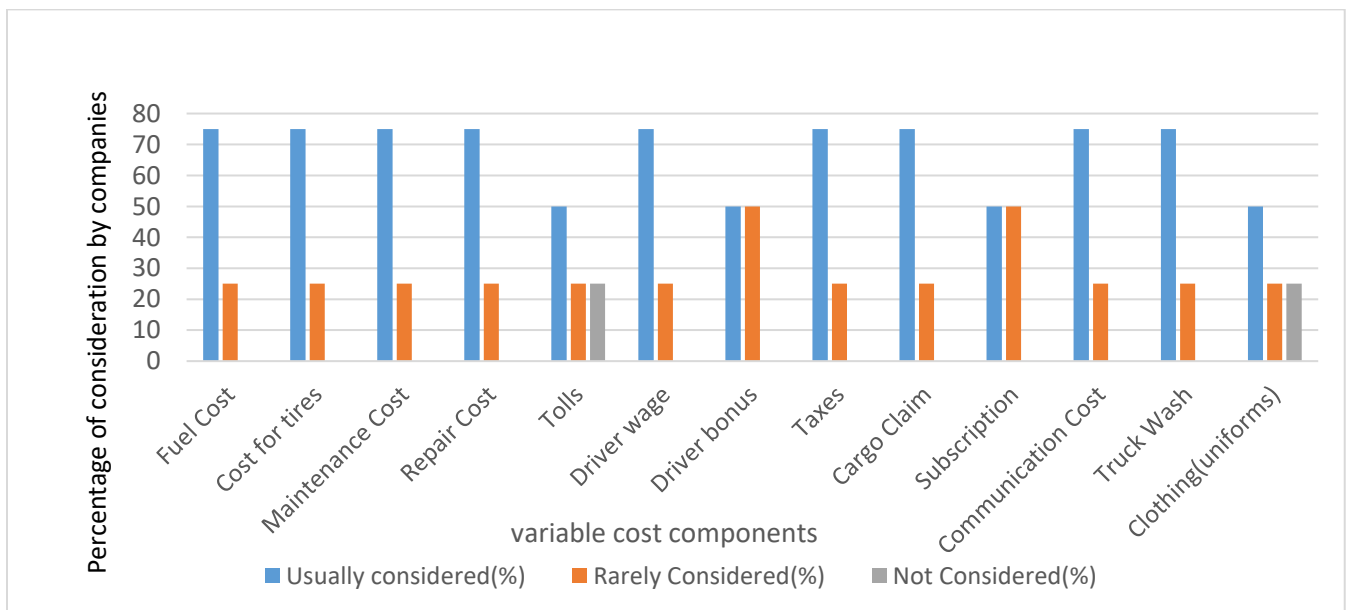


Figure 11: Percentage companies considering variable cost component

4.2.3. Profit Margin

Based on the questionnaire, the profit margin for the five different companies is shown in table 14 below.

Table 14: Range of Profit Margin of the existing practice

Company	Profit Margin (%)
C1	10-15
C2	30-35
C3	15-20
C4	Not constant/market based
C5	>35

Table 14 indicates the five companies that implement different profit margins ranges. The reason for this high/ small profit margin could be the type of the company. As observed, some of the companies run other related businesses and do not rely only on the transport operation while other companies rely only on this business. Those companies with additional business possess smaller profit margin.

4.2.4. Existing freight tariff on the corridor

Based on the questionnaire with the transport companies, the existing tariff for the four cargo types from 2014-2016 is shown in the Figure 12 below.

