Truck Costing Model
for Transportation Managers

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Abstract

A software model was developed to estimate truck costs under different equipment configurations, input prices, and gross vehicle weights. The software was developed to obtain for many different configurations and trip characteristics. Important conclusions can be drawn from running simulations include the sensitivity of costs and equipment use, wait time and trip distance, labor, and fuel price. Relationships of cost variables and the cost of operations are important for trucking companies and shippers.

Disclaimer

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EXECUTIVE SUMMARY

Truckers face different input prices, product characteristics, truck configurations, geographical characteristics, firm size, and driving practices. Thus, it is difficult to obtain current estimates of costs for particular independent owner/operators. The software that was developed determines costs for a variety of truck configurations, product characteristics, and input prices. A firm's costs are determined by its equipment, characteristics of products hauled, and input prices associated with a typical movement for that firm.

The truck costing software may provide information to many in the trucking and or shipping industry. Anyone estimating transportation costs need reliable estimates of owner/operator costs. Also some shippers need accurate truck cost information to negotiate desirable rates and determine the appropriate mode of transportation.

A stand alone Truck Costing Model was developed using Microsoft Visual Basic for Windows. The model in this study has many useful features. Costs can be obtained for many different configurations and trip characteristics. Important conclusions can be drawn from running simulations include the sensitivity of costs and equipment use, wait time and trip distance, labor, and fuel price. The relationships of these variables and the cost of operations are important for trucking interests.

The simulations and sensitivity analysis determined the truck cost model's flexibility and inadequacies. Factors influencing costs of owner/operators include annual miles, trip distance, and truck speed for fuel efficiency. Decreasing annual miles may be critical for the trucker debating on waiting for a better revenue load. The opportunity cost of waiting may more than make up for the additional revenue received. Another interesting factor in the model is the wait time. Initial assumptions exclude wait time, but loading and unloading time for short movements are the driving force of increased costs. The shorter the trip, the greater the impact of loading and unloading time on cost.

CHAPTER 1.   INTRODUCTION

The motor carrier industry has been a recurrent subject for cost studies. Most referenced studies use an economic-engineering approach to estimate trucking costs. The economic-engineering model estimates the production function with a given set of factor prices. Some studies use surveys as a data collecting tool to arrive at costs by averaging information received from the survey. Cost components are easily identified in the economic-engineering approach and thus, cost estimates of a new startup firm are readily available. A weakness of the economic-engineering approach is that results are based on average values of input prices and resource usage, and are accurate for a limited population. Furthermore, a new study must be undertaken to update the results.

This model aims to provide for adaptability for the different users. The focus is on individual motor carrier costing for a single movement.

Justification

An Owner/Operator Spreadsheet Costing Model developed in 1996 has been useful. However, it is based on a spreadsheet and lacked functionality of a stand alone model or software product. A new visual basic model has been developed to be a stand alone product that may be employed by transportation professionals and researchers. The model can be expanded to include many truck configurations.

Although the trucking industry is perceived as a competitive homogenous industry, many characteristics segment the industry into subindustries. The trucking industry is classified as either local or intercity. Vast differences exist between these two segments. Local carriers include intracity services such as delivery, dump trucks, garbage trucks, and other services (Titus, 1994). Intercity trucking is classified between less-than-truckload (trucks hauling less than 10,000 pounds) and the truckload sectors. The focus of the software product is on the intercity truckload sector and, more specifically, a specific movement of a single tractor trailer unit.

Many small truckload (TL) firms operate in the motor carrier industry. An estimated 575,000 trucking companies operate in the United States (Federal Motor Carrier Administration, 2002). It is estimated that more than 95 percent of trucking companies have less than $1 million in gross revenue (Coyle, Bardi, and Novak, 1994). Many of these smaller companies are owner/operators or small firms with a single unit or only a few trucks.

Truckers face different input prices, product characteristics, truck configurations, geographical characteristics, firm size, and driving practices. Thus, obtaining current estimates of costs for particular independent owner/operators is difficult. The software that was developed determines costs for a variety of truck configurations, product characteristics, and input prices. A firm's costs are determined by its equipment, characteristics of products hauled, and input prices associated with a typical movement for that firm.

