VEHICLE EFFICIENCY
AND
AGRICULTURE TRANSPORT
IN GHANA

by

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A Thesis submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Abstract

This thesis studies the VOC associated with the transportation of agricultural commodities in Ghana using Kumasi and the Ashanti Region as a case study. The present state of the agricultural sector is described in terms of three interactive systems: the transport system, the agriculture system, and the flow pattern of vehicles and commodities. A survey is used as an information base to construct a TOC model based on average actual operating conditions. The TOC model is expanded to include costs under three theoretical operating conditions: enforced loading conditions, maximum vehicle utilization, and increased fuel efficiency. Three options identified as potentially beneficial to the transport industry and the Ghanaian economy, are presented and evaluated: using larger vehicles, maximizing vehicle utilization, and increasing fuel consumption. Evaluation takes into consideration the effects of implementation on the actors involved - producers, transport owners and operators, transport organizations, and the government. Recommendations put forth suggest that the Ghanaian government in cooperation with the GPRTU and lorry park operations institute the following programs and policies:

- enforce registered loading allowance.
- encourage higher vehicle utilization by controlling the number of vehicles registered and ensuring adequate service on all routes.
- encourage the use of larger vehicles. Union porters consolidate and load all vehicles at GPRTU lorry parks; larger vehicles could be loaded rather than smaller ones.

It is further recommended that the Ghanaian government examine the benefits of using foreign aid to effect such fleet and operational changes rather than focus on capital intensive infrastructure improvements in order to improve transport efficiency.

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CHAPTER 1: INTRODUCTION

1.1 Background

Ghana, formerly known as the Gold Coast, covers an area of over 238,000 square kilometres on the west coast of Africa (Figure 1.1). When Ghana gained independence from Great Britain in 1957 it held 10 per cent of the world gold supply and was the largest exporter of cocoa [Gould, 1960]. The country had an extensive road network developed primarily for cocoa export. Ghana suffered an economic downturn in the late 1960's and throughout the 1970's due in part to falling world cocoa prices. The economy 'hit bottom' in 1982-83 with widespread drought, declining cocoa production (as farmers returned to growing subsistence crops), and a deteriorating road network. In mid-1983, Ghana adopted economic policies including a devaluation of the Cedi, which opened the door for International Monetary Fund (IMF) assistance. By 1984, Ghana was showing its first period of economic growth in 10 years.

Although the situation in Ghana has improved, its economic health remains dependent on agriculture. Approximately 60% of its 14 million inhabitants are employed in the agricultural sector and 68% of its export earnings in 1987 came from cocoa and timber [TecnEcon, 1987]. Much of the Ghanaian freight transport demand comes from its agricultural sector. Crops are transported, generally by road, either to urban centres for domestic consumption or to ports for export. Road transport is responsible for 94% of the ton-miles of freight transport in Ghana; rail is used for the remaining 6 % [TecnEcon, 1987].

The Ashanti Region, one of the nine regions of Ghana, and more particularly Kumasi its capital, are used as a case study in this thesis. The Ashanti Region is one of the largest regions in Ghana in terms of both area and population. It occupies a central position in Ghana: the central node in the main road network; the apex of the railway triangle; and the centre of the main agricultural production area. Kumasi's main market, one of the largest in West Africa [Rémy,1992], handles a large proportion of the north-south flow of agricultural and other commodities.

Road transportation of agricultural commodities is an important issue in Ghanaian economy. The vehicles themselves and some of their operating costs such as fuel, lubricants, tires and spare parts are imported and therefore constitute a hard currency cost to the economy. Minimizing hard currency costs by maximizing vehicle productivity would have a positive effect on Ghana's economy.

Vehicle productivity is generally measured as cost per unit of payload movement or cost per tonne-kilometre of payload. Productivity is related to vehicle characteristics (size, weight, type etc.) and operating characteristics (utilization rates, loading characteristics, fuel consumption etc.). Changes in productivity are effected through changes in the types of vehicles used and their operating characteristics. Productivity issues are addressed through weight and dimension regulations in developed countries where a method of enforcement is in place. In developing countries, where the regulations are rarely enforced, government programs and policies are used more effectively to influence productivity.

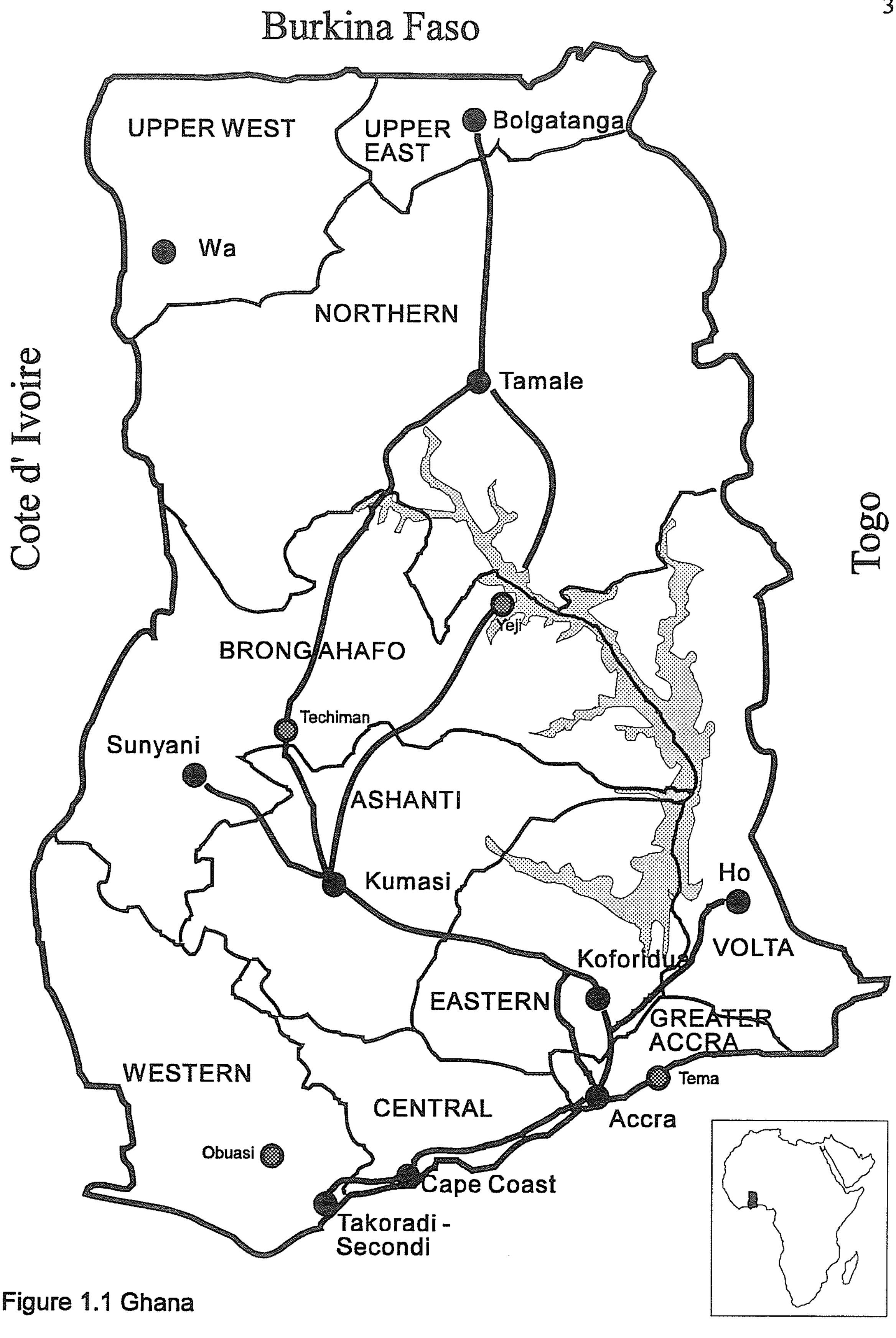


Figure 1.1 Ghana

This thesis examines vehicles used in the transportation of agricultural commodities in Ghana, using the Ashanti Region as a case study. Productivity of the vehicles currently in use is examined in order to identify and recommend policy and program changes to effect improvements to productivity, thereby reducing the hard currency costs of agricultural commodity transport.

1.2 Objectives and Scope

The objectives of this research are:

(1) to develop a methodology and information base to evaluate policy and program options specifically intended to affect the physical and operating characteristics of highway vehicles servicing the agricultural sector in Ghana;

(2) to identify potential policy and program options relevant to Ghana;

(3) to apply the methodology and related models to evaluate potential options, using the case study approach;

(4) to recommend appropriate policy and program options.

The scope of the research is focused on policy and program options specifically intended to affect the numbers, sizes and weights, and types of motorized vehicles used in agricultural transport, and their operating characteristics (eg, fuel type, fuel economy, utilization, engineering unit costs). Policies and programs directed at imposing or influencing controlled prices and service levels, safety standards, and community impacts are beyond the scope of this work. Similarly, detailed analyses relating to the non-motorized component of the agricultural transport system are beyond the scope of the research.

1.3 Organization of the Thesis

The thesis is divided into seven sections. The first two serve as introductions to the agricultural and transport sectors in Ghana and to the framework used in analysis and evaluation. Section three presents a review of existing truck operating cost models and the techniques used for analysis. Section four describes the present Ghanaian situation in terms of three interactive systems which affect the transportation of agricultural commodities: the activity system or agriculture in the Ashanti region; the transport system or the assembly of networks, vehicles and regulations within which the transport occurs; and the flow system or the pattern of vehicle and commodity movements. Section five presents a truck operating cost model using data obtained through a vehicle survey conducted in the Kumasi area. Truck operating costs for three operating conditions, other than actual average operating conditions, are presented and analyzed: operation within allowable loading parameters, operation at maximum utilization levels, and operation with increased fuel efficiency. Section six analyses and evaluates the options put forth in the previous sections. Changes to the three interactive systems are analysed and evaluated in terms of changes made to the types and operating characteristics of the vehicles used. Section seven presents the observations and conclusions of the thesis, and makes recommendations regarding the policy and program options most likely to create a positive change to the transportation of agricultural commodities in Ghana.

CHAPTER 2: FRAMEWORK FOR ANALYSIS AND EVALUATION

The Manheim model [Manheim, 1979] serves as the framework for analysis and evaluation. Manheim's approach to transportation problems situates the problem within a global context; in this manner, the *problem* is more easily identified and defined. The framework facilitates the identification of the *variables* and the *constants* of the problem to be analyzed. Evaluation of the possible solutions is carried out by examining the changes in the *dependent variables* caused by changes imposed on the *independent variables.*

In this research project, the global context is restricted to Ghana's agricultural sector and more specifically, the Ashanti region. The *problem* is identified as the transportation of agricultural commodities. The *constants* are components of the agricultural system which are not amenable to change in the scope of this study (production and consumption patterns, seasonal variations, marketing practices...), the transportation infrastructure, the transport regulations, the pattern of commodity movement, to name but a few. The *independent variables* are the vehicles used in the transport of agricultural commodities. The *dependent variables* are the operating characteristics of the vehicles used (fuel consumption, loading characteristics, utilization rates...). Once the problem is defined, the constants and variables identified, policy and program options to improve the performance of the existing systems may be put forth. The following section describes the Manheim framework in more detail and as specifically applied to the Ghanaian research situation.

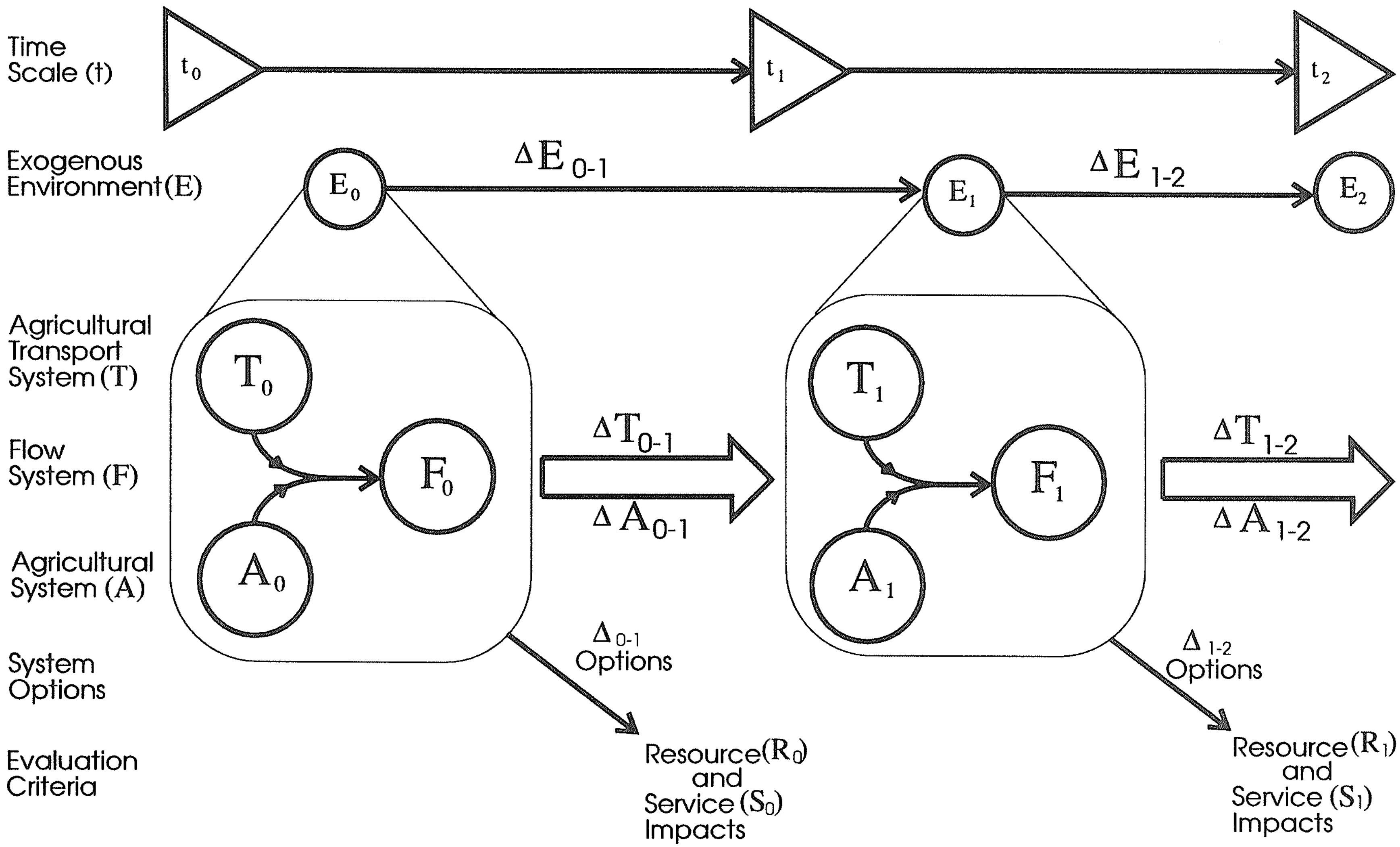


Figure 2.1 Framework for Analysis and Evaluation
Source: After Manheim

2.1 The Basic Systems Analysis Model

The agricultural sector of Ghana, its marketing mechanisms, and its transport systems, operate in a complex, interactive manner, responding to many interests and pressures, which change with time. To facilitate meaningful analysis and evaluation of potential changes in the transport system, it is useful to formulate a simplified view to identify its key interdependencies, and to asses the impact of changes in one or another of system components. Figure 2.1 illustrates the basic system framework used in this research.

The framework is defined by four basic elements: the Agricultural system (**A**); the Transport system (**T**); the Flow pattern (**F**); and the Environment (**E**).

The driving force for the system of interest is the **Agricultural System (A)**. It is comprised of: the production pattern; the consumption pattern; market organization considerations; storage and handling facilities and practices; and government policies, regulations and practices. Production and consumption patterns dictate vehicle movements for a given commodity in a given season.

The Agriculture system in the Ghanaian context is the pattern of agricultural production, consumption, and marketing which creates the demand on the Transport system. Where commodities are produced, where they are consumed, in what quantities, and in which season they are shipped, where and how they are bought and sold, are all factors which will define the agricultural transportation demand. Variations in the Agriculture system patterns will affect the demands on the Transport system and the resulting Flow patterns.

The agricultural **Transport System (T)** is comprised of, or characterized by: the transport infrastructure; the vehicles used and their physical characteristics; specified prices; operational policies and practices; and government policies regulations and practices. The Transport system is the organizational and physical framework which responds to the demands of the Activity system to produce the resulting Flow pattern.

The transport system in the Ghanaian context is the network of roads, the vehicles which assure the transport of agricultural commodities, and the operational and regulatory system within which they interact. The extent of the road network, its physical characteristics, and its state of repair are important characteristics of the Transport system. The type of vehicles plying the roads, their age, size, and operating characteristics define the Transport system. The marketing structure and transport hiring practices typical of the area affect **T** and its interactions with **A.** Finally, government policies, regulations and practices specifically imposed for purposes of governing or modifying the characteristics and performance of the transport system are important factors influencing not only the transportation system but its interaction with **A** and the resulting **F**.

As illustrated in Figure 2.1, at any point in time, **A** and **T** interact to effect a pattern of commodity and in turn vehicular movement, designated here as the **Flow Pattern (F)**. The movements can be characterized by such variables as: quantities of commodity movement; quantities of related vehicle movement; temporal distributions (seasonal and daily); origin-destination patterns; service quality factors; and resources consumed. **F** is a direct result of the interaction of **A** and **T**. Any changes (imposed or otherwise) occurring to either **A** or **T** will affect **F.**

This research is particularly concerned with the consequences of changes made to **T** on **F** and **A**. These consequences can be evaluated by measuring the change in level of service provided (**S**) and the resources consumed (**R**), caused by the changes imposed on **T**. In this case, resources consumed are measured in terms of productivity or relative cost per tonne-kilometre (T-km) of commodity movement. Level of service is measured in terms of cost to the shipper or relative availability of transport. For example, a change in the size of truck used to transport goods from farm to primary market might be encouraged by policy changes in order to decrease the cost of transportation per T-km. Such a change would bring about a decrease in the cost of fuel per T-km but might also be responsible for a decrease in the number of trips required and a lower frequency of service provided to producers.

Some factors affecting the system, and therefore the interaction of **A** and **T** on **F**, are external to the system itself and are referred to as the **Exogenous Environment (E)**. Some of these factors that might come into play in the Ghanaian system are aid agency donations; World Bank support/research; and world commodity prices. The direct effect and study of the factors involved in the Exogenous environment are beyond the scope of this research.

The four basic elements of the framework interact in a dynamic way. In Figure 2.1, time 0 is defined as the present situation in which the exogenous environment ($\mathbf{E}_0$) and the historical precedents have influenced the characteristics of the Activity System ($\mathbf{A}_0$) and the Transport System ($\mathbf{T}_0$), and their resultant Flow Pattern ($\mathbf{F}_0$). The efficiency (as measured in terms of resources consumed) and effectiveness (as measured in terms of levels of service experienced by users) of $\mathbf{F}_0$ in turn generates or stimulates change (**A** and/or **T**). In addition, such changes can be artificially imposed (e.g. enforcement of load limits). Coupled with relevant changes in **E** (e.g. decreases in World Bank support), imposed changes stimulate new $\mathbf{A}_1$ and $\mathbf{T}_1$ systems, and therefore a new flow pattern $\mathbf{F}_1$ which in turn produces a new level of resource consumption ($\mathbf{R}_1$) and level of service ($\mathbf{S}_1$). The process is continuous.

2.2 The Generic Transport System Options of Interest

The research is focused on the vehicle component of the transport system. Other aspects of the transport system are assumed constant in order to isolate the impacts of proposed changes to policies and programs affecting the vehicles and their operating characteristics. The transport infrastructure, its extent and state, is taken as remaining unchanged over time for the purpose of this research. The agricultural system - production and consumption patterns, seasonal changes to the pattern, quantities produced, domestic and export crops - is also treated as constant for the purpose of this research.

Components of the framework that are analyzed are those concerning the vehicles used in the transport of agricultural commodities and the vehicles' operating characteristics. Some of the program and policy options that directly affect the vehicles and their operating characteristics are the weight and dimension policies of the country, and their enforcement. Other relevant program and policy options include: fleet development programs or controls (such as imports), vehicle manufacturing or modification support, and driver and owner education programs.

Although non-motorized transport is an important component of the Ghanaian transport system, a complete study of the non-motorized transport system, its interaction with motorized transport and its role in the transport of agricultural commodities is beyond the scope of this research.

2.3 The Basis for Evaluation

> "The primary product of evaluation should be a summary of the key issues to be considered by interested parties in reaching a decision on a course of action". [Manheim, 1979: p.332]

The process of evaluation is based on examining the various options identified by the data and determining the effects of each of these options. Manheim suggests that the process begin by creating an impact tableau and a value information file. The impact tableau shows, for each of the alternative transportation plans being considered, "the consequences for each actor, by the type of impact" [Manheim, 1979]. The value information file on the other hand, presents the values or preferences of the actors on each of the options being evaluated. Impacts identified in this process may be quantitative, qualitative or descriptive and may be positive or negative, depending on the actor. The evaluation process then continues by examining the issues first from the perspective of each affected actor, then from the perspective of each action or option, and finally from the perspective of the process as a whole. Other possible options, impacts, or actors may in this way be identified and accounted for throughout the evaluation process. Each identified option is therefore examined from three different perspectives and possible impacts reviewed at each step before final recommendations are made.

The method described by Manheim emphasizes evaluation of each identified option (including the null or 'do nothing' option) based on the analysis of positive and negative impacts on all affected actors. Such a method permits the evaluation of the impacts caused by each option and facilitates the identification of the best possible alternative. The method is used in the thesis to identify policy and program actions most suited to the Ghanaian transport industry and to make recommendations regarding the implementation of appropriate changes.

CHAPTER 3. TRUCK OPERATING COST MODELS

3.1 Analysis Techniques

Vehicle operating cost (VOC) models are based on three different analysis techniques: mechanistic, deterministic, and stochastic. Current models typically use a combination of analysis techniques but one of the three approaches generally typifies the models. Figure 3.1 illustrates the salient features of each approach.

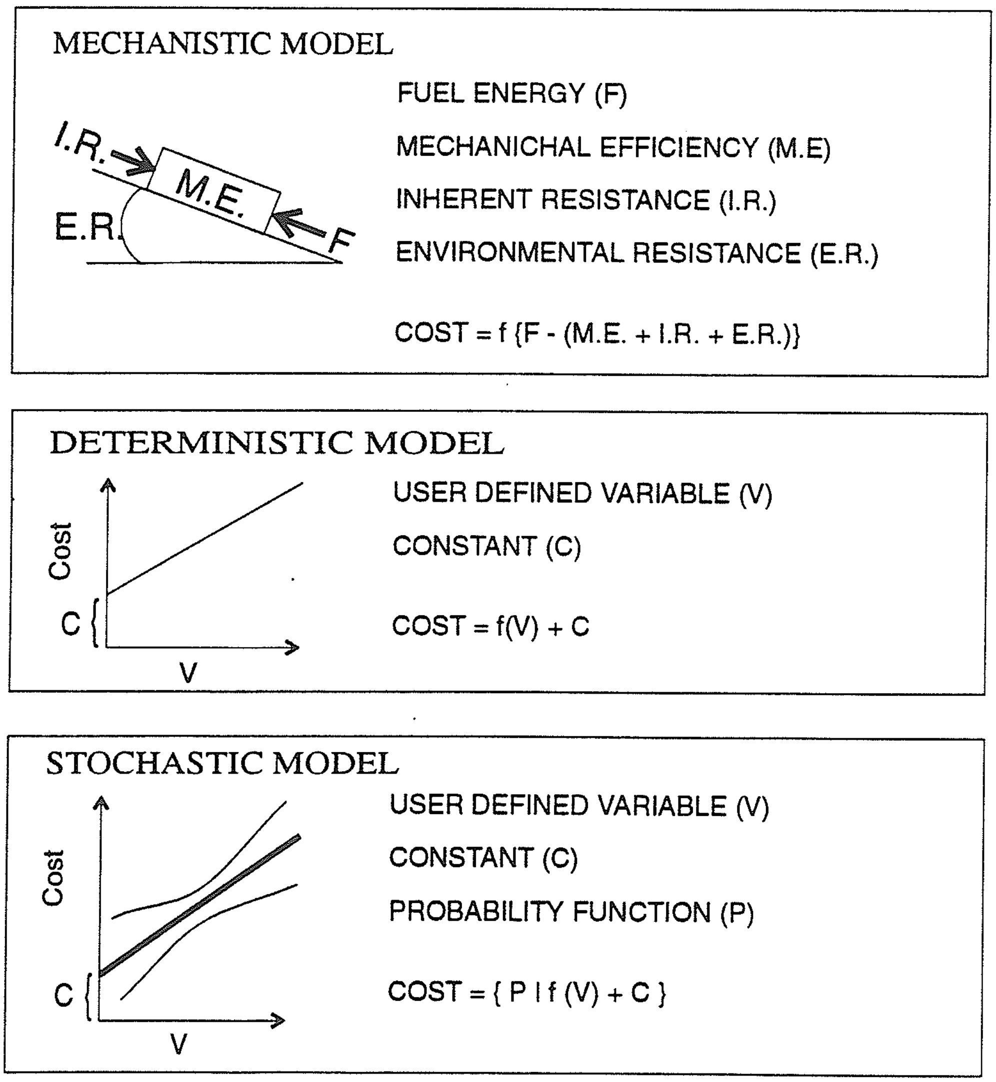


Figure 3.1 Three Approaches to VOC

3.1.1 The Mechanistic Approach

Mechanistic models are based on the physical and mechanical aspects of operating a vehicle; they are sometimes referred to as vehicle performance models. The three components of mechanistic models are mechanical efficiency, inherent resistance, and environmental resistance. Mechanical efficiency refers to the proportion of energy that is used by a vehicle to effectuate movement. Inherent resistance refers to a vehicle's resistance to movement on a straight, level surface in still air. Environmental resistance refers to a vehicle's resistance to motion due to grade changes, curvature, and wind.

Mechanical efficiency is vehicle-specific and varies with type of engine and type of fuel. Diesel engines are 35% to 40% more efficient than gasoline engines [Fitch, 1983]. Substantial improvements to mechanical efficiency and therefore to fuel efficiency have been made to truck design in the last decades. Variable speed fans that operate only when necessary are reported to improve efficiency by 8% to 10% in diesel powered trucks. Transmission improvements increase efficiency by 10% to 14% [Fitch, 1983]. These figures illustrate mechanical efficiency improvements in newer trucks operating under ideal conditions and near perfect maintenance. It should be noted that the significant improvements to efficiency made in newer truck designs highlights the relationship between vehicle age and vehicle efficiency.

Components of inherent resistance are rolling resistance and aerodynamic drag. Rolling resistance, basically a frictional force, depends on the vehicle's weight, type of tires, road condition and vehicle speed. Rolling resistance has been shown to increase linearly with vehicle weight and speed. The use of radial tires as opposed to bias ply tires decreases resistance by 25%. Rougher road conditions or soft running surfaces such as sand or mud increase resistance by as much as a factor of 3 over concrete in excellent condition. Aerodynamic drag, caused by motion through air, increases with the vehicle's frontal area and with the square of the vehicle's speed. Aerodynamic drag is affected by the vehicle's shape; curved edges and flowing forms reduce drag. As much as 50% of a truck's engine power is used to counter the effects of aerodynamic drag at highway cruising speeds. [Fitch, 1983]

Resistance to motion is also affected by changes in grade, curvature, and wind - environmental resistance. Grade resistance is the energy required to produce changes in elevation, and is proportional to gross vehicle weight and percent grade. The value of grade resistance is approximately 20 lbs. of resistance per ton, per percent grade. Curvature resistance is the energy required to effect a change in direction; it is proportional to gross vehicle weight and degree of curvature. The energy required to negotiate changes in direction is generally significantly smaller than that required to effectuate a change in elevation. This is especially true for larger vehicles where fuel consumption is not significantly altered with road curvature [Watanatada et al., 1987]. Wind resistance is the force required to overcome wind forces; its effect is dependent on wind force and direction. Head and tail winds are treated as aerodynamic drag and are therefore proportional to area exposed and the square of the wind velocity. Cross winds are lateral forces, proportional to the exposed area and the square of the wind velocity, but the effective resistance produced by a lateral force is much less than that produced by a direct force. The resistance produced by head and tail winds can be compared to grade resistance and cross winds to curvature resistance.

Vehicle performance is further affected by vehicle characteristics such as configuration and number of axles, driver performance such as acceleration and deceleration rates, as well as environmental characteristics such as temperature and elevation. Driver performance affects vehicle efficiency by 7% to 9%. Temperature effects are 1% per 5° C above or below 29.4° C, and altitude effects are 3% loss in efficiency per 1000 feet. [Fitch, 1983]

The factors influencing vehicle performance described above form what is known as the mechanistic approach to vehicle performance and operating costs. The approach is a vehicle-specific, trip-specific method of analysing vehicle performance. Aspects of the model are used in rating efficiencies of vehicle mechanical improvements but the complexity of the model makes its use inefficient as a tool for making policy or operating decisions. Other models have been developed for policy and operating decisions but all models are based on the technological framework of the mechanistic approach.

3.1.2 The Deterministic Approach

Most VOC models fall into the broad category of a deterministic approach. Several types of deterministic VOC models exist but all are based on data derived from field conditions rather than the controlled conditions of the mechanistic approach. Models based on the deterministic approach rely on large data bases that reflect operating conditions in an actual working environment to derive average costs for specific operating conditions.

Deterministic models are designed for analysis of specific problems such as the relationship between tire inflation and fuel consumption. Key factors are made explicit; all other factors included in the mechanistic approach still operate but at an implicit level. Implicit factors are not separated out in the process of analysis and may be expressed as constants or assumed values. For example, models of vehicle fuel consumption are frequently expresses as a function of vehicle weight and take on the form

Fuel consumption = A + B (Weight)

where A and B are constants. The key factor in this relation is vehicle weight and all other factors which affect fuel consumption are implicitly included in the constant terms or designated as fixed. The fixed parameters of deterministic models are generally expressed as the conditions within which the model is valid i.e. vehicle age and area of operation.

The deterministic approach encompasses a broad spectrum of models, from those firmly based in the technological framework found in the mechanistic approach, to those which are applied to a limited area of VOC. It is therefore difficult to make general statements about deterministic models. However in all models using the deterministic approach, the choice of explicit variables expressed and the values chosen for implicit variables are dictated by the model's end purpose or use. In this way, deterministic models can be classified as user-defined models. Assumptions and variables of two deterministic models are examined in section 3.2.

3.1.3 The Stochastic Approach

The stochastic approach is a refinement of the deterministic approach; both approaches are based on large data bases and are user-defined regarding the implicit and explicit variables. Stochastic models differ from deterministic models in that they address the variable nature of VOC. Data collected from actual operating conditions will reflect a broader range of values than are exhibited by a deterministic model. For example, in a deterministic model, fuel consumption is expressed as a linear function of vehicle weight. The linear function indicates the mean, or most probable value, of data collected. Stochastic models address the variability found in the vehicle population by expressing the range of values for which the model holds true, or an explicit probabilistic function, rather than a single value represented by the sample mean. In this way, a model can be used not only to represent the current average operating conditions but also to gauge the model's sensitivity to changes of the given variables. The sensitivity analysis of a stochastic model is a powerful tool used to determine the relative merit of various options to be analyzed.

3.2 Examples of VOC Models

Classic examples of VOC models currently in use are examined in the following section. The fist two models are examples of deterministic models but they differ in their perspective, the use for which they were designed, and the variables they use implicitly and explicitly. A schematic illustration of the deterministic models is shown in Figure 3.2. The third is an example of a stochastic model.

MODEL	EXPLICIT VARIABLES	IMPLICIT VARIABLES
TRIMAC	Vehicle Characteristics - weight - utilization - type of fuel - type of freight	Road Characteristics - curvature - grade - roughness
HDM	Road Characteristics - curvature - grade - roughness - pavement structural parameters	Vehicle Characteristics - utilization - type of freight - loading characteristics

Figure 3.2 Deterministic Models: User-Defined Parameters

3.2.1 The TRIMAC Model

The Trimac model is an example of truck costs viewed from the fleet operator's point of view; it is used extensively for truck operational costing and rate-determining purposes in the Canadian trucking context. It was designed by Trimac Consulting Services Ltd. for Transport Canada and is published every two years. The Trimac model is based on "realistic average productivity information and prevailing factor unit cost levels" [Trimac, 1988]. In other words, the Trimac model is based on average actual operating costs for trucks operating in the various regions of Canada. The Trimac model is a generic, deterministic model which yields an upper-end estimate of operating costs. It assigns operating costs according to region, configuration, commodity, and utilization level.

The Trimac model makes a series of assumptions about operating conditions and assigns current costs under these conditions to arrive at a base case average truck cost per running hour or kilometre. The assumptions are an integral part of the model as they dictate the conditions under which the costs are valid. Although costs are given for single vehicle units, trucks are assumed to operate within a fleet and such costs as administration and mechanic's labour are assigned to a vehicle as a portion of fleet costs. Commodities carried are grouped into two categories, dry freight (average density 250 kg/m^3) with which vehicles tend to be restricted by volume (cube-out), and bulk commodities (average density 900 kg/m^3) with which vehicles tend to be restricted by weight (weight-out). Load-unload times are also averaged to reflect driver hours and the hourly rates involved in this activity.

Fixed as well as variable costs are included in the model. The average age of the Canadian vehicle fleet is used as the age of the representative base case for the purpose of the study: 3-year-old tractors and 5-year-old trailers. Vehicle write-off and depreciation costs are related to new replacement costs. Administration and interest costs are set to 14% of revenue, and insurance costs at 3% of revenue "which seems to be the average of most operations" [Trimac, 1988]. Profit is designated as 10% of total pre-tax revenue.

Once operating conditions for all vehicles in each region have been established, costs are calculated for each base case. Region specific driver wage rates are then applied, either on an hourly rate or a kilometre-base rate. Fuel costs are calculated using average actual regional fuel consumption rates and wholesale fuel prices in the most heavily populated area of each province. Maintenance and repair costs represent the expected cost of labour, parts, and oil for the type of equipment and assumes a program of preventive maintenance. Tire costs are based on the regional cost of new tires, tire life, retread costs and retreaded tire life.

Once base case scenarios are calculated for each type of operation a sensitivity analysis is performed on various operating factors. Unit cost adjustment factors are assigned for winter-only operation on winter roads; for higher or lower proportions of loaded operation; for trip length variation; and for specialized equipment operation. The unit cost adjustment factors along with the base cases permit the use of the Trimac model for costing estimates over a wide range of operating circumstances.

Although many assumptions are used throughout the Trimac model, they are explicitly stated. Data and costs for the model are collected and published biennially making the model a good indicator for cost trends within the Canadian trucking industry.

3.2.2 The HDM Model

The World Bank's Highway Design and Maintenance Model (HDM) is a deterministic model taken from the point of view of a highway agency. The model was developed by the World Bank based on research in India, Kenya, the Caribbean, and Brazil between 1971 and 1982. It was designed to meet the needs of highway agencies, particularly in developing countries, for evaluating policies, standards and programs of road construction and maintenance. The HDM model views vehicle costs and infrastructure costs as components of the total transportation cost; it links infrastructure conditions to truck operating costs.