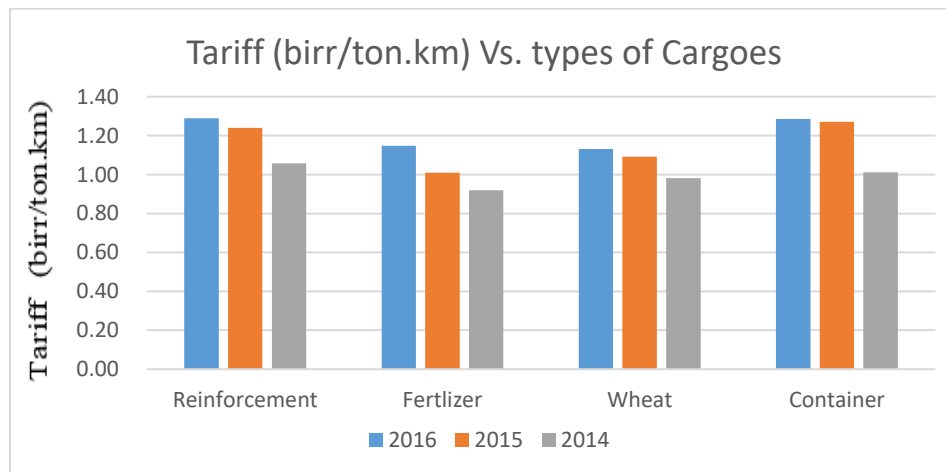


Figure 12: existing tariff for the selected cargo types

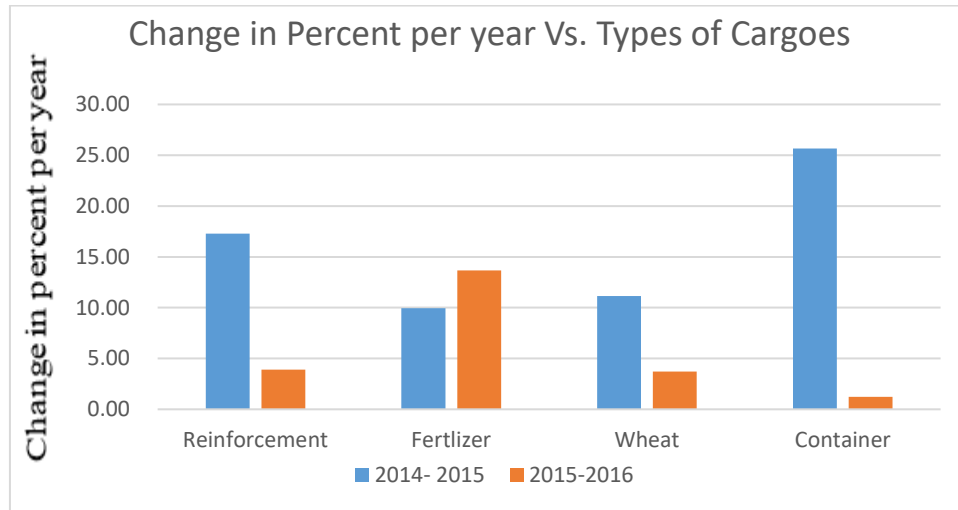


Figure 13: Change in Percent for Three Successive Years

Figure 12 above shows the existing tariff for three different years considering four items. As it would be understood, the tariff has an incremental nature from year to year. Figure 13 on the other hand, clarifies that the change in price from 2014- 2015 is greater for container followed by a very small change in the next year (2015-2016). The fertilizer on the other hand, shows a greater increment for the first change (2014-2015) than the next (2015-2016). This pattern could be because of the absence of scientific tariff determination practice.

4.3. Estimation of road user costs using HDM-4

The road user costs in HDM-4 is the sum of travel time cost, vehicle operating cost and accident cost. For the purpose of this study, the road user costs was considered to be the sum of travel time cost and vehicle operating costs.

4.3.1. Traffic analysis

Seasonal Adjustment Factor

The seasonal adjustment factor is the adjustment for the seasonal variation throughout a year. This was computed for the start of the analysis year, 2016. It was computed based on the ERA traffic counting method which implements three counting cycles per the year of counting. These factors

are the average values of the ratios between the AADT of the year and the ADT of each cycle of that year, for this case 2016. Table 15 displays the seasonal adjustment factors.