The truck costing software may provide information to many in the trucking and or shipping industry. Anyone estimating transportation costs need reliable estimates of owner/operator costs. Also some shippers need accurate truck cost information to negotiate desirable rates and determine the appropriate mode of transportation.

Owner/operator cost information helps larger trucking firms that use owner/operators. Owner/operators lease (enter into contract) to a larger firm and current cost estimates may be beneficial to both parties in negotiating the agreement.

The trucking industry is not homogenous; but, the industry approximates perfect competition because it has limited entry barriers, a large number of firms, virtually perfect information, and its small independent truckers mainly are price takers. There are many entries and exits from the industry annually. For firms needing the owner/operator services, sustainability may reduce search costs and improve transportation service through reduced turnover.

Current transportation cost estimates are essential for economic development or those providing feasibility of possible manufacturing or other facilities. Current cost information again may allow intermodal transportation rate comparisons and provide transportation information vital to the location of a new facility.

Objectives

The primary objective of this project was to develop a software model that provides truck cost information reflecting differences in equipment, product, and trip characteristics of an individual firm. A secondary objective was to provide additional performance measures for decision makers who use truck cost information[1]. The different performance measures generated can be used by different entities for specific purposes.

Research Methods

Developing costs in the trucking industry requires use of many data sources. Secondary data sources include data for equipment, trip, and industry characteristics. A literature review was conducted to identify data from prior truck costing studies and to evaluate past methods to form assumptions and determine relevant costs for the industry. Interviews were conducted with various trucking experts to gather data related to trucking costs. A Microsoft Visual Basic model was developed to link relevant truck costs to performance measures. A highlight of the model is that sensitivity analysis can be conducted to determine the model's sensitivity to changing input variables. The model's design enables a user to change most parameters to fit individual needs.

Data

Data used to build the original truck cost spreadsheet model came from a variety of sources including interview and secondary data sources. Some data and formulas used in the original spreadsheet model have been updated and verified for reliability. The new software model also allows the user to change data that does not reflect a particular input, equipment cost, or trip characteristic.

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[1]A performance measure in the trucking industry is the unit cost such as per-mile, per-ton, per hour etc.

Cost Summary

Factors affecting costs in the trucking industry include economies of size, economies of utilization, and the makeup of variable and fixed costs. Economies of size for small firms and owner/operators are minimal, and the cost structure of owner/operators vary from larger firms because management and overhead costs may be low or negligible. For small firms or owner/operators, increasing company size by adding power units may result in volume discounts for purchasing larger quantities of inputs.

Utilization of equipment is the most important factor affecting motor carriers. High use of equipment lowers average fixed costs. It would be expected that small changes in equipment use may have a large impact on costs for the owner/operator.

Paper Organization

This paper is divided into five parts. Industry cost structure and the literature are examined. Model development is explained. Model results and sensitivity analysis are presented and a conclusion and summary.

CHAPTER 2.   MODEL DESCRIPTION

Bierman, Bonini, and Hausman (1991) describe a model as a "simplified representation of an empirical situation." This software model attempts to replicate the actual movement of a product by a motor carrier. Variables are classified as decision variables, exogenous variables, intermediate variables, policies and constraints, or performance measures. Decision variables are under the control of the decision maker. The other types of variables affect the model, but their values cannot be determined by the decision maker.

Exogenous or external variables are outside the decision maker's control. Intermediate variables are used to relate decision variables and exogenous variables to performance measures (Bierman, et al., 1991). Exogenous and intermediate variables are represented in various places throughout the model.

Truck costs are a function of decisions made by a company or owner/operator. The differences in equipment characteristics, and operational structure, along with different trip characteristics, result in a somewhat unique cost structure for a particular movement and/or firm. Firm costs such as fuel, insurance, labor, maintenance and repair costs vary depending on geography, new versus used, and freight being transported. The model allows decision makers to change parameters to reflect different decisions which impact transportation cost.

The software model can calculate truck cost for many commodities using different truck equipment combinations and input prices. This application provides per mile, per hour, per bushel, per hundredweight, per ton, per gallon, and the option of a user defined unit cost or performance measure for a particular trip.

The following sections describe features of the model and provide examples for use. Formulas and other data also are displayed.