Watanatada et al. (1987) estimated that road user costs (road taxes, vehicle operating costs and depreciation) represent a much greater proportion of the national budget for transportation costs than do road construction and maintenance. It is estimated that road user costs can account for up to 90% of the total life cycle costs of a 2-lane highway serving a few thousand vehicles per day [Watanatada et al., 1987]. The data from Brazil show that fuel consumption, tire wear, and the time related components of running costs represent 75% of total operating costs of typical truck operations; maintenance, parts and labour, and lubricants represent the remaining 25% of operating costs. The objective of the HDM model is to maximize benefits from available resources by minimizing VOC where VOC are taken to be a function of road characteristics.

The HDM uses what has been described as an aggregate-mechanistic approach. The model is based on a mechanistic type of approach in which vehicle speed characteristics and vehicle utilization are the main variables used to predict vehicle costs. Vehicle unit depreciation and interest are fixed costs and therefore inversely proportional to vehicle utilization, and utilization is modeled as a function of vehicle speed. Other vehicle costs, such as fuel consumption, tire wear, and crew costs, are predicted as a function of vehicle speed. The prediction of vehicle speed is based on roadway attributes (vertical alignment, horizontal alignment, and surface characteristics) and the basic relationships explained in the mechanistic approach (vehicle mass, vehicle drive force, gravitational force, air resistance, and rolling resistance). The resulting model is validated with independent data, in this case data collected in Brazil. Once validated, the model is transformed to an aggregate form - a series of algebraic relations - using numerical methods.

The HDM is presented as a computer program. Input data include region specific roadway information, fleet characteristics, and costs. Model predictions calibrated from Brazilian data are included as an example. Predictions are given in graphical form to illustrate sensitivity of truck user costs to roadway characteristics, and in tabular form for various sizes of trucks operating under loaded and unloaded conditions over paved and unpaved roads.

3.2.3 The Non-deterministic Nature of Truck Costs

The non-deterministic nature of truck costs is examined through a sensitivity analysis of the weight and dimension parameters affecting productivity or the cost of trucking [Sparks, 1986]. The first step in the analysis is a deterministic evaluation of the costs associated with truck operation: parameters included under the two broad categories of vehicle capacity and utilization, and tractor costs. The deterministic evaluation yields a most likely cost for each of the parameters. Maximum and minimum costs, boundary values within which parameters are likely to fall 98% of the time, are then established for each of the parameters. Parameters to which productivity is sensitive are established by this process. For example, productivity of a 5-axle flat deck truck is deemed to be very sensitive to "vehicle capacity and utilization as measured by vehicle tare weight and total annual distance, and tractor cost as measured by distance wage rate" [Sparks, 1986].

This type of analysis is useful in determining the relative merit of various options to improve productivity. Sparks uses the study to analyse the relative merits of different truck configurations as they would be affected by changes in weight and dimension regulations. However, the model illustrates that this type of sensitivity analysis is useful in determining cost sensitivity of the input parameters in any model.

The Trimac and the HDM models discussed previously were developed as deterministic models. Each model explores sensitivity of truck costs from either the operator's or the agency's point of view. The Trimac model shows how truck costs are sensitive to region, utilization rates, road surface, and type of vehicle by giving values for each of these types of operation. The HDM model shows how truck costs are sensitive to road attributes, vehicle attributes, and regional factors by illustrating the relationship of truck costs to each of the parameters. However, neither of these models indicates explicitly the sensitivity of costs to variations within the examined parameters. The HDM and Trimac models, due to their deterministic nature, express the mean value or the cost most likely to occur, with given parameters. The stochastic nature of truck costs clearly shows that variations from the mean value, or the probable spread of likely values, gives a clearer indication of sensitivity to change of basic parameters and costs than do deterministic models.

3.3 Classic Productivity Studies

VOC studies carried out by various agencies have yielded some general conclusions on the types of vehicles that are most cost efficient. Two of these studies are included in this section.

3.3.1 TRED Report

The Transportation Research Education Development (TRED) Foundation published a study regarding VOC and optimal vehicle size [TRED, 1980]. The research, conducted in the United States, studied the effect of heavy truck size on operating costs in hauling a given tonnage of freight over a given distance. The purpose of the study was to determine the advantages and disadvantages of permitting larger trucks to operate on highways. The study compared fuel consumption and loading effects on pavements and bridges for ten vehicle combinations hauling a load of fixed weight and varying density over a given distance. The smallest vehicle was a 55 foot 5-axle tractor semi-trailer combination (3-S2) and the largest a 105 foot 9-axle double combination (3-S2-4).

The basic premise of the TRED study was that longer vehicles with more axles represent the most practical solution to efficient highway transportation. Efficiency of highway transport was measured in terms of loading on the infrastructure, fuel efficiency, and environmental effects such as noise and air pollution.

The example used throughout the study was the transportation of 2,000 tons of freight of varying density over 400 miles. Fuel costs are used as a measure of productivity of each vehicle combination, with productivity measured in terms of number of trips required and payload ton-miles per gallon of fuel. (The study used the same linear function to calculate fuel consumption for the various combinations.) Line-haul costs, defined as "the over-the-road costs which accrue from the time a tractor-trailer combination leaves the freight terminal of origin until it reaches the freight terminal of destination" [TRED, 1980], are also used as a measure of productivity.

The conclusion reached by the TRED study is that "productivity is enhanced as the vehicle size and weight increases" [TRED, 1980]. A summary of report findings is shown in Figure 3.3 where the various vehicle combinations' relative performance is rated. This figure supports the report's concluding remarks which recommend the use of longer and heavier truck combinations to increase productivity of a nation's highway transport network.

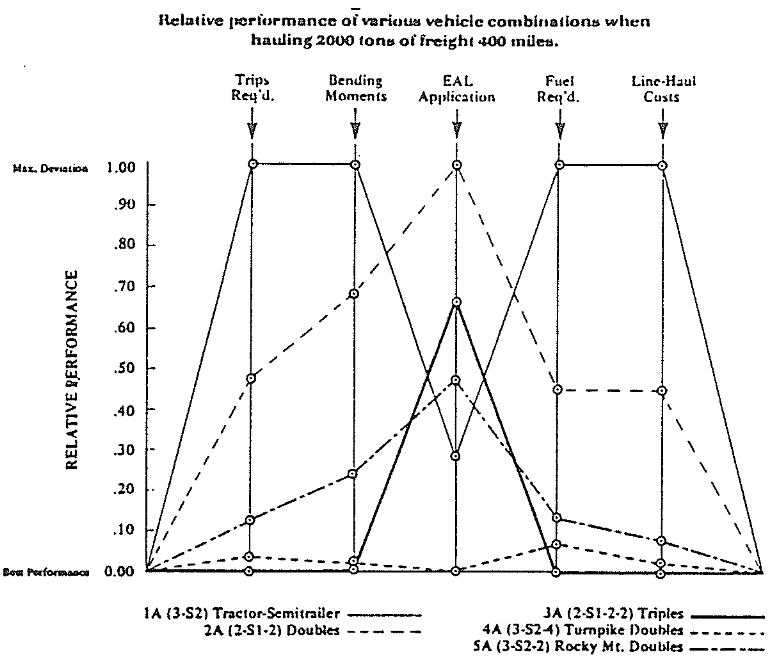


Figure 3.3 Relative Performance of Vehicles
Source: TRED, 1980

3.3.2 The Turner Proposal

The Turner Proposal [TRB Report 227, 1990 from Turner, 1984] advocates a new approach to truck size and weight regulations in the United States. Turner proposed the use of trucks with lower axle weights but larger gross weight thus reducing pavement wear but increasing productivity. The adoption of the proposal would increase the number of axles on a given truck while reducing the allowable weight limit on each axle giving way to larger configurations.

The ramifications of adopting the Tuner proposal were evaluated in the Transportation Research Board's (TRB) “Special Report 227: New Trucks for Greater Productivity and Less Road Wear”. The TRB evaluated the impacts of adopting the proposal: productivity, safety and traffic, bridges, and pavement. The study predicts that if Turner trucks were adopted it would affect 23% of the existing combination-truck miles of traffic representing savings to carriers of 12% of line-haul operating costs. Safety and interference with traffic flow would show a marginal improvement over the non-adoption scenario due to the decline in overall annual mileage realized by increasing productivity of vehicles (larger trucks). The major cost of adopting the Turner Proposal would be in the improvement of current bridges and increased design standards on new bridges over the primary road network. The cost of replacing bridges due to increased fatigue and adopting new design criteria represents an annualized increase of approximately 10% in bridge capital expenditures. Pavement costs would be significantly reduced by the adoption of Turner trucks; Turner trucks reduce pavement wear by 40% per truck-mile. Overall, adoption of Turner trucks is said to produce a 19% reduction in the rate of wear caused by traffic. Overall costs to highway agencies are predicted to reduce significantly if the proposal was accepted because savings realized due to less pavement wear would more than offset the higher bridge costs. [TRB Special Report 227; 1990]

The Turner proposal and the TRED report underline the importance of the relationship between truck productivity and infrastructure costs. The impact on the infrastructure caused by a change to vehicle size and weight regulations is evaluated in the Turner proposal. The TRED report emphasised the increased productivity and lower transport costs achieved through the use of larger trucks. The Turner Proposal and the TRED report, addressing the issue of vehicle productivity are in direct contrast to the World Bank's HDM model, which studied the impacts of infrastructure improvements on VOC. Since road user costs represent the greatest proportion of a national transportation budget it is evident that decisions affecting VOC will have the greatest effect on minimizing transportation costs. Decreasing VOC may be achieved through infrastructure improvements (as suggested by the World Bank), or through vehicle improvements (as suggested by the evidence of the mechanistic approach). Alternatively, productivity increases (as suggested in the Turner Proposal and TRED Report) can be used to decrease transportation costs on a global rather than unit or per truck basis. Results from the HDM show that infrastructure improvements have a limited effect on the operating costs of larger vehicles [Watanatada et al., 1987]. These studies demonstrate that vehicle and productivity issues are important and should be dealt with in the analysis of agricultural transport in Ghana.

CHAPTER 4: THE EXISTING SYSTEMS

The activity, transport and flow systems are described in their present state (as of July to November, 1992) in this chapter. The main source of new data is a series of surveys carried out in Kumasi from August to October 1992. A description of survey methods is included in this section prior to the description of the existing systems.

4.1 Data Collection

The research undertaken for this thesis is vehicle-based and Ghana-specific. Vehicle operating costs and characteristics were needed to create a model based on current operating conditions and vehicles. The Ashanti Region, and more specifically Kumasi, were chosen as a representative area on which to base the case study. Previous transportation studies in Ghana have mainly been concerned with the effect of road development on social and economic development in the rural areas [Hine, Riverson and Kwakye,1983; Riverson and Afele, 1974]. The Highway Design and Maintenance Model (HDM), designed specifically for third world use by the World Bank, uses road conditions as the model variable to determine operating costs.

The original intention was for the researcher to collect data through a series of interviews with drivers at lorry parks. Several problems were inherent to this approach. First was the language problem: even though English is the official language of Ghana, it is not a first language to any Ghanaian and many people without a formal education are not fluent in English. Second was the fact that a limited amount of data can be collected in this manner and that the construct of a valid VOC model requires a substantial amount of data. Furthermore, if other interviewers were hired to augment the data collected, it would be difficult to control the results of unstructured interviews. For these reasons, a survey of drivers using a questionnaire was deemed to be the most reasonable method of obtaining the necessary information.

4.1.1 Main Survey

The main survey was designed to obtain information on the costs and methods of operation of the current vehicle fleet transporting agricultural commodities in Ghana. The purpose of the survey was to accumulate enough relevant information to build an up-to-date Truck Operating Cost model. To achieve this, the survey needed to be comprehensive and extensive, and at the same time not be so lengthy as to tax the cooperation of the respondents. The resulting questionnaire was based on one used in a similar research in Pakistan in 1985-87, designed by the Overseas Unit of the Transport Research Laboratory (TRL), United Kingdom, and the National Transport Research Centre, Pakistan. Modifications to the questionnaire and survey methods were made to reflect the Ghanaian methods of operation and other logistic restraints. A copy of the questionnaire is included as Appendix A.

The questionnaire comprises 71 questions grouped into ten sections, as follows:

1. Interview details: place and date of interview, and interviewer.
2. Vehicle information: make, model, age, weight, and configuration.
3. Driver information: experience, number of drivers and mates regularly employed.
4. Load information: type, quantity, distance carried, loading details, and waiting time.

5. Ownership and Management: revenues, rest periods, regular routes, number of trips, and seasonality.

6. Vehicle finance: current value, purchase cost, and purchase financing of vehicle.

7. Insurance: type and cost.

8. Running and repair costs: license, tires, maintenance, fuel consumption, and average utilization.

9. Accidents: number, type, and severity.

10. Driver problems: open question for respondents.

The original Pakistan survey was designed to be a roadside survey. The logistics of carrying out such a survey in Ghana would have taken the project beyond its time and financial constraints. It was therefore decided that the surveys would take place at lorry parks within Kumasi. The survey data would be complemented by interviews with larger transporters and calibrated using 6-hour traffic counts at major routes into and out of Kumasi.

Ten survey locations at lorry parks were chosen to give the most representative sample of the range of vehicles and commodities being transported in the Ashanti Region. The surveyors were recruited from among the third year Planning students at the University of Science and Technology in Kumasi with the requirement that they be fluent in Twi and English. The questionnaires were printed in English but the majority of the interviews were done in Twi with the interviewers recording answers in English. (Translation of the questionnaire was discussed but deemed unnecessary due to the high level of fluency of the interviewers.) The survey was conducted between August 24 and September 5, 1992. A total of 500 questionnaires were completed yielding 482 useable forms. Respondents were generally co-operative with interviewers and very few problems were reported in spite of the length of the questionnaire. Interviews were reported to take between 20 and 30 minutes to complete depending on the respondent and the vehicle being operated.

4.1.2 Survey of Large Transporters

A questionnaire for larger transporters was designed to complement the main survey. The purpose of this second survey was to gather more information on larger, and articulated vehicles, and to obtain information about transporters that operate fleets of vehicles, rather than the one and two truck operations that are the norm found from the lorry park surveys.

Four organisations were contacted to be interviewed about their transportation systems: the Ghana Food Distribution Corporation (GFDC), the Ghana Cocoa Board (COCOBOD), the Ghana Timber Board, and RESIGHA (a company which deals in residue cocoa). A copy of the survey form for large transporters is included as Appendix B. The GFDC was very co-operative and provided both an interview and a written summary of their transport facilities and operations. The COCOBOD provided a written summary of information. The Timber Board suggested that individual timber companies would be in a better position to provide the type of information requested, however none of the companies approached were able to provide any information. RESIGHA gave no response.

Results obtained from the large transporters was such that it was not useable in the VOC model. Data obtained from the GFDC were similar to the information found from the main survey. The GFDC in the Ashanti Region operates a small fleet of six 8 tonne payload capacity vehicles of which two were out-of-service due to repairs. The COCOBOD operates a fleet of 33 rigid vehicles and 10 articulated vehicles in the Ashanti Region. However information provided by the COCOBOD included no fixed costs (such as insurance and roadworthiness certificates) and no maintenance costs or schedules.

4.1.3 Vehicle Count

A traffic count of truck movements into and out of Kumasi was designed to verify the results of the main survey. The traffic count was to encompass one of the peak travel periods which occur after 06:00 and before 18:00 due to the night curfew on freight vehicles and the market hours. The six-hour period from 12:00 to 18:00 was chosen to serve this purpose and also to compare results obtained with a similar traffic count undertaken in 1986 [Adarkwa, 1986].

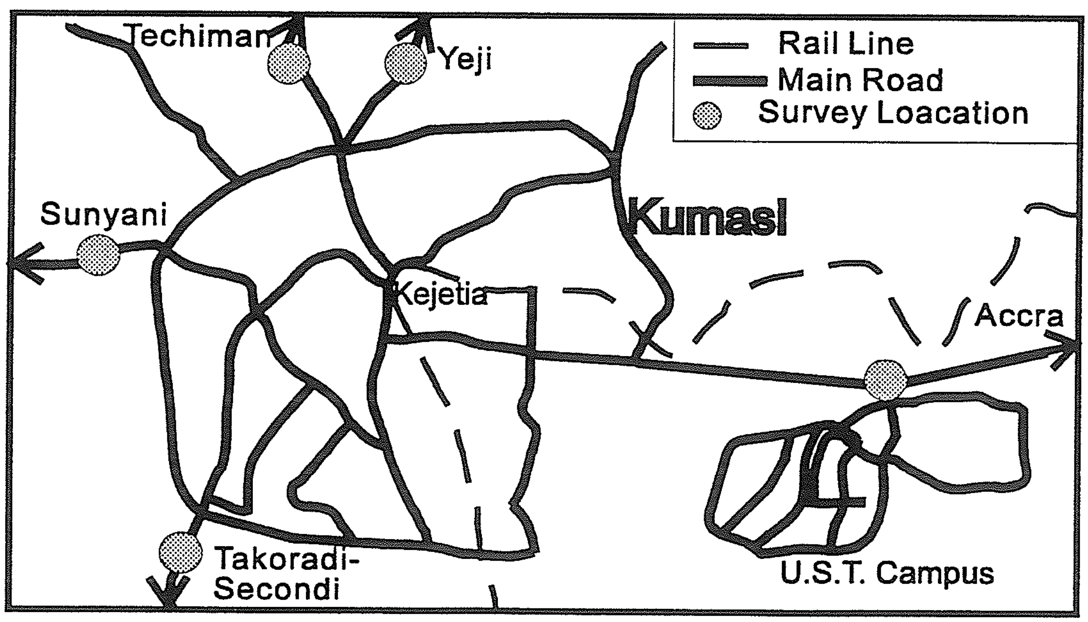


Figure 4.1 Kumasi, showing locations of traffic counts

The vehicle count took place between September 19 and 24 at the five major routes leading from Kumasi (see Figure 4.1). Truck traffic in both directions was counted and classified as to type and number of axles, estimate of payload capacity, and type of load. Types of vehicles were either articulated (tractor semi-trailer units), rigid (straight truck), or mixed passenger/goods vehicles. An estimate of vehicle payload capacity was used to determine vehicle size for the rigid and mixed types of vehicles. Vehicle load was classified as either full, part, empty or unknown; and as either mixed passengers/agricultural commodities, agricultural commodities, manufactured goods, other, or unknown.

The data base described above forms the core of the new information used throughout the research. The data collected serves as an information base on the existing systems and their interaction.

4.2 The Transport System

The agricultural transport system comprises the physical and organizational environment within which the vehicles operate as well as the vehicles themselves. The system operates in response to the demands of the agricultural market and within the organizational structure that operates in the country. The demands of the agricultural market influence the type and number of vehicles in operation, and the type of market organization present in Ghana dictates to a certain extent the loading characteristics of the vehicles. Other influencing factors on the transport system are the road network and the rules and regulations.

4.2.1 The Road Network

The Ghanaian road network comprises approximately 36,000 kilometres of road. Trunk roads and urban arterials make up 14,400 kilometres of the network (of which approximately 6,000 are paved) with feeder roads making up the remaining 21,600 kilometres. The Ghanaian road classification system is based on the level of service they are intended to provide: primary roads provide for long distance inter-regional movement; secondary roads provide access from primary roads to other towns; and feeder roads serve as access roads for agricultural and local economic activity [Fekpe, 1992].Typical design cross sections and photographs of trunk and feeder roads are presented in Figures 4.2a and 4.2b.

Access to cocoa-producing areas was the main impetus in extending the feeder road network in Ghana. However in recent years more emphasis has been placed on maintenance of the road network rather than on its expansion. The World Bank Staff Appraisal Report of 1990-91 states that in 1988 only 24% of roads in the trunk network could be described as being in good condition. Ghana has since embarked on a road maintenance program which is designed to ensure that 68% of the trunk network is in good condition by 1997. The feeder road network maintenance program is concentrated on cocoa evacuation roads. [World Bank Staff Appraisal Report, 1990-91]

Condition of both the trunk and feeder roads varies across the network. Trunk roads are generally passable in all seasons although some are in poor condition, especially in more remote locations. Feeder roads vary from good to very poor condition with some being impassable in the rainy season; in this condition they are used as footpaths and headloading is used to evacuate crops.

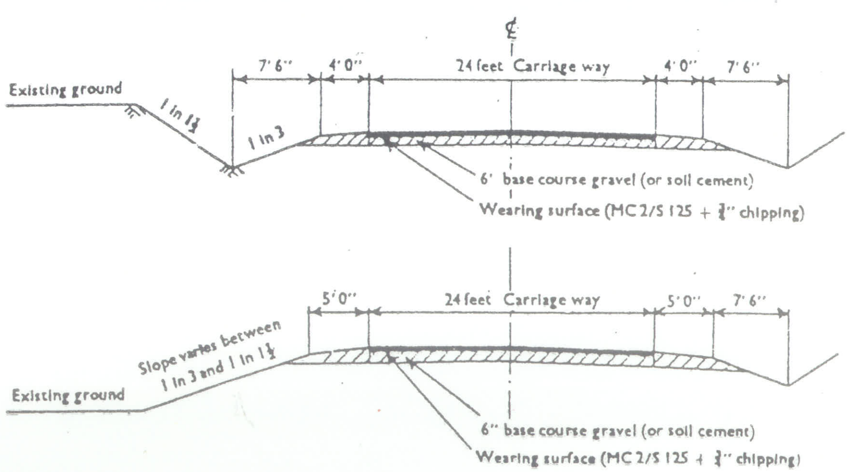


Figure 4.2a Trunk Road: good condition
Source: de Graft-Johnson and Riverson, 1971.

Figure 4.2b Feeder Road: fair condition
Source: de Graft-Johnson and Riverson, 1971.

4.2.2 Rules and Regulations

Size and weight regulations currently in force in Ghana are based on the Road Traffic Ordinance of 1952 from the colonial days of the British Gold Coast. However, "observance and enforcement of regulations is the exception rather than the rule in most respects" [TecnEcon, 1987]. In spite of this, it is important to understand the present legal framework within which vehicles operate and within which policy changes could be made.

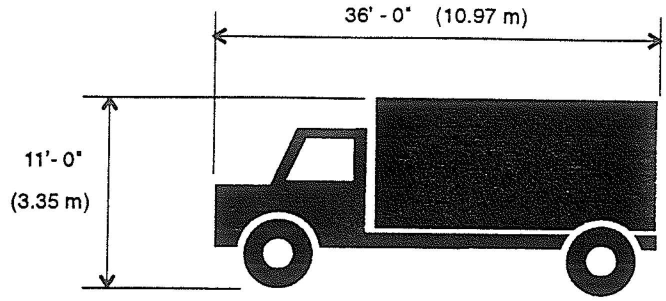
According to Road Traffic Regulations 1974, L.I. 953, maximum sizes for vehicles operating on Ghanaian highways are:

Width:	8 ft. 3 in.	(2.5 m)
Length:		
motor vehicle or trailer:	36 ft. 0 in.	(11.0 m)
articulated vehicle:	42 ft. 8 in.	(13.0 m)
Height:	11 ft. 0 in.	(3.4 m)

Maximum allowed weights are:

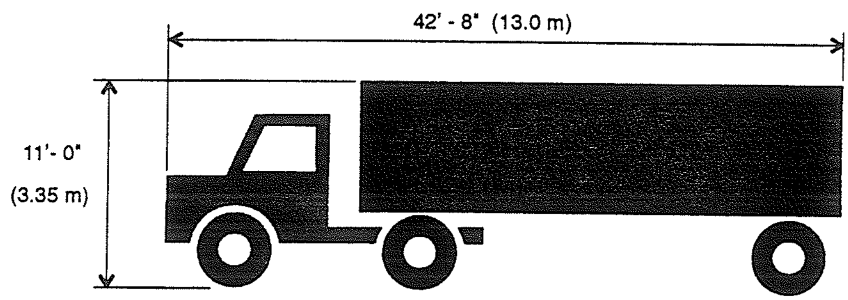
	tons	tonnes
Maximum net weight:		
motor vehicle or motor vehicle and trailer:	16	14.5
Maximum gross weight on single axle:	10	9.0
Non-articulated vehicles maximum gross weight:		
on 2 axles:	16	14.5
on 3 axles:	22	20.0
on more than 3 axles:	28	25.4
Articulated vehicles maximum gross weight:		
on 3 axles:	24	21.8
on 4 and more axles:	32	29.0
Log Carrying vehicles	3 logs	

The maximum allowable weights and dimensions of typical vehicles are illustrated in Figure 4.3.



Straight Trucks : Maximum GVW

2 axles	16 tons	(14.5 tonnes)
3 axles	22 tons	(20.0 tonnes)
4+ axles	28 tons	(25.4 tonnes)



Tractor Semi-Trailers : Maximum GVW

3 axles	24 tons	(21.8 tonnes)
4+ axles	32 tons	(29.0 tonnes)

Maximum Gross Weight per Axle : 10 tons 9 tonnes

Figure 4.3 Maximum Weights and Dimensions
Source: Road Traffic Regulations 1974, L.I. 953
Republic of Ghana

4.2.3 Vehicles

Estimates of the number of vehicles involved in freight transport, and more specifically in the transport of agricultural commodities in Ghana, vary according to source and vehicle classification used. This thesis uses figures obtained from the survey and traffic count, described in 4.1, and assumes it to be a representative sample of vehicles used in agricultural commodity transport in the Ashanti Region.

TYPES

Agricultural commodity transport in Ghana, and more particularly in the Ashanti Region, is not confined to freight vehicles alone. The market and production structures are such that much of the initial transport is done using headloading and mixed passenger/goods vehicles. The extent and amount of headloading as a means of transporting agricultural commodities is beyond the scope of this research; however its importance in the hierarchy should not be demeaned nor forgotten. Primary vehicles used for the transport of passengers and goods in the study area are known as "waton kyene" (twi for 'have you brought salt') and "mammy trucks". The "waton kyene" (Figure 4.4) has a metal body on a truck chassis and a carrying capacity of between 5 and 7 tonnes. The "mammy wagon" (Figure 4.4) has a wooden body on a truck chassis and a carrying capacity of either 1.5 to 3 tonnes or 3 to 5 tonnes. Recently, carrying passengers in wooden bodied vehicles has been prohibited and mixed loads are also carried in mini-buses and covered pick-up trucks.

Figure 4.4a "Waton Kyene"

Figure 4.4b "Mammy Wagon"

Traffic count data in the Kumasi area in September 1992 yielded the traffic mix shown in Table 4.1.

Table 4.1. Vehicle Mix and Loading Conditions
Source: Traffic count

	TRACTOR SEMI-TRAILERS		STRAIGHT TRUCKS	
	#	%	#	%
Traffic Mix	418	24	1298	76
Loaded	209	50	729	56
LOAD (as % of Loaded Vehicles)				
Agricultural	119	57	185	25
Mixed	0	0	214	29

Straight vehicles account for approximately 76% of truck traffic and 56% of these vehicles are loaded. Articulated vehicles account for the remaining 24% and 50% of them are loaded. Table 4.1 shows that over half of all loaded vehicles going to and from Kumasi at the time of the study were carrying agricultural commodities, the proportion being similar for both rigid (54%) and articulated (57%) vehicles. Roughly 30% of the articulated vehicles counted as carrying agricultural commodities were identified as carrying either logs or sawn timber.

Vehicle types can be classified according to vehicle configuration or vehicle payload capacity as well as the broad “straight” and “tractor semi-trailer” categories shown above. Fleet composition according to configuration and payload capacity is shown in Tables 4.2 and 4.3.

Table 4.2 Fleet Composition: Configuration

CONFIGURATION	NUMBER	%
"MAMMY WAGON"	97	20
"WATON KYENE"	100	21
STRAIGHT TRUCKS	245	51
ARTICULATED	38	8
UKNOWN	2	0
TOTAL	482	100

Table 4.3 Fleet Composition: Payload Capacity

PAYLOAD CAPACITY	NUMBER	%
UP TO 1 TONNE	92	19
1 TO 3 TONNES	43	9
3 TO 5 TONNES	248	51
5 TO 10 TONNES	30	6
10 TO 20 TONNES	16	3
UNKNOWN	53	11
TOTAL	482	100

The tables show the distribution of configuration and size of vehicles carrying agricultural commodities in the Kumasi area. Over 50% of the vehicles surveyed are straight trucks, which generally only carry goods. "Mammy Wagons" and "waton kyenes" (41%) are vehicles which generally carry a mixed load of passengers and goods. The majority of vehicles surveyed (51%) have a payload capacity of between 3 and 5 tonnes with the 5 tonne capacity being the most common in this category. Vehicles up to 3 tonnes account for 28% of the fleet. Vehicles with a payload capacity greater than 5 tonnes account for only 9% of the fleet.

Tractor semi-trailers represent 8% of the respondents to the questionnaire yet they represent 24% of the fleet according to the vehicle traffic count. This discrepancy can be explained in part by the fact that only vehicles carrying agricultural commodities were considered in the survey, whereas the traffic count recorded all trucks passing the survey point. Also, a large percentage of articulated vehicles carrying agricultural commodities are timber hauling vehicles that do not typically acquire loads at lorry parks where most of the questionnaires took place. Given that 119 of the 518 vehicles carrying agricultural commodities or mixed loads are tractor semi-trailers, they should comprise approximately 23% of the questionnaire respondents.

AGE

Age is also an important factor in describing the fleet of vehicles responsible for the transport of agricultural commodities in the Ashanti Region. Over 75% of the questionnaire respondents did not know the age of the vehicles they were operating. A cumulative distribution graph of the vehicles with known ages is shown in Figure 4.5.

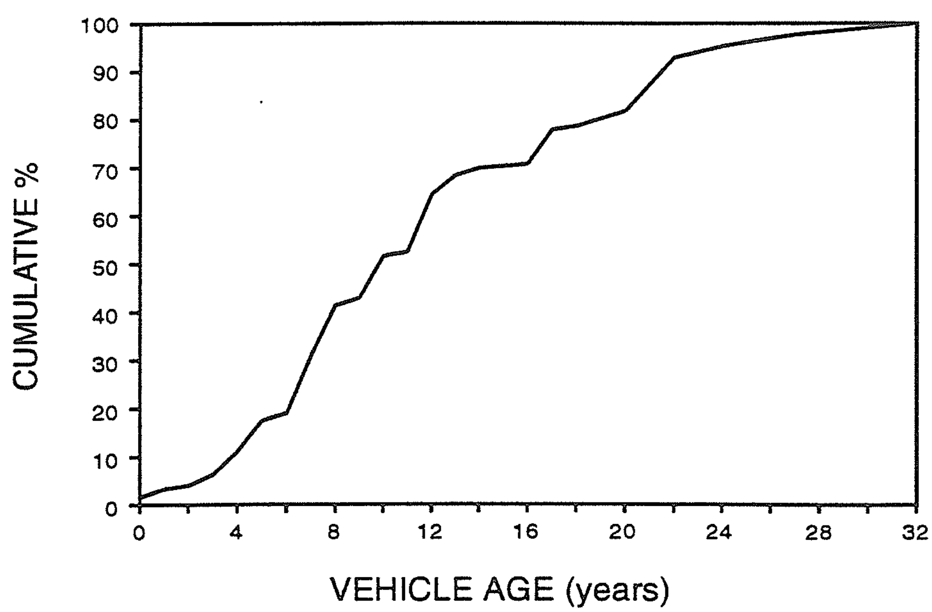


Figure 4.5 Age Distribution of Fleet

The fiftieth percentile is at approximately 10 years; half the vehicles in the fleet are over 10 years old. The twenty-fifth percentile is at 6.5 years; the seventy-fifth is at 17 years. (Newer trucks probably tend to be over-represented in the survey because their age is known. A large number of vehicles are imported into Ghana as second-hand vehicles and their age is not known.)

LOADING

Vehicle loading characteristics are an important factor in determining the fleet's operating characteristics. Payload capacity and loading conditions were known for 86% of the vehicles surveyed; 75% of them were loaded. Exact load weight was unknown to the driver in most cases, and weight was calculated from average weight for commodities carried. A list of commodities and average weights is given as Appendix C.

The survey shows a higher representation of loaded vehicles than the vehicle count which showed 50% to 60% of loaded vehicles. It is assumed, for the purpose of this research, that loading characteristics of the vehicles surveyed is representative of the vehicle population. Table 4.4 indicates loading conditions for surveyed vehicles according to payload capacity.

Table 4.4 Loading Conditions by Payload Capacity

Payload Capacity	Loaded #	Loaded %	Average Load % of Capacity	Less than 100% Load #	Less than 100% Load %	Carrying Passengers #	Carrying Passengers %	Passenger Insurance #	Passenger Insurance %
<= 1 T	76	83	227	13	17	12	16	36	39
1 - 3 T	32	73	107	14	44	3	9	13	30
3 - 5 T	180	73	184	54	30	19	11	53	21
5 - 10 T	18	60	72	10	56	2	11	7	23
10 -20 T	15	94	263	U/K	0	0	0	0	0
Total	321	75	184	91	28	36	11	109	25

U/K - Unknown

Further calculations based on the figures shown in Table 4.4 show that vehicles are loaded to an average of 184% of their registered payload capacity. Further, 28% of loaded vehicles are carrying loads that are less than or equal to their registered payload capacity.

Only 11% of loaded vehicles were carrying passengers as well as agricultural commodities although 25% of all vehicles surveyed reported that they are insured to carry passengers. Over a third of vehicles with a payload capacity up to 3 tonnes are insured to carry passengers. One fifth of vehicles with payload capacity between 3 and 10 tonnes are insured to carry passengers.

Vehicles in Ghana are insured to carry *either* passengers or goods. Passengers travelling in freight vehicles and goods transported in passenger vehicles are therefore not insured [S.I.C.]. Mixed loads of passengers and goods generally occur when small producers accompany their goods to market. Quantities of goods carried by each producer do not warrant hiring a vehicle and goods are transported with the producer by the most readily available vehicle.

Results of the survey show that 53% of loaded vehicles use lorry parks either as a main source of loads or to obtain backhauls if the main haul was obtained directly from a customer. Only 20% of loaded vehicles surveyed had obtained their loads from sources other than lorry parks or customers. Most of the other sources were recorded by vehicles owned and operated by a specific company and used for hauling their own commodities, such as trucks hauling goods for a public or private corporation. Table 4.5 shows the method of obtaining loads for all loaded vehicles by payload capacity.

Table 4.5. Method of Obtaining Loads

			Current Load Obtained							
Payload Capacity	Loaded #	Loaded %	Lorry Park #	Lorry Park %	Directly From Customer #	Directly From Customer %	B/H at Park #	B/H at Park %	Other Means #	Other Means %
<= 1 T	76	83	30	39	39	51	16	41	6	8
1 - 3 T	32	73	11	34	14	44	4	29	7	22
3 - 5 T	180	73	68	38	76	42	31	41	35	19
5 - 10 T	18	60	8	44	4	22	1	25	5	28
10 -20 T	15	94	1	7	1	7	0	0	12	80

The table shows that a majority of vehicles obtain their loads directly from customers (42%) rather than from lorry parks (37%) or from other sources (20%). However 39% of vehicles obtaining loads directly from customers acquired backhauls at lorry parks. Lorry parks therefore play a significant role in the transportation of agricultural commodities in the Ashanti Region.