Table 15: Seasonal Adjustment Factors

Section	Car	Land	Small	Large	Small	Medium	Large	Truck and
Addis Ababa-Bishoftu	1	1	1	1	1	1	1	1
Bishoftu-Adama	1	1	1	1	1	1	1	1
Adama-Awash	0.8	0.82	0.83	0.83	0.84	0.8	0.79	1.06
Awash-Mille	0.9	0.91	0.91	0.91	0.92	0.9	0.9	1.03
Mille-Semera	1	1	1	1	1	1	1	1
Semera-Serdo	1	1	1	1	1	1	1	1
Serdo-Galafi	1	1	1	1	1	1	1	1

Composition of traffic on the corridor

The composition of AADT for the sections considered is as shown on the Table 16 below. Since the analysis start year was 2016, this composition represents the 2016 traffic volume. From the proportion, it is easy to understand that Bishoftu-Adama has the highest proportion while the lower traffic volume sections are the sections between Awash and Galafi.

Table 16: Proportion of AADT among the seven sections

Section	AADT	Composition (%)
Addis Ababa-Bishoftu	11126	27.60
Bishoftu-Adama	17160	42.57
Adama-Awash	5594	13.88
Awash-Mille	1972	4.89
Mille-Semera	1501	3.72
Semera-Serdo	1489	3.67
Serdo-Galafi	1474	3.66

4.3.2. Annual km traveled by vehicles

The annual km refers to the total kilometers of travel per annum. The data was collected from the transport companies through a questionnaire. The study considered one-way trip for the case road user costs estimation. Half of the average annual km traveled was considered to account the half trip for both cases. The data collection were model-specific (refer ANNEX 2). Bases on the data, the pertinent model types on the corridor are Trucker, Ero-truck, Volvo and Sino-truck. The annual km is computed based on the number of trips of a vehicle per month. In some companies, vehicles perform 4 round trips per month with 12 working months. Other companies' vehicles perform 5 round trips per month with 10 or 12 effective working months. Table 17 below presents the annual km traveled.

Table 17: Annual Km traveled by Vehicles (Source: Transport Companies, 2017)

<i>Company</i>	<i>Annual Km traveled by single truck(Km)</i>
<i>C1</i>	<i>92,500</i>
<i>C2</i>	<i>111000</i>
<i>C3</i>	<i>88800</i>
<i>C4</i>	<i>88800</i>

4.3.3. Road user costs

Determination of road user costs took into account all road network and vehicle fleet data. This considered two scenarios. The first one is fully loaded vehicles traveling from Djibouti- Addis Ababa. This is the most common case, especially for the focused cargo types. The second scenario was for empty trucks running from Addis Ababa to Djibouti. This was assumed to represent the case for the vehicles running empty because of the trade imbalance. The road user costs were determined on the annual basis which imply the total cost incurred by the road users on the presence of the existing traffic volume. This considered the road condition as well as the vehicle resource costs. Table 18 and 19 below present the road user costs for the fully loaded trucks and empty trucks respectively.

Case -1: Considering an full load of 40 tonnes (trip from Djibouti to Addis Ababa)

Table 18: Annual Road Users cost considering 40 tonnes of carriage load

<i>Section</i>	Annual average road users cost (Truck and Trailer), ETB/veh.km				
	2016	2017	2018	2019	2020
Addis Ababa-Bishoftu	44.26	53.06	61.97	65.16	66.01
Bishoftu-Adama	50.86	58.89	65.14	67.01	67.01
Adama-Awash	29.35	30.82	33.09	36.36	40.51
Awash-Mille	29.12	30.25	31.35	32.76	35.12
Mille-Semera	29.06	30.41	31.71	33.55	36.71
Semera-Serdo	28.78	29.06	30.02	31.08	32.35
Serdo-Galafi	30.04	31.37	32.83	35.46	39.75
Addis Ababa-Galafi	241.47	263.86	286.11	301.38	317.46

As table 17 indicates, the annual average cost has an incremental nature form year to year of 7.18%.