Model Description

The software interface must have parameter entries and definitions prior to trip simulations being computed. The program can be run repeatedly, allowing for different inputs simulating different input parameters. The sensitivity analysis feature of the model allows the user to see how sensitive the model is to changing input prices and how those changes reflect cost. The model was constructed using Visual Basic programming language. Visual Basic allows a programmer to develop applications with graphical user interfaces that run in Microsoft's Windows without the complexity generally associated with Windows programming.

This application includes three forms: a splash screen form, a main form, and a small pop up form used to add new commodity type or unit. The next section provides a brief description of the model and then describes the different pages in depth with a visual display.

Brief Description

The operator of the software defines the firm's operating and trip characteristics. The model calculates costs based on those decisions and there are many options available. The model is unique, as it can be run for many different options, and the options may be compared to determine a low cost solution. This section first explains the contents of the different pages. Next, it describes calculations the model performs, and last it discusses the performance measures or output of the model.

Truck Costing Page

Most decisions for the user are on page one of the Truck Cost Analysis Model. The ownership decision is presented first. The user chooses whether the equipment is owned or leased. This decision is presented in what is termed a combo box. The combo box is located at the far right of the first page of the model. The second decision could be the configuration of the truck being simulated. The choices are Rocky Mountain Double (RMD), Conventional, Spread Tandem, and Tridem.[2]

Table 2.1. Initial Choices Page One Truck Cost Analysis Program

Ownership Choices	Configuration	Trailer Types	Commodity Type	Labor
✓Own	✓RMD	✓Van	✓Barley	✓Per Mile
Lease	Conventional	Flatbed	Corn	Per Hour
	Spread Tandem	Hopper	Oats	
	Tridem	Reefer	Flax	
		Tanker	Wheat	
		53' Dry Van	Flax	
			Soybeans	
			Sunflowers	

NOTE: ✓Check mark indicates the choice made to compute the example.

The next decisions on page one of the Truck Cost Analysis Model are operational and trip characteristics. These decisions, as discussed previously, are on the left side. Included are annual miles, the specific trip miles, and payload. Annual miles default is set at 100,000 miles, but can be changed by the user. Trip distance is calculated by adding fronthaul, backhaul, and deadhead miles. The user must enter fronthaul, backhaul and deadhead miles. Tractor, trailer, and total GVW are computed by adding equipment weight and payload. The user must enter payload weight. Equipment weight is retrieved from the table on the Trailer page automatically. If a user has a different weight it is to be entered into the table.

Input prices are set on page one of the model. Labor rates also are set by the user. A wait time can be set for loading and unloading, which contributes to labor costs, or can be considered an opportunity cost of equipment. Other inputs for the user include the interest rate for return on investment (ROI) and lease rates, fuel prices, maintenance and repair rate, salvage value as a percentage of new, and the purchase tax or sales tax.

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[2]Rocky Mountain Double is a six-axle semi truck pulling a two-axle trailer. Conventional is a five-axle semi (most common), a spread tandem is a five-axle semi where the trailer axles are set apart to take advantage of weight restrictions. A tridem is a six-axle semi.

Fixed Cost Page

The Fixed Cost page includes computed values and others that can be changed. On this page the tractor price can be changed and the estimated useful life for the tractor and the trailer can be varied to reflect different equipment usage affecting annual equipment price. In the equipment ownership and lease expense sections costs are displayed along with depreciation and ROI.

Also on the Fixed Cost page are the license, taxes, and insurance entries with defaults set. Computed in the table is the annual fixed costs, which are converted to the different performance measures.

Variable Cost Page

The Variable Cost Page contains five sections. The sections are tire, fuel, maintenance and repair, labor, and total variable costs. In the tire section is the cost per tire separated by tractor tires and trailer tires. There is cost per mile loaded and empty for both tractor and trailer. There also is calculated cells for weight per tire and costs per mile per tire.

The fuel costs have cells for calculations on miles per gallon empty and loaded, and adjusted for speed. The final cells in the table are fuel cost per mile loaded and empty.

The maintenance and repair section shows the calculated values for loaded and empty. This section is calculated by the model and those calculations are explained later.