4.2.4 Lorry Park System

The vehicle survey revealed that lorry parks are an important factor of the transportation system in the Ashanti Region. Since more than half of the agricultural commodities transported in the region are processed through lorry parks, they are an essential component of the transport system. An understanding of the lorry park system is fundamental to the study.

Lorry parks function throughout Ghana. The vast majority of them are operated by the Ghana Private Road Transport Union (GPRTU) who control 80% of the Ghanaian transport industry [Regional Industrial Relation Officer, GPRTU of TUC, Ashanti Region]. Generally, the parks belong to the municipality but their operation is given over to a managing organization which is usually the GPRTU. Large lorry parks are generally organized according to type of vehicle, type of transport, and final destination. For example, in the main lorry park in Kumasi, Kejetia, different areas of the park are designated to buses, taxis, and freight vehicles. Further, areas are designated for each type of vehicle by destination, for example at the main lorry park in Kumasi, taxis to the University, Airport, and Asafo market are found at the same location; but buses for those same destinations are in a different area in the park.

Vehicles queue for loads and are loaded on a first come first serve basis, the customer having no choice of vehicle. This queuing system applies for all types of vehicles at all lorry parks. Each vehicle is registered at a given lorry park for a given route and must wait its turn for a return load. A fee is charged by the GPRTU to register for a route and the amount is route dependent; a higher fee is paid for what is deemed to be a more profitable route. Registration fees are paid once for the lifetime of the vehicle. A vehicle may be registered on more than one route but may not queue for two routes at the same time. That is, a vehicle registered on two routes may not make one run while keeping its place in the other queue.

The GPRTU levies user charges on vehicles using the parks as well as charging a registration fee on given routes. The user fee is a commission paid on the value of the transport; it is 5% according to GPRTU officials but may be as high as 10% according to survey response and other interviews. Daily tolls, C100 in Kumasi, are also charged as an entry fee into the park. The toll fee is collected on behalf of the local municipal authority for rental and upkeep. The GPRTU is also charged with the collection of the 3% income tax on behalf of the Internal Revenue Service.

Loading, consignment, and consolidation of less than truckload (LTL) freight is done by porters who are also members of the GPRTU. The consignor hires porters, generally at the market, who will transport and load the goods as well as find and hire an appropriate vehicle. Porters are usually paid a percentage of the transporter's user fee.

Transporters in the for-hire business are compelled to use lorry parks in order to acquire loads. Interviews with other transport organizations suggest that the GPRTU holds a virtual monopoly of the transport industry especially in the Ashanti Region. It is reported that loads acquired and off-loaded outside lorry parks by non-registered vehicles are still required to pay the usual commission as well as the income tax to GPRTU representatives [interview with PROTOA, Kumasi].

4.3 The Agriculture System

Kumasi's main market is one of the largest in West Africa and it serves as a consolidation/distribution point for many agricultural commodities neither grown in nor destined for the Ashanti Region. The part of the agricultural system that creates a demand on the transport system of the Ashanti Region and defines its flow pattern includes the marketing structure. Kumasi and therefore the Ashanti Region, play an important role in the Ghanaian agricultural market.

4.3.1 Agricultural Commodities

Ghana is a net exporter of agricultural commodities according to the World Bank Database (1989). Agricultural exports account for over 60% of its acquisition of foreign exchange with cocoa and cocoa products representing approximately 90% of its agricultural exports in $US (excluding timber products). Other agricultural exports are coffee, sheanuts, fish, and non-traditional exports such as pineapple, yam and kola nuts. Major agricultural imports are cereals and cereal products and sugar which were responsible for 59% (in $US) of agricultural imports into Ghana in 1989 [World Bank Database, 1989]. Other agricultural imports are fish, cotton, fertilizers, milk, and livestock and meat.

Ghana also produces agricultural commodities for domestic consumption. These include a variety of grain crops (maize, rice, millet, guinea corn), tubers (cassava, yam, cocoyam, plantain), pulses and nuts (groundnuts, beans, coconuts) as well as vegetables (tomatoes, garden eggs, okra, onions, pepper) and fruits (pineapple, oranges, mangoes, bananas) which are normally found in markets throughout most of Ghana.

Ghana comprises three distinct geographical zones: coastal plains, tropical rain forest, and semi-arid area. Each of these areas has a different climate, growing season, and agricultural practices. Different commodities typically are produced in each of the regions but most commodities are consumed in all regions.

4.3.2 Production and Consumption Patterns

Two broad production/consumption agricultural patterns exist in Ghana: the export pattern and the domestic pattern. The export pattern is directed from the areas of production throughout the country towards the two main ports (Tema and Takoradi-Secondi) for export. This pattern applies mostly to cocoa and timber as the two main agricultural crops. The domestic pattern of production and consumption is not as simple and straightforward as that of export commodities. Export crops have a wide production network and a narrow consumption network in Ghana; domestic crops have both wide production and consumption networks.

Production areas for the two main export crops, cocoa and timber, are concentrated in the tropical rain forest area of Ghana. Main production areas for cocoa encompass parts of Western, Ashanti, Eastern, and Brong Ahafo Regions. Main production areas for timber are the Ashanti and Brong Ahafo Regions. Since the majority of these crops are exported, their 'consumption' areas are the ports at Tema and Takoradi-Secondi.

Major production areas for domestic agricultural commodities in Ghana vary with the commodity. Major surplus areas for maize are found in the Northern Region and in eastern Brong Ahafo region . Surplus areas for yams are found in the North Region, north-eastern Brong Ahafo Region, and northern Volta Region . Tomatoes, other fresh vegetables, and irrigation project (off-season) vegetables are found in north Eastern Region, Ashanti Region, and Greater Accra Region. Major livestock producing areas are found in northern Ghana (Northern, Upper East, and Upper West Regions). In general terms, grain crops and livestock are produced in the northern, more arid areas where there is only one definite rainy season. Other vegetable crops as well as cocoa and timber are produced in the tropical rain forest area which enjoys two rainy seasons. Coastal areas are responsible for major coconut and pineapple productions. [PPMED, 1989]

Major consumption areas for domestic agricultural commodities in Ghana "are almost invariably the urban towns/cities of Accra, Tema, Kumasi, Secondi-Takoradi, Ho, Tamale, and the Obuasi mining town, whose markets on the average record the highest food prices in the country" [CTCS, 1992: p.17]. With the exception of Tamale, in the Northern Region, all major consumption areas are located in the southern third of Ghana; three of the major consumption centres (Accra, Tema, and Takoradi-Secondi) are on the coast.

4.3.3 The Marketing System

The marketing system for agricultural commodities in Ghana follows different procedures according to end market: export or domestic. Typically, export commodities are produced in large quantities specifically for external markets. In the case of cocoa, farmers sell their produce directly to Produce Marketing Board depots located in villages in the production areas. Cocoa is concentrated at the origin to transport and export in bulk quantities. Domestic commodities are produced in smaller quantities, with producers generally selling surplus quantities. Domestic commodity producers then depend largely on a series of itinerant traders, market-based traders, wholesalers, and retailers to get their produce to the final consumers.

Both major agricultural export crops, cocoa and timber, follow similar marketing patterns. Both crops are concentrated at the origin and are transported to final export from the concentration point in large, generally articulated, vehicles. Both crops rely on a single marketing agent between producer and export: either the COCOBOD, or the Timber Board or a timber company.

Domestic commodities, due to their pattern of production and consumption, are submitted to a series of marketing agents. The small amount of surplus produce that each farmer has for sale must be consolidated a number of times before it reaches the final wholesaler and the end retailer and consumer. Surplus produce is bought from the farmer by an itinerant trader who may buy produce from a number of farmers in the area. Due to the small quantities they sell, producers are reliant on the itinerant traders to buy their goods and transport them to market. The traders often provide credit or production inputs to the farmers and in exchange obtain commitment on supply. Itinerant traders sell produce at a local market to a market-based assembly trader. The market-based traders are generally led by a market or produce "queen" who exerts some control over trading prices and practices at the given market. Produce bought and consolidated by the assembly trader is then bought by a wholesaler at a village or regional market. Produce is bought, consolidated, and sold in this manner until it reaches the final wholesaler who will in turn sell to retailers. Depending on the locations of first sale and final consumption, produce may be bought and sold five times between producer and final retailer.

Certain markets in Ghana, due to their central location, function as consolidation/distribution centres from which commodities are shipped to several other areas. Kumasi is an example of such a market for north and southbound agricultural and commercial commodities. Techiman serves as a consolidation/distribution market for such commodities as maize and yam.

4.4 The Flow Pattern

Seasonality and quantity of production in the agriculture system influence the amount of transport required and at what time. Availability and type of transport affect the marketing of agricultural commodities. The flow pattern generated by the interaction is qualified by commodity and vehicle flows, and quantified by the resources consumed and level of service provided.

The pattern of commodity movement may also be explained by Galtung's centre-periphery theory [Galtung, 1978]. Galtung's theory states that under-developed and developed countries or regions develop an interdependency that is based on the peripheral or underdeveloped regions providing raw materials to the centre or developed regions. The exchange between the centre and the periphery is unequal, nearly to the point of exploitation. The Ghanaian situation is such that the centre, defined here as the main population centres or roughly the Accra-Kumasi corridor, is supplied with raw material (food and agricultural commodities on which the economy depends) by the peripheral regions or the subsistence-level producers. The relationship is exemplified by the road network which has a dendritic structure and eventually leads to Accra. Kumasi serves as the gateway city, on the edge of the periphery, providing an all-important link between the centre and the periphery.

4.4.1 Commodity Flows

Commodity flows are defined by production seasons for the different commodities in the various regions. Table 4.6 shows the harvesting periods for various crops by region.

Table 4.6 Major Crop Harvest Seasons by Region

CROP	REGION	HARVEST PERIOD
Maize	rainforest	August-September
	north	September-October
Rice	coastal/rainforest	August-September
	north	October-December
Millet	north	October-December
Guinea corn	rainforest/north	October/December
Cassava	rainforest	April-June
	north	November-December
Yam	rainforest	July-December
	north	August-December
Cocoyam	rainforest	April-June
Groundnuts	rainforest	August-September
	north	September-November
Beans	rainforest	August-September
	north	September-November
Tomatoes	coastal	March-April
	rainforest	September-October
		February
	north	February-March
Garden Eggs	rainforest	September-December
Okro	all regions	October
Onions	north	June & March
Pepper	rainforest	March-April
	north	October-November
Pineapple	coastal	April-June
Orange	rainforest	October-November
Mangoes	rainforest	May-June
	north	November-January
Cotton	north	October-December
Oil Palm	rainforest	February-April

[Source: Ministry of Agriculture]

The regions described in Table 4.6 refer to the geographical regions of Ghana as described above (Section 4.3.2 Production and Consumption Patterns). Information from Table 4.6 regarding harvesting seasons reveals that the rainforest area enjoys two harvest seasons a year; the first is from February to June with the peak in April; the second, more important season, is from August to December with the peak in September. Harvest of cocoa coincides with the second harvest season, in November and December. The north region has only one major harvest season, from September to December, with the peak in November. The coast, like the rainforest, has two harvests but the seasons are shorter on the coast with one harvest in August-September and one in March-June.

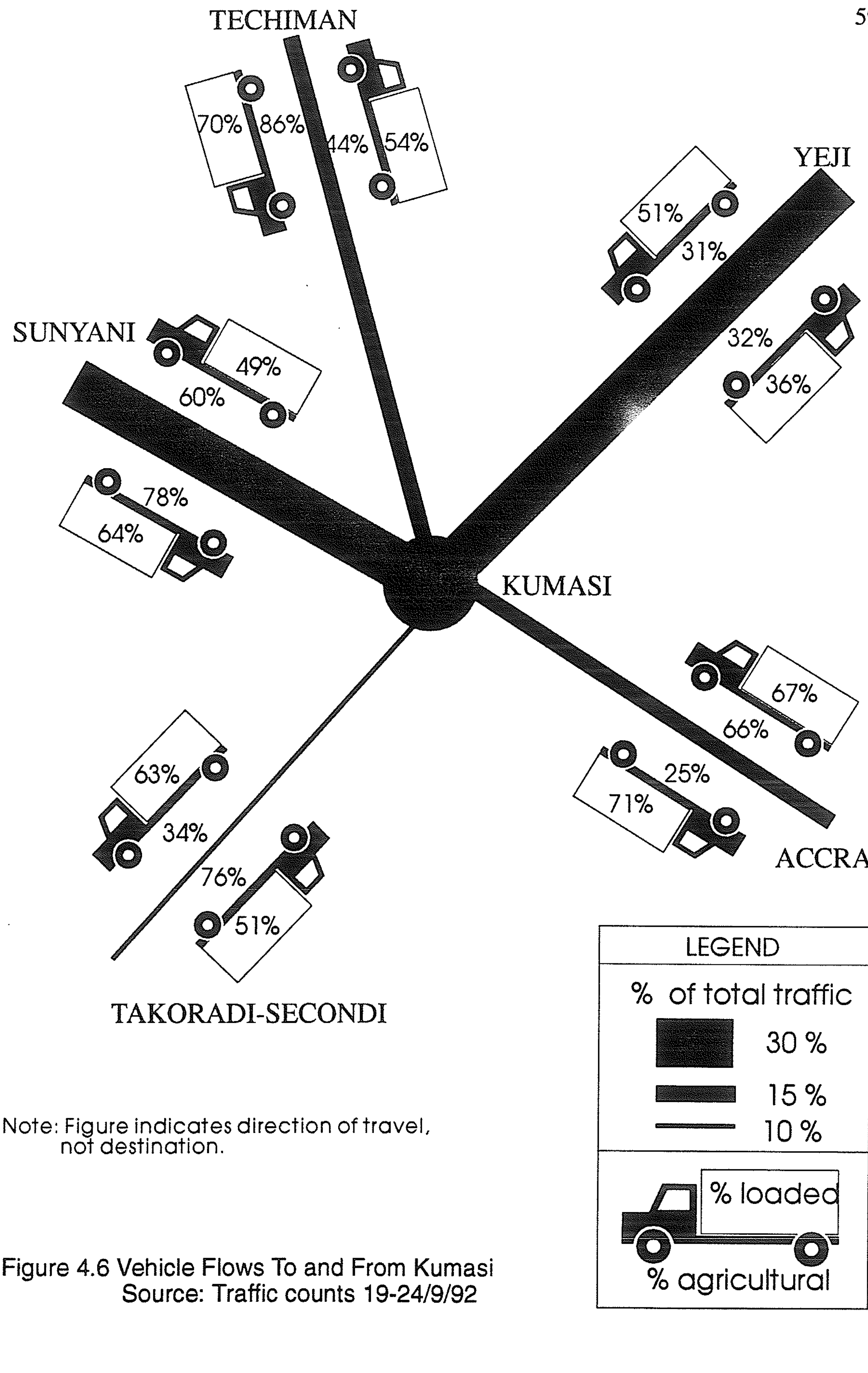
Agricultural commodities in Ghana are consumed or exported in the south of the country. The export points of Tema and Takoradi-Secondi are on the coast and the main population centres are located in the southern regions of Ghana. Commodity flows are therefore generally north-south.

Kumasi has historically enjoyed a preferred role in the transportation network of Ghana and still maintains the position of gateway city to the northern regions. Its position at the apex of the rail triangle (Takoradi-Secondi; Accra-Tema; Kumasi) and at the 'main node' of the trunk road network (see map of Ghana, Figure 1.1) has assured its importance within the transport network. Kumasi's central position in the transportation network has caused it to become an important city in the agricultural commodity market and it serves as an assemblage and break of bulk point for many commodities destined for the northern or southern regions.

4.4.2 Vehicle Flows

Agricultural transport demand in Ghana was estimated to be approximately 630 million tonne-kilometres in 1987 [TecnEcon, 1987]. The figure included 50 million tonne-kilometres for cocoa, 180 million for food grains, and 400 million for other farm products. The Ministry of Agriculture (MOA) figures (PPMED Statistics Division) give production levels of 7.7 million metric tonnes for 1987, exclusive of cocoa. These figures result in an average transport rate of 88 kilometres for every tonne of agricultural commodity produced in Ghana in 1987. Over 90% of the resulting transport is done by road.

Data obtained from the traffic counts around Kumasi are shown schematically in Figure 4.6 to illustrate vehicle direction, loading condition and number carrying agricultural commodities.



Note: Figure indicates direction of travel, not destination.

Figure 4.6 Vehicle Flows To and From Kumasi
Source: Traffic counts 19-24/9/92

Vehicles carrying agricultural commodities represent 57% of loaded trucks travelling to Kumasi and 54% of loaded trucks travelling from Kumasi according to the traffic counts done in Kumasi in September 1992 (63% of all trucks were either loaded or partly loaded). Vehicles to and from the north (Sunyani, Techiman and Yeji) represent 74% of all traffic to and from Kumasi with 59% of loaded vehicles carrying agricultural commodities to Kumasi and 40% of loaded vehicles carrying agricultural commodities from Kumasi. Vehicles to and from the south (Accra and Takoradi-Secondi) represent 26% of all traffic to and from Kumasi with 39% of loaded vehicles carrying agricultural commodities to Kumasi and 70% of loaded vehicles carrying agricultural commodities from Kumasi. Clearly, the flow of agricultural commodities going south is more significant than that going north. The north-south flow is more pronounced on the southern routes (from Kumasi to Accra and Takoradi-Secondi). Flow of agricultural commodities on northern routes is heavier on the southern journey than it is on the northern journey, but the difference is not as great illustrating the role of Kumasi as a dissemination point in the network.

Another method of qualifying the vehicle flow in and around Kumasi is to locate the trip and vehicle origins of vehicles surveyed for the research. Table 4.7 gives the origin of the vehicle for its present trip, the owner's home province or vehicle base, and the driver's home province or base of operations.

Table 4.7 Vehicle and Trip Origins

REGION	CURRENT ORIGIN #	CURRENT ORIGIN %	OWNER BASE #	OWNER BASE %	DRIVER BASE #	DRIVER BASE %
Ashanti	253	52	378	78	371	77
Kumasi*	129	51	302	80	275	74
Brong Ahafo	118	24	42	9	46	10
Central	2	0	2	0	2	0
Eastern	0	0	3	1	3	1
Greater Accra	29	6	16	3	15	3
Northern	26	5	12	2	14	3
Upper East	17	4	5	1	8	2
Upper West	10	2	3	1	3	1
Volta	0	0	1	0	2	0
Western	19	4	9	2	9	2
Other	7	1	1	0	1	0
Unknown	1	0	10	2	8	2
TOTAL	482		482		482	

* All percentages for Kumasi are given as a portion of the Ashanti Region.

Table 4.7 shows that 52% of current trip origins were based in the Ashanti region and that 51% of those were based within the Kumasi municipal area. The Kumasi-based trip origins include those vehicles that were empty and had been waiting for a load in Kumasi at least overnight at the time of the survey. "Other" trip origins were all from out of the country: five from Togo, one from Burkina Faso, and one from Cote d'Ivoire. A higher percentage of vehicles give the Ashanti Region as the vehicle base (78%) or as the base of operation (77%) than as the current trip origin.

CHAPTER 5: TRUCK OPERATING COST MODEL

5.1 Framework of the Ghanaian TOC Model

The data on truck operating costs and characteristics collected in Kumasi in 1992 are used to formulate a Truck Operating Cost (TOC) model. The model is a deterministic model based on mean value parameters obtained from the raw data. This is a "Trimac-like" model which divides the vehicles according to type by number of axles, load (mixed passenger/goods or freight), and size (payload capacity). The model is used to establish average costs of the various types of vehicles used in the transportation of agricultural commodities in Ghana. Further, the model is used to predict TOC for operating conditions other than average actual conditions.

Two broad categories of vehicles are examined in the TOC model: straight trucks and tractor semi-trailers. All straight trucks surveyed were 2-axle trucks; this category is divided into two use classes: mixed passenger/goods vehicles and freight trucks. The straight trucks in both classes are further subdivided according to payload capacity: up to 1 tonne, 1 to 3 tonnes, 3 to 5 tonnes, and greater than 5 tonnes. Tractor semi-trailers are all freight vehicles and are divided into classes according to the number of axles: 2-S1 and 2-S2. Vehicle classification of the TOC model is illustrated in Figure 5.1.

Truck operating costs for the model are expressed as annual, per kilometre, and per payload tonne-kilometre (T-km). Yearly costs divided by the average annual distance travelled yield the cost per kilometre. Annual costs divided by average annual T-km (average annual distance/2 x average payload) yield the cost per tonne-kilometre. For the purpose of the model, 50% of the average annual distance is considered to be loaded. Truck operating costs for the model are identified as fixed or variable. Fixed costs are those which do not vary with utilization. Variable costs are a function of utilization.

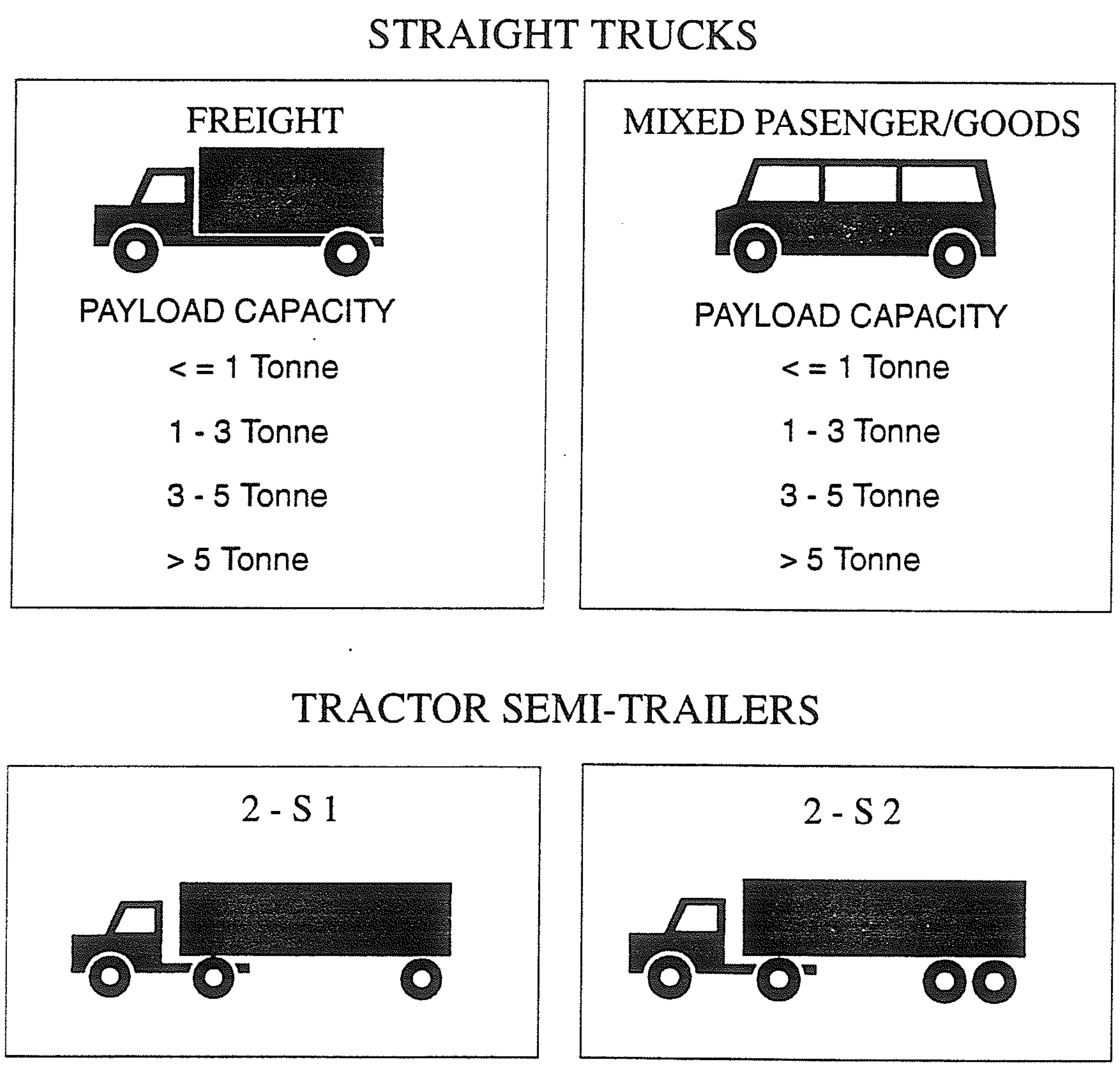


Figure 5.1 Vehicle Classification

5.1.1 Fixed Costs

Costs included as fixed costs in the Ghanaian TOC model are: labour expenses, insurance, roadworthiness certificate, and capital costs. Including labour expenses as a fixed cost is problematic. Testing the questionnaire indicated that in some instances workers are not paid a wage but rather given informal payments (often referred to as "chop money") or alternately, receive both informal payments and a wage. The category labour expense is an attempt to calculate the full cost of employees to truck operation; it includes both formal (wages) and informal payments - Expenses = wage + informal payments.

Although it is recognized that the informal portion of labour expenses is a function of utilization, the main portion of labour expenses is wages, and so informal costs are integrated with wages in this model as labour expenses. Labour expenses for driver(s) and mate(s) are generally paid monthly rather than on an hourly or distance-related rate. Since they are incurred whether the vehicle is being operated, waiting to be loaded, or out-of-service for repairs, they are designated to be a fixed cost.

All vehicles operating in Ghana must carry insurance[1], and obtain a roadworthiness certificate[2]. Both these costs are incurred as long as it is on the road and are not a function of utilization; they are therefore fixed costs.

Capital costs in the model are expressed as an average annual cost. Purchase price is converted to 1992 cedis using the ratio of Consumer Price Index (CPI) between the year of purchase and 1992. Straight line depreciation is assumed between year of purchase and current value:

$$D = \frac{P - S}{N}$$

where D is the estimate of annual depreciation, P is the purchase price, S is the salvage or current value, and N is the length of ownership. Capital costs (C.C.) for 1993 are estimated to be depreciation cost plus the opportunity cost of capital or:

$$C.C.(93) = D + S(i)$$

where D and S are as above and (i) is the real interest rate. An interest rate of 10% is used: the difference between current bank rate (19%) and an estimated inflation rate (9%). The 9% inflation rate is an average of inflation rates for 1989 to 1991. All costs are given in 1992 Cedis.

Since vehicle capital costs are calculated on an average annual basis and are not a function of vehicle utilization, they are included with the fixed costs in the TOC model.

5.1.2 Variable Costs

Costs included as variable costs in the model are: repair, tire replacement, fuel, and loading charges. These costs are a function of utilization, and mean utilization rates are calculated for each type of vehicle. Journey distance is the average of mean journey distances obtained from the survey; the data are augmented using actual distances between origin and destination. Number of trips per month is calculated using the average of mean monthly utilization divided by journey distance calculated above. Average monthly distance is the product of number of journeys and journey distance. Average number of days off the road due to repairs is taken into account in order to estimate annual distance travelled. A sample calculation is given in Endnote 3.

Repair costs are calculated using the mean of the estimated average monthly cost of repairs. The assumption is made that mean repair costs apply to a vehicle of mean age and that the repair costs are a function of vehicle utilization. Yearly repair costs are taken as 12 times the mean monthly repair cost; costs per kilometre and per tonne-kilometre are calculated from the mean yearly cost.

Tire replacement schedules are sorted according to number of wheels on the vehicles; the mean number of tires replaced for the most common vehicle is used. Prices were obtained for new and "home second hand" tires; however it was assumed that most tire replacements would be home seconds. ("Home second hand" tires are imported used tires.) Retreads are available in Ghana but their use is not common. Tire cost and sizes are shown in Table 5.1.

Table 5.1 Tire Sizes and Cost

		COST (Cedis)	
Truck Size	Tire Size	New (Import)	Home Second
<= 1 T	600 x 14/8	43253	18000
1 - 3 T	750 x 16/10	59081	25000
3 - 5 T	825 x 20/12	128750	40000
> 5 T	1000 x20/16	158880	55000
Tractor Semi	1100 x 20/16	190372	66000

[Source: personal notes from B.R.R.I, Kumasi]

Fuel costs are calculated using the mean fuel consumption rate for vehicles in each class. August 1992 fuel prices (diesel, 165 Cedis/litre; petrol, 198 Cedis/litre) are used to calculate yearly costs.

Loading and unloading charges are taken to be the mean costs incurred by vehicles using lorry parks. Since a majority of vehicles obtain their load or their backhaul load at a lorry park this is considered a valid assumption.

5.2 Straight Trucks: Freight

The class of straight trucks carrying freight includes all vehicles designated as rigid vehicles indicating that they were not insured to carry passengers. This describes 226 (47%) of the vehicles surveyed. A summary of vehicle characteristics is given in Table 5.2 and a summary of vehicle operating costs under average actual conditions in Table 5.3; costs are given as Cedis per Tonne-kilometre (C/T-km). Vehicle operating cost data are found in a more complete form in Appendix D. A comparison of relative operating costs of all types of freight trucks is given in Figure 5.2.

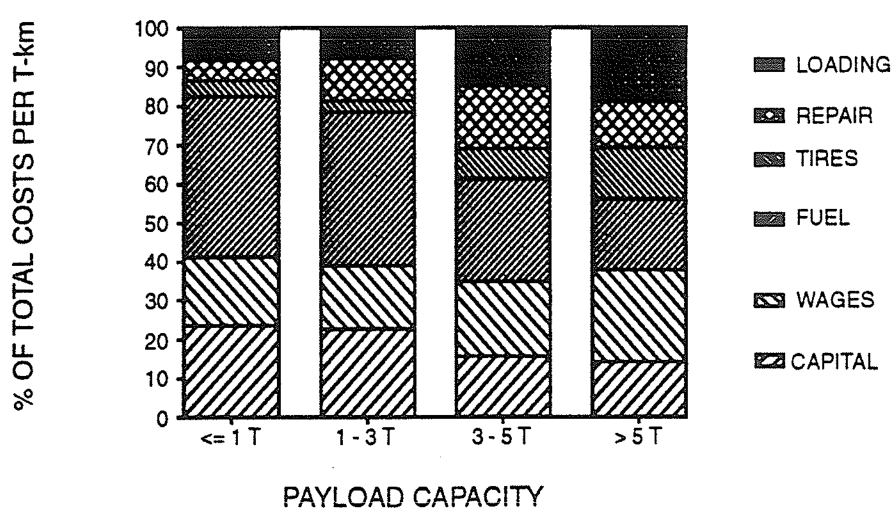


Figure 5.2 Relative Cost Components: Freight
Actual Average Operating Conditions

Table 5.2 Vehicle Characteristics: Freight

	PAYLOAD CAPACITY			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
NUMBER OF VEHICLES	35	19	147	16
CONFIGURATION				
Rigid Truck	35	19	146	16
Other			1	
MAKE				
Peugeot	6			
Toyota	7			
Albion			27	
Benz		6	43	3
Leyland			15	3
Ford				3
VW	5	5		
Other	17	8	62	7
CYLINDERS				
4	29	11	8	3
6	5	6	129	13
8			4	
FUEL				
Petrol	23	6	3	1
Diesel	12	12	143	15
WEIGHT AND CAPACITY				
GVW (T)	2.28	5.00	10.13	11.84
Tare (T)	1.52	2.76	5.18	3.81
Payload (T)	0.76	2.24	4.95	8.03
AGE (years)	8.1	9.6	14.3	10.0
INSURANCE				
Commercial	29	15	86	15
General	27	15	119	11
Other	2			4
Type				
3rd Party	28	15	92	11
Comprehensive	1		2	1
Other	6	4	53	4
CARRYING PASSENGERS	2	0	1	0
MANAGEMENT AND OWNERSHIP				
Vehicle Owner				
Individual	28	10	116	14
Driver	7	5	18	1
Other		4	13	1
Managed with Other Vehicles				
Yes	6	5	44	5
no. of vehicle	3	2	3	3
Regular Route	14	10	65	8
ACCIDENTS LAST YEAR				
None	32	16	123	14
1	2	1	19	1
2	1	1	3	1
3			1	

Table 5.3 Truck Operating Costs: Freight
Actual Average Operating Conditions

	2-AXLE STRAIGHT TRUCKS			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
NO. OF VEHICLES	35	19	147	16
FIXED COSTS				
WAGES	28.82	36.14	8.87	23.89
INSURANCE	0.41	0.74	0.20	0.37
CAPITAL COST	38.73	50.05	7.27	14.55
VARIABLE COSTS				
FUEL	67.62	87.72	12.38	18.74
TIRES	6.82	6.61	3.62	13.39
REPAIR	8.44	23.78	7.34	11.78
LOADING	13.14	17.07	6.80	19.01
TOTAL (C/T-km)	163.98	222.11	46.48	101.73

5.2.1 Payload Capacity: Less than or equal to 1 Tonne

A snapshot of the typical vehicle in this class would show an eight-year-old Toyota or Peugeot, 4-cylinder, petrol-fuelled pick-up truck with a payload capacity of 0.75 tonne. The vehicle is owned and managed by an individual who is not the driver, 40% of its trips are made over a regular route, and it is not managed with any other vehicles. (Less than 1/5 of vehicles are managed with, on average, 2 other vehicles.) The vehicle carries third party insurance, and is insured as a commercial vehicle to carry general freight. Vehicle characteristics are shown in Table 5.2.

The typical vehicle obtains 61% of its loads directly from a customer, 35% are obtained from a lorry park, and 4% from other sources. The customer guarantees 21% of its backhaul loads; 32% are obtained from lorry parks; 37% are empty; and the rest are obtained from other sources. Wait time for the current load was more than twice as long at lorry parks (26.5 hours) than it was for loads obtained from customers (9.9 hours). Average time between loads is 28 hours. The vehicle typically spends from 18 to 36 days a year out-of-service due to repairs.

Mean utilization and costs for this class of truck are shown in Table 5.3 and Appendix D. Analysis of costs, Figure 5.2, shows that fixed costs represent 43% and variable costs 57% of the total operating costs. The most significant fixed costs are vehicle capital costs at 25% of total costs; and the most significant variable cost is fuel at 43% of total costs.

5.2.2 Payload Capacity: 1 - 3 Tonnes

A snapshot of the typical vehicle in this class would show a 10- year-old, European (Benz or VW), 4-cylinder, diesel-fuelled straight truck with a payload capacity of 2.25 tonnes. The truck is owned and operated by an individual who is not the driver, more than half of its trips are made over a regular route, and it is not managed with other vehicles. (One quarter of the trucks are managed with, on average, 1 other truck.) The truck carries third party insurance and is insured as a commercial vehicle for general cartage. Vehicle characteristics are shown in Table 5.2.

The typical vehicle obtains 50% of its loads directly from a customer, 36% are obtained from lorry parks and 14% from other sources. The customer doesn't guarantee any of its backhaul loads; 29% are obtained at a lorry park; 43% are empty; and the remainder are obtained from other sources. Wait time for the current load was more than six times as long at lorry parks (64 hours) than it was for loads obtained from customers (10 hours). Average time between loads is 39 hours. The vehicle typically spends from 4 to 36 days a year out-of-service due to repairs.