Case-2: Considering empty load (for the trip from Addis-Ababa to Djibouti)

Table 19: Annual average road users cost considering empty vehicles

<i>Section</i>	Annual average road users cost (Truck and Trailer), ETB/veh.km				
	2016	2017	2018	2019	2020
Addis Ababa-Bishoftu	40.66	49.87	58.91	62.06	62.73
Bishoftu-Adama	44.21	53.81	61.31	63.56	63.56
Adama-Awash	29.43	31.03	33.12	35.87	39.48
Awash-Mille	29.37	30.78	32.08	33.51	35.71
Mille-Semera	29.30	30.99	32.50	34.29	37.19
Semera-Serdo	29.01	29.34	30.52	31.80	33.14
Serdo-Galafi	30.48	32.09	33.62	36.05	39.98
Addis Ababa-Galafi	232.46	257.91	282.06	297.14	311.79

Figure 14 below shows the variation of cost with the two varying loading weights. The graph for operating load of 40 tonnes represent the trip from Djibouti- Addis Ababa. In this case, the freight vehicles are assumed to be fully loaded, which is the case for most of import trips especially for targeted cargo types. The other graph is for the trip from Addis Ababa- Djibouti corridor by which vehicles were taken to be empty (representing the case of majority of empty running vehicle).



Figure 14: Comparison of road users cost for empty load vs. full load

4.4. Comparison with the existing tariff

The comparison is based on the annual average tariff given for each items, the annual trips made and road user costs estimated using HDM-4. The annual trips made for the vehicles are 4 or 5 trips per month with effective working months ranging from 10 to 12 months. The average values of the return trips is then founded to be 53 trips per year. Based on this value, the annual cost is given in the table below.

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Cargo	Tariff (2016) birr/ton-km	Annual Trips(No.)	Annual tariff(birr/km)
Wheat	1.13	53	2395.6
Fertilizer	1.15	53	2438
Reinforcement bar	1.29	53	2734.8
Container	1.29	53	2734.8

Considering the only fully loaded case, it is visible that the annual user cost is very small compared to the annual tariff which was considered to account the annual trips and the tariff. This comparison is only for 2016. The average value of the annual tariff is 2575.8 birr/km while the value determined by HDM-4 for the same year is 247.47 birr/km. Although the road user costs determined by HDM-4 did not considered the profit margin, two values have a significant difference.

CHAPTER FIVE

DISCUSSION

5.1. Organization of freight transport operators

The organization of cross boarder dry freight transport operators is in two ways. The first one are associations and the second are the transport companies. The arrangement of the transport companies is more organized than the associations. The organization of the association is less formal. It may be considered as the means of reaching on individual transport operators. It is also visible that this arrangement will be difficult for control and enforcement of laws. As the majority of the freight vehicles are under the association, this may call for attention for revision of the arrangement.

5.2. Freight Vehicles on the corridor

The freight vehicles that pass through the corridor have the capacity between 20-40 tonnes. Observing the distribution of the vehicles into three levels and the other two sub divisions, the majority of the vehicles are included under 1-A. This group stands for the vehicles with a capacity of between 30-40 tonnes having service year range of between 0-10 years. This indicates as the majority of the vehicles are under recommended service year. In contrast, considering the same level (Level 1), the vehicles with capacity between 20-29.9 tonnes are very small, which accounts only for 1.2% of the total number of vehicles. There are also vehicles aged under Level 3. This level of ranges account for 21.8% of the total vehicle fleet. This will need a drift emphasis as their presence may have environmental effect related to emission problems. The question related to the maximum practical service time is not even clear in the context of the vehicles age description above 20.

5.3. Tariff setting practice

The tariff setting practice experienced currently is not scientifically based. It is dependent more on profitability and the market. The government also uses this practice in order to set its own tariff and impose on the transport operators. This type of tariff setting is considered as tariff setting through negotiation. In case where the transport operators participate in a tender for any required service, the tender will be prepared as per the requisite of service. The preparation of the tender is far away from scientific procedure. Transport cost account about two-third of the total logistics

cost. This will make a note as transport cost determination seeks a through consideration. For landlocked countries like Ethiopia, the practice will exacerbate the natural condition, being land locked. As studies on land locked countries recount, being land locked was a reason for most of least developed countries. Other countries use advanced practice such as modelling the cost of freight vehicles. Some other studies consider both external and internal cost components. The study by Janic (2007) developed a model for freight transport system by internalizing the external cost. There were different factors considered through modeling of the full cost such as network use, intensity of operation, technology in use and the internal and external cost components. Another research also argue that even though freight cost are posed by operators and passed on the customers, the environment and congestion effects are on the whole community. This is also the concern of environmentalist as heavy trucks have environmental consequences (Piecyk & McKinnon, 2007). The studies showed that it is very crucial to study cost components of a freight transport. The size of freight vehicles which is comparatively larger, compared to other vehicles, and its impact also will be proportional. Unscientific prediction of each cost component is visible to be devastating for the economic and environmental values of the country.