The labor cells show the labor cost per mile, from driving and waiting. These entries are calculated from decisions made on page one of the model.

Trailer Page

The Trailer page contains two tables. The first table has the trailer weights. These are used throughout to determine GVW, tire numbers, and other calculations. These can be changed before the model is run for specific trailer weights for different equipment to provide a more accurate cost estimate.

The second table is the trailer prices. These are default prices established from industry experts. These prices can be changed before the model is run for specific equipment providing a more accurate cost estimate.

Cost Summary Page

The Cost Summary page contains the performance measures or the output of the software model. The measures are separated into fixed and variable costs and also into different costing units or performance measurements. Variable costs are fuel, labor, tires, and maintenance and repair. Fixed costs are equipment costs, license and taxes, insurance, and management and overhead.

As stated earlier, these costs are measured using several different performance measures. These measures are per mile, per hour, per bushel, per hundredweight, per ton, per trip, per gallon or other unit that can be designated by the user at the outset of running the model.

Sensitivity Analysis Page

The Sensitivity Analysis page contains many variables that can be changed to see the model's reaction or sensitivity to these variables. The variables can be chosen independently and positive and negative percentages can be used to test sensitivity. The change in costs are presented as percentage effects on original costs. This provides the user with flexibility in testing variables' influences on truck costs.

CHAPTER 3. MODEL DISPLAY AND EXPLANATION

This chapter will show different displays of the model and explain how entries may be changed. The goal is to provide a user with an understanding of how to use the model. As stated earlier, the model is made up of different pages that are accessed by using "SSTabs." The following description and figures explains and shows how to use the model.

Software Model Display

The truck cost software application splash screen is displayed as the application loads. An example of the splash screen is shown as Figure 3.1.
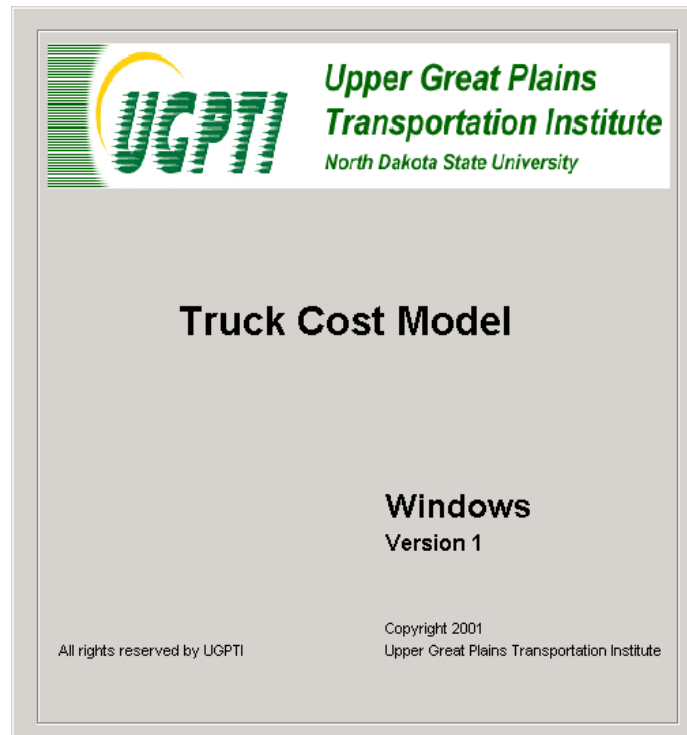

Figure 3.1. Splash Screen – Displayed when the Program Starts

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Main Form

The main form is a standard Visual Basic form. It includes six pages, five combo boxes, and many "text fields." Some "text fields" are input parameters while others display the computed values of the program. The first page contains most of the input text fields. Some input parameters and combo boxes have default values, but the user also is allowed to change any input value before running a simulation. When all input values are set, the user can calculate the truck cost by pressing the "Compute" button. Pressing the "Print" button prints the page currently being displayed. Pressing the "Exit" button exits the application (Figure 3.2).