Mean utilization and costs for this class of truck are shown in Table 5.3 and Appendix D. Analysis of costs, Figure 5.2, shows that fixed costs represent 41% and variable costs 59% of the total operating costs. The most significant fixed costs are vehicle capital costs at 23% of total costs; and the most significant variable cost is fuel at 41% of total costs.

5.2.3 Payload Capacity: 3 - 5 Tonnes

A snapshot of the typical vehicle in this class would show a 14-year-old European vehicle (Benz or Albion), 6-cylinder, diesel-fuelled straight truck with a payload capacity of 4.95 tonnes. The vehicle is owned and managed by an individual who is not the driver, 44% of its trips are made on a regular route and it is not managed with other vehicles. (Less than one third of the trucks are managed with, on average, 2 other vehicles.) The vehicle carries third party insurance and is insured as a commercial vehicle for general cartage. Vehicle characteristics are shown in Table 5.2.

The typical vehicle obtains 42% its loads directly from a customer, 37% are obtained at lorry parks, and 21% from other sources. The customer guarantees 13% of backhaul loads; 38% are obtained from a lorry park; 29% are empty; and the remainder are obtained from other sources. Wait time for the current load was nearly three times as long at lorry parks (218 hours) than it was for loads obtained from customers (73 hours). Average time between loads is 139 hours. The vehicle typically spends from 60 to 70 days a year out-of-service due to repairs.

Mean utilization and costs for this class of truck are shown in Table 5.3 and Appendix D. Analysis of costs, Figure 5.2, shows that fixed costs represent 38% and variable costs 62% of the total operating costs. The most significant fixed costs are wages at 21% of total costs; and the most significant variable cost is fuel at 29% of total costs.

5.2.4 Payload Capacity: Greater than 5 Tonnes

A snapshot of the typical vehicle in this class would show a 10- year-old, European or American vehicle (Leyland or Ford), 6- cylinder, diesel-fuelled straight truck with a payload capacity of 8.03 tonnes. The vehicle is owned and managed by an individual who is not the driver, half of its trips are made on a regular route and it is not managed with other vehicles. (Less than one third of the trucks are managed with, on average, 2 other vehicles.) The vehicle carries third party insurance and is insured as a commercial vehicle for general cartage. Vehicle characteristics are shown in Table 5.2.

The typical vehicle obtains 38% of its loads from a lorry park, 38% directly from a customer, and 24% from other sources. Backhauls loads are usually not guaranteed by the customer; 33% of them are obtained from a lorry park; and the remainder are obtained from other sources. Wait time for the current load was significantly longer at lorry parks (128 hours) than it was for loads obtained from customers (89 hours). Average time between loads is 107 hours. The vehicle typically spends from 45 to 60 days a year out-of-service due to repairs.

Mean utilization and costs for this class of truck are shown in Table 5.3 and Appendix D. Analysis of costs, Figure 5.2, shows that fixed costs represent 42% and variable costs 58% of the total operating costs. The most significant fixed costs are wages at 26% of total costs; and the most significant variable cost is maintenance at 27% of total costs.

5.3 Straight Vehicles: Mixed Loads

The class of straight vehicles carrying mixed passenger/goods loads includes all vehicles designated in the survey as bus, “waton kyene”, and “mammy wagon” as well as the vehicles indicating they were insured to carry passengers. This describes 217 (45%) of the vehicles surveyed. A summary of vehicle characteristics is given in Table 5.5 and a summary of vehicle operating costs under average actual conditions in Table 5.4, costs are given in Cedis per Tonne-kilometre (C/T-km). Vehicle operating cost data are found in a more complete form in Appendix D. A comparison of relative cost components of all types of vehicles in the mixed passenger/goods class is given in Figure 5.3.

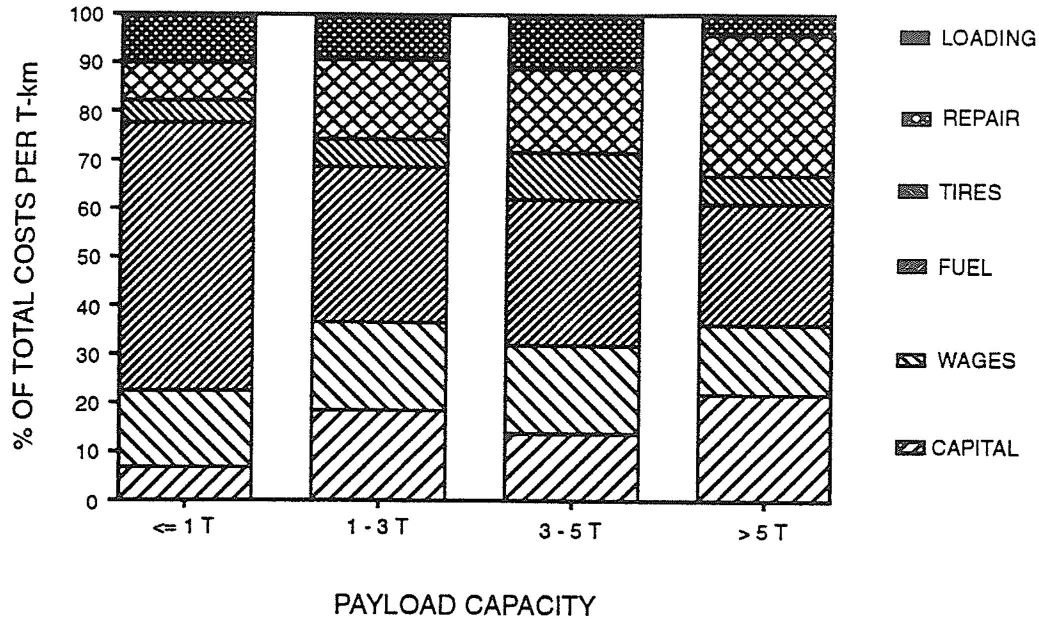


Figure 5.3 Relative Cost Components: Mixed

Table 5.4 Truck Operating Costs: Mixed
Actual Average Operating Conditions

	2-AXLE STRAIGHT TRUCKS			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
NO. OF VEHICLES	57	24	85	14
FIXED COSTS				
WAGES	30.37	29.43	17.98	16.97
INSURANCE	0.72	0.58	0.57	0.43
CAPITAL COST	13.20	30.02	13.69	25.67
VARIABLE COSTS				
FUEL	106.70	51.77	29.71	29.14
TIRES	8.96	9.40	9.66	6.87
REPAIR	14.81	26.69	17.05	33.89
LOADING	19.13	14.54	10.53	4.40
TOTAL (C/T-km)	193.89	162.43	99.19	117.37

Table 5.5 Vehicle Characteristics: Mixed

	PAYLOAD CAPACITY			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
NUMBER OF VEHICLES	57	24	85	14
CONFIGURATION				
Bus	32	7	4	
Rigid Trucks	16	4	13	
Waton Kyene	2	9	63	13
Other	7	4	5	1
MAKE				
Nissan	26			
Toyota	14			
Bedford		9	34	6
Benz		7	27	6
Other	17	8	24	2
CYLINDERS				
4	51	12	6	1
6	3	11	77	8
8	1			4
FUEL				
Petrol	43	7	3	
Diesel	14	17	80	14
WEIGHT AND CAPACITY				
GVW (T)	2.33	7.03	10.07	13.95
Tare (T)	1.57	4.63	5.14	5.42
Payload (T)	0.77	2.18	4.93	9.30
AGE (years)	9.3	4.1	13.1	9.9
INSURANCE				
Commercial	55	21	81	14
General	17	6	26	5
Passengers	36	13	53	8
Other	2	2	2	1
Type				
3rd Party	48	14	56	11
Comprehensive		4	5	2
Other	9	6	24	1
CARRYING PASS.	10	3	18	2
MANAGEMENT AND OWNERSHIP				
Vehicle Owner				
Individual	44	15	76	11
Driver	12	7	6	2
Managed with Other Vehicles				
Yes	13	6	23	4
no. of vehic	3	2	3	2
Regular Route	32	13	46	7
ACCIDENTS LAST YEAR				
None	55	18	71	14
1	2	4	10	
2		1	4	
3		0		
4		1		

5.3.1 Payload Capacity: Less than or equal to 1 Tonne

A snapshot of the typical vehicle in this class would show a nine-year-old, Japanese-made (Nissan or Toyota), 4-cylinder, petrol- fuelled mini-bus with a payload capacity of 0.75 tonne. The vehicle is owned and managed by an individual who is not the driver, more than half its trips are made over a regular route, and it is not managed with other vehicles. The vehicle carries third party insurance, is insured as a commercial vehicle to carry passengers but carries passengers approximately one trip every six. Vehicle characteristics are shown in Table 5.5.

The typical vehicle obtains 42% of its loads at a lorry park, 44% directly from a customer, and 14% from other sources. The customer guarantees 30% of backhaul loads; 50% are obtained through a lorry park; and the remainder are either obtained from other sources or are empty. Waiting time for the current load was approximately 10 hours for loads obtained at lorry parks or directly through customers. Average empty time between loads is 20 hours. The vehicle typically spends 22 to 36 days a year out-of-service due to repairs.

Mean values for operating characteristics and costs are derived from survey data which lead to mean utilization and unit costs, shown in Table 5.4 and in Appendix D. Analysis of costs, Figure 5.3, shows that fixed costs represent 24% of the vehicle's operating costs and variable costs 76%. The most significant fixed costs are wages at 16% of total costs; and the most significant variable cost is fuel at 58% of total costs.

5.3.2 Payload Capacity: 1 - 3 Tonnes

A snapshot of the typical vehicle in this class would show a four-year-old, European-made (Bedford or Benz), 4-cylinder, diesel-fuelled "waton kyene" with a payload capacity of 2.25 tonnes. The vehicle is owned and managed by an individual who is not the driver, more than half of its trips are made on a regular route, and it is not managed with other vehicles. The vehicle carries third party insurance, is insured as a commercial vehicle to carry passengers but carries passengers less than one trip every eight. Vehicle characteristics are shown in Table 5.4.

The typical vehicle obtains 35% of its loads at lorry parks, 41% directly from a customer, and 24% from other sources. The customer guarantees 57% of backhaul loads; 29% are obtained from lorry parks; and the remainder are obtained from other sources. Wait times are significantly shorter for current loads obtained from customers (6.6 hours) than for those obtained from lorry parks (19.8 hours). Average empty time between loads is 26 hours. The vehicle typically spends 37 days a year out-of-service due to repairs.

Mean utilization and unit costs are shown in Table 5.5 and in Appendix D. Analysis of costs, Figure 5.3, shows that fixed costs represent 39% of the vehicle's operating cost and variable costs 61%. Wages and capital costs each represent approximately half of the fixed costs. The most significant variable cost is fuel at 33% of total costs.

5.3.3 Payload Capacity: 3 - 5 Tonnes

A snapshot of the typical vehicle in this class would show a 13-year-old, European-made (Bedford or Benz), 6-cylinder, diesel- fuelled "waton kyene" with a payload capacity of 4.95 tonnes. The vehicle is owned and managed by an individual who is not the driver, more than half of its trips are made on a regular route, and it is not managed with other vehicles. (One quarter of the vehicles are managed with, on average, 2 other vehicles.) The vehicle carries third party insurance, is insured as a commercial vehicle to carry passengers but carries passengers approximately one trip every five. Vehicle characteristics are shown in Table 5.5.

The typical vehicle obtains 45% of its loads at lorry parks, 50% directly from a customer, and 5% from other sources. The customer guarantees 14% of backhaul loads; 48% are obtained at a lorry park; 10% are empty; and the remainder are obtained from other sources. Waiting time for the current load was more than twice as long at lorry parks (201 hours) than for those obtained from customers (82 hours). Average empty time between loads is 98 hours. The vehicle typically spends between 48 and 55 days a year out-of-service due to repairs.

Mean utilization and unit costs for this class of vehicle are shown in Table 5.4 and Appendix D. Analysis of costs, Figure 5.3, shows that fixed costs represent 34% of the vehicle's operating costs and variable costs 66%. The most significant of fixed costs are wages at 19% of total costs; the most significant variable cost is fuel at 32% of total costs.

5.3.4 Payload Capacity: Greater than 5 Tonnes

A snapshot of the typical vehicle in this class would show a 10- year-old, European (Bedford or Benz), 6-cylinder, diesel-fuelled "waton kyene" with a payload capacity of 9.25 tonnes. The vehicle is owned and operated by an individual who is not the driver, half of its trips occur over a regular route, and it is not managed with other vehicles. (More than one quarter of the vehicles are managed with, on average, one other vehicle.) The vehicle carries third party insurance, is insured as a commercial vehicle to carry passengers but carries passengers approximately one trip every seven. Vehicle characteristics are shown in Table 5.5.

The typical vehicle obtains more than 63% of its loads from a lorry park, 25% directly from a customer and the remainder from other sources. The customer guarantees half of the backhaul loads, others are obtained at lorry parks. Waiting time for the current load was nearly three times as long at lorry parks (136 hours) than for those obtained from customers (48 hours). Average empty time between loads is 95 hours. The vehicle typically spends between 36 and 62 days a year out-of-service due to repairs.

Mean utilization and unit costs for this class of truck are shown in Table 5.4 and Appendix D. Analysis of costs, Figure 5.3, shows that fixed costs represent 37% of the vehicle's total operating costs and variable costs 63%. The most significant fixed costs are vehicle capital costs at 22% of total costs; and the most significant variable cost is maintenance at 35% of total costs.

The category of tractor semi-trailers represents 39 (8%) of the vehicles surveyed; 17 of which are 2-S1, 17 are 2-S2, and 5 are other configurations. Survey data obtained from tractor semi-trailers was insufficient to provide meaningful analysis results. An analysis similar to that of freight trucks and mixed passenger/goods vehicles was nonetheless carried out and the results are included in Appendix E.

5.4 Effects of Operational Changes on TOC

The TOC model developed from survey data describes costs and operating practices valid for average actual operating conditions in the Ashanti Region of Ghana.

Three issues, loading, utilization, and fuel consumption, are deciding factors in the structure of the costing model and their effect is examined in the following sections. The model developed for average actual operating conditions is used to predict costs under other operating conditions: at allowable load limits, at maximum utilization, and with increased fuel efficiency. The consequences of each of these operating conditions are examined for freight trucks and mixed passenger/goods vehicles. It is assumed for the purpose of analysis that the mixed passenger/goods vehicles are carrying freight only.[4]

5.4.1 Operating at Allowable Load Limits

Survey data show that the average loaded vehicle is operating at 184% of registered payload capacity. Only 36% of the loaded vehicles carried loads less than or equal to their registered payload capacity. Figure 5.4 illustrates the loading characteristics of all loaded vehicles surveyed. The figure indicates that 43% of vehicles carry 100% to 200% of payload capacity, 10% carry 200% to 300% of payload capacity, and 11% are loaded beyond 300% of capacity.

In the "Allowable Load Limit" case, vehicles are assumed to be operating at full load capacity - without exceeding the registered load capacity - on all loaded journeys. Fixed costs (wages, insurance, roadworthiness certificate, and capital costs) are assumed to remain the same as for average actual operating conditions. Journey distance and amount of freight moved per year (tonnes) are assumed to be the same as for average actual operating conditions. Under these conditions, a truck would operate on the same route and carry the same amount of freight as it did under average actual conditions but its load would always be exactly the amount permitted on its registration; it would be neither over- nor under-loaded. Loading factor is assumed to be 50%, that is half the journeys are empty. Fuel consumption is assumed to follow the findings of Clayton (1981-84) [Nix, 1991] due to the average age of the freight vehicles and

$$km/l = 2.65 - 0.0207\ (GVW)$$

with GVW (tonnes) equal to tare for half the total annual distance and GVW equal to tare plus registered payload for the other half. Resulting fuel consumption rates are comparable to the averages calculated for actual conditions and permit the differentiation between loaded and empty journeys. Maintenance costs (tires and repairs) per kilometre from average actual operating conditions are used as the basis for maintenance costs in the new model. That is:

New Maintenance Costs = Average maintenance cost per km x New annual km.

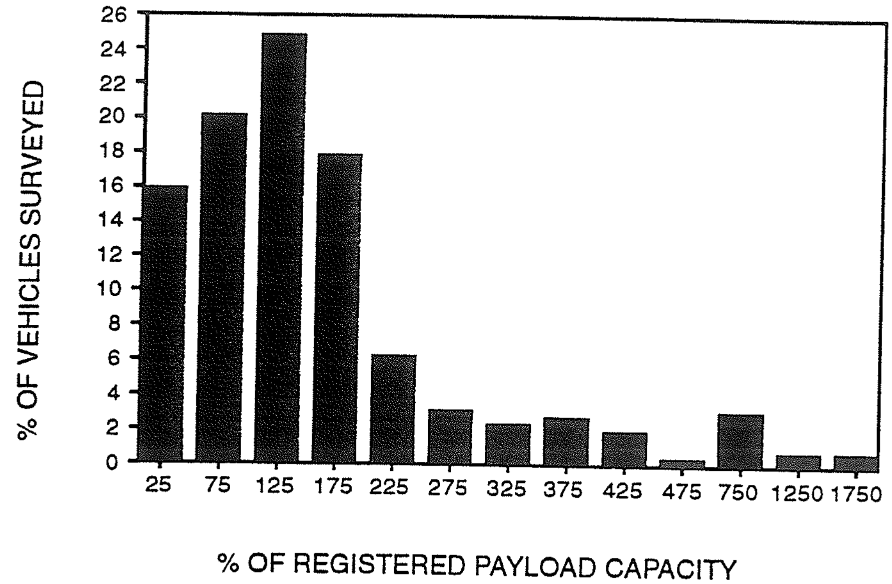


Figure 5.4 Loading Characteristics

FREIGHT TRUCKS

Results of the analysis for freight trucks are summarized in Table 5.6; complete results are included in Appendix F. A comparison between total costs per tonne-kilometre under both actual and legal operating conditions is shown in Figure 5.5. (Note: The tractor semi-trailers are not included in the comparison due to the lack of accurate data. They are, however, included in Appendix F for completeness.)

Table 5.6 Truck Operating Costs: Freight
Allowable Load Limits

	2-AXLE STRAIGHT TRUCKS			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
FIXED COSTS				
WAGES	28.82	36.10	8.87	24.27
INSURANCE	0.41	0.74	0.20	0.37
CAPITAL COST	38.72	49.99	7.27	14.56
VARIABLE COSTS				
FUEL	199.59	57.06	26.77	16.54
TIRES	20.37	6.16	7.77	11.20
REPAIR	25.21	22.19	15.75	9.86
LOADING	39.23	15.93	14.59	15.91
TOTAL (C/T-km)	352.35	188.17	81.22	92.71
TOTAL (C/T-km) - Average Actual Operating Conditions	163.98	222.11	46.48	101.73

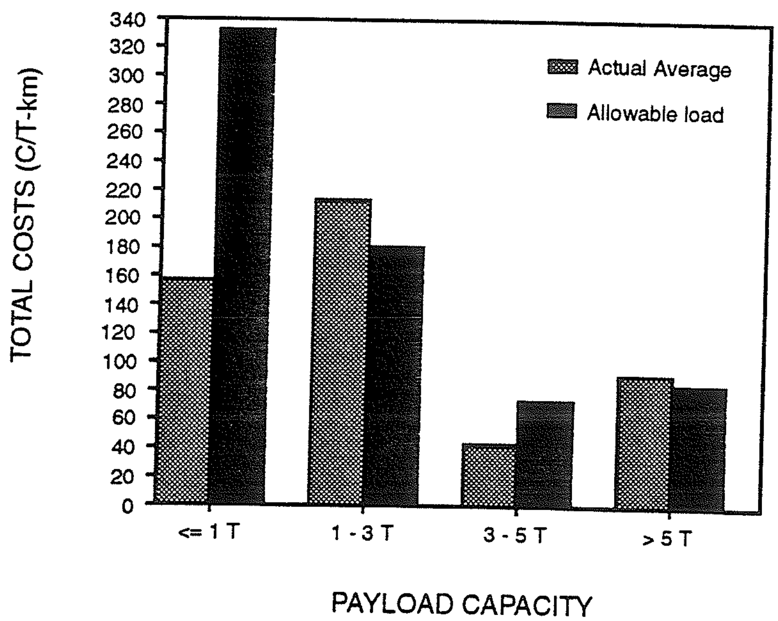


Figure 5.5 Comparative Costs: Freight
Actual - Allowable

Total costs per tonne-kilometre increase under allowable load conditions for trucks that were overloaded under average actual conditions. This is due to the assumption made that the same total amount of freight was to be moved under both types of operating conditions. For example, trucks with a payload capacity of less than one tonne (actual loading 300% of registered capacity) travel 25582 km per year to move 220 tonnes of freight under actual conditions; but under allowable loading conditions, the same truck must travel nearly three times the distance to transport an equivalent 220 tonnes of freight.

Total costs per tonne-kilometre decrease under allowable load conditions for trucks that were not loaded to capacity under average actual conditions. For example, trucks with a payload capacity of 1 - 3 tonnes (actual loading 93% of capacity) travel 25347 km per year to move 149 tonnes of freight under actual conditions; but under allowable loading conditions, the same truck travels 93% of that distance to transport an equivalent 149 tonnes of freight.

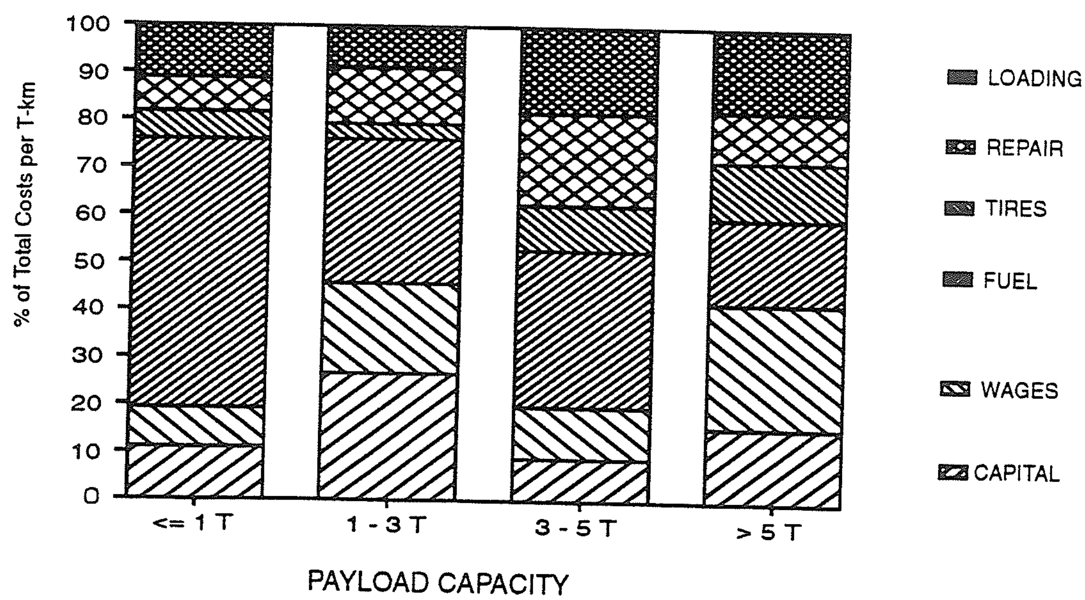


Figure 5.6 Relative Cost Components: Freight Allowable Loading

Operating costs under allowable loading conditions show a general decrease in cost per tonne-kilometre with increasing vehicle payload capacity (Figure 5.5). Figure 5.6 shows a decrease in the relative importance of capital costs and an increase in relative fuel costs (compare to Figure 5.2) for vehicles that were overloaded under actual average conditions; capital costs increase and fuel costs decrease for vehicles that were not loaded to capacity. Repair costs and fuel costs show the same trends under both circumstances: relative repair costs increase with vehicle size and relative fuel costs decrease with vehicle size.

MIXED PASSENGER/GOODS VEHICLES

Results of the analysis for operation at allowable load limits of mixed passenger/ goods vehicles are summarized in Table 5.7; complete results are included in Appendix F.

Table 5.7 Truck Operating Costs: Mixed
Allowable Load Limits

	2-AXLE STRAIGHT TRUCKS			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
FIXED COSTS				
WAGES	30.40	29.51	17.94	16.98
INSURANCE	0.72	0.58	0.57	0.43
CAPITAL COST	13.21	30.10	13.65	25.69
VARIABLE COSTS				
FUEL	197.07	59.85	26.87	14.50
TIRES	16.16	8.75	9.50	4.98
REPAIR	23.73	24.85	16.77	24.56
LOADING	34.54	13.54	10.36	3.19
TOTAL (C/T-km)	315.83	167.18	95.66	90.33
TOTAL (C/T-km) - Average Actual Operating Conditions	193.89	162.45	99.19	117.37

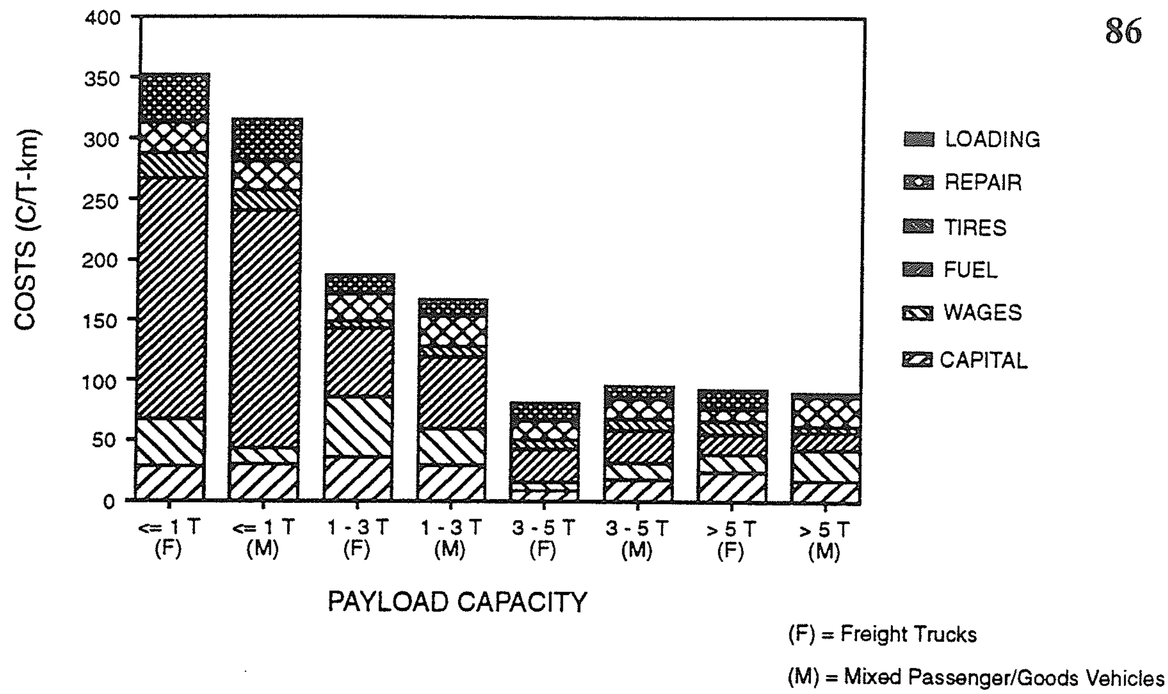


Figure 5.7 Comparative Costs: Freight-Mixed Allowable Loading

Figure 5.7 illustrates that under allowable loading conditions costs for both freight trucks and mixed vehicles show similar trends, that is, they decrease with increasing vehicle size. However, the difference in cost per T-km between freight trucks and mixed vehicles is less pronounced than it is under average actual operating conditions (End Note 4). Mixed vehicles in all but one instance (3 - 5T payload capacity) show a slightly lower cost than freight vehicles but this is due to the difference in loading characteristics under actual conditions.

5.4.2 Operating under Maximum Utilization

Survey data show that the average freight truck makes eight 246 km journeys per month, waits over 4 days between loads, and spends 52 days a year out-of-service due to repairs. The average mixed passenger/goods vehicles makes nineteen 192 km journeys per month, waits nearly 3 days between loads, and spends 43 days a year out-of-service due to repairs. (Long times out-of-service due to repairs are caused in part by vehicle age - older vehicles require more maintenance - and in part by the difficulty in obtaining spare parts and tires in Ghana.)

In the "Maximum Utilization" case, vehicles are assumed to be operating at maximum utilization: allowable load capacity and maximum number of journeys. Fixed costs (wages, insurance, roadworthiness certificate, and capital costs) are assumed to remain the same as for average actual operating conditions. Journey distance and load/unload time are assumed to be the same as for average actual operating conditions. Loading factor is assumed to be 50%, that is half the journeys are empty. Fuel consumption and maintenance costs remain as they were for the allowable loading operating conditions (see 5.4.1). Maximum utilization is calculated using the average actual journey speed and the average load/unload time for each type of vehicle, so that:

Journey time = distance/average speed + loading time.

Maximum number of one-way journeys in a day is calculated based on 12 hours of running time plus two loading periods - assuming that a vehicle can load or unload before and after the running curfew. Annual number of journeys is calculated using the number of daily journeys (rounded down to the nearest whole number), 52 weeks per year, and 5 days per week.

FREIGHT TRUCKS

Summarized results of the analysis are shown in Table 5.8; complete results are included in Appendix G. A comparison of total costs per tonne-kilometre under actual, allowable loading, and maximum utilization operating conditions is shown in Figure 5.8. (Note: The tractor semi-trailers are not included in the comparison due to the lack of accurate data . The figures are included in Appendix G for completeness.)

Table 5.8 Truck Operating Costs: Freight
Maximum Utilization

	2-AXLE STRAIGHT TRUCKS			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
FIXED COSTS				
WAGES	21.39	9.24	4.25	1.64
INSURANCE	0.31	0.19	0.09	0.03
CAPITAL COST	28.74	12.79	3.48	0.98
VARIABLE COSTS				
FUEL	199.63	57.06	26.77	16.54
TIRES	20.37	6.16	7.77	11.20
REPAIR	25.21	22.19	15.75	9.86
LOADING	39.23	15.93	14.59	15.91
TOTAL (C/T-km)	334.88	123.56	72.70	56.16
TOTAL (C/T-km) - Average Actual Operating Conditions	163.98	222.11	46.48	101.73
TOTAL (C/T-km) - "Allowable Load" Operating Conditions	352.35	188.17	81.22	92.71

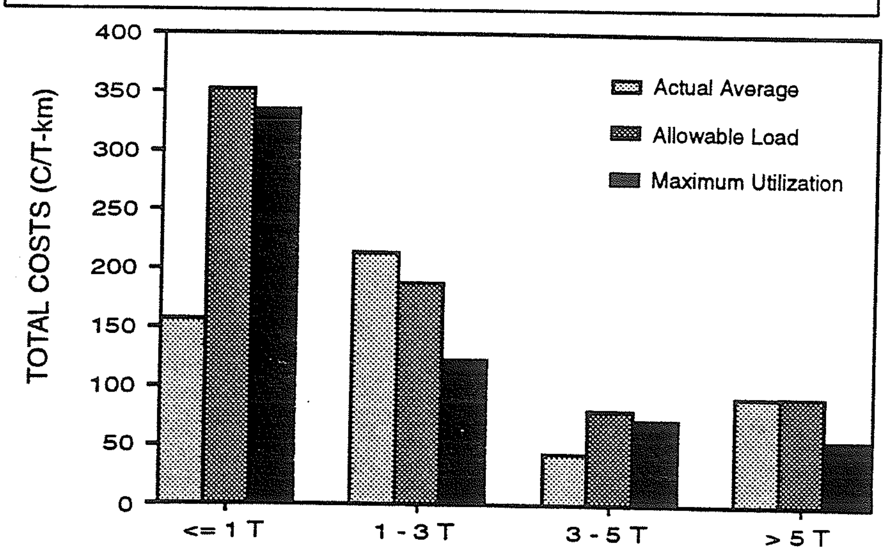


Figure 5.8 Comparative Costs: Freight
Actual-Allowable-Maximum

Total costs per tonne-kilometre are lower operating at maximum utilization than allowable loading conditions for all freight carrying vehicles. Maximum utilization allows all vehicles to increase the annual amount of freight moved and decrease the cost per tonne kilometre. The smallest trucks (<=1 T payload capacity) increased freight moved by 35% and decreased costs by 5% over the allowable loading scenario. Trucks with a payload capacity of 1 to 3 tonnes nearly quadrupled the annual amount of freight moved and saw their costs decrease by 34%. Three to five tonne payload trucks more than doubled the annual freight moved and decreased costs by 10%. The largest straight trucks (> 5 T payload) moved nearly 15 times more freight per year and decreased costs by 40%. Costs for truck types that were greatly overloaded under actual average operating conditions (<=1 T, 3-5 T) remain higher under maximum utilization than they are actually; the increased utilization does not compensate for the overloading.

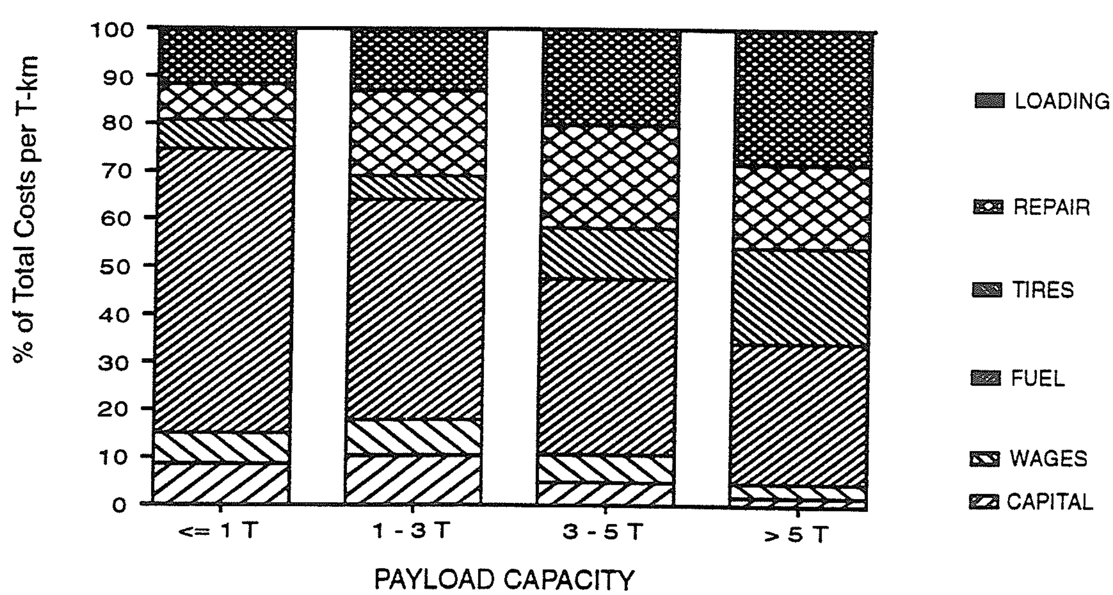


Figure 5.9 Relative Cost Components: Freight Maximum Utilization

Figure 5.9 shows a decrease in the relative importance of fuel costs with increasing truck size; and a general decrease in the importance of fixed costs over average actual operating conditions. Fuel costs increase for all types of trucks with increased utilization, however the relative importance of fuel to total costs decreases with truck size. Although fuel consumption increases with truck size, fuel costs represent a smaller proportion of total costs per tonne-kilometre as truck size increases. The truck size/relative fuel cost relationship becomes apparent with all trucks operating at maximum utilization: fuel costs represent 60% of total costs for trucks with a payload capacity of less than 1 T; 46% for 1 - 3 T payload trucks; 37% for 3 - 5 T payload trucks; and 29% for >5 T payloads. Fixed costs (wages, insurance, roadworthiness certificate, and capital costs) are significantly less important under maximum utilization, where they represent 5% to 21% of total costs, than they are under actual average operating conditions, where they represent 35% to 47% of total costs. Increased utilization increases the distance-related costs of operation, variable costs, and decreases the relative importance of fixed costs.