On the other hand, some companies showed a practice of break-even analysis. These companies considered some of transport cost components which were considered on another researches. As Figure 10 displays, among fixed cost parameters only road tax is not considered by 25% of the companies while 50 % of the companies consider this under rarely basis. Most of the parameters under fixed cost components are considered by 75% of the companies. On the other hand, for variable cost components, there are three cost components that are not considered by 25 % of the companies; while other parameters have a better consideration. The backside of this procedure is that prediction of each cost component is through previous experience. This practice could be a better one but still is not scientific when we come to parameter determination procedures.

5.4. Profit Margin

The profit margin has different variations among the focus transport companies. The companies having other income means use smaller profit margins while the other companies who are solely dependent on the transport operation possess larger profit margin.

5.5. Road user costs of HDM-4 model

The road user costs determination was done into ways. The first one was considering the trip from the Djibouti to Addis Ababa with a truck carriage capacity of 40 tonnes. The other consideration was for the trip from Addis Ababa to Djibouti considering the empty trucks. The result is on annual bases which implies the annual road users cost that a vehicle expend per km of the travel. For instance, on the section between Addis Ababa and Bishoftu, the annual road user costs is 44.26 birr/km, for a vehicle travelling from Djibouti to Addis Ababa with carriage capacity of 40 tonnes. This implies that the total annual road user costs per km of a vehicle traveling on the section between Addis Ababa and Bishoftu is 44.26, which computed as the average value of the total volume of traffic road user costs. The road user costs are the result of the multiplication on the unit costs and the vehicle resources whereas the annual road user costs are the multiplication of road user costs per vehicle type by the total annual traffic volume of the corresponding vehicle. Therefore, the average annual road user costs are computed as the average value of road user costs of the total traffic volume for a given vehicle type. The road user costs have an incremental nature from year to year, which would be the reason of the increasing of vehicle resource costs from year to year. Section-wise, in a given year the cost pattern is correlated to AADT.

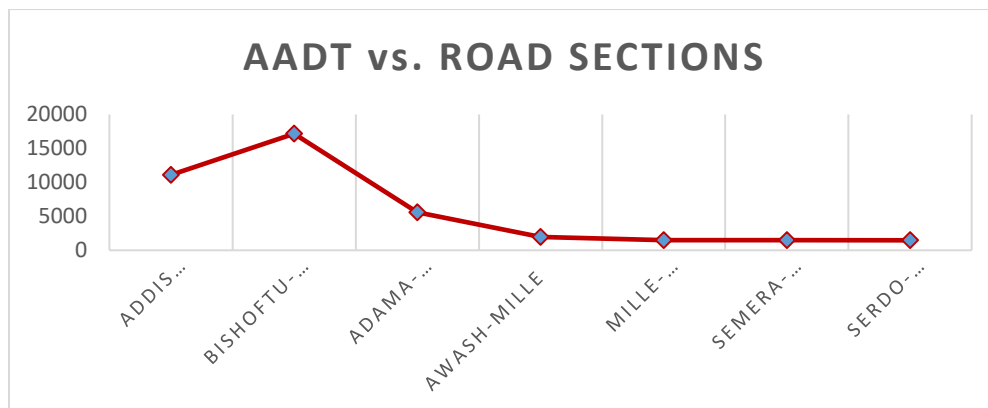


Figure 15: AADT vs. Road Section (source: ERA, 2016)