Figure 3.2. Trip Specifics Page Showing the Configuration Combo Box Options

The page displayed in Figure 3.2 contains the "Truck Costing" page. Other pages of the program can be accessed by clicking on the desired tab at the top of the page and these pages include:

- ✓ Fixed cost
- ✓ Variable Cost
- ✓ Trailer
- ✓ Cost Summary
- ✓ Sensitivity

The tabs are called "SSTabs" each Tab contains other pages or controls. This display is similar to a multiple page spreadsheet displaying other accessible sheets. Only one tab is active at a time. Another explanation of "SSTab" control is that it resembles the labels on a group of file folders located in a file drawer. Using a "SSTab" control, six multiple pages are defined in the main form or window of the application (Figure 3.2).

Users can navigate between pages either by pressing "CTRL+TAB" on the keyboard, or by clicking the left mouse button on the caption of each tab.

Combo Boxes

The "Truck Costing" page contains five "combo boxes." The configuration combo box allows the user to select the configuration of the truck from four different options (Figure 3.2). The configuration options are defined by axle numbers and are Conventional, Rocky Mountain Double (RMD), Spread Tandem, and Tridem. A Conventional configuration is a typical five-axle semi truck with three axles on the tractor and two axles on the trailer. A Rocky Mountain Double (RMD) typically is a seven-axle truck. A Spread Tandem is the same as the conventional five-axle except the axle on the rear axle is spread 120 inches to conform to the bridge formula. By spreading the axles, the two axles can carry 40,000 pounds versus 34,000 pounds for a standard tandem. The spread tandem is used almost exclusively on flatbed trailers where loads are likely to be distributed over the axles. The Tridem axle configuration is used on some truck configurations to increase gross vehicle weight. This application is mostly for gravel and grain but has other uses such as concrete trucks and tankers. For the tridem trailer, the gross vehicle weight can increase from 80,000 to 91,000, or 93,000 pounds, depending on the axle spread but must conform with Bridge Formula B[3].

The Trailer Type options combo box provides a choice from six different trailer types including; van, flatbed, hopper, tanker, reefer, and 53-foot dry van (Figure 3.3). The choice is made by positioning the mouse over the box and right clicking, a drop down menu of choices appears. Simply click on your choice of equipment and automatically the appropriate equipment weights and values are used in the model. If the user has different equipment weights or values, these can be changed before a simulation is run by going to the "Trailer" page and clicking the "edit" button. Some combinations of tractor configuration and trailer types are not appropriate, if the user chooses any such combination an error message will appear, asking the user to change the combination.

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[3]Bridge formulas are created to determine the maximum gross weight allowable on the structure and still meet strict safety requirements. North Dakota highways and interstates use Bridge Formula B to determine the allowable gross weight on bridges. State highways and Interstates use the same bridge formula. Current bridge formulas allow extra weight for longer vehicles and for vehicles with more axles. Longer vehicles reduce bridge stress and more axles on a vehicle reduces its impact on pavement (LeAnn Emmer, interview, July, 2000).
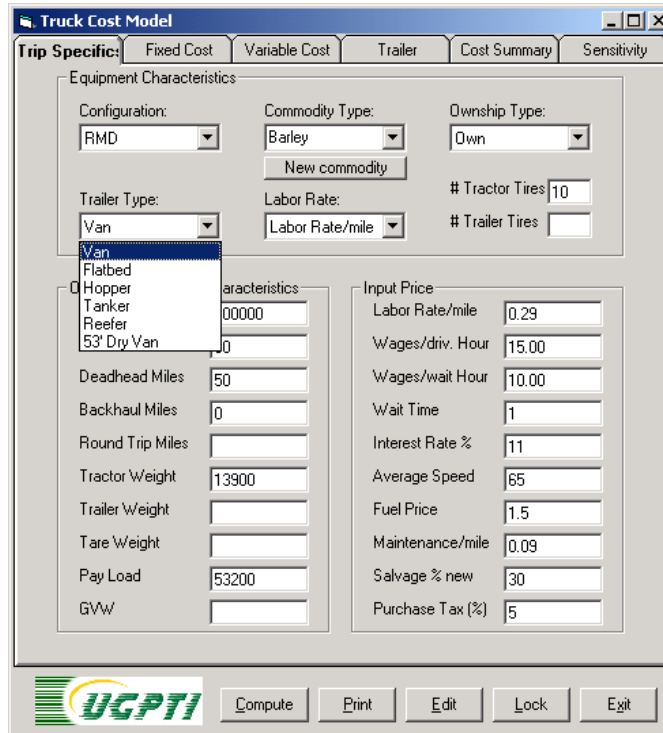
Figure 3.3. Trip Specifics Page Showing the Trailer Type Combo Box Options