MIXED PASSENGER/GOODS VEHICLES

Summarized results of the analysis for operation at maximum utilization of mixed passenger/goods vehicles are shown in Table 5.9, complete results are included in Appendix G.

Table 5.9 Truck Operating Costs: Mixed
Maximum Utilization

	2-AXLE STRAIGHT TRUCKS			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
FIXED COSTS				
WAGES	19.01	8.48	2.42	2.11
INSURANCE	0.45	0.17	0.07	0.06
CAPITAL COST	8.26	8.66	1.84	3.20
VARIABLE COSTS				
FUEL	197.07	59.85	26.87	14.50
TIRES	16.16	8.75	9.50	4.98
REPAIR	26.73	24.85	16.77	24.56
LOADING	34.54	13.54	10.36	3.19
TOTAL (C/T-km)	302.22	124.30	67.83	52.60
TOTAL (C/T-km) - Average Actual Operating Conditions	193.89	162.45	99.19	117.37
TOTAL (C/T-km) - "Allowable Load" Operating Conditions	315.83	167.18	95.66	90.33

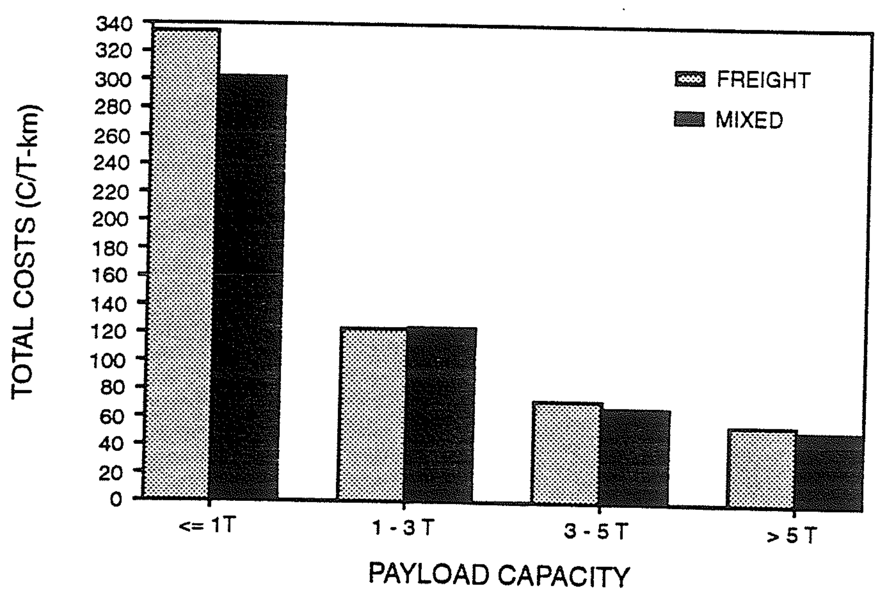


Figure 5.10 Comparative Costs: Freight-Mixed
Maximum Utilization

Figure 5.10 illustrates the similarity in cost structure between mixed vehicles and freight trucks when operated under similar operating conditions. Small differences in total cost between the smallest vehicles (<= 1 T payload capacity) are due to the differences in capital costs.

5.4.3 Operating with Increased Fuel Efficiency

In this case, vehicles are assumed to be operating at maximum utilization (allowable loading and maximum number of journeys), but with increased fuel efficiency. Fuel consumption is assumed to follow the findings of DriveSave/ TruckSave (1989) [Nix, 1991], that is:

$$km/l = 3.47 - 0.022\ (GVW)$$

with GVW (tonnes) equal to tare for half the total annual distance and GVW equal to tare plus payload for the other half.

This scenario is used to simulate the use of newer vehicles. The assumption is made that other age-related costs such as capital and repair costs remain the same as for the average actual case. It is acknowledged that this assumption may be tenuous, however the fuel consumption data in question (DriveSave/TruckSave) are dated and the resulting vehicle would be 3 years old (rather than the actual average of 10 years). The increase in fuel efficiency is argued to result from changes in mechanical efficiency, configuration (improved aerodynamics etc.); and driver habits; changes that do not deteriorate with vehicle age. All other costs, fixed and variable, remain the same as under the maximum utilization case.

FREIGHT TRUCKS

Summarized results of the analysis for freight trucks are shown in Table 5.10; complete results are included in Appendix H. A comparison between total costs per tonne-kilometre under actual, legal, maximum utilization, and increased fuel efficiency operating conditions is shown in Figure 5.11. (Note: The tractor semi-trailers are not included in the comparison due to the lack of accurate data. The figures are included in Appendix H for completeness.)

Table 5.10 Truck Operating Costs: Freight
Increased Fuel Efficiency

	2-AXLE STRAIGHT TRUCKS			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
FIXED COSTS				
WAGES	21.39	9.24	4.25	1.64
INSURANCE	0.31	0.19	0.09	0.03
CAPITAL COST	28.74	12.79	3.48	0.98
VARIABLE COSTS				
FUEL	152.02	43.36	20.20	12.47
TIRES	20.37	6.16	7.77	11.20
REPAIR	25.21	22.19	15.75	9.86
LOADING	39.23	15.93	14.59	15.91
TOTAL (C/T-km)	287.27	109.86	66.13	52.09
TOTAL (C/T-km) - Average Actual Operating Conditions				
	163.98	222.11	46.48	101.73
TOTAL (C/T-km) - Allowable Load Operating Conditions				
	352.35	188.17	81.22	92.71
TOTAL (C/T-km) - Maximum Utilization Operating Conditions				
	334.88	123.56	72.70	56.16

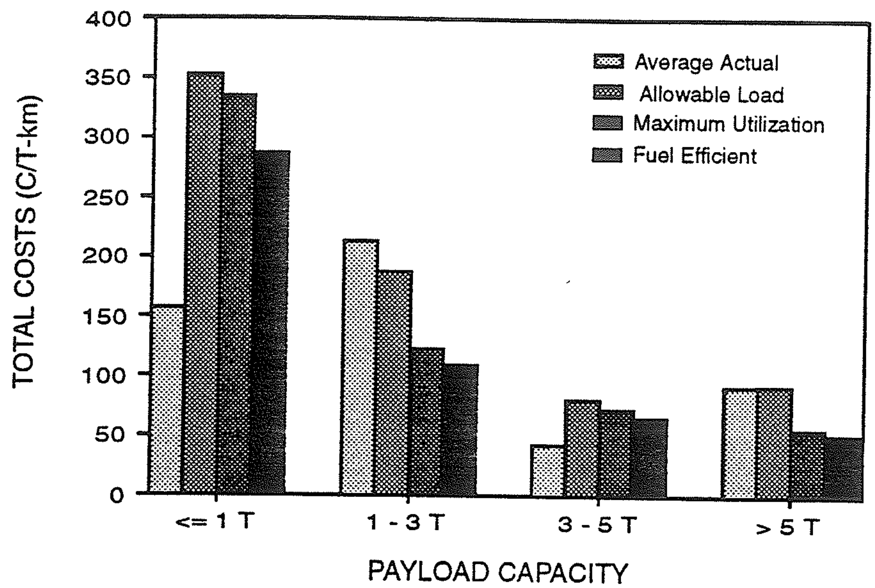


Figure 5.11 Comparative Costs: Freight
Actual-Allowable-Maximum-Fuel

Total costs decrease by 7% to14% for all trucks with improved fuel efficiency over the maximum utilization scenario (14% decrease in cost for trucks with payload capacity of less than 1 tonne; 11% decrease for 1 - 3 tonne payload trucks; 10% decrease for 3 - 5 tonne; and 7% decrease for greater than 5 tonne payload trucks).

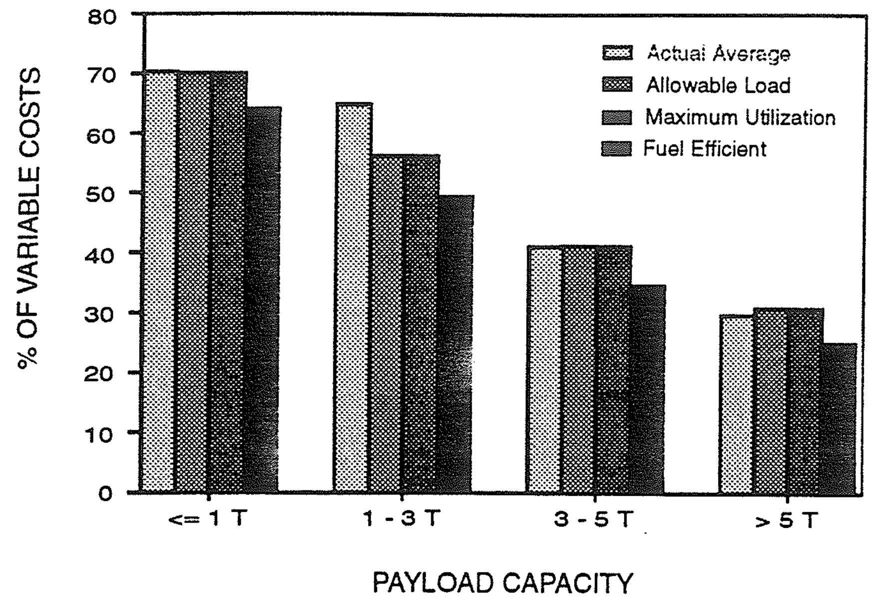


Figure 5.12 Relative Fuel Cost: Freight
Increased Fuel Efficiency

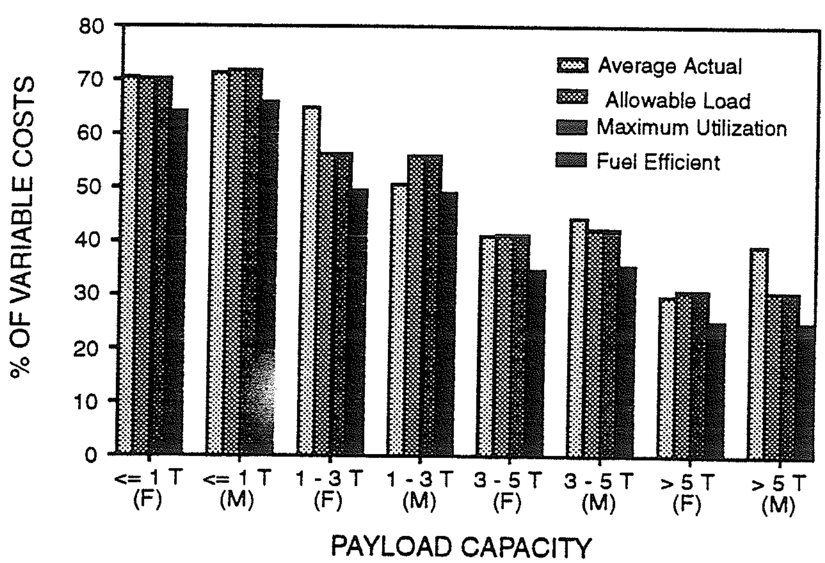
Reductions in total costs brought about by increased fuel efficiency are reflected in a reduction in variable costs. Figure 5.12 shows the change in fuel costs as a percentage of variable costs for the four operating conditions. Fuel costs remain a relatively constant proportion of variable costs over the first three scenarios -actual average, allowable loading, and maximum utilization- but decrease in importance with improved fuel efficiency.

MIXED PASSENGER/GOODS VEHICLES

Results of the analysis for operation with increased fuel efficiency of mixed passenger/goods vehicles are summarized in Table 5.11; complete results are included in Appendix H.

Table 5.11 Truck Operating Costs: Mixed
Increased Fuel Efficiency

	2-AXLE STRAIGHT TRUCKS			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
FIXED COSTS				
WAGES	19.01	8.48	2.42	2.11
INSURANCE	0.45	0.17	0.07	0.06
CAPITAL COST	8.26	8.66	1.84	3.20
VARIABLE COSTS				
FUEL	150.07	45.30	20.27	10.90
TIRES	16.16	8.75	9.50	4.98
REPAIR	26.73	24.85	16.77	24.56
LOADING	34.54	13.54	10.36	3.19
TOTAL (C/T-km)	255.22	109.75	61.23	49.00
TOTAL (C/T-km) - Average Actual Operating Conditions	193.89	162.45	99.19	117.37
TOTAL (C/T-km) - "Allowable Load" Operating Conditions	315.83	167.18	95.66	90.33
TOTAL (C/T-km) - Maximum Utilization Operating Conditions	302.22	124.30	67.83	52.60



F = Freight trucks
M = Mixed Passenger/Goods Vehicles

Figure 5.13 Comparative Fuel Costs: Freight-Mixed
Increased Fuel Efficiency

Figure 5.13 shows the change in fuel costs as a percentage of variable costs for freight trucks and mixed vehicles for all operating conditions. Fuel costs remain a relatively constant proportion of variable costs over the first three scenarios - actual average, allowable loading, and maximum utilization - but decrease in importance with increased fuel efficiency. Fuel costs as a proportion of variable costs are similar between vehicles of the same payload capacity and decrease with vehicle size for both freight trucks and passenger vehicles.

The three variations to operating characteristics of freight trucks described in the above sections serve to illustrate the effects of overloading, low utilization rates, and fuel consumption on the cost of transporting agricultural commodities. The comparison between freight trucks and mixed passenger/goods vehicles shows that under similar operating conditions and transporting freight only, vehicle design has little effect on transportion costs.

Endnotes

1. All vehicles operating in Ghana must carry a minimum of insurance known as the Act policy; it covers death and injury claims only. Vehicles may be insured over and above the Act policy with third party insurance (covers other's vehicle and property), fire and theft insurance (covers third party accidents and own vehicle fire and theft except if fire caused by motor vehicle accident), or comprehensive insurance (covers the insurers' vehicle as well as third party liabilities and includes fire and theft coverage). All vehicles used for commercial purposes in Ghana are insured to carry either passengers or freight (but not both), with freight vehicles designated as carrying "own goods" (that is goods belonging to the vehicle's owner) or general cartage (that is vehicles which are for hire). [SIC, 1992]

2. All privately-owned vehicles in Ghana must obtain a roadworthiness certificate every six months which signifies that the vehicle has passed a safety inspection and has been declared roadworthy [Kwakye, 1991]

3. Sample calculation of mean utilizatization rate.
   All numbers given are for 2-axle freight vehicles with 3-5T payload capacity.

   Journey Distance:
   Estimated present journey distance = 278 km (146 responses)
   Actual present journey distance = 286 km (126 responses)
   Regular route, harvest season = 373 km (67 responses)
   Regular route, farming season = 390 km (58 responses)
   Regular route, actual distance = 382 km (61 responses)

   Journey distance =

$$\frac{278*146 + 286*126 + 373*67 + 390*58 + 382*61}{146 + 126 + 67 + 58 + 61}$$

$$= 322 \text{ km}$$

Monthly Utilization:
Regular route, harvest season (actual distance) = 1791 km
(58 responses)
Regular route, farming season (actual distance) = 774 km
(52 responses)
Regular route, harvest season (estimated distance) = 2584 km
(61 responses)
Regular route, farming season (estimated distance) = 1228 km
(54 responses)
Average weekly distance x 4 = 2824 km
(57 responses)

Monthly utilization =

$$\frac{1791*58 + 772*52 + 2584*61 + 1228*54 + 2824*57}{58 + 52 + 61 + 54 + 57}$$

= 1876 km

Monthly trips:
= Monthly utilization / Journey distance
= 1876 km / 322 km
= 5.83 or 6 trips

Mean monthly utilization:
= Journey distance * monthly trips
= 322 km * 6 trips
= 1932 km

Annual distance:
Off road due to repair, last year = 70 days
Mean monthly utilization = 1932 km
Months off road = 70 days / 30 days = 2.33 months

Annual distance =
(12 - 2.33) months * 1932 km
= 18682 km

4. A distinction is made in the TOC model between vehicles designated as carrying freight or mixed passenger/goods. The issue with freight carried on passenger vehicles is not principally one of operating cost but rather one of passenger and vehicle safety. These are important issues in the Ghanaian context but they are beyond the scope of this research. However the fact remains that agricultural commodities in Ghana are commonly transported in vehicles designed for passenger transport.

   The operating characteristics and cost structures of these vehicles are examined following the same process as for freight vehicles. Figure 5.12 compares the cost components of freight transport per T-km for freight and mixed vehicles under actual average operating conditions. The figure shows that for all but one payload capacity (1-3 T), it is more expensive to move goods using vehicles designed primarily for passenger transport than vehicle designated for freight transport under average actual operating conditions.

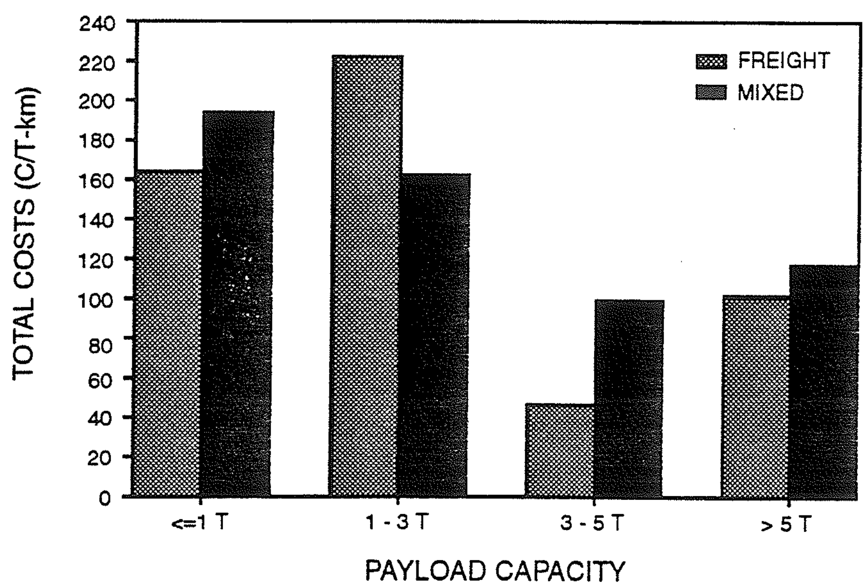


Figure 5.14 ComparitiveCosts: Freight-Mixed
Actual Average Operating Conditions

CHAPTER 6: ANALYSIS OF TRANSPORT OPTIONS

Key issues in the transportation of agricultural commodities in Ghana were raised in previous chapters: loading, utilization, and fuel consumption. Program and policy options addressing the issues are put forth in this chapter. Evaluation of the options involves consideration of the interests of the actors involved.

6.1 Transport Options

Cost comparisons between vehicles operating under average actual (over-loaded) loading conditions and allowable loading conditions show that operating costs per T-km increase when loading is decreased (Table 5.6). Enforcing registered load allowances in Ghana without altering operating practices would therefore increase transport costs for operators and transport prices to producers. Transport costs per T-km for actual average, allowable loading, maximum utilization, and increased fuel efficiency operating conditions, of straight freight trucks are shown in Figure 6.1. (Tractor semi-trailer data from the Kumasi survey do not permit adequate analysis and are not included in the cost comparison.)

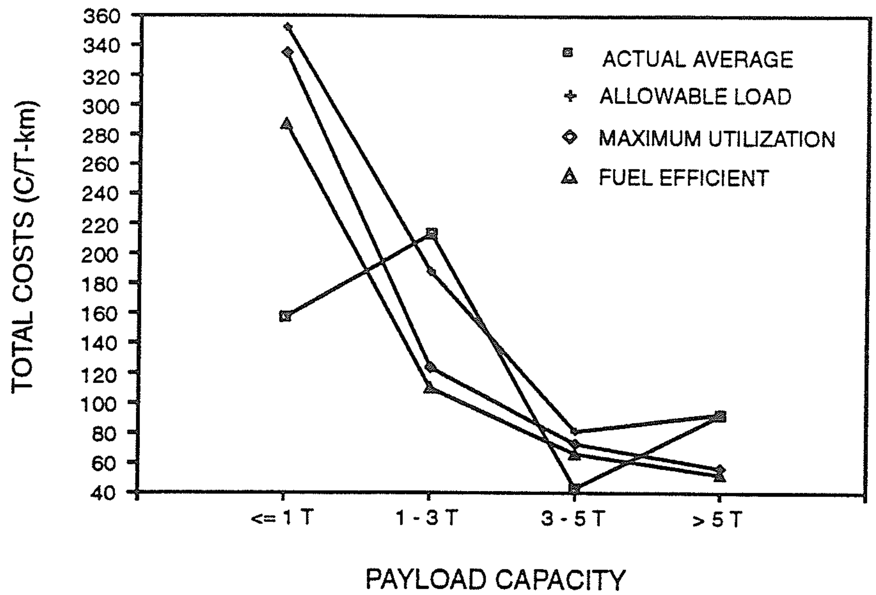


Figure 6.1 Cost Comparison: Freight Trucks

Previous research [TRED, 1980; TRB Report 227, 1990] has shown that larger, properly loaded vehicles have a less detrimental effect on roadways than do smaller, overloaded vehicles. Although the TRED and TRB research is directed primarily at North American tractor semi-trailers, the conclusions are not vehicle or region-specific. Transport options to be considered further will assume that allowable load operating conditions are to be enforced.

6.1.1 Vehicle Size

Figure 6.1 shows that operating costs per T-km decrease as vehicle size increases for the straight vehicles. Findings from other research [TRED, 1980; TRB Report 227, 1990; Trimac, 1988] show that the relation between operating cost and vehicle size holds true for articulated vehicles. Ghanaian and previous research then indicate that a financial benefit is gained from transporting agricultural commodities using larger vehicles.

The use of larger vehicles in the transportation of agricultural commodities could offset the increase in cost per T-km caused by the enforcement of registered load allowances. For example, transportation under actual conditions in a vehicle with a registered payload capacity of one tonne or less, loaded to 300% of its payload capacity costs 164 C/T-km; enforcing registered load allowances increases costs to 352 C/T-km; carrying the load in a truck with a 1 - 3 T payload capacity reduces costs to 188 C/T-km; loading in a 3 - 5 T capacity truck further reduces costs to 81 C/T-km (less than the cost under average conditions in the smaller, overloaded truck).

The relationship between truck size and transport cost is illustrated using as an example the costs associated with transporting 2000 T of freight 200 km using each of the four types of straight freight trucks. Number of truck-days is calculated using average vehicle speed and loading time, and allowing for the 12-hour curfew on freight vehicles. Number of truck-years is calculated using 52 five-day weeks per year. Capital costs are calculated using the number of truck-years required to move the freight and the average annual capital costs per truck. Results of the analysis are given in Table 6.1.

Table 6.1 Comparison of Costs: 2000 T; 200km
Enforced Loading Conditions, Maximum Utilization

	Payload Capacity			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
Journeys Required	5263	1786	808	498
Truck-years (#)	10.1	3.4	3.1	1.0
Total Costs (C/T-km)	321	119	86	62
Fixed Costs (C/T-km)	19	20	13	4
Variable Costs (C/T-km)				
Repair & Tires	46	28	24	21
Fuel	200	57	27	17
Loading	26	14	24	21

The example demonstrates the cost effectiveness of using larger vehicles. Total cost of transporting the given freight is over 5 times more using the smallest than the largest straight freight truck. Further gains could be made from the introduction of tractor semi-trailer units, however available Ghanaian data on these units do not permit the inclusion of figures in the comparison.

6.1.2 Vehicle Utilization

Another change to current operating practices that would substantially reduce transport costs is an increase in vehicle utilization. Under present operating conditions freight trucks average 22% of the distance travelled under maximum operating conditions. Low utilization rates are due to long wait times between loads and time out-of-service for repairs; the average freight truck waits over 4 days between loads and spends 52 days a year out-of-service due to repairs. The same example of moving 2000 T of freight 200km is used to illustrate the increase in transportation costs caused by low utilization. Average time between loads and repair time of each type of freight truck is used to calculate the number of weekly journeys made by the vehicle. Loading to capacity and no backhauls is assumed as for the first example. Loading time is considered as part of the wait between loads; no allowance is made for the 12-hour curfew; and possible running time is a 7-day week (the survey indicated that drivers generally take time off while waiting for a load). Results of the analysis are given in Table 6.2.

Table 6.2 Comparison of Costs: 2000 T; 200 km
Average Utilization (Wait and Repair Times)

	Payload Capacity			
	<= 1 T	1 - 3 T	3 - 5 T	> 5 T
Journeys Required	5263	1786	808	498
Truck-years (#)	36.4	12.1	18.9	11.2
Total Costs (C/T-km)	451	169	373	99
Fixed Costs (C/T-km)	180	70	190	41
Variable Costs (C/T-km)				
Repair & Tires	46	28	24	21
Fuel	200	57	27	17
Loading	26	14	24	21

Total transportation costs per T-km increase when average wait and repair times are used to estimate current utilization rates in the set transportation problem. Variable costs (fuel, repair, tires and loading costs) are the same per T-km for both examples. The sharp increase in costs seen with actual utilization rates is due to an increase in fixed costs caused by the increase in the number of truck-years required. Truck-years are a measure of the number of average trucks required to move 2000 T of freight 200 km. Truck-years required range from 1 to 10 under the maximum utilization scenario simulated in the first example, and from 11 to 36 under the average utilization of the second example. Fixed costs then increase from 3 to 10 times with the decrease in utilization. Figure 6.3 illustrates the change in total costs per T-km caused by the decrease in utilization.

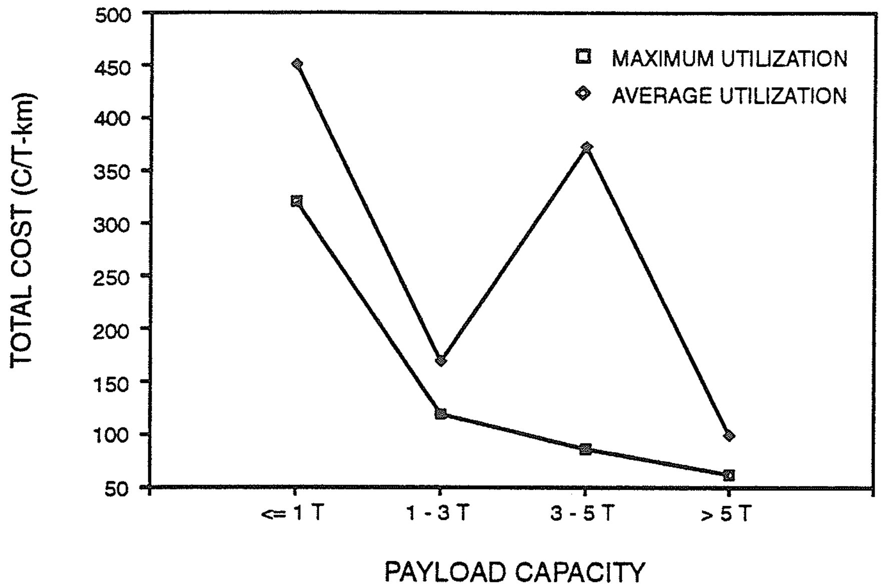


Figure 6.2 Comparison of Costs: 2000 T; 200 km
Maximum Utilization - Average Utilization

Low utilization rates such as those found in the example above and in actual conditions increase transport costs per T-km by more than 40% over costs under maximum utilization for all types of freight vehicles: costs increase by 40% for freight trucks with a payload capacity of 1 T or less; by 42% for 1 - 3 T payload trucks; by 334% for 3 - 5 T payload trucks; and by 60% for trucks with payload capacities greater than 5 T.

Low utilization caused by long wait and repair times causes a change in the size-cost relationship that was seen under a maximum utilization scenario (Figure 6.1). The 3 - 5 T payload capacity vehicles with the largest increase in cost are also the vehicles with the longest average wait and repair times: an average of 139 hours (5.8 days) between loads and 65 days a year out-of-service due to repairs. Transport costs per T-km are higher for 3 - 5 T payload capacity trucks than they are for 1 - 3 T payload trucks and only 17% lower than for the smallest type of trucks. Under maximum utilization costs for 3 - 5 T payload capacity trucks are 27% lower than for 1 - 3 T trucks, and 73% lower than for trucks with a payload capacity of 1 T or less. Utilization rates are then a major factor in the transportation cost structure.

6.1.3 Fuel Costs

Since fuel is an imported commodity that must be purchased with hard currency, decreasing transport fuel costs is an important issue to Ghana. The TOC model developed in Chapter 5 suggests that fuel costs represent, on average, 31% of total transport costs under average actual operating conditions. Significant improvements to transport costs could be gained from improvements in vehicle fuel consumption.

The Chesher and Harrison VOC research [1987] shows that vehicle fuel consumption is a function of speed, road characteristics (gradient, roughness and curvature), and vehicle characteristics (GVW or power to weight ratio). Optimal speed (speed at which fuel consumption is minimized) for light goods vehicles is predicted to be,on average, 37 km/h; optimal speed for medium trucks is, on average, 35 km/h. (Average speed for Ghanaian freight vehicles under average actual conditions varies between 31 and 47 km/h.) The most significant road characteristic is gradient (measured as rise + fall in m/km) with an average 18% increase in fuel consumption of medium trucks resulting from a sevenfold increase in gradient (10 m/km to 70 m/km). A fivefold increase in road roughness (2000 mm/km to 10000 mm/km) increases fuel consumption, on average, by 5%. Results from similar analysis of the effect of curvature on fuel consumption are inconclusive: data from Kenya and the Caribbean suggest that fuel consumption decreases as curvature increases; data from Brazil and India suggest the opposite. In either case, the change in fuel consumption with curvature is, on average, less than 1%. The average decrease in fuel cost per T-km resulting from combined road characteristic improvements (sevenfold decrease in gradient, fivefold decrease in road roughness) is 15% for medium trucks. [Renic, 1992]

Data from the Ghanaian TOC model reveal that under maximum utilization conditions, total costs per T-km decrease by 63% between <=1T and 1 - 3 T payload capacity trucks; however fuel costs per T-km decrease by 72% for the same trucks. In all cases, fuel costs decrease more than total costs when two sizes of vehicles are compared. The decrease in fuel costs resulting from using a larger vehicle is more significant than the decrease in fuel costs resulting from improved road conditions. Fuel consumption improvements may also be realized through changes in vehicle characteristics. Technology changes have improved vehicle fuel consumption by approximately 30% between 1981-84 (Clayton) and 1989 (DriveSave/TruckSave) [Nix, 1991]. Reducing fuel costs may then be best addressed through operational (using larger vehicles) and technological (using newer vehicles) changes than through improvements to the infrastructure.

6.2 Transport Interests

A number of actors play key and supporting roles in the Ghanaian transport industry. Their interests must be considered in the evaluation of any proposed option involving changes in the current transport system or its method of operation.

6.2.1 Producers

There are two broad classes of producers in Ghana: export (cocoa and timber), and domestic (food crops). The export producers generally ship their goods in large quantities using own-account vehicles, that is vehicles that are operated exclusively for the evacuation of a given export crop. Domestic producers generally ship their goods in small quantities on vehicles generally hired through the lorry parks.

The main interest of producers, domestic and import, is the level of service provided by transporters; that is, the availability and cost of transport. Producers need access to affordable transport on a regular basis. The Ministry of Agriculture estimates that 15% to 25% of major foodcrops spoil before they can be evacuated from the point of production [from Ansah, 1988]. In the case of cocoa, evacuation from area depots is overseen by the COCOBOD and the producer is responsible only for the transport from field to depot.

6.2.2 Transporters

The interest group of transporters is divided into two categories: owners and drivers. Survey results show that a large proportion (73%) of the straight trucks used in LTL transport of domestic agricultural commodities are not operated as a part of a fleet but rather on a one truck basis. Truck owners then seek out the most profitable route for each vehicle and the most profitable type of vehicle to operate. Average costs and revenues for straight vehicles under actual operating conditions are shown in Table 6.3. According to these data, operators seeking to maximize earnings would have no incentive to use larger vehicles, or to change their operating practices - the most profitable vehicles tend to be the most overloaded.

Table 6.3 Costs and Revenues: Actual Average Conditions

Payload	Capacity	A COSTS (C/T-km)	B REVENUES (C/T-km)	B-A (C/T-km)
Freight				
	<= 1 T	164	663	499
	1 - 3 T	222	168	-54
	3 - 5 T	46	91	45
	> 5 T	102	114	12
	2 - S2	38	30	-8
Mixed				
	<= 1 T	194	196	2
	1 - 3 T	162	228	66
	3 - 5 T	99	110	11
	> 5 T	117	124	7

Vehicle operators are generally given little managerial responsibilities - only 20% of them were able to answer any questions on vehicle finance and 15% of drivers surveyed are owner/operators - and they are generally paid a fixed monthly wage.

Their main interest is therefore one of job security; they have little motivation or opportunity to change operating practices.

6.2.3 Transport Organizations

There are two types of transport organizations in Ghana; those which are primarily employee organizations and those which are primarily owner organizations. The most influential transport organization is the GPRTU (Ghana Private Road Transport Union) which is a union representing drivers and porters. The GPRTU controls approximately 80% of the lorry parks in Ghana. The Union is responsible for vehicle registration on particular routes, collection of user fees, daily tolls, and income taxes. Loading, consignment, and consolidation of LTL freight is done by Union porters. Policing of the lorry parks is done by the Union's own force. Owner organizations in Ghana are numerous but they do not wield the same power within the transport industry as the GPRTU. However the interests of transport owners - profitability of transport operations - must be considered in the evaluation of proposed transport options.

6.2.4 Government

The Ghanaian Government has an interest in optimizing the national agricultural transport industry: 60% of its hard currency is earned from the sale of agricultural commodities; over 90% of agricultural commodities are transported by road; transport costs can be responsible for as much as 60% of the retail price of domestic foodstuffs [CTCS, 1992]; transport inputs (vehicles, fuel, spare parts) are imported at a hard currency cost to the country. Ghana then has an interest in maximizing hard currency earnings and transport efficiency, and minimizing transport and hard currency costs.

6.3 Evaluation of Transport Options

The proposed transport options are interlinked and require a change in operational practices. For example, simply enforcing load allowances would cause transportation costs per T-km to increase; to realize a cost saving from the enforcement of load allowances requires a simultaneous increase in vehicle utilization rates. Transport costs are further decreased with the transportation of commodities in larger vehicles and an increase in fuel efficiency. Evaluation of options assumes enforced loading conditions and examines the effects of increased utilization, the use of larger vehicles, and increased fuel efficiency. Operating practices are examined within each of the presented transport options.