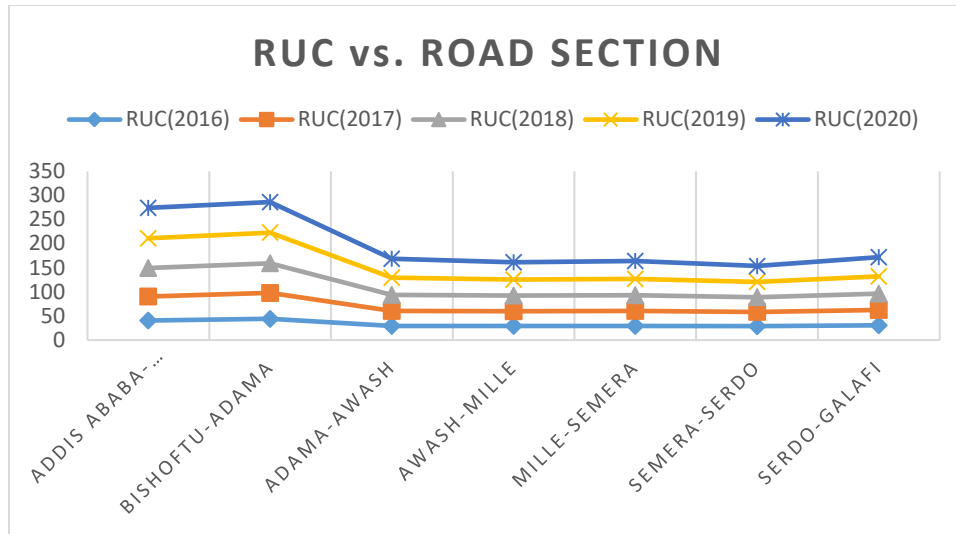


Figure 16: relation between RUC and Road Sections

As figure 15 and 16 indicate, the AADT and RUC show similar patterns. This is the indicator for the road user costs are affected by the number of vehicles on the section road.

On the other hand, comparing the two scenarios described in the Tables 18 and 19, it is shown that the two cases have almost similar road user costs. This will call for attention so that empty trucks get minimized through the trade balance between export and import.

5.6. Sensitivity Analysis

Sensitivity analysis was conducted for the three parameters from the road network and vehicle fleet. These parameters are roughness, traffic volume and annual kilometer travelled. HDM-4 uses a term called impact elasticity to determine the degree of the sensitivity of the parameters. Impact elasticity refers to the ratio of the percentage change of the result to the percentage change of the input parameters. The degree of sensitivity of the parameters based on HDM-4 is shown in Table 20 below.

Table 20: Impact elasticity range of HDM-4

Impact	Sensitivity Class	Impact elasticity
High	S- I	>0.5
Moderate	S- II	0.2-0.5
Low	S- III	0.050-0.20
Negligible	S- IV	<0.05

Based on the computation, the impact elasticity is shown in the tables 21, 22 and 23.

Table 21: Impact elasticity for Roughness

<i>Section</i>	Impact elasticity(for change in % of roughness value)				
	10%	20%	30%	40%	50%
Addis Ababa-Bishoftu	0.2	1.0	1.3	1.2	1.0
Bishoftu-Adama	0.1	0.8	0.9	0.8	0.6
Adama-Awash	0.2	0.3	0.4	0.6	0.8
Awash-Mille	0.1	0.2	0.3	0.3	0.4
Mille-Semera	0.1	0.2	0.3	0.4	0.5
Semera-Serdo	0.0	0.0	0.1	0.2	0.2
Serdo-Galafi	0.1	0.2	0.3	0.5	0.6

Table 22: Impact elasticity for traffic volume

<i>Section</i>	Impact elasticity(for change in % of Traffic Volume)				
	10%	20%	30%	40%	50%
Addis Ababa-Bishoftu	0.02	0.92	0.64	0.49	0.41
Bishoftu-Adama	0.07	0.07	0.07	0.07	0.07
Adama-Awash	0.13	0.22	0.29	0.35	0.27
Awash-Mille	0.01	0.01	0.01	0.01	0.01
Mille-Semera	0.01	0.01	0.01	0.01	0.01
Semera-Serdo	0.00	0.00	0.00	0.00	0.00
Serdo-Galafi	0.01	0.01	0.01	0.01	0.01