The Commodity Type is chosen from a list of several commodities. The list includes; barley, corn, oats, rye, wheat, flax, soybean, and sunflower (Figure 3.4).
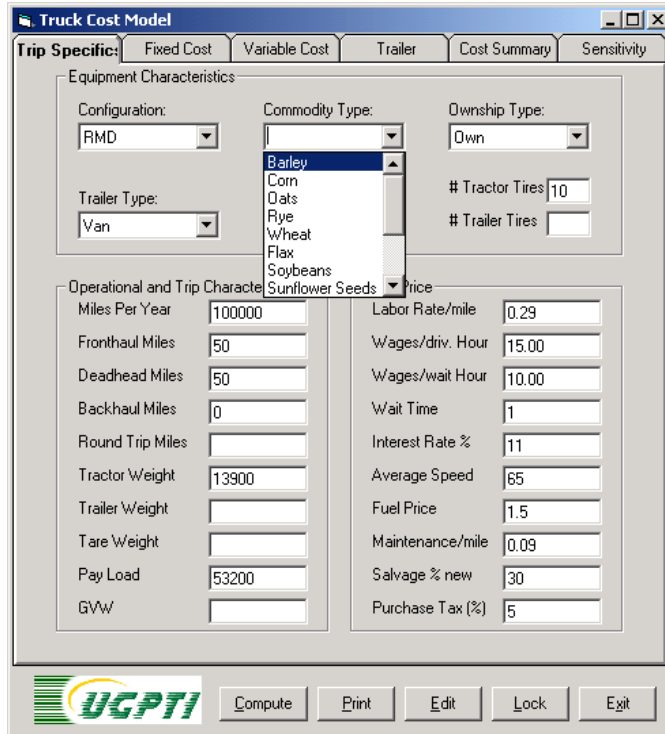
Figure 3.4. Commodity Type Combo Box

If the desired commodity is not in the combo list, the user can add new commodities or freight items. Visual Basic hides forms and displays them only when needed. Such forms are termed "pop up" forms. In this application a "pop up" form is used to add new products in the commodity type list (Figure 3.4). Items are added by pressing the "New Commodity" button below the "Commodity Type" combo box. A small form will appear that has only two text fields; Name, and Weight/Bushel or Unit (Figure 3.5). When adding a commodity or freight item the weight per unit also must be provided. Other units may be used, such as engines, boxes of paper, or any type of freight.

The user keys in the text fields as input values and presses the "OK" button to confirm. It will add the new commodity to the combo list and set the new commodity as the current commodity (Figure 3.5). The added freight item will remain in the combo list until the application is closed.

The "Labor Rate Type" combo box provides a choice of per hour or per mile basis. The "Own/ Lease" choice combo box is used to designate whether the tractor is owned or leased. The "Truck Costing" page also features most of the operational and trip characteristics, and input prices.

Figure 3.5. New Commodity Combo Box.