6.3.1 Larger Vehicles

The example used in section 6.1.1 and the TOC model developed previously (Figure 6.1) demonstrate the cost effectiveness of using larger vehicles. Savings of 63% are realized from moving from a vehicle with a payload capacity of 1T or less to one with a payload capacity of 1 to 3 T; savings of 28% are realized between 1 to 3 T trucks and 3 to 5 T trucks; and savings of 28% are realized between 3 to 5 T trucks and trucks with a payload capacity greater than 5 T. The Trimac data show a 63% decrease in costs between trucks with payload capacity of 6.6 T and tractor semi-trailers with a payload capacity of 22.7 T [Trimac, 1988]. Using larger trucks to transport agricultural commodities would result in lower transport costs by increasing the payload to GVW ratio and thereby reducing costs per unit of productivity.

Fleet characteristics would change significantly as a result of using larger vehicles to transport agricultural commodities. The total number of trucks required would decrease as illustrated in the example of section 6.1.1 where one of the largest trucks could be used to replace 10 of the smallest trucks and transport the same freight at one fifth the cost. The number of trucks required on a given route would decrease as a result of using larger trucks and the level of service to producers would decrease as fewer trips would be necessary. Such a measure could decrease the agricultural transport fleet by reducing the number of trucks on each route; but it could also permit an increase in service to currently under-serviced areas; smaller vehicles could ply shorter routes and serve as a "feeder" service to the larger vehicles. Implementation of measures promoting the use of larger vehicles would require a more hierarchical concentration and dissemination network, and a flexible system capable of responding to fluctuating transport demands. Promoting the use of larger vehicles would affect each of the key interests and actors.

PRODUCERS: In a competitive environment, lower costs per T-km to transporters could reduce transport costs to producers. Small producers of domestic commodities might suffer from the implementation of such measures because they tend to ship in small, LTL quantities of perishable goods,and less frequent service could result in more losses due to spoilage. However, the smaller vehicles could provide a more frequent service to producers and better connecting services for marketing agents thereby making the domestic market operate more efficiently.

OWNERS AND OPERATORS: The change in fleet necessary to implement measures promoting the use of larger vehicles would benefit current owners of larger vehicles as the demand for their vehicles increased. However, current owners of smaller vehicles would have to alter their operations to fit into the concentration-dissemination pattern evolving from such measures. The enforcement of load allowances would facilitate the transition as it would become apparent that transport costs were much lower in larger vehicles. The cost of altering the fleet of vehicles would however fall to transport owners. Areas of service for varying sizes of vehicles would also change, with the smaller vehicles more in demand on shorter routes away from the main markets.

TRANSPORT ORGANIZATIONS: The GPRTU would largely be responsible for implementing measures required to ensure the use of larger vehicles. The onus would fall largely on the porters who are responsible for consolidation of LTL freight and ultimately choice of vehicle. Some lorry park operations might have to be altered to accommodate the larger vehicles and the change in operating practices. The GPRTU, could see many of its members adversely affected by the measures; larger vehicles could mean fewer vehicles and fewer drivers.

Organizations representing transport owners would benefit from the changes through their members. Owner organizations might be pressed to help owners develop new services and routes for the smaller vehicles and implement feeder services for larger vehicles.

GOVERNMENT: Implementation of measures to encourage the use of larger, legally loaded vehicles would decrease road wear and therefore road maintenance costs. Measures leading to the use of larger vehicles would reduce transport costs and hard currency costs to the country. An increase in level of service to producers caused by the implementation of a feeder service by smaller vehicles to production communities would increase the efficiency of domestic crop transport and marketing.

6.3.2 Increased Utilization

The example used in section 6.1.2 illustrates the costs associated with low utilization rates caused by long wait and repair times (Figure 6.2). Costs per T-km decrease with higher utilization for all sizes of vehicles. The example used of transporting 2000T of freight 200 km under maximum and average utilization rates indicates that cost savings incurred under maximum utilization conditions were fixed costs which decreased tenfold for nearly all categories of trucks (Tables 6.1 and 6.2). Increased utilization rates then decrease transport costs through a decrease in fixed costs by reducing the number of vehicles required to transport a given amount of freight or alternatively, increasing truck productivity (T-km) to reduce the proportion of fixed costs per productivity unit.

The number of trucks required on a given route would decrease as a result of increasing utilization rates; wait times would be decreased; and long periods out-of-service due to repairs could jeopardize a route. Such a measure could decrease the agricultural transport fleet by reducing the number of trucks on each route; but it could also permit an increase in service to currently under-serviced areas. Increasing vehicle utilization rates would affect each of the key interests and actors.

PRODUCERS: Transport costs to producers could decrease due to lower costs per T-km for transporters. Increased utilization could increase level of service provided to small producers in less accessible areas. Enforced load allowances might bring a more regular service to producers: instead of one trip loaded at 200% of capacity, trucks would make two trips, doubling the service provided and making smaller, more frequent shipments possible (desirable when shipping perishable foodcrops).

OWNERS AND OPERATORS: Higher utilization rates and lower transport costs would be beneficial to owners. Enforcement of loading allowances would reduce wear on vehicles decreasing repair and maintenance costs. However, reducing the number of trucks required on each route could put some operations out of business unless new routes or services were offered by vehicles no longer needed on established routes. Vehicles frequently in need of service or immobilized for long periods of time could find it difficult to operate under such conditions.

TRANSPORT ORGANIZATIONS: The GPRTU would largely be responsible for implementing measures required to ensure allowable loading and maximum utilization. The number of vehicles registered on each route would be controlled and loading conditions enforced. The GPRTU, could also see many of its members adversely affected by the measures; higher utilization could mean fewer vehicles and fewer drivers. Drivers who get a salary unrelated to utilization would work more hours for the same salary, at least in the short term.

Organizations representing transport owners would benefit from the changes through their members. Owner organizations might be called upon to help owners develop new services and routes to counter the decrease in vehicles needed on present defined routes.

GOVERNMENT: Implementation of measures to enforce load allowances would decrease road wear and therefore road maintenance costs. Measures to increase vehicle utilization would reduce transport costs and hard currency costs to the country. An increase in level of service to producers would decrease the amount of loss due to spoilage and increase the efficiency of domestic crop production.

6.3.3 Increase Fuel Efficiency

Increasing fuel efficiency through operational and technological changes is an important factor in reducing transportation costs in Ghana. Operational changes have been addressed in previous sections. The technological improvements (aerodynamic and mechanical) in vehicles over the last ten years have reduced fuel consumption by 30% [Nix,1991]. Given that the average vehicle is over 10 years old, significant improvements to fuel consumption could be achieved through the use of newer vehicles.

Unless operational changes are made within the transport industry the increased capital costs of newer vehicles could decrease the profitability of transport operations and increase transport costs. Promoting the use of newer vehicles would affect each of the key interests and actors.

PRODUCERS: Transport costs to producers could decrease due to lower costs per T-km for transporters.

OWNERS AND OPERATORS: The increased capital costs incurred from the purchase of newer vehicles would increase transport costs to owners; however operational changes (increased utilization and the use of larger vehicles) and increased fuel efficiency could offset these increases.

TRANSPORT ORGANIZATIONS: Both the GPRTU and owner organizations could develop financial assistance programs designed to encourage operators to purchase newer equipment. Further assistance could be provided with training programs developed to increase fuel efficiency and decrease transport costs through improved vehicle maintenance and driver habits.

GOVERNMENT: Policies and programs designed to encourage the importation of newer vehicles along with the implementation of operational changes would decrease fuel consumption and some of the hard currency costs of transportation.

Measures introduced to encourage maximum utilization of vehicles and the use of larger and newer vehicles for the transportation of agricultural commodities in Ghana will produce changes to the fleet and its current operating practices. The transport options depend on the enforcement of load allowances to bring about improvements to the cost and efficiency of the current transport system. The success of any policy and program measures introduced to the current transport industry in Ghana needs the sanction and cooperation of the GPRTU as the controlling organization in lorry parks and LTL freight and the major transport agent for domestic commodities.

CHAPTER 7: CONCLUSIONS AND RECOMMENDATIONS

The primary objective of the thesis is to develop a methodology and an information base with which to formulate and evaluate policy and program options affecting the physical and operating characteristics of highway vehicles servicing the agricultural sector in Ghana. The methodology for analysis and evaluation, based upon the Manheim model, divides the transportation of agricultural commodities in Ghana into three interactive systems -agriculture, transport, and flow. Each system is examined under its present operating condition. A survey of vehicles operating in and around the Kumasi area is utilized as the information base to design a TOC (Truck Operating Cost) model. The basic TOC model is used to calculate costs under additional operating conditions: allowable load limits, maximum utilization, and increased fuel efficiency.

The methodology, information base, and TOC model are used to identify and evaluate potential program and policy transport options relevant to Ghana. The key transport issues raised are overloading, low vehicle utilization rates, and an aged vehicle fleet with high fuel consumption rates. These issues are examined in light of three main policy and program transport options: using larger vehicles, increasing vehicle utilization, and increasing fuel efficiency. Included within these three main transport options are enforcement of load allowances and consideration of operating practices. The transport options are evaluated in terms of their effect on the key transport interests: producers, transporters, transport organizations, and the government of Ghana.

7.1 Observations and Conclusions

The TOC model and research from other sources demonstrate the relationship between vehicle size and transport costs; TOC per payload T-km decrease with increased vehicle size due a decrease in the GVW to tare ratio. The use of small vehicles results in high unit transport costs. For example, transporting freight in vehicles other than small pick-up trucks (payload <=1 T) would result in a saving of at least 63% per T-km.

Low vehicle utilization and high overloading, common under actual average operating conditions, are major determinants of the present transport cost structure in Ghana. Low utilization caused by long times between loads and long periods out-of-service due to repairs are partially compensated through high overloading. High overloading decreases unit costs to transporters but increases road maintenance costs to government. Low utilization increases unit costs to transporters; it is a function of lorry park operations and the number of vehicles plying each route. TOC increase when load allowances are enforced but decrease when higher utilization rates are imposed.

Evaluation of transport options reveals that significant reductions in fuel costs per T-km are achieved through the use of larger vehicles. The technological advances of newer vehicles reduce fuel consumption, an aging fleet results in higher fuel and maintenance costs. Operational changes encouraging the use of larger vehicles and policies encouraging the importation of newer vehicles would serve to decrease the hard currency cost of fuel in Ghana.

Changes in current operational practices are necessary for the transport industry to realize benefits from the enforcement of load allowances . These changes include: an increase in vehicle utilization, the use of larger vehicles, and an increase in fuel efficiency. Changes would occur primarily in lorry park operations which are responsible for much of the domestic commodity transport and LTL freight in Ghana. The development of a more hierarchical domestic transport fleet is essential to the implementation of measures encouraging the use of larger vehicles.

Evaluating the effects of implementing the proposed transport options (assuming enforcement of load allowances in all cases) reveals that:

- fewer trucks are required to transport a given amount of agricultural commodities by increasing vehicle size and by increasing vehicle utilization, thereby reducing transport costs.

- frequency of service to producers is decreased unless measures are adopted to service less accessible areas or open new routes. Simultaneous measures need to be introduced promoting a more hierarchical concentration-dissemination system; using smaller vehicles as "feeder" vehicles providing service directly to producers and using larger vehicles from concentration points on the network.

- some owners and operators would be put out of business unless measures are adopted to increase service or open new routes.

- the GPRTU (Ghana Private Road Transport Union), as the controlling organization in lorry parks and LTL (less than truckload) freight, would largely be responsible for implementing measures required to ensure allowable loading conditions, maximum utilization, and the use of larger vehicles. The Union, in its present role, would also be a key player in ensuring service to producers and new opportunities for owners and operators.

- the Government of Ghana benefits through lower road maintenance costs, due to enforced load allowances, and lower hard currency costs, due to lower transport costs and increased fuel efficiency. An increase in the efficiency of domestic crop transport could result from an increased level of service on currently under-serviced routes and the development of a concentration-dissemination network.

A distinction is made in the TOC model between trucks designated as carrying freight and vehicles carrying mixed passengers/goods. The designation is made on the basis of vehicle configuration and insurance type. A comparison between mixed passenger/goods vehicles carrying only freight and freight trucks in similar operating conditions reveals that vehicle configuration has little effect on transportation costs. The main issue is not one of cost but of safety and insurance.

7.2 Policy and Program Options for Ghana

Recommendations developed from the thesis focus on the transport of domestic commodities and LTL freight centred in lorry parks. Although some vehicles carrying export commodities were surveyed, the majority of the questionnaires involved the transport of domestic commodities due to the location of the surveys (mainly lorry parks) and the season of survey (harvest season for domestic crops but not cocoa). Transport of export commodities is mainly through private companies (timber) and "own account" fleets (cocoa) and study of their transport costs would require a different research design and approach.

The importance of the GPRTU in the transport of agricultural commodities in Ghana is underlined throughout the thesis. The Union should therefore be called upon to play a significant role in the development and implementation of any changes to the transport system. In fact, in its present role as the controlling agent in 80% of Ghana's lorry parks, the cooperation of the GPRTU is essential to the success of any transport option to be considered.

The Ghanaian government in cooperation with the GPRTU and lorry park operators could institute the following programs and policies in order to increase the efficiency of the transportation of agricultural commodities:

- *enforce registered loading allowances.* GPRTU porters load all vehicles in lorry parks and the charge is levied on a unit basis. Average unit weights for common commodities could easily be established and load allowances calculated as a number of loading units. ie. number of bags of coal

- *encourage higher utilization.* This could be achieved by controlling the number of vehicles licensed as commercial vehicles and/or the number of vehicles registered by the GPRTU on each route, and ensuring that all designated routes are adequately serviced.

- *encourage the use of larger vehicles.* Since union porters consolidate all LTL freight and designate the vehicle of choice, consolidation into larger vehicles could be accomplished through them.

- *assist in the development of a more hierarchical and interactive transport network.* The GPRTU has the potential to decide on the number and size of vehicles registered for each route in 80% of Ghanaian lorry parks; this could be used to match more appropriately transport demand and supply, and develop a "feeder" system between smaller trucks and routes and larger ones.

Current foreign aid programs designed to assist Ghana in the development of their transport system are concentrated on infrastructure improvements. Infrastructure improvements are capital intensive and result in marginal improvements in transport costs. Policy and program options do not require large capital expenditiures and can result in significant transport cost savings. This thesis has demonstrated the cost savings achievable through policy and program options designed to affect the number and type of vehicles transporting agricultural commodities in Ghana. The benefit of using foreign aid transport programs to assist the Ghanaian government in effecting fleet and operational changes (for example, loans for larger, newer vehicles) should be examined.

7.3 Recommendations for Further Research

Tractor semi-trailers, though included in the framework of the TOC model, were not included in the analysis due to a lack of data. Research from other sources has demonstrated the advantages to transport cost and infrastructure maintenance gained from the use of larger vehicles. Further research specifically designed to determine unit transport costs of tractor semi-trailers in Ghana would serve to complete the TOC model developed in this thesis. As was indicated in the thesis, this area of research would have significant implications on the transport of agricultural commodities destined for export, cocoa and timber. These commodities are an important source of hard currency for the country.

Further research on frequency and cost of service to producers could help in the development of a more hierarchical and interactive transport network. The transportation industry is driven by the demand for commodity movement and a clearer understanding of this demand could be beneficial to the industry. This type of research would facilitate the development of a "feeder" system in that the service could better parallel the demand.

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APPENDIX A:
QUESTIONNAIRE

AGRICULTURAL COMMODITY TRANSPORT SURVEY

PART I. INTERVIEW DETAILS

Questionnaire Number
Place

Interviewer
Date

PART II. VEHICLE INFORMATION

1. **REGISTRATION NUMBER:**

2. **VEHICLE MAKE:**

3. i) **MODEL YEAR** : a) 19 b) Don't know
   ii) **MODEL TYPE/NUMBER:** a)______ b) Don't know
   iii) **NUMBER OF ENGINE CYLINDERS:** a)__ b) Don't know
   iv) **TYPE OF FUEL USED:**
   a) Petrol b) Diesel

4. **CURRENT CONFIGURATION :**
   a) Rigid truck b) Articulated vehicle
   c) Tractor unit alone d) Truck with trailer
   e) Waton kyene f) Tro-tro
   g) Other (specify)

5. **i) NUMBER OF AXLES** :
   a) Main vehicle b) Trailer

   ii) NUMBER OF WHEELS :
   a) Main vehicle b) Trailer

6. **MAIN BODY TYPE :**
   a) Flat b) High sided c) Low sided
   d) Box e) Tipper
   f) Other (specify)

7. **i) REGISTERED NET WEIGHT :**
   a) _____ tons OR _____ kgs
   b) Don't know

   ii) REGISTERED GROSS WEIGHT :
   a) _____ tons OR _____ kgs
   b) Don't know

PART III. DRIVER DETAILS

8. **RESPONDANT** : a) Principal Driver
   b) Driver's Mate

9. i) **WHEN DID DRIVER FIRST START DRIVING COMMERCIAL VEHICLES?** 19
   ii) **WHEN WAS YOUR DRIVER'S LICENSE FIRST OBTAINED?**
   a) 19 b) Don't know

10. **HOW LONG HAS DRIVER BEEN WITH THIS VEHICLE?**
    a) Under 1 year b) 1 year c) 2 years
    d) 3 years e) 4 years
    f) more than 4 years: give __ years

11. **HOW MANY DRIVERS ARE USUALLY CARRIED ON EACH TRIP?**
    a) One b)Two
    c) More than two: give number

12. **HOW MANY DRIVER'S MATES ARE USUALLY CARRIED ON EACH TRIP?**
a) None b) One c) Two
d) More than two: give number e) Don't know

PART IV. VEHICLE LOAD

These questions refer to the highway trip immediately prior to arrival at lorry park.

13. **WAS THE TRUCK LOADED OR EMPTY?**
a) Truck loaded __ **Go to question 14**
b) Truck empty __ **Go to question 27**

14. **PRINCIPAL CARGO** :
a) Passengers ___ Number
b) Goods ___ Types:

15. **TOTAL CARGO WEIGHT OR QUANTITY** :
a) ___ tons OR ___ kgs OR ___ lbs
b) ___ bags of
c) ___ numbers of
d) Don't know

16. **HOW FULL WAS VEHICLE?**
a) Full load b) Part load c) Don't know

17. **MULTIPLE LOADING:** Is there more than one village where cargo was picked up or delivered on the journey?
a) Yes __ (see below) b) No c) Don't know

If YES, indicate how many points of loading
_____ points

18. **PLEASE INDICATE CARGO ORIGIN AND DESTINATION** :
For multiple loadings give first village.

i) **Load origin**: a) village
district _______region
b) Don't know

ii) **Load destination**: a) village
district _____region
b) Don't know

19. i) **GIVE APPROXIMATE JOURNEY DISTANCE BETWEEN FIRST ORIGIN AND FINAL DESTINATION OF CARGO:**
a) ___ miles OR ___ kilometres
b) Don't know

ii) **GIVE APPROXIMATE JOURNEY TIME:**
a) ___ hours ___ days
b) Don't know

20. **INDICATE ROUTE TAKEN FROM ORIGIN TO DESTINATION VIA INTERMEDIATE TOWN OR VILLAGE, IF APPLICABLE.**

21. **HOW WAS THIS LOAD OBTAINED?**
a) At a lorry park
Go to Question 22
b) Pre-arranged with customer
Go to question 23
c) Other (please specify)
Go to Question 24
d) Don't know
Go to Question 24

22. **IF LOAD WAS OBTAINED AT A LORRY PARK:**
i) What was the charge (toll ticket)?
a)____ Cedis b) Don't know

ii) How much time was spent loading/unloading vehicle?
a)__ minutes b)__ hours c)Don't know

iii) What was the charge for loading/unloading?
a)______ Cedis b) Don't know

iv) How much time was spent waiting for load?
a)___ hours b)__ days c) Don't know

Go to question 24

23. **IF LOAD WAS PRE-ARRANGED WITH CUSTOMER:**
i) Does the customer guarantee a load back?
a)Yes b)No _(see below) c)Don't know

IF NOT, where will you obtain load?
__ return empty
__ lorry park
Other (specify)
__ Don't know

ii) How much time was spent loading/unloading vehicle?
a)__ minutes b)__ hours c) Don't know

iii) How much time was spent waiting for load?
a)__ hours b)__ days c) Don't know

24. **i) Please give total revenue for the trip:**
a)_____ Cedis b) Don't know

ii) Please give total revenue for last month:
a)_____ Cedis b) Don't know

25. **BEFORE PICKING UP THE LAST LOAD, HOW FAR DID THE TRUCKHAVE TO TRAVEL EMPTY?**
a) No distance b) __ miles OR __ kms
c) Don't know

26. **INCLUDING RUNNING TIME, HOW LONG WAS THE TRUCK EMPTYBETWEEN PUTTING DOWN THE PREVIOUS LOAD AND PICKING UP THE LAST LOAD?**
a) If less than one day, give hours ___ hrs
b) If more than one full day, give days: ___ days

GO TO QUESTION 31.

27. **IS THIS VEHICLE BASED IN KUMASI?**
Yes_ **Go to Question 31. No _ ** Go to Question 28.

28. **WHAT WAS YOUR JOURNEY ORIGIN?**
a) village ________district ______region b) Don't know

29. **WHAT WAS YOUR JOURNEY DESTINATION?**
a) village ________district ______region b) Don't know

30. **GIVE APPROXIMATE JOURNEY DISTANCE:**
a) ____ miles OR _____ kms
b) Don't know

31. **WHAT IS CURRENT JOURNEY PURPOSE?**
a) Attending market day
b) To pick up passengers
c) To pick up freight
d) Other reason (state)
e) Waiting for backhaul

32. **HOW LONG HAS VEHICLE BEEN WAITING FOR A LOAD?**
a) __ hours
b) __ days
c) Don't know

PART V. OWNERSHIP & MANAGEMENT OF VEHICLE

33. **IS PRINCIPAL DRIVER THE REGISTERED OWNER?**
a) No __ (see below)
b) Yes
c) Don't Know

If NOT, what relationship does the REGISTERED OWNER have with the truck?

a) He is the owner (sole or joint) who takes full profit/losses of the truck
b) He is a previous owner who is selling the truck
c) He is an owner who hires out the truck on a regular basis
d) Government body, public corporation
e) Commercial company
f) Other (specify)
g) Don't Know

34. **WHO OWNS THE VEHICLE?**
a) Federal Government
b) Public sector corporation
c) Commercial company
d) Private individual
e) Family partnership
f) Non-family partnership
g) Other (specify)
h) Don't know

35. **WHAT IS THE RELATIONSHIP BETWEEN DRIVER AND TRUCK?**

a) Truck is on hire-purchase to driver alone
Go to Question 39
b) Truck is on hire-purchase to driver and others
Go to Question 38
c) Principal driver is exclusive sole owner
Go to Question 39
d) Principal driver owns a part share of truck
Go to Question 38
e) Principal driver is a salaried employee
Go to Question 36
f) Vehicle is rented by driver
Go to Question 36
g) Vehicle is borrowed or by other arrangement
Go to Question 36
h) Don't know
Go to Question 36

36. **PLEASE GIVE:**
i) Principal driver's revenue per month: ___ cedis.
ii) Principal driver's daily expenses: ___ cedis.

iii) Second driver's revenue per month: ___ cedis.
iv) Second driver's daily expenses: ___ cedis.

v) Driver's mate wages per month: ___ cedis.
vi) Driver's mate daily expenses: ___ cedis.

37. **IF DRIVER DOES NOT OWN ANY TRUCKS (AND IS NOW AN EMPLOYEE) HAS HE EVER BEEN IN THE TRANSPORT BUSINESS FOR HIMSELF?**
a) No b) Yes c) Don't know
Go to Question 40.

38. **IF DRIVER HAS A PART SHARE IN THE VEHICLE THEN APPROXIMATELY HOW MANY PEOPLE HAVE A PARTNERSHIP IN THE TRUCK?**
a) __ people b) Don't know

39. **DOES THE DRIVER OWN OTHER TRUCKS?**
a) Yes __ (see below) b) No c) Don't know

If YES i) **How many trucks are exclusively owned by the driver?**
a) __ trucks b) Don't know

ii) **How many trucks does the driver have a part share in?**
a) __ trucks b) Don't know

40. **WHERE IS THE VEHICLE MAINLY BASED (IF THERE IS NO SPECIFIC BASE GIVE PRINCIPAL PLACE WHERE OWNERS LIVE)?**
a) village ________district ______region b) Don't know

41. **WHERE DOES THE DRIVER'S IMMEDIATE FAMILY LIVE?**
a) village ________district ______region b) Don't know

42. **ON AVERAGE, HOW OFTEN DOES DRIVER RETURN HOME TO HIS FAMILY?**
a) Daily b) Once every __ days
c) Don't know

43. **ON AVERAGE, HOW OFTEN AND FOR HOW MANY DAYS, IS REST TAKEN BY THE DRIVER EVERY MONTH?**
a) Rest is taken __ times per month and each rest time lasts for __ days.
b) Don't know

44. **DOES THE VEHICLE NORMALLY PLY A REGULAR ROUTE?**
a) Yes (please specify) b) No c) Don't know

45. **ON AVERAGE, HOW MANY TRIPS PER MONTH DOES THE VEHICLE MAKE:**

i) During harvest season: a)__trips b)Don't know
ii) Off season: a)__trips b)Don't know

46. i)**WHAT IS THE AVERAGE JOURNEY DISTANCE FOR THIS VEHICLE?**
a) **During harvest season:**
1.____ kilometres OR ___ miles
2.Don't know
b) **During off season:**
1.____ kilometres OR ___ miles
2.Don't know

ii) **WHAT IS THE AVERAGE JOURNEY TIME FOR THIS VEHICLE?**
a) **During harvest season**
1.____ hours OR ___ days
2.Don't know
b) **During off season**
1.____ hours OR ___ days
2.Don't know

47. i) **ON AVERAGE, HOW FAR DOES THE VEHICLE TRAVEL BETWEEN OBTAINING LOADS?**
a) ____ kilometres OR ___ miles
b) Don't know

ii) **ON AVERAGE, HOW MUCH TIME DOES THE VEHICLE SPEND WAITING FOR EACH LOAD?**
a) ____ hours OR ___ days
b) Don't know

48. **IS THE TRUCK OWNED AND MANAGED IN COMMON WITH OTHERTRUCKS?**
a) Yes __ (see below) b) No c) Don't know

If YES, approximately how many trucks are managed together?
a) Trucks b) Don't know

PART VI. VEHICLE FINANCE

49. **CAN THE DRIVER ANSWER QUESTIONS ON THE PURCHASE ANDFINANCE OF THE TRUCK?**
a) No __**Go to question 58**
b) Yes__**Go to question 50**

50. **WHAT IS THE CURRENT APPROXIMATE VALUE OF THE TRUCK?**
a) _____ cedis b) Don't know

51. **WHEN DID THE CURRENT OWNER FIRST OBTAIN THIS TRUCK?**
a) ___ month ___ year
b) Don't know

52. **WAS VEHICLE PAID IN ONE LUMP SUM?**
a) Yes __ (see below) b) No c) Don't know

If YES,
i) **What was the total amount paid?**
_____ cedis Don't know

ii) **How was the money raised for outright purchase?**

1. Purchaser/s contributed from own resources C
2. Loan from family C
3. Loan from friends C
4. Loan from a bank C
5. Gifts of money C
6. Loan from an agent / money lender C
7. Other sources C
8. Don't know

GO TO QUESTION 54.

53. **IF VEHICLE WAS NOT PAID IN ONE LUMP SUM, THEN:**

i) **What was the lump sum cash value at time of purchase?**
a) ______ cedis b) Don't know

ii) **What was the initial deposit?**
a) ______ cedis b) Don't know

iii) **Apart from the initial deposit what was the total amount to be repaid?**
a) ______ cedis c) Don't know

FOR ALL TRUCKS WHERE REPAYMENTS ARE OR HAVE BEEN MADE
ANSWER QUESTIONS 54 - 57

54. **WHAT WAS THE REPAYMENT PERIOD TO PAY OFF ALL COMMITMENTS?**
a) Until _____ (month) 19
OR for ____ months
b) Don't know

55. **HOW MUCH WAS THE VALUE OF EACH REPAYMENT?**
a) Each month____cedis b) Don't know

56. **IS THE LOAN / HIRE PURCHASE STILL OUTSTANDING?**
a) Yes __ (see below) b) No c) Don't Know

If YES, i) Are the repayments late?
a) Yes b) No c) Don't Know

ii) How easy is it to meet the loan repayments?
a) easy b) difficult
c) very difficult d) impossible
e) Don't Know

57. **TO WHOM ARE/WERE THE REPAYMENTS MADE?**

a) Bank or financial institution
b) Relative c) Friend
d) Seller of vehicle e) Agent/money lender
f) Other g) Don't know

PART VII. INSURANCE

58. **WHAT TYPE OF INSURANCE DOES THE TRUCK HAVE?**
a) Act Policy (minimum insurance)
b) Third party Policy
Please give coverage limit _____ Cedis
c) Fire and theft Policy
d) Comprehensive Policy
Please give coverage limit for third party __Cedis
e) None (government vehicle)
f) Other (Please specify)
g) Don't know

59. **IS THE VEHICLE INSURED AS A COMMERCIAL VEHICLE?**
a) Yes (see below) b) No c) Don't know
If YES, what is it insured to carry?
a) Passengers
b) Own goods
c) General cartage
d) Special types
d) Don't know

60. **GIVE APPROXIMATE ANNUAL PREMIUM :**
a) _______ cedis b) Don't know

PART VIII. RUNNING COSTS AND REPAIRS

61. **WHAT ARE THE LICENSING (REGISTRATION) FEES FOR THE VEHICLE?**
a) ______ cedis b) Don't know

62. **WHAT ARE THE ROADWORTHINESS CERTIFICATE FEES FOR THE VEHICLE?**
a) ______cedis every 6 months b) Don't know

63. **CAN DRIVER ESTIMATE HOW LONG THE TRUCK HAS BEEN OFF THE ROAD BECAUSE OF REPAIRS** (less than 1 day = 0)?

i) **During the last month?**
a) __ total days b) Don't know
ii) **During the last year?**
a) __ total days b) Don't know

64. **HOW OFTEN ARE TYRES BOUGHT FOR THE TRUCK?**
a) ___ tyres purchased every ___ months
b) Don't know

65. **EXCLUDING TYRES, HOW MUCH ON AVERAGE IS SPENT ON REPAIRS EACH MONTH?**
a) _____ cedis   b) Don't know

66. **WHEN THE TRUCK IS NOT UNDER REPAIR, THEN ON AVERAGE:**

i) How far is the truck run per week?
a) _____ miles OR ____ kilometres
b) Don't know

ii) How much fuel is used per week?
a) _____ cedis OR ____ litres
b) Don't know

67. **DOES THE DRIVER DO ANY VEHICLE MAINTENANCE HIMSELF?**
a) __Yes (see below)   b) __No   c) Don't know

If YES, specify what and how often.
a) Change the oil ___, once every
b) Grease and lubricate ___, once every
c) Rotate tires ___, once every
d) Other (please specify)
________________Once every

PART IX. ACCIDENTS

68. **DURING 1991 HOW MANY ACCIDENTS WAS THE TRUCK INVOLVED IN?**

a) None _ **Go to Question 71.
b) Give number ___ ** Go to Question 69.
b) Don't know ___ ** Go to question 71.

69. **DID THE MOST SERIOUS ACCIDENT INVOLVE THE FOLLOWING?**
a) Fatal injury   b) Hospitalized
c) Minor injury   d) No injury
e) Don't know

70. **FOR THE MOST SERIOUS ACCIDENT, WHAT TYPE OF COLLISION OCCURRED TO THE TRUCK?**
a) Nose to tail   b) Side
c) Head on   d) Hit pedestrian
e) Hit animal   f) Hit obstacle
g) Roll over   h) Other
i) Don't know

PART X. DRIVERS' PROBLEMS

71. **Please list the major problems facing truck drivers today:**

i)

ii)

iii)

APPENDIX B

SURVEY FOR LARGE TRANSPORTERS

AGRICULTURAL COMMODITY TRANSPORT STUDY

This survey is carried out as part of a Master's Degree in Transportation Engineering at the University of Manitoba in Canada. Any information that is given is being used solely for research purposes and it will remain confidential.

Questions for Large Operators

Vehicle details:
-number of vehicles in fleet
-types of vehicles (make, model, year)
-configuration and net weight
-type of fuel used

Utilization rates:
-average number of kilometres travelled monthly
  -during harvest season
  -off season

Vehicle loads:
-average loaded weight
-average journey distance
-average journey time
-% of empty backhauls (if back hauling is usual, how are the loads obtained)
-average 'turnaround' time
-number of drivers and mates carried on each vehicle and their wages (plus benefits if applicable)

Vehicle maintenance:
-average time vehicle off road for maintenance (or % of fleet off road per month)
-tire replacement schedule and cost
-average fleet monthly repair and maintenance cost (including mechanics wages and parts)
-do drivers carry out any regular maintenance on the road
-current value of vehicles, replacement policy and approximate cost of new vehicles

Vehicle insurance:
-type of insurance carried and yearly premiums
-licensing fees
-roadworthiness certificate costs

Safety record:
-number of accidents for fleet in 1991
-severity of accidents
-types of accidents

Problems facing large hauling companies in Ghana today.