Table 23: Impact elasticity for annual km traveled

<i>Section</i>	Impact elasticity(for change in % of Annual km Traveled)				
	<i>10%</i>	<i>20%</i>	<i>30%</i>	<i>40%</i>	<i>50%</i>
Addis Ababa-Bishoftu	<i>0.11</i>	<i>0.11</i>	<i>0.10</i>	<i>0.10</i>	<i>0.10</i>
Bishoftu-Adama	<i>0.09</i>	<i>0.09</i>	<i>0.08</i>	<i>0.08</i>	<i>0.08</i>
Adama-Awash	<i>0.13</i>	<i>0.12</i>	<i>0.12</i>	<i>0.11</i>	<i>0.11</i>
Awash-Mille	<i>0.12</i>	<i>0.12</i>	<i>0.12</i>	<i>0.11</i>	<i>0.11</i>
Mille-Semera	<i>0.12</i>	<i>0.12</i>	<i>0.11</i>	<i>0.11</i>	<i>0.11</i>
Semera-Serdo	<i>0.12</i>	<i>0.12</i>	<i>0.11</i>	<i>0.11</i>	<i>0.11</i>
Serdo-Galafi	<i>0.12</i>	<i>0.12</i>	<i>0.12</i>	<i>0.12</i>	<i>0.11</i>

Based on the results, the impact elasticity for roughness is in different ranges of sensitivity class. For small percent alter of roughness, the impact has been found to be low while for higher percentage changes, there is a proportional impact. This could imply that roughness of the road value is very important and is determinant of road user costs. On the other hand, traffic Volume has high impact for some sections and low for the others. On Addis Ababa- Bishoftu Section, it has high impact while low on Bishoftu- Adama Section. The reason could be that the Bishoftu-Adama section has the highest traffic volume and any further increment may not have such a significant effect. On the contrary, the low traffic volume section also exhibited low to negligible impact of traffic volume which could be because of the small traffic volume and further increment may not have a big impact. The third parameter, annual km traveled, was found to be a less sensitive parameter.

CHAPTER SIX

CONCLUSION AND RECOMMENDATION

4.1. 6.1. Conclusions

Based on the results of the study, the following conclusions are derived:

- The freight vehicles that are currently common on Addis Ababa-Djibouti corridor have a capacity of between 20-40 tonnes.
- The majority of the freight vehicles on the corridor, about 80% of the total, are owned by associations whereas the rest of the vehicles are owned by transport companies.
- About 52% of freight vehicles are between 1-10 years of service lives while 21.8% of vehicles are above 20 years of service lives.
- No scientific study/survey had been practiced for establishment of tariff so far. In this regard, 60% of the transport companies determine tariff using inputs of previous experiences, while the rest completely rely on the market.
- The profit margin varies among the companies. There is a maximum profit margin of above 35% and a minimum of between 10% and 15%.
- Existing tariff has an incremental nature from year to year. Between the years 2014-2016, the maximum tariff was 1.29 birr/ton-km while the minimum values was 0.92 birr/ton-km.
- The road user costs determined by HDM-4 method has an incremental nature. The cost was determined for 100% load factor and empty carriage. The road user costs of the two scenarios are substantially the same.
- The comparison of road user costs determined by the HDM-4 model and the existing practice have shown a significant difference.
- The roughness has been found to be more sensitive for road user costs while traffic volume has been seen to be dependent on the original traffic volume of the section. Annual km traveled is less sensitive.

6.2. Recommendation

The following recommendations are forwarded;

- Proper organization of the transport association is very vital. The government should give special attention and formalize the organization of the associations.
- Establishment of tariff in Ethiopia should be based on scientific studies.
- The government should strive to balance between export and import so that unnecessary waste of vehicles operating costs towards Djibouti Should be minimized.
- Alternative port need to be developed in order to improve the efficiency of the import.

6.3. Future research direction

- Developing a model to account all costs and related parameters would be necessary. This could incorporate all internal and external cost components.
- This thesis considered only the vehicle operating cost and travel time cost for the determination of the road user costs. Accident cost could be for further research consideration.