APPENDIX C:

AGRICULTURAL COMMODITY UNITS AND WEIGHTS

Usual Wholesale Units of Sale for Agricultural Commodities
[Source: Commodity Ctransport Cost Study, GhanExim, 1991]

Commoditiy	Unit of Sale
Maize	Bag, 100 kg
Millet	Bag, 93 kg
Guinea Corn	Bag, 109 kg
Rice (Milled)	Bag,100 kg
Yams (Tuber)	1.4 kg/tuber
Cocoyams	Bag, 91 kg
Cassava	Bag, 91 kg
Gari	Bag, 68 kg
Kokonte	Bag, 59 kg
Plantain (Bunch)	Avg. 10 kg
Oranges	Bag, 90 kg
Pineapples	1.5 kg each
Banana (Bunch)	Avg. 8 kg
Tomatoes	Crate, 52 kg
Garden Eggs	Bag, 27 kg
Onions	Bag, 23 kg
Dried Pepper, long	Bag, 16 kg
Fresh Pepper, long	Bag, 82 kg
Groundnut	Bag, 82 kg
Cowpeas	Bag, 109 kg
Fish, smoked	Mini-basket, 15 kg
Fish, fresh	Carton, 20 kg
Kola	Bag, 120 kg
Copra	Bag, 40 kg
Cocoa	Bag, 63 kg
Charcoal	Bag, 70 kg
Cotton	Bag, 40 kg
Kenke wrappers	Bag, 10 kg
Cattle (live)	400 kg
Sheep/Goat (live)	25 kg

APPENDIX D: TOC MODEL
ACTUAL AVERAGE OPERATING CONDITIONS

Truck Operating Costs
Type of truck, Type of load
Payload Capacity

Average Actual Operating Conditiions

A	1-way Journey Distance (km)	Class Average
B	Registered GVW (T)	Class Average
C	Tare Weight (T)	Class Average
D	Payload Capacity (T)	[B - C]
E	Payload (T)	Class Avgerage
F	Speed (km/h)	Class Average
G	Average Load/Unload Time (h)	Class Average
H	Average 1-way Journey Time (h)	[A/F + G]
I	Monthly 1-way Journeys (#)	Average monthly / A
J	Monthly Distance (km)	[I * A]
K	Out-of-service Time (days/year)	Class Average
L	Annual Distance (km)	[(12 - K/30) * J]
M	Annual Quantity (T)	[L/2 / A * E]
N	Annual Productivity (T-km)	[M * A]
O	Fuel Consumption (km/l)	Class Average
P	Tires per Year (#)	Class Average
Q	Monthly Repair Costs (C)	Class Average
R	Load/Unload Charge- L. Park (C)	Class Average
S	Fuel - Diesel (C/l)	August 1992 price
T	Tires - Home second (C/tire)	August 1992 price

COSTS PER TRUCK

	ANNUAL	per km	per T-km	% Of Total Costs
FIXED				
Driver	[12 * Class Avg.]	[/ L]	[/ M]	
Mate (#)	[# * 12 * Class Avg.]	[/ L]	[/ M]	
Insurance	[Class Average]	[/ L]	[/ M]	
Roadworthiness	[Class Avg.]	[/ L]	[/ M]	
Capital Cost	[Class Avg.]	[/ L]	[/ M]	
Total	[Total Fixed Costs]	[/ L]	[/ M]	
VARIABLE				
Fuel	[L / O * S]	[/ L]	[/ M]	
Repair	[12 * Q]	[/ L]	[/ M]	
Tires	[P * T]	[/ L]	[/ M]	
Loading	[L / A * R]	[/ L]	[/ M]	
Total	[Total Variable Costs]	[/ L]	[/ M]	
TOTAL COSTS	[Total Annual Costs]	[/ L]	[/ M]	

Truck Operating Costs
2-axle Straight Truck, Freight
<= 1 T Payload (petrol)

Average Actual Operating Conditions

1-way Journey Distance (km)	132
Registered GVW (T)	2.28
Tare Weight (T)	1.52
Payload Capacity (T)	0.76
Payload (T)	2.27
Speed (km/h)	40
Load/Unload Time (h)	0.9
1-way Journey Time (h)	4.2
Monthly 1-way Journeys (#)	17
Monthly Distance (km)	2244
Out-of-service Time (days/year)	18
Annual Distance (km)	25582
Annual Quantity (T)	220
Annual Productivity (T-km)	29035
Fuel Consumption (km/l)	2.58
Tires per Year (#)	11
Monthly Repair Costs (C)	20429
Load/Unload Charge- L. Park (C)	1968
Fuel - Petrol (C/l)	198
Tires - Home second (C/tire)	18000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	593220	23.19	20.43	12.5
Mate (1)	243600	9.52	8.39	5.1
Insurance	8860	0.35	0.31	0.2
Roadworthiness	3024	0.12	0.10	0.1
Capital Cost	1124407	43.95	38.73	23.6
Total	1973111	77.13	67.96	41.4
VARIABLE				
Fuel	1963239	76.74	67.62	41.2
Repair	245148	9.58	8.44	5.1
Tires	198000	7.74	6.82	4.2
Loading	381398	14.91	13.14	8.0
Total	2787785	108.98	96.01	58.6
TOTAL COSTS	4760896	186.11	163.97	

Truck Operating Costs
2-axle Straight Truck, Freight
1 - 3 T Payload (diesel)

Average Actual Operating Conditions

1-way Journey Distance (km)	178
Registered GVW (T)	5.00
Tare Weight (T)	2.76
Payload Capacity (T)	2.24
Payload (T)	2.09
Speed (km/h)	47
Load/Unload Time (h)	1.5
1-way Journey Time (h)	5.3
Monthly 1-way Journeys (#)	12
Monthly Distance (km)	2136
Out-of-service Time (days/year)	4
Annual Distance (km)	25347
Annual Quantity (T)	149
Annual Productivity (T-km)	26488
Fuel Consumption (km/l)	1.80
Tires per Year (#)	7
Monthly Repair Costs (C)	52500
Load/Unload Charge- L. Park (C)	3175
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	25000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	738000	29.12	27.86	12.5
Mate (1)	219276	8.65	8.28	3.7
Insurance	13588	0.54	0.51	0.2
Roadworthiness	6028	0.24	0.23	0.1
Capital Cost	1325725	52.30	50.05	22.5
Total	2302617	90.84	86.93	39.1
VARIABLE				
Fuel	2323493	91.67	87.72	39.5
Repair	630000	24.85	23.78	10.7
Tires	175000	6.90	6.61	3.0
Loading	452120	17.84	17.07	7.7
Total	3580613	141.26	135.18	60.9
TOTAL COSTS	5883230	232.11	222.11	

Truck Operating Costs
2-axle Straight Truck, Freight
3 - 5 T Payload (diesel)

Average Actual Operating Conditions

1-way Journey Distance (km)	323
Registered GVW (T)	10.13
Tare Weight (T)	5.18
Payload Capacity (T)	4.95
Payload (T)	10.62
Speed (km/h)	31
Load/Unload Time (h)	4.4
1-way Journey Time (h)	14.8
Monthly 1-way Journeys (#)	6
Monthly Distance (km)	1938
Out-of-service Time (days/year)	70
Annual Distance (km)	18734
Annual Quantity (T)	308
Annual Productivity (T-km)	99478
Fuel Consumption (km/l)	2.51
Tires per Year (#)	9
Monthly Repair Costs (C)	60841
Load/Unload Charge- L. Park (C)	11666
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	40000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	494568	26.40	4.97	10.7
Mate (2)	388224	20.72	3.90	8.4
Insurance	15072	0.80	0.15	0.3
Roadworthiness	4508	0.24	0.05	0.1
Capital Cost	723199	38.60	7.27	15.6
Total	1625571	86.77	16.34	35.2
VARIABLE				
Fuel	1231518	65.74	12.38	26.6
Repair	730092	38.97	7.34	15.8
Tires	360000	19.22	3.62	7.8
Loading	676628	36.12	6.80	14.6
Total	2998238	160.04	30.14	64.8
TOTAL COSTS	4623809	246.81	46.48	

Truck Operating Costs
2-axle Straight Truck, Freight
> 5 T Payload (diesel)

Average Actual Operating Conditions

1-way Journey Distance (km)	262
Registered GVW (T)	11.84
Tare Weight (T)	3.81
Payload Capacity (T)	8.03
Payload (T)	6.72
Speed (km/h)	46
Load/Unload Time (h)	2.3
1-way Journey Time (h)	8.0
Monthly 1-way Journeys (#)	4
Monthly Distance (km)	1048
Out-of-service Time (days/year)	45
Annual Distance (km)	11004
Annual Quantity (T)	141
Annual Productivity (T-km)	36973
Fuel Consumption (km/l)	2.62
Tires per Year (#)	9
Monthly Repair Costs (C)	36286
Load/Unload Charge- L. Park (C)	16733
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	55000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	559524	50.85	15.13	14.9
Mate (2)	324000	29.44	8.76	8.6
Insurance	9743	0.89	0.26	0.3
Roadworthiness	4236	0.38	0.11	0.1
Capital Cost	537832	48.88	14.55	14.3
Total	1435335	130.44	38.82	38.2
VARIABLE				
Fuel	693000	62.98	18.74	18.4
Repair	435432	39.57	11.78	11.6
Tires	495000	44.98	13.39	13.2
Loading	702786	63.87	19.01	18.7
Total	2326218	211.40	62.92	61.8
TOTAL COSTS	3761553	341.84	101.74	

Truck Operating Costs
2-axle Straight Truck, Mixed
<= 1 T Payload (petrol)

Average Actual Operating Conditions

17% Carrying Passengers

1-way Journey Distance (km)	77
Registered GVW (T)	2.33
Tare Weight (T)	1.57
Payload Capacity (T)	0.77
Payload (T)	1.39
Speed (km/h)	48
Load/Unload Time (h)	1.0
1-way Journey Time (h)	2.6
Monthly 1-way Journeys (#)	40
Monthly Distance (km)	3080
Out-of-service Time (days/year)	22
Annual Distance (km)	34701
Annual Quantity (T)	313
Annual Productivity (T-km)	24117
Fuel Consumption (km/l)	2.67
Tires per Year (#)	12
Monthly Repair Costs (C)	29769
Load/Unload Charge- L. Park (C)	1024
Fuel - Petrol (C/l)	198
Tires - Home second (C/tire)	18000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	552528	15.92	22.91	11.8
Mate (1)	180000	5.19	7.46	3.8
Insurance	14133	0.41	0.59	0.3
Roadworthiness	3098	0.09	0.13	0.1
Capital Cost	318418	9.18	13.20	6.8
Total	1068177	30.78	44.29	22.8
VARIABLE				
Fuel	2573357	74.16	106.70	55.0
Repair	357228	10.29	14.81	7.6
Tires	216000	6.22	8.96	4.6
Loading	461483	13.30	19.13	9.9
Total	3608068	103.97	149.60	77.2
TOTAL COSTS	4676245	134.76	193.89	

Truck Operating Costs
2-axle Straight Truck, Mixed
1 - 3 T Payload (diesel)

Average Actual Operating Conditions

12% Carrying Passengers

1-way Journey Distance (km)	179
Registered GVW (T)	7.03
Tare Weight (T)	4.63
Payload Capacity (T)	2.18
Payload (T)	2.03
Speed (km/h)	39
Load/Unload Time (h)	5.3
1-way Journey Time (h)	9.9
Monthly 1-way Journeys (#)	15
Monthly Distance (km)	2685
Out-of-service Time (days/year)	38
Annual Distance (km)	28819
Annual Quantity (T)	163
Annual Productivity (T-km)	29251
Fuel Consumption (km/l)	3.14
Tires per Year (#)	11
Monthly Repair Costs (C)	65063
Load/Unload Charge- L. Park (C)	2642
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	25000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	672000	23.32	22.97	14.1
Mate (1)	189000	6.56	6.46	4.0
Insurance	13541	0.47	0.46	0.3
Roadworthiness	3570	0.12	0.12	0.1
Capital Cost	878130	30.47	30.02	18.5
Total	1756241	60.94	60.04	37.0
VARIABLE				
Fuel	1514374	52.55	51.77	31.9
Repair	780756	27.09	26.69	16.4
Tires	275000	9.54	9.40	5.8
Loading	425362	14.76	14.54	9.0
Total	2995492	103.94	102.41	63.0
TOTAL COSTS	4751733	164.88	162.45	

Truck Operating Costs
2-axle Straight Truck, Mixed
3 - 5 T Payload (diesel)

Average Actual Operating Conditions

21% Carrying Passengers

1-way Journey Distance (km)	264
Registered GVW (T)	10.07
Tare Weight (T)	5.14
Payload Capacity (T)	4.93
Payload (T)	4.85
Speed (km/h)	60
Load/Unload Time (h)	7.2
1-way Journey Time (h)	11.6
Monthly 1-way Journeys (#)	7
Monthly Distance (km)	1848
Out-of-service Time (days/year)	55
Annual Distance (km)	18788
Annual Quantity (T)	173
Annual Productivity (T-km)	45561
Fuel Consumption (km/l)	2.29
Tires per Year (#)	11
Monthly Repair Costs (C)	64744
Load/Unload Charge- L. Park (C)	6744
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	40000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	516516	27.49	11.34	11.4
Mate (2)	302664	16.11	6.64	6.7
Insurance	21308	1.13	0.47	0.5
Roadworthiness	4368	0.23	0.10	0.1
Capital Cost	623585	33.19	13.69	13.8
Total	1468441	78.16	32.23	32.5
VARIABLE				
Fuel	1353721	72.05	29.71	30.0
Repair	776928	41.35	17.05	17.2
Tires	440000	23.42	9.66	9.7
Loading	479948	25.55	10.53	10.6
Total	3050597	162.37	66.96	67.5
TOTAL COSTS	4519038	240.53	99.19	

Truck Operating Costs
2-axle Straight Truck, Mixed
> 5 T Payload (diesel)

Average Actual Operating Conditions

14% Carrying Passengers

1-way Journey Distance (km)	239
Registered GVW (T)	13.95
Tare Weight (T)	5.42
Payload Capacity (T)	9.3
Payload (T)	6.74
Speed (km/h)	40
Load/Unload Time (h)	4.8
1-way Journey Time (h)	10.8
Monthly 1-way Journeys (#)	9
Monthly Distance (km)	2151
Out-of-service Time (days/year)	62
Annual Distance (km)	21367
Annual Quantity (T)	301
Annual Productivity (T-km)	72005
Fuel Consumption (km/l)	1.68
Tires per Year (#)	9
Monthly Repair Costs (C)	203333
Load/Unload Charge- L. Park (C)	3540
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	55000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	972000	45.49	13.50	11.5
Mate (2)	249600	11.68	3.47	3.0
Insurance	26750	1.25	0.37	0.3
Roadworthiness	4550	0.21	0.06	0.1
Capital Cost	1848249	86.50	25.67	21.9
Total	3101149	145.14	43.07	36.7
VARIABLE				
Fuel	2098505	98.21	29.14	24.8
Repair	2439996	114.20	33.89	28.9
Tires	495000	23.17	6.87	5.9
Loading	316476	14.81	4.40	3.7
Total	5349977	250.39	74.30	63.3
TOTAL COSTS	8451126	395.53	117.37	

Truck Operating Costs
Tractor Semi-trailer, 2-S1

Average Actual Operating Conditions

1-way Journey Distance (km)	116	
Registered GVW (T)	16.78	
Tare Weight (T)	10.12	
Payload Capacity (T)	6.66	
Payload (T)	0.3	
Speed (km/h)	35	
Load/Unload Time (h)	3.0	(Customer)
1-way Journey Time (h)	6.3	
Monthly 1-way Journeys (#)	5	
Monthly Distance (km)	580	
Out-of-service Time (days/year)	44	
Annual Distance (km)	6109	
Annual Quantity (T)	8	
Annual Productivity (T-km)	916	
Fuel Consumption (km/l)	3.46	
Tires per Year (#)	26	
Monthly Repair Costs (C)	56667	
Load/Unload Charge- L. Park (C)	N/A	
Fuel - Diesel (C/l)	165	
Tires - Home second (C/tire)	66000	

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	480708	78.68	524.56	14.4
Mate (1)	144000	23.57	157.14	4.3
Insurance	12000	1.96	13.09	0.4
Roadworthiness	3200	0.52	3.49	0.1
Capital Cost	U/K	0.00	0.00	0.0
Total	639908	104.74	698.28	19.2
VARIABLE				
Fuel	291341	47.69	317.92	8.8
Repair	680004	111.31	742.04	20.4
Tires	1716000	280.88	1872.54	51.6
Loading	0	0.00	0.00	0.0
Total	2687345	439.88	2932.50	80.8
TOTAL COSTS	3327253	544.62	3630.79	

Truck Operating Costs
Tractor Semi-trailer, 2-S2

Average Actual Operating Conditions

1-way Journey Distance (km)	257	
Registered GVW (T)	27.85	
Tare Weight (T)	17.34	
Payload Capacity (T)	10.51	
Payload (T)	34.84	
Speed (km/h)	37	
Load/Unload Time (h)	4.5	(Customer)
1-way Journey Time (h)	11.4	
Monthly 1-way Journeys (#)	7	
Monthly Distance (km)	1799	
Out-of-service Time (days/year)	39	
Annual Distance (km)	19249	
Annual Quantity (T)	1305	
Annual Productivity (T-km)	335323	
Fuel Consumption (km/l)	1.77	
Tires per Year (#)	23	
Monthly Repair Costs (C)	263333	
Load/Unload Charge- L. Park (C)	3000	
Fuel - Diesel (C/l)	165	
Tires - Home second (C/tire)	66000	

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	840000	43.64	2.51	6.6
Mate (1)	90000	4.68	0.27	0.7
Insurance	U/K	0.00	0.00	0.0
Roadworthiness	7000	0.36	0.02	0.1
Capital Cost	5012380	260.39	14.95	39.6
Total	5949380	309.07	17.74	47.0
VARIABLE				
Fuel	1794426	93.22	5.35	14.2
Repair	3159996	164.16	9.42	25.0
Tires	1518000	78.86	4.53	12.0
Loading	224700	11.67	0.67	1.8
Total	6697122	347.92	19.97	53.0
TOTAL COSTS	12646502	656.99	37.71	

APPENDIX E:

TRACTOR SEMI-TRAILERS

Tractor Semi-Trailers

The class of tractor semi-trailers includes all vehicles designated as articulated. This describes 39 (8%) of the vehicles surveyed. A summary of vehicle characteristics is given in Table E.1 and a summary of vehicle operating costs under average actual conditions in Table E.2. Vehicle operating cost data is found in a more complete form in Appendix D. A comparison of relative operating costs of both types of vehicles in the tractor semi-trailer class, 2-S1 and 2-S2, is given in Figure E.1.

Table E.1 Vehicle Characteristics: Tractor Semi-trailers

Tractor Semi-trailer

	CONFIGURATION		
	2-S1	2-S2	Other
NUMBER OF VEHICLES	17	17	5
MAKE			
Benz	6	14	3
Leyland	7		
MAN		3	
Other	4		2
CYLINDERS			
6	15	13	4
8		1	1
FUEL			
Diesel	17	17	5
WEIGHT AND CAPACITY			
GVW (T)	16.78	27.85	
Tare (T)	10.12	17.34	
Payload (T)	6.66	10.51	
AGE (years)	7.0	14.0	12.3
INSURANCE			
Commercial	11	13	
General	1	4	1
Special	1		
Own Goods		4	
Type			
3rd Party	9	8	3
Act	1		
Comprehensive		1	
Other	7	8	2
MANAGEMENT AND OWNERSHIP			
Vehicle Owner			
Individual	2	5	2
Driver	0	1	0
Private Co.	15	7	2
Managed with Other Vehicles			
Yes	16	13	3
no. of vehicle	17	6	9
Regular Route	1	9	1
ACCIDENTS LAST YEAR			
None	14	11	4
1	3	2	0
2	0	3	1
3	0	1	0

Table E.2 Truck Operating Costs: Tractor Semi-trailers
Actual Average Operating Conditions

	TRACTOR SEMI-TRAILERS 2-S1	2-S2
NO. OF VEHICLES	17	17
FIXED COSTS		
WAGES	681.70	2.78
INSURANCE	16.58	0.02
CAPITAL COST	U/K	14.95
VARIABLE COSTS		
FUEL	317.92	5.35
TIRES	1872.54	4.53
REPAIR	742.04	9.42
LOADING	0.00	0.67
TOTAL (C/T-km)	3630.78	37.72

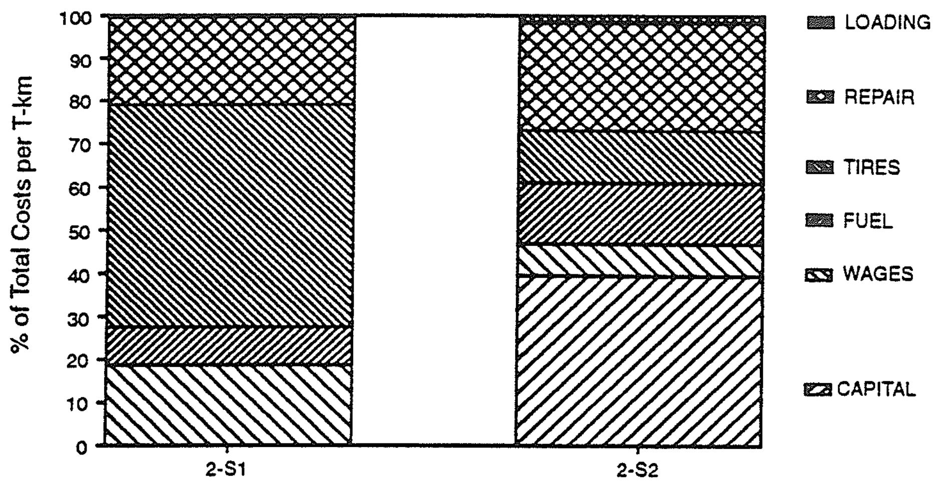

Figure E.1 Relative Cost Components: Tractor Semi-trailers
Actual Average Operating Conditions

5.4.1 Configuration: 2-S1

A snapshot of the typical vehicle in this class would show a 7- year-old, European (Benz or Leyland), 6 cylinder, diesel-fuelled 2-axle tractor with a single axle trailer (2-S1) and a payload capacity of 6.66 tonnes. The vehicle is owned and managed by a private company and it is managed with 17 other trucks. Virtually none of its trips are made on a regular route. The vehicle carries third party insurance and is insured as a commercial vehicle to carry the company's goods. The vehicle's principal load is round timber; 86% of the loaded vehicles were carrying, on average, 3 logs.

The typical vehicle obtains most of its loads directly from the company that own and operates it; 7% of its loads are obtained directly from a customer. Backhauls for loads obtained from customers are all obtained at a lorry park. Wait time for the current load at lorry parks was one hour. Average time between loads is 58 hours. The vehicle typically spends from 36 to 44 days a year out-of-service due to repairs.

Mean utilization and costs for this class of truck are shown in Table 5.6 and Appendix D. Analysis of costs, Figure 5.4, show that fixed costs represent 19% and variable costs 81% of the total operating costs. The most significant fixed costs are wages at 19% of total costs; and the most significant variable cost is maintenance at 72% of total costs. The figures quoted above are the result of an analysis similar to that performed on all other vehicle types. However capital costs were unknown for all 2-S1 vehicles and payload weight unknown for all but one vehicle due to the high proportion of timber trucks. Drivers of this type of vehicle are generally hired by a timber company and vehicle finances are not managed by the drivers.

5.4.2 Configuration: 2-S2

A snapshot of the typical vehicle in this class would show a 14- year-old, European (Benz or MAN), 6 cylinder, diesel-fuelled 2-axle tractor with a 2-axle trailer and a payload capacity of 10.51 tonnes. The vehicle is owned and managed by a private company and it is managed with 6 other trucks (40% of the vehicles are owned and managed by an individual who is not the driver). Approximately 50% of its trips are made on a regular route. The vehicle carries third party insurance and is insured as a commercial vehicle to carry the company's goods or for general cartage. Nearly half of the vehicle's loads consist of round timber; 40% of the loaded vehicles were carrying, on average, 5 logs.

The typical vehicle obtains most of its loads directly from the company that own and operates it; 20% of its loads are obtained directly from a customer and 20% from a lorry park. Backhauls for loads obtained from customers are generally empty (67%) or obtained from sources other than a lorry park. Wait time for the current load through a customer was 36 hours. Average time between loads is 64 hours. The vehicle typically spends from 24 to 39 days a year out-of-service due to repairs.

Mean utilization and costs for this class of truck are shown in Table 5.6 and Appendix D. Analysis of costs, Figure 5.4, show that fixed costs represent 48% and variable costs 52% of the total operating costs. The most significant fixed costs are vehicle capital costs at 40% of total costs; and the most significant variable cost is maintenance at 37% of total costs. The figures quoted above are the result of an analysis similar to that performed on all other vehicle types. However capital costs were unknown for all but one 2-S2 truck and payload weight unknown for 40% of the loaded vehicles (timber trucks).

APPENDIX F: TOC MODEL
ALLOWABLE LOADING OPERATING CONDITIONS

Truck Operating Costs
Type of truck, Type of load
Payload Capacity

Allowable Loading Operating Conditions

A	1-way Journey Distance (km)	Class Average
B	Registered GVW (T)	Class Average
C	Tare Weight (T)	Class Average
D	Payload Capacity (T)	[B - C]
E	Payload (T)	[B - C]
F	Speed (km/h)	Class Average
G	Average Load/Unload Time (h)	Class Average
H	Average 1-way Journey Time (h)	[A/F + G]
I	Monthly 1-way Journeys (#)	
J	Monthly Distance (km)	
K	Out-of-service Time (days/year)	
L	Annual Distance (km)	[M/E * A * 2]
M	Annual Quantity (T)	Average Actual
N	Annual Productivity (T-km)	[M * A]
	Fuel Consumption (km/l)	From Clayton 1981-84
O	Loaded	[2.65 - 0.0207 * B]
P	Empty	[2.65 - 0.0207 * C]
Q	Tires - Cost per km (C)	Average Actual
R	Repair Costs per km (C)	Average Actual
S	Load/Unload Charge- L. Park (C)	Class Average
T	Fuel - Diesel (C/l)	August 1992 price
U	Tires - Home second (C/tire)	August 1992 price

COSTS PER TRUCK

	ANNUAL	per km	per T-km	% Of Total Costs
FIXED				
Driver	[12 * Class Avg.]	[/ L]	[/ M]	
Mate (#)	[# * 12 * Class Avg.]	[/ L]	[/ M]	
Insurance	[Class Average]	[/ L]	[/ M]	
Roadworthiness	[Class Avg.]	[/ L]	[/ M]	
Capital Cost	[Class Avg.]	[/ L]	[/ M]	
Total	[Total Fixed Costs]	[/ L]	[/ M]	
VARIABLE				
Fuel	[(L/2/O + L/2/P) * T]	[/ L]	[/ M]	
Repair	[L * R]	[/ L]	[/ M]	
Tires	[L * Q]	[/ L]	[/ M]	
Loading	[L / A * S]	[/ L]	[/ M]	
Total	[Total Variable Costs]	[/ L]	[/ M]	
TOTAL COSTS	[Total Annual Costs]	[/ L]	[/ M]	

Truck Operating Costs
2-axle Straight Truck, Freight
<= 1 T Payload (petrol)

Allowable Loading Operating Conditions

1-way Journey Distance (km)	132
Registered GVW (T)	2.28
Tare Weight (T)	1.52
Payload Capacity (T)	0.76
Payload (T)	0.76
Speed (km/h)	40
Load/Unload Time (h)	0.9
1-way Journey Time (h)	4.2
Monthly 1-way Journeys (#)	
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	76421
Annual Quantity (T)	220
Annual Productivity (T-km)	29040
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.60
Empty	2.62
Tire Cost per km (C)	7.74
Repair Costs per km (C)	9.58
Load/Unload Charge- L. Park (C)	1968
Fuel - Petrol (C/l)	198
Tires - Home second (C/tire)	18000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	593220	7.76	20.43	5.8
Mate (1)	243600	3.19	8.39	2.4
Insurance	8860	0.12	0.31	0.1
Roadworthiness	3024	0.04	0.10	0.0
Capital Cost	1124407	14.71	38.72	11.0
Total	1973111	25.82	67.94	19.3
VARIABLE				
Fuel	5796024	75.84	199.59	56.6
Repair	732114	9.58	25.21	7.2
Tires	591499	7.74	20.37	5.8
Loading	1139368	14.91	39.23	11.1
Total	8259005	108.07	284.40	80.7
TOTAL COSTS	10232116	133.89	352.34	

Truck Operating Costs
2-axle Straight Truck, Freight
1 - 3 T Payload (diesel)

Allowable Loading Operating Conditions

1-way Journey Distance (km)	178
Registered GVW (T)	5.00
Tare Weight (T)	1.52
Payload Capacity (T)	2.24
Payload (T)	2.24
Speed (km/h)	47
Load/Unload Time (h)	1.5
1-way Journey Time (h)	5.3
Monthly 1-way Journeys (#)	
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	23680
Annual Quantity (T)	149
Annual Productivity (T-km)	26522
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.55
Empty	2.62
Tire Cost per km (C)	6.90
Repair Costs per km (C)	24.85
Load/Unload Charge- L. Park (C)	3175
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	25000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	738000	31.17	27.83	14.8
Mate (1)	219276	9.26	8.27	4.4
Insurance	13588	0.57	0.51	0.3
Roadworthiness	6028	0.25	0.23	0.1
Capital Cost	1325725	55.98	49.99	26.6
Total	2302617	97.24	86.82	46.1
VARIABLE				
Fuel	1513259	63.90	57.06	30.3
Repair	588457	24.85	22.19	11.8
Tires	163394	6.90	6.16	3.3
Loading	422388	17.84	15.93	8.5
Total	2687499	113.49	101.33	53.9
TOTAL COSTS	4990116	210.73	188.15	

Truck Operating Costs
2-axle Straight Truck, Freight
3 - 5 T Payload (diesel)

Allowable Loading Operating Conditions

1-way Journey Distance (km)	323
Registered GVW (T)	10.13
Tare Weight (T)	5.18
Payload Capacity (T)	4.95
Payload (T)	4.95
Speed (km/h)	31
Load/Unload Time (h)	4.4
1-way Journey Time (h)	14.8
Monthly 1-way Journeys (#)	
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	40196
Annual Quantity (T)	308
Annual Productivity (T-km)	99484
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.44
Empty	2.54
Tire Cost per km (C)	19.22
Repair Costs per km (C)	38.97
Load/Unload Charge- L. Park (C)	11666
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	40000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	494568	12.30	4.97	6.1
Mate (1)	388224	9.66	3.90	4.8
Insurance	15072	0.37	0.15	0.2
Roadworthiness	4508	0.11	0.05	0.1
Capital Cost	723199	17.99	7.27	9.0
Total	1625571	40.44	16.34	20.1
VARIABLE				
Fuel	2663039	66.25	26.77	33.0
Repair	1566421	38.97	15.75	19.4
Tires	772559	19.22	7.77	9.6
Loading	1451769	36.12	14.59	18.0
Total	6453787	160.56	64.87	79.9
TOTAL COSTS	8079358	201.00	81.21	

Truck Operating Costs
2-axle Straight Truck, Freight
> 5 T Payload (diesel)

Allowable Loading Operating Conditions

1-way Journey Distance (km)	262
Registered GVW (T)	11.84
Tare Weight (T)	3.81
Payload Capacity (T)	8.03
Payload (T)	8.03
Speed (km/h)	46
Load/Unload Time (h)	2.3
1-way Journey Time (h)	8.0
Monthly 1-way Journeys (#)	
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	9201
Annual Quantity (T)	141
Annual Productivity (T-km)	36942
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.40
Empty	2.57
Tire Cost per km (C)	44.98
Repair Costs per km (C)	39.57
Load/Unload Charge- L. Park (C)	16733
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	55000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	572724	62.25	15.50	16.7
Mate (2)	324000	35.21	8.77	9.5
Insurance	9743	1.06	0.26	0.3
Roadworthiness	4236	0.46	0.11	0.1
Capital Cost	537832	58.45	14.56	15.7
Total	1448535	157.43	39.21	42.3
VARIABLE				
Fuel	610871	66.39	16.54	17.8
Repair	364083	39.57	9.86	10.6
Tires	413861	44.98	11.20	12.1
Loading	587635	63.87	15.91	17.2
Total	1976450	214.81	53.50	57.7
TOTAL COSTS	3424985	372.24	92.71	

Truck Operating Costs
2-axle Straight Truck, Mixed
<= 1 T Payload (petrol)

Allowable Loading Operating Conditions

1-way Journey Distance (km)	77
Registered GVW (T)	2.33
Tare Weight (T)	1.57
Payload Capacity (T)	0.77
Payload (T)	0.77
Speed (km/h)	48
Load/Unload Time (h)	1.0
1-way Journey Time (h)	2.6
Monthly 1-way Journeys (#)	
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	62600
Annual Quantity (T)	313
Annual Productivity (T-km)	24101
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.60
Empty	2.62
Tire Cost per km (C)	6.22
Repair Costs per km (C)	10.29
Load/Unload Charge- L. Park (C)	1024
Fuel - Petrol (C/l)	198
Tires - Home second (C/tire)	18000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	552528	8.83	22.93	7.2
Mate (1)	180000	2.88	7.47	2.3
Insurance	14133	0.23	0.59	0.2
Roadworthiness	3098	0.05	0.13	0.0
Capital Cost	318418	5.09	13.21	4.1
Total	1068177	17.06	44.32	13.9
VARIABLE				
Fuel	4749673	75.87	197.07	61.8
Repair	644154	10.29	26.73	8.4
Tires	389372	6.22	16.16	5.1
Loading	832499	13.30	34.54	10.8
Total	6615698	105.68	274.50	86.1
TOTAL COSTS	7683875	122.75	318.82	

Truck Operating Costs
2-axle Straight Truck, Mixed
1 - 3 T Payload (diesel)

Allowable Loading Operating Conditions

1-way Journey Distance (km)	179
Registered GVW (T)	7.03
Tare Weight (T)	4.63
Payload Capacity (T)	2.18
Payload (T)	2.18
Speed (km/h)	39
Load/Unload Time (h)	5.3
1-way Journey Time (h)	9.9
Monthly 1-way Journeys (#)	
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	26768
Annual Quantity (T)	163
Annual Productivity (T-km)	29177
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.50
Empty	2.55
Tire Cost per km (C)	9.54
Repair Costs per km (C)	27.09
Load/Unload Charge- L. Park (C)	2642
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	25000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	672000	25.10	23.03	13.8
Mate (1)	189000	7.06	6.48	3.9
Insurance	13541	0.51	0.46	0.3
Roadworthiness	3570	0.13	0.12	0.1
Capital Cost	878130	32.81	30.10	18.0
Total	1756241	65.61	60.19	36.0
VARIABLE				
Fuel	1746370	65.24	59.85	35.8
Repair	725142	27.09	24.85	14.9
Tires	255366	9.54	8.75	5.2
Loading	395088	14.76	13.54	8.1
Total	3121966	116.63	107.00	64.0
TOTAL COSTS	4878207	182.24	167.19	

Truck Operating Costs
2-axle Straight Truck, Mixed
3 - 5 T Payload (diesel)

Allowable Loading Operating Conditions

1-way Journey Distance (km)	264
Registered GVW (T)	10.07
Tare Weight (T)	5.14
Payload Capacity (T)	4.93
Payload (T)	4.93
Speed (km/h)	60
Load/Unload Time (h)	7.2
1-way Journey Time (h)	11.6
Monthly 1-way Journeys (#)	
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	18528
Annual Quantity (T)	173
Annual Productivity (T-km)	45672
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.44
Empty	2.54
Tire Cost per km (C)	23.42
Repair Costs per km (C)	41.35
Load/Unload Charge- L. Park (C)	6744
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	40000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	516516	27.88	11.31	11.8
Mate (2)	302664	16.34	6.63	6.9
Insurance	21308	1.15	0.47	0.5
Roadworthiness	4368	0.24	0.10	0.1
Capital Cost	623585	33.66	13.65	14.3
Total	1468441	79.25	32.15	33.6
VARIABLE				
Fuel	1227017	66.22	26.87	28.1
Repair	766141	41.35	16.77	17.5
Tires	433930	23.42	9.50	9.9
Loading	473311	25.55	10.36	10.8
Total	2900399	156.54	63.50	66.4
TOTAL COSTS	4368840	235.79	95.66	

Truck Operating Costs
2-axle Straight Truck, Mixed
> 5 T Payload (diesel)

Allowable Loading Operating Conditions

1-way Journey Distance (km)	239
Registered GVW (T)	13.95
Tare Weight (T)	5.42
Payload Capacity (T)	9.3
Payload (T)	9.3
Speed (km/h)	40
Load/Unload Time (h)	4.8
1-way Journey Time (h)	10.8
Monthly 1-way Journeys (#)	
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	15471
Annual Quantity (T)	301
Annual Productivity (T-km)	71939
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.36
Empty	2.54
Tire Cost per km (C)	23.17
Repair Costs per km (C)	114.2
Load/Unload Charge- L. Park (C)	3540
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	55000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	972000	62.83	13.51	15.0
Mate (2)	249600	16.13	3.47	3.8
Insurance	26750	1.73	0.37	0.4
Roadworthiness	4550	0.29	0.06	0.1
Capital Cost	1848249	119.47	25.69	28.4
Total	3101149	200.45	43.11	47.7
VARIABLE				
Fuel	1043467	67.45	14.50	16.1
Repair	1766760	114.20	24.56	27.2
Tires	358457	23.17	4.98	5.5
Loading	229148	14.81	3.19	3.5
Total	3397833	219.63	47.23	52.3
TOTAL COSTS	6498982	420.08	90.34	

Truck Operating Costs
Tractor Semi-trailer, 2-S1

Allowable Loading Operating Conditions

1-way Journey Distance (km)	116
Registered GVW (T)	16.78
Tare Weight (T)	10.12
Payload Capacity (T)	6.66
Payload (T)	6.66
Speed (km/h)	35
Load/Unload Time (h)	3.0
1-way Journey Time (h)	6.3
Monthly 1-way Journeys (#)	
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	279
Annual Quantity (T)	8
Annual Productivity (T-km)	928
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.30
Empty	2.44
Tire Cost per km (C)	280.88
Repair Costs per km (C)	111.31
Load/Unload Charge- L. Park (C)	N/A
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	66000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	480708	1724.95	518.00	62.5
Mate (1)	144000	516.72	155.17	18.7
Insurance	12000	43.06	12.93	1.6
Roadworthiness	3200	11.48	3.45	0.4
Capital Cost	U/K	0.00	0.00	0.0
Total	639908	2296.22	689.56	83.3
VARIABLE				
Fuel	19405	69.63	20.91	2.5
Repair	31020	111.31	33.43	4.0
Tires	78275	280.88	84.35	10.2
Loading	0	0.00	0.00	0.0
Total	128700	461.82	138.69	16.7
TOTAL COSTS	768608	2758.04	828.24	

Truck Operating Costs
Tractor Semi-trailer, 2-S2

Allowable Loading Operating Conditions

1-way Journey Distance (km)	257
Registered GVW (T)	27.85
Tare Weight (T)	17.34
Payload Capacity (T)	10.51
Payload (T)	10.51
Speed (km/h)	37
Load/Unload Time (h)	4.5
1-way Journey Time (h)	11.4
Monthly 1-way Journeys (#)	
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	63822
Annual Quantity (T)	1305
Annual Productivity (T-km)	335385
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.07
Empty	2.29
Tire Cost per km (C)	78.86
Repair Costs per km (C)	164.16
Load/Unload Charge- L. Park (C)	3000
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	66000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	840000	13.16	2.50	3.1
Mate (1)	90000	1.41	0.27	0.3
Insurance	U/K	0.00	0.00	0.0
Roadworthiness	7000	0.11	0.02	0.0
Capital Cost	5012380	78.54	14.95	18.5
Total	5949380	93.22	17.74	22.0
VARIABLE				
Fuel	4837535	75.80	14.42	17.9
Repair	10477032	164.16	31.24	38.7
Tires	5033009	78.86	15.01	18.6
Loading	745005	11.67	2.22	2.8
Total	21092580	330.49	62.89	78.0
TOTAL COSTS	27041960	423.71	80.63	

APPENDIX G: TOC MODEL
MAXIMUM UTILIZATION OPERATING CONDITIONS

Truck Operating Costs
Type of truck, Type of load
Payload Capacity

Maximum Utilization Operating Conditions

A	1-way Journey Distance (km)	Class Average
B	Registered GVW (T)	Class Average
C	Tare Weight (T)	Class Average
D	Payload Capacity (T)	[B - C]
E	Payload (T)	[B - C]
F	Speed (km/h)	Class Average
G	Average Load/Unload Time (h)	Class Average
H	Average 1-way Journey Time (h)	[A/F + G]
I	Daily 1-way Joourneys (#)	[(12 + 2G) / H] Rounded down to whole number.
J	Monthly Distance (km)	
K	Out-of-service Time (days/year)	
L	Annual Distance (km)	[I * 52 * 5 * A]
M	Annual Quantity (T)	[L/A /2 * E]
N	Annual Productivity (T-km)	[M * A]
	Fuel Consumption (km/l)	From Clayton 1981-84
O	Loaded	[2.65 - 0.0207 * B]
P	Empty	[2.65 - 0.0207 * C]
Q	Tires - Cost per km (C)	Average Actual
R	Repair Costs per km (C)	Average Actual
S	Load/Unload Charge- L. Park (C)	Class Average
T	Fuel - Diesel (C/l)	August 1992 price
U	Tires - Home second (C/tire)	August 1992 price

COSTS PER TRUCK

	ANNUAL	per km	per T-km	% Of Total Costs
FIXED				
Driver	[12 * Class Avg.]	[/ L]	[/ M]	
Mate (#)	[# * 12 * Class Avg.]	[/ L]	[/ M]	
Insurance	[Class Average]	[/ L]	[/ M]	
Roadworthiness	[Class Avg.]	[/ L]	[/ M]	
Capital Cost	[Class Avg.]	[/ L]	[/ M]	
Total	[Total Fixed Costs]	[/ L]	[/ M]	
VARIABLE				
Fuel	[(L/2/O + L/2/P) * T]	[/ L]	[/ M]	
Repair	[L * R]	[/ L]	[/ M]	
Tires	[L * Q]	[/ L]	[/ M]	
Loading	[L / A * S]	[/ L]	[/ M]	
Total	[Total Variable Costs]	[/ L]	[/ M]	
TOTAL COSTS	[Total Annual Costs]	[/ L]	[/ M]	

Truck Operating Costs
2-axle Straight Truck, Freight
<= 1 T Payload (petrol)

Maximum Utilization Operating Conditions

1-way Journey Distance (km)	132
Registered GVW (T)	2.28
Tare Weight (T)	1.57
Payload Capacity (T)	0.76
Payload (T)	0.76
Speed (km/h)	40
Load/Unload Time (h)	0.9
1-way Journey Time (h)	4.2
Daily 1-way Journeys (#)	3
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	102960
Annual Quantity (T)	296
Annual Productivity (T-km)	39125
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.60
Empty	2.62
Tire Cost per km (C)	7.74
Repair Costs per km (C)	9.58
Load/Unload Charge- L. Park (C)	1968
Fuel - Petrol (C/l)	198
Tires - Home second (C/tire)	18000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	593220	5.76	15.16	4.5
Mate (1)	243600	2.37	6.23	1.9
Insurance	8860	0.09	0.23	0.1
Roadworthiness	3024	0.03	0.08	0.0
Capital Cost	1124407	10.92	28.74	8.6
Total	1973111	19.16	50.43	15.1
VARIABLE				
Fuel	7810364	75.86	199.63	59.6
Repair	986357	9.58	25.21	7.5
Tires	796910	7.74	20.37	6.1
Loading	1535040	14.91	39.23	11.7
Total	11128671	108.09	284.44	84.9
TOTAL COSTS	13101782	127.25	334.87	

Truck Operating Costs
2-axle Straight Truck, Freight
1 - 3 T Payload (diesel)

Maximum Utilization Operating Conditions

1-way Journey Distance (km)	178
Registered GVW (T)	5.00
Tare Weight (T)	1.52
Payload Capacity (T)	2.24
Payload (T)	2.24
Speed (km/h)	47
Load/Unload Time (h)	1.5
1-way Journey Time (h)	5.3
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	92560
Annual Quantity (T)	582
Annual Productivity (T-km)	103667
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.55
Empty	2.62
Tire Cost per km (C)	6.90
Repair Costs per km (C)	24.85
Load/Unload Charge- L. Park (C)	3175
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	25000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	738000	7.97	7.12	5.8
Mate (1)	219276	2.37	2.12	1.7
Insurance	13588	0.15	0.13	0.1
Roadworthiness	6028	0.07	0.06	0.0
Capital Cost	1325725	14.32	12.79	10.4
Total	2302617	24.88	22.21	18.0
VARIABLE				
Fuel	5914914	63.90	57.06	46.2
Repair	2300116	24.85	22.19	18.0
Tires	638664	6.90	6.16	5.0
Loading	1651000	17.84	15.93	12.9
Total	10504694	113.49	101.33	82.0
TOTAL COSTS	12807311	138.37	123.54	

Truck Operating Costs
2-axle Straight Truck, Freight
3 - 5 T Payload (diesel)

Maximum Utilization Operating Conditions

1-way Journey Distance (km)	323
Registered GVW (T)	10.13
Tare Weight (T)	5.18
Payload Capacity (T)	4.95
Payload (T)	4.95
Speed (km/h)	31
Load/Unload Time (h)	4.4
1-way Journey Time (h)	14.7
Daily 1-way Journeys (#)	1
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	83980
Annual Quantity (T)	644
Annual Productivity (T-km)	207851
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.44
Empty	2.54
Tire Cost per km (C)	19.22
Repair Costs per km (C)	38.97
Load/Unload Charge- L. Park (C)	11666
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	40000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	494568	5.89	2.38	3.3
Mate (1)	388224	4.62	1.87	2.6
Insurance	15072	0.18	0.07	0.1
Roadworthiness	4508	0.05	0.02	0.0
Capital Cost	723199	8.61	3.48	4.8
Total	1625571	19.36	7.82	10.8
VARIABLE				
Fuel	5563849	66.25	26.77	36.8
Repair	3272701	38.97	15.75	21.7
Tires	1614096	19.22	7.77	10.7
Loading	3033160	36.12	14.59	20.1
Total	13483805	160.56	64.87	89.2
TOTAL COSTS	15109376	179.92	72.69	

Truck Operating Costs
2-axle Straight Truck, Freight
> 5 T Payload (diesel)

Maximum Utilization Operating Conditions

1-way Journey Distance (km)	262
Registered GVW (T)	11.84
Tare Weight (T)	3.81
Payload Capacity (T)	8.03
Payload (T)	8.03
Speed (km/h)	46
Load/Unload Time (h)	2.3
1-way Journey Time (h)	8.0
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	136240
Annual Quantity (T)	2088
Annual Productivity (T-km)	547004
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.40
Empty	2.57
Tire Cost per km (C)	44.98
Repair Costs per km (C)	39.58
Load/Unload Charge- L. Park (C)	16733
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	55000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	572724	4.20	1.05	1.9
Mate (2)	324000	2.38	0.59	1.1
Insurance	9743	0.07	0.02	0.0
Roadworthiness	4236	0.03	0.01	0.0
Capital Cost	537832	3.95	0.98	1.8
Total	1448535	10.63	2.65	4.7
VARIABLE				
Fuel	9045220	66.39	16.54	29.4
Repair	5392379	39.58	9.86	17.6
Tires	6128075	44.98	11.20	20.0
Loading	8701160	63.87	15.91	28.3
Total	29266835	214.82	53.50	95.3
TOTAL COSTS	30715370	225.45	56.15	

Truck Operating Costs
2-axle Straight Truck, Mixed
<= 1 T Payload (petrol)

Maximum Utilization Operating Conditions

1-way Journey Distance (km)	77
Registered GVW (T)	2.33
Tare Weight (T)	1.57
Payload Capacity (T)	0.77
Payload (T)	0.77
Speed (km/h)	48
Load/Unload Time (h)	1.0
1-way Journey Time (h)	2.6
Daily 1-way Journeys (#)	5
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	100100
Annual Quantity (T)	501
Annual Productivity (T-km)	38539
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.60
Empty	2.62
Tire Cost per km (C)	6.22
Repair Costs per km (C)	10.29
Load/Unload Charge- L. Park (C)	1024
Fuel - Petrol (C/l)	198
Tires - Home second (C/tire)	18000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	552528	5.52	14.34	4.7
Mate (1)	180000	1.80	4.67	1.5
Insurance	14133	0.14	0.37	0.1
Roadworthiness	3098	0.03	0.08	0.0
Capital Cost	318418	3.18	8.26	2.7
Total	1068177	10.67	27.72	9.2
VARIABLE				
Fuel	7594924	75.87	197.07	65.2
Repair	1030029	10.29	26.73	8.8
Tires	622622	6.22	16.16	5.3
Loading	1331200	13.30	34.54	11.4
Total	10578775	105.68	274.50	90.8
TOTAL COSTS	11646952	116.35	302.22	

Truck Operating Costs
2-axle Straight Truck, Mixed
1 - 3 T Payload (diesel)

Maximum Utilization Operating Conditions

1-way Journey Distance (km)	179
Registered GVW (T)	7.03
Tare Weight (T)	4.63
Payload Capacity (T)	2.18
Payload (T)	2.18
Speed (km/h)	39
Load/Unload Time (h)	5.3
1-way Journey Time (h)	9.9
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	93080
Annual Quantity (T)	567
Annual Productivity (T-km)	101457
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.50
Empty	2.55
Tire Cost per km (C)	9.54
Repair Costs per km (C)	27.09
Load/Unload Charge- L. Park (C)	2642
Fuel - diesel (C/l)	165
Tires - Home second (C/tire)	25000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	672000	7.22	6.62	5.3
Mate (1)	189000	2.03	1.86	1.5
Insurance	13541	0.15	0.13	0.1
Roadworthiness	3570	0.04	0.04	0.0
Capital Cost	878130	9.43	8.66	7.0
Total	1756241	18.87	17.31	13.9
VARIABLE				
Fuel	6072655	65.24	59.85	48.1
Repair	2521537	27.09	24.85	20.0
Tires	887983	9.54	8.75	7.0
Loading	1373840	14.76	13.54	10.9
Total	10856015	116.63	107.00	86.1
TOTAL COSTS	12612256	135.50	124.31	

Truck Operating Costs
2-axle Straight Truck, Mixed
3 - 5 T Payload (diesel)

Maximum Utilization Operating Conditions

1-way Journey Distance (km)	264
Registered GVW (T)	10.07
Tare Weight (T)	5.14
Payload Capacity (T)	4.93
Payload (T)	4.93
Speed (km/h)	60
Load/Unload Time (h)	7.2
1-way Journey Time (h)	11.6
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	137280
Annual Quantity (T)	1282
Annual Productivity (T-km)	338395
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.44
Empty	2.54
Tire Cost per km (C)	23.42
Repair Costs per km (C)	41.35
Load/Unload Charge- L. Park (C)	6744
Fuel - diesel (C/l)	165
Tires - Home second (C/tire)	40000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	516516	3.76	1.53	2.2
Mate (2)	302664	2.20	0.89	1.3
Insurance	21308	0.16	0.06	0.1
Roadworthiness	4368	0.03	0.01	0.0
Capital Cost	623585	4.54	1.84	2.7
Total	1468441	10.70	4.34	6.4
VARIABLE				
Fuel	9091274	66.22	26.87	39.6
Repair	5676528	41.35	16.77	24.7
Tires	3215098	23.42	9.50	14.0
Loading	3506880	25.55	10.36	15.3
Total	21489780	156.54	63.50	93.6
TOTAL COSTS	22958221	167.24	67.84	

Truck Operating Costs
2-axle Straight Truck, Mixed
> 5 T Payload (diesel)

Maximum Utilization Operating Conditions

1-way Journey Distance (km)	239
Registered GVW (T)	13.95
Tare Weight (T)	5.42
Payload Capacity (T)	9.3
Payload (T)	9.3
Speed (km/h)	40
Load/Unload Time (h)	4.8
1-way Journey Time (h)	10.8
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	124280
Annual Quantity (T)	2418
Annual Productivity (T-km)	577902
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.36
Empty	2.54
Tire Cost per km (C)	23.17
Repair Costs per km (C)	114.2
Load/Unload Charge- L. Park (C)	3540
Fuel - diesel (C/l)	165
Tires - Home second (C/tire)	55000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	972000	7.82	1.68	3.2
Mate (2)	249600	2.01	0.43	0.8
Insurance	26750	0.22	0.05	0.1
Roadworthiness	4550	0.04	0.01	0.0
Capital Cost	1848249	14.87	3.20	6.1
Total	3101149	24.95	5.37	10.2
VARIABLE				
Fuel	8382405	67.45	14.50	27.6
Repair	14192776	114.20	24.56	46.7
Tires	2879568	23.17	4.98	9.5
Loading	1840800	14.81	3.19	6.1
Total	27295549	219.63	47.23	89.8
TOTAL COSTS	30396698	244.58	52.60	

Truck Operating Costs
Tractor Semi-trailer, 2-S1

Maximum Utilization Operating Conditions

1-way Journey Distance (km)	116
Registered GVW (T)	16.78
Tare Weight (T)	10.12
Payload Capacity (T)	6.66
Payload (T)	6.66
Speed (km/h)	35
Load/Unload Time (h)	3.0
1-way Journey Time (h)	6.3
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	60320
Annual Quantity (T)	1732
Annual Productivity (T-km)	200866
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.30
Empty	2.44
Tire Cost per km (C)	280.88
Repair Costs per km (C)	111.13
Load/Unload Charge- L. Park (C)	N/A
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	66000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	480708	7.97	2.39	1.7
Mate (1)	144000	2.39	0.72	0.5
Insurance	12000	0.20	0.06	0.0
Roadworthiness	3200	0.05	0.02	0.0
Capital Cost	U/K	0.00	0.00	0.0
Total	639908	10.61	3.19	2.2
VARIABLE				
Fuel	4200235	69.63	20.91	14.7
Repair	6703362	111.13	33.37	23.5
Tires	16942682	280.88	84.35	59.5
Loading	0	0.00	0.00	0.0
Total	27846279	461.64	138.63	97.8
TOTAL COSTS	28486187	472.25	141.82	

Truck Operating Costs
Tractor Semi-trailer, 2-S2

Maximum Utilization Operating Conditions

1-way Journey Distance (km)	257
Registered GVW (T)	27.85
Tare Weight (T)	17.34
Payload Capacity (T)	10.51
Payload (T)	10.51
Speed (km/h)	37
Load/Unload Time (h)	4.5
1-way Journey Time (h)	11.4
Daily 1-way Journeys (#)	1
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	66820
Annual Quantity (T)	1366
Annual Productivity (T-km)	351139
Fuel Consumption (km/l) [2.65 - 0.0207 * GVW]	
Loaded	2.07
Empty	2.29
Tire Cost per km (C)	78.86
Repair Costs per km (C)	164.16
Load/Unload Charge- L. Park (C)	3000
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	66000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	840000	12.57	2.39	3.0
Mate (1)	90000	1.35	0.26	0.3
Insurance	U/K	0.00	0.00	0.0
Roadworthiness	7000	0.10	0.02	0.0
Capital Cost	5012380	75.01	14.27	17.9
Total	5949380	89.04	16.94	21.2
VARIABLE				
Fuel	5064769	75.80	14.42	18.1
Repair	10969171	164.16	31.24	39.1
Tires	5269425	78.86	15.01	18.8
Loading	780000	11.67	2.22	2.8
Total	22083366	330.49	62.89	78.8
TOTAL COSTS	28032746	419.53	79.83	

APPENDIX H: TOC MODEL

INCREASED FUEL EFFICIENCY OPERATING CONDITIONS

Truck Operating Costs
Type of truck, Type of load
Payload Capacity

Increased Fuel Efficiency

A	1-way Journey Distance (km)	Class Average
B	Registered GVW (T)	Class Average
C	Tare Weight (T)	Class Average
D	Payload Capacity (T)	[B - C]
E	Payload (T)	[B - C]
F	Speed (km/h)	Class Average
G	Average Load/Unload Time (h)	Class Average
H	Average 1-way Journey Time (h)	[A/F + G]
I	Daily 1-way Journeys (#)	[(12 + 2G) / H] Rounded down to whole number.
J	Monthly Distance (km)	
K	Out-of-service Time (days/year)	
L	Annual Distance (km)	[I * 52 * 5 * A]
M	Annual Quantity (T)	[L/A /2 * E]
N	Annual Productivity (T-km)	[M * A]
	Fuel Consumption (km/l)	From DriveSave/TruckSave 1989
O	Loaded	[3.47 - 0.022 * B]
P	Empty	[3.47 - 0.022 * C]
Q	Tires Cost per km (C)	Average Actual
R	Repair Costs per km (C)	Average Actual
S	Load/Unload Charge- L. Park (C)	Class Average
T	Fuel - Diesel (C/l)	August 1992 price
U	Tires - Home second (C/tire)	August 1992 price

COSTS PER TRUCK

	ANNUAL	per km	per T-km	% Of Total Costs
FIXED				
Driver	[12 * Class Avg.]	[/ L]	[/ M]	
Mate (#)	[# * 12 * Class Avg.]	[/ L]	[/ M]	
Insurance	[Class Avg.]	[/ L]	[/ M]	
Roadworthiness	[Class Avg.]	[/ L]	[/ M]	
Capital Cost	[Class Avg.]	[/ L]	[/ M]	
Total	[Total Fixed Costs]	[/ L]	[/ M]	
VARIABLE				
Fuel	[(L/2/O + L/2/P) * T]	[/ L]	[/ M]	
Repair	[L * R]	[/ L]	[/ M]	
Tires	[L * Q]	[/ L]	[/ M]	
Loading	[L / A * S]	[/ L]	[/ M]	
Total	[Total Variable Costs]	[/ L]	[/ M]	
TOTAL COSTS	[Total Annual Costs]	[/ L]	[/ M]	

Truck Operating Costs
2-axle Straight Truck, Freight
<= 1 T Payload (petrol)

Increased Fuel Efficiency

1-way Journey Distance (km)	132
Registered GVW (T)	2.28
Tare Weight (T)	1.57
Payload Capacity (T)	0.76
Payload (T)	0.76
Speed (km/h)	40
Load/Unload Time (h)	0.9
1-way Journey Time (h)	4.2
Daily 1-way Journeys (#)	3
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	102960
Annual Quantity (T)	296
Annual Productivity (T-km)	39125
Fuel Consumption (km/l) [3.47 - 0.022 * GVW]	
Loaded	3.42
Empty	3.44
Tire Cost per km (C)	7.74
Repair Costs per km (C)	9.58
Load/Unload Charge- L. Park (C)	1968
Fuel - Petrol (C/l)	198
Tires - Home second (C/tire)	18000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	593220	5.76	15.16	5.3
Mate (1)	243600	2.37	6.23	2.2
Insurance	8860	0.09	0.23	0.1
Roadworthiness	3024	0.03	0.08	0.0
Capital Cost	1124407	10.92	28.74	10.0
Total	1973111	19.16	50.43	17.6
VARIABLE				
Fuel	5947569	57.77	152.02	52.9
Repair	986357	9.58	25.21	8.8
Tires	796910	7.74	20.37	7.1
Loading	1535040	14.91	39.23	13.7
Total	9265876	89.99	236.83	82.4
TOTAL COSTS	11238987	109.16	287.26	

Truck Operating Costs
2-axle Straight Truck, Freight
1 - 3 T Payload (diesel)

Increased Fuel Efficiency

1-way Journey Distance (km)	178
Registered GVW (T)	5.00
Tare Weight (T)	1.52
Payload Capacity (T)	2.24
Payload (T)	2.24
Speed (km/h)	47
Load/Unload Time (h)	1.5
1-way Journey Time (h)	5.3
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	92560
Annual Quantity (T)	582
Annual Productivity (T-km)	103667
Fuel Consumption (km/l) [3.47 - 0.022 * GVW]	
Loaded	3.36
Empty	3.44
Tire Cost per km (C)	6.90
Repair Costs per km (C)	24.85
Load/Unload Charge- L. Park (C)	3175
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	25000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	738000	7.97	7.12	6.5
Mate (1)	219276	2.37	2.12	1.9
Insurance	13588	0.15	0.13	0.1
Roadworthiness	6028	0.07	0.06	0.1
Capital Cost	1325725	14.32	12.79	11.6
Total	2302617	24.88	22.21	20.2
VARIABLE				
Fuel	4494726	48.56	43.36	39.5
Repair	2300116	24.85	22.19	20.2
Tires	638664	6.90	6.16	5.6
Loading	1651000	17.84	15.93	14.5
Total	9084506	98.15	87.63	79.8
TOTAL COSTS	11387123	123.02	109.84	

Truck Operating Costs
2-axle Straight Truck, Freight
3 - 5 T Payload (diesel)

Increased Fuel Efficiency

1-way Journey Distance (km)	323
Registered GVW (T)	10.13
Tare Weight (T)	5.18
Payload Capacity (T)	4.95
Payload (T)	4.95
Speed (km/h)	31
Load/Unload Time (h)	4.4
1-way Journey Time (h)	14.7
Daily 1-way Journeys (#)	1
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	83980
Annual Quantity (T)	644
Annual Productivity (T-km)	207851
Fuel Consumption (km/l) [3.47 - 0.022 * GVW]	
Loaded	3.25
Empty	3.36
Tire Cost per km (C)	19.22
Repair Costs per km (C)	38.97
Load/Unload Charge- L. Park (C)	11666
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	40000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	494568	5.89	2.38	3.6
Mate (1)	388224	4.62	1.87	2.8
Insurance	15072	0.18	0.07	0.1
Roadworthiness	4508	0.05	0.02	0.0
Capital Cost	723199	8.61	3.48	5.3
Total	1625571	19.36	7.82	11.8
VARIABLE				
Fuel	4198120	49.99	20.20	30.5
Repair	3272701	38.97	15.75	23.8
Tires	1614096	19.22	7.77	11.7
Loading	3033160	36.12	14.59	22.1
Total	12118076	144.30	58.30	88.2
TOTAL COSTS	13743647	163.65	66.12	

Truck Operating Costs
2-axle Straight Truck, Freight
> 5 T Payload (diesel)

Increased Fuel Efficiency

1-way Journey Distance (km)	262
Registered GVW (T)	11.84
Tare Weight (T)	3.81
Payload Capacity (T)	8.03
Payload (T)	8.03
Speed (km/h)	46
Load/Unload Time (h)	2.3
1-way Journey Time (h)	8.0
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	136240
Annual Quantity (T)	2088
Annual Productivity (T-km)	547004
Fuel Consumption (km/l) [3.47 - 0.022 * GVW]	
Loaded	3.21
Empty	3.39
Tire Cost per km (C)	44.98
Repair Costs per km (C)	39.58
Load/Unload Charge- L. Park (C)	16733
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	55000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	572724	4.20	1.05	2.0
Mate (2)	324000	2.38	0.59	1.1
Insurance	9743	0.07	0.02	0.0
Roadworthiness	4236	0.03	0.01	0.0
Capital Cost	537832	3.95	0.98	1.9
Total	1448535	10.63	2.65	5.1
VARIABLE				
Fuel	6821335	50.07	12.47	23.9
Repair	5392379	39.58	9.86	18.9
Tires	6128075	44.98	11.20	21.5
Loading	8701160	63.87	15.91	30.5
Total	27042949	198.49	49.44	94.9
TOTAL COSTS	28491484	209.13	52.09	

Truck Operating Costs
2-axle Straight Truck, Mixed
<= 1 T Payload (petrol)

Increased Fuel Efficiency

1-way Journey Distance (km)	77
Registered GVW (T)	2.33
Tare Weight (T)	1.57
Payload Capacity (T)	0.77
Payload (T)	0.77
Speed (km/h)	48
Load/Unload Time (h)	1.0
1-way Journey Time (h)	2.6
Daily 1-way Journeys (#)	5
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	100100
Annual Quantity (T)	501
Annual Productivity (T-km)	38539
Fuel Consumption (km/l) [3.47 - 0.022 * GVW]	
Loaded	3.42
Empty	3.44
Tire Cost per km (C)	6.22
Repair Costs per km (C)	10.29
Load/Unload Charge- L. Park (C)	1024
Fuel - Petrol (C/l)	198
Tires - Home second (C/tire)	18000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	552528	5.52	14.34	5.6
Mate (1)	180000	1.80	4.67	1.8
Insurance	14133	0.14	0.37	0.1
Roadworthiness	3098	0.03	0.08	0.0
Capital Cost	318418	3.18	8.26	3.2
Total	1068177	10.67	27.72	10.9
VARIABLE				
Fuel	5783291	57.78	150.07	58.8
Repair	1030029	10.29	26.73	10.5
Tires	622622	6.22	16.16	6.3
Loading	1331200	13.30	34.54	13.5
Total	8767142	87.58	227.49	89.1
TOTAL COSTS	9835319	98.25	255.21	

Truck Operating Costs
2-axle Straight Truck, Mixed
1 - 3 T Payload (diesel)

Increased Fuel Efficiency

1-way Journey Distance (km)	179
Registered GVW (T)	7.03
Tare Weight (T)	4.63
Payload Capacity (T)	2.18
Payload (T)	2.18
Speed (km/h)	39
Load/Unload Time (h)	5.3
1-way Journey Time (h)	9.9
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	93080
Annual Quantity (T)	567
Annual Productivity (T-km)	101457
Fuel Consumption (km/l) [3.47 - 0.022 * GVW]	
Loaded	3.32
Empty	3.37
Tire Cost per km (C)	9.54
Repair Costs per km (C)	27.09
Load/Unload Charge- L. Park (C)	2642
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	25000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	672000	7.22	6.62	6.0
Mate (1)	189000	2.03	1.86	1.7
Insurance	13541	0.15	0.13	0.1
Roadworthiness	3570	0.04	0.04	0.0
Capital Cost	878130	9.43	8.66	7.9
Total	1756241	18.87	17.31	15.8
\				
Fuel	4596156	49.38	45.30	41.3
Repair	2521537	27.09	24.85	22.6
Tires	887983	9.54	8.75	8.0
Loading	1373840	14.76	13.54	12.3
Total	9379516	100.77	92.45	84.2
TOTAL COSTS	11135757	119.64	109.76	

Truck Operating Costs
2-axle Straight Truck, Mixed
3 - 5 T Payload (diesel)

Increased Fuel Efficiency

1-way Journey Distance (km)	264
Registered GVW (T)	10.07
Tare Weight (T)	5.14
Payload Capacity (T)	4.93
Payload (T)	4.93
Speed (km/h)	60
Load/Unload Time (h)	7.2
1-way Journey Time (h)	11.6
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	137280
Annual Quantity (T)	1282
Annual Productivity (T-km)	338395
Fuel Consumption (km/l) [3.47 - 0.022 * GVW]	
Loaded	3.25
Empty	3.36
Tire Cost per km (C)	23.42
Repair Costs per km (C)	41.35
Load/Unload Charge- L. Park (C)	6744
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	40000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	516516	3.76	1.53	2.5
Mate (2)	302664	2.20	0.89	1.5
Insurance	21308	0.16	0.06	0.1
Roadworthiness	4368	0.03	0.01	0.0
Capital Cost	623585	4.54	1.84	3.0
Total	1468441	10.70	4.34	7.1
VARIABLE				
Fuel	6860259	49.97	20.27	33.1
Repair	5676528	41.35	16.77	27.4
Tires	3215098	23.42	9.50	15.5
Loading	3506880	25.55	10.36	16.9
Total	19258765	140.29	56.91	92.9
TOTAL COSTS	20727206	150.98	61.25	

Truck Operating Costs
2-axle Straight Truck, Freight
> 5 T Payload (diesel)

Increased Fuel Efficiency

1-way Journey Distance (km)	262
Registered GVW (T)	11.84
Tare Weight (T)	3.81
Payload Capacity (T)	8.03
Payload (T)	8.03
Speed (km/h)	46
Load/Unload Time (h)	2.3
1-way Journey Time (h)	8.0
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	136240
Annual Quantity (T)	2088
Annual Productivity (T-km)	547004
Fuel Consumption (km/l) [3.47 - 0.022 * GVW]	
Loaded	3.21
Empty	3.39
Tire Cost per km (C)	44.98
Repair Costs per km (C)	39.58
Load/Unload Charge- L. Park (C)	16733
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	55000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	572724	4.20	1.05	2.0
Mate (2)	324000	2.38	0.59	1.1
Insurance	9743	0.07	0.02	0.0
Roadworthiness	4236	0.03	0.01	0.0
Capital Cost	537832	3.95	0.98	1.9
Total	1448535	10.63	2.65	5.1
VARIABLE				
Fuel	6821335	50.07	12.47	23.9
Repair	5392379	39.58	9.86	18.9
Tires	6128075	44.98	11.20	21.5
Loading	8701160	63.87	15.91	30.5
Total	27042949	198.49	49.44	94.9
TOTAL COSTS	28491484	209.13	52.09	

Truck Operating Costs
Tractor Semi-trailer, 2-S1

Increased Fuel Efficiency

1-way Journey Distance (km)	116
Registered GVW (T)	16.78
Tare Weight (T)	10.12
Payload Capacity (T)	6.66
Payload (T)	6.66
Speed (km/h)	35
Load/Unload Time (h)	3.0
1-way Journey Time (h)	6.3
Daily 1-way Journeys (#)	2
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	60320
Annual Quantity (T)	1732
Annual Productivity (T-km)	200866
Fuel Consumption (km/l) [3.47 - 0.022 * GVW]	
Loaded	3.10
Empty	3.25
Tire Cost per km (C)	280.88
Repair Costs per km (C)	111.13
Load/Unload Charge- L. Park (C)	N/A
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	66000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	480708	7.97	2.39	1.8
Mate (1)	144000	2.39	0.72	0.5
Insurance	12000	0.20	0.06	0.0
Roadworthiness	3200	0.05	0.02	0.0
Capital Cost	U/K	0.00	0.00	0.0
Total	639908	10.61	3.19	2.3
VARIABLE				
Fuel	3137300	52.01	15.62	11.4
Repair	6703362	111.13	33.37	24.4
Tires	16942682	280.88	84.35	61.8
Loading	0	0.00	0.00	0.0
Total	26783343	444.02	133.34	97.7
TOTAL COSTS	27423251	454.63	136.53	

Truck Operating Costs
Tractor Semi-trailer, 2-S2

Increased Fuel Efficiency

1-way Journey Distance (km)	257
Registered GVW (T)	27.85
Tare Weight (T)	17.34
Payload Capacity (T)	10.51
Payload (T)	10.51
Speed (km/h)	37
Load/Unload Time (h)	4.5
1-way Journey Time (h)	11.4
Daily 1-way Journeys (#)	1
Monthly Distance (km)	
Out-of-service Time (days/year)	
Annual Distance (km)	66820
Annual Quantity (T)	1366
Annual Productivity (T-km)	351139
Fuel Consumption (km/l) [3.47 - 0.022 * GVW]	
Loaded	2.86
Empty	3.09
Tire Cost per km (C)	78.86
Repair Costs per km (C)	164.16
Load/Unload Charge- L. Park (C)	3000
Fuel - Diesel (C/l)	165
Tires - Home second (C/tire)	66000

COSTS PER TRUCK

	ANNUAL	per km	per T-km	%
FIXED				
Driver	840000	12.57	2.39	3.1
Mate (1)	90000	1.35	0.26	0.3
Insurance	U/K	0.00	0.00	0.0
Roadworthiness	7000	0.10	0.02	0.0
Capital Cost	5012380	75.01	14.27	18.8
Total	5949380	89.04	16.94	22.3
VARIABLE				
Fuel	3714205	55.59	10.58	13.9
Repair	10969171	164.16	31.24	41.1
Tires	5269425	78.86	15.01	19.7
Loading	780000	11.67	2.22	2.9
Total	20732802	310.28	59.04	77.7
TOTAL COSTS	26682182	399.31	75.99	