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Annex 1: Interview Question

1. What are the most common commodities imported through Djibouti?
2. How do you determine tariff?
3. What are the criteria used for tariff determination?
4. How do you quantify the cost parameters?
5. What is the profit margin?
6. What are the problem related to escalation of tariff?

Annex 2: Data Collection Sheet

Data Collection Sheet

These data is going to be used for a research purpose. The research is conducted on pricing of the freight vehicles. It is required to collect the vehicle characteristic data of vehicles along the Addis-Djibouti corridor. As the characteristics are model sensitive, the descriptions of the characteristics with the model type is very important. The confidentiality of the data you are going to provide is insured. Thank you for your cooperation.

Name of the association /PLC _____

Capacity of the vehicle _____

Model type of the vehicle _____

<i>Basic characteristics</i>	
<i>Physical</i>	
Passenger car Space equivalence	
No. of Wheels	
No. of axles	
<i>Tires</i>	
Tyre Type:(Bias-ply,Radial-	
Base no. of recaps	
Retread cost (%)	
<i>Utilization</i>	
Annual Km (Km)	
Working Hours (hrs.)	
Average Life (years)	
Private use (%)	
Passengers (Persons)	
Work Related Passenger trip (%).	
<i>Loading</i>	
ESALF	
Operating Weight	
<i>Economic Unit Cost</i>	
<i>Time Value</i>	
Passenger Working time(Per hour)	
Passenger Non-working time(Per-	
Cargo(per time)	

<i>Economic Data</i>	
<i>Economic Unit Cost</i>	
<i>Vehicle Resource</i>	
Cost of new vehicle	
Replacement of tyre	
Fuel(per Liter)	
Lubricating oil(per Liter)	
Maintenance labour (per hour)	
Crew wages(per hour)	
Annual Overhead	
Annual Interest	
<i>Financial Unit Cost</i>	
<i>Vehicle Resources</i>	
Cost of new vehicle	
Replacement of tyre	
Fuel(per Litre)	
Lubricating oil(per Litre)	
Maintenance labour (per hour)	
Crew wages(per hour)	
Annual Overhead	
Annual Interest (%)	

Annex 3: Questionnaire on tariffing practice

Questionnaire

This Questionnaire is prepared for a purpose of research which is conducted on Estimation of the tariff for freight vehicles considering Addis Ababa-Djibouti corridor as a case study. As your response is the backbone for the result, I appreciate your commitment and cooperation in giving the correct answers. As this is required only for a research, the confidentiality of the information you provide will be well-guaranteed.

Which tariff estimation parameters does your company consider? Please mark under one of the three types of consideration options based on your experience for both fixed and variable operating cost components.

Fixed of Operating Cost Components

Parameter	Usually considered	Rarely Considered	Not Considered
Cost of vehicle Ownership			
Cost of License Ownership			
Road Tax			
Cargo and Vehicle Insurance Cost			
Vehicle parking Cost			
Cost for Technical Inspection of vehicles			
Costs for Legal Services			
Cost for accounting Services			
Cost for Insurance of road freight transport Profes-			

Variable Operating Cost Components

Parameter	Usually considered	Rarely Considered	Not Considered
Fuel Cost			
Cost for tires			
Maintenance Cost			
Repair Cost			
Tolls			
Driver wage			
Driver bonus			
Taxes			
Fined			
Cargo Claim			
Subscription			
Communication Cost			
Truck Wash			
Clothing(uniforms)			
Daily Costs (meal, accommodation, etc.)			

How do you quantify the each parameters?

- from previous experience
- Based on study/survey
- Based on the market
- By other method

Please mention it _____

In which interval does your Profit Margin lay?

- 10-15
- 15-20
- 20-25
- 25-30
- 30-35
- above 35

Annex 4: Data collection sheet for rate of four cargoes

This data sheet will be used to collect tariff for four items listed in the table. It is required to have a data of at least three years. The data will be used only for a research purpose. The accuracy of the data is very important. Your cooperation is very much appreciated.

	Rate(Birr/ton.km)/Year		
Cargo Type	2014	2015	2016
Wheat			
Reinforcement			
Fertilizer			
Container			