The next decisions on the "Truck Costing" page of the Truck Cost Analysis Model are the operational and trip characteristics. These decisions, as previously discussed , are on the left side of the "Truck Costing" page. Included are annual miles, the specific trip miles, and payload. Annual miles default is set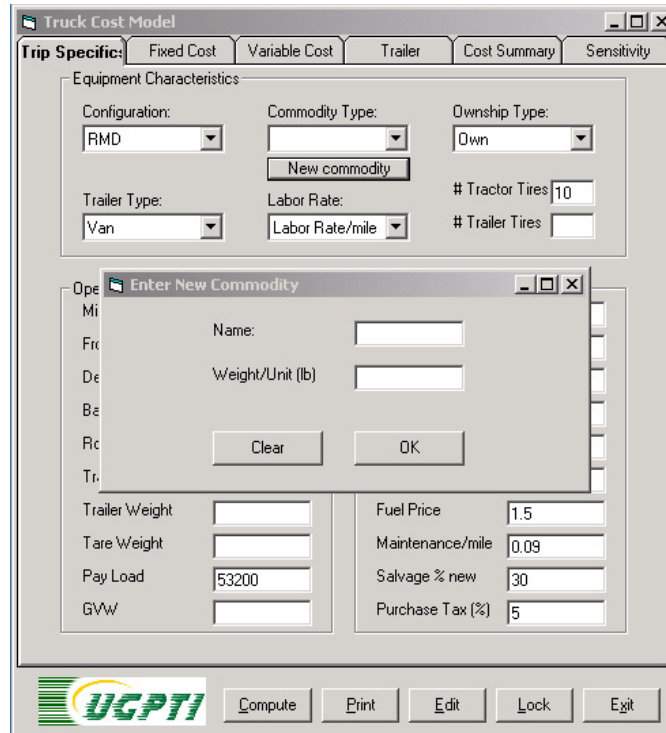 at 100,000 miles, but can be changed by the user. Trip distance is calculated by adding fronthaul, backhaul, and deadhead miles. The user must enter fronthaul, backhaul and deadhead miles. Tractor, trailer, and total GVW are computed by adding equipment weight and payload. The user must enter payload weight. Equipment weight is retrieved from the table on the "Trailer" page automatically. If a user has a different weight, it is to be entered into the table by editing the "Trailer" page.

Input prices are set on page one of the model. Defaults are entered, but the program allows the user to change entries. Labor rates can be set, and a wait time can be entered for loading and unloading, which contributes to labor costs, or can be considered an opportunity cost of equipment. Other inputs for the user include the interest rate for return on investment (ROI) or the lease rates, fuel prices, maintenance and repair rate, the salvage value as a percentage of new, and the purchase tax or sales tax.

Fixed Cost Page

The Fixed Cost page includes computed values and others that can be changed. On this page the tractor price can be changed, and the estimated useful life for the tractor and the trailer can be changed to reflect different equipment usage affecting annual equipment price. The trailer cost is changed on the "Trailer" page. In the equipment ownership and lease expense sections costs are displayed along with depreciation and ROI.

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Figure 3.6. Fixed Cost Page before Computing Costs (shows only the default input values).

Also on the "Fixed Cost" page are the default values for license, taxes, and insurance. The user of the model may enter the appropriate value. These values are based on annual costs. The table computes annual fixed costs and converts annual to cost per mile.

Variable Cost Page

The Variable Cost Page contains five sections. The sections are tire, fuel, maintenance and repair, labor, and total variable costs (Figure 3.7.).

Figure 3.7. Variable Cost Page before Computing Costs (shows only the default input values).

In the tire section the cost per tire is separated for tractor tires and trailer tires. There is a cost per mile loaded and empty for tractor and trailer. There also are calculated cells for weight per tire and costs per mile per tire. Tire cost and estimated use may be changed by the user on the "Variable Cost" page.

The fuel costs have cells for calculations on miles per gallon empty and loaded, and adjusted for speed. The final cells in the table are fuel cost per mile loaded and empty. Fuel price is an input that may be changed on the "Truck Costing" page. Per mile costs are based on a formula that is explained in Input section of the report.

The maintenance and repair section shows the calculated values for loaded and empty. The per mile maintenance and repair value may be changed by the user on the "Truck Costing" page. The final calculation for maintenance and repair is based on weight and is explained in Input section.

The labor show the labor cost per mile, from driving and waiting. These entries are calculated from decisions made on the "Truck Costing" page of the model. A user may chose either per mile or a per hour labor rate or a combination. If a combination is chose, then the per hour rate is used if a wait time is entered on the "Truck Costing" page of the software model.

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Trailer Page

The "Trailer" page contains two tables. The first table has the trailer weights. These are used throughout to determine GVW, tire numbers, and other calculations. These can be changed before the model is run for specific trailer weights for different equipment to provide a more accurate cost estimate. The user finds the appropriate cell that describes the trailer type and truck configuration and enters the desired trailer wieght.

**Figure 3.8. Trailer Weight and Purchase Price
Tables in the Trailer Page.**

The second table is the trailer prices. The default prices listed in the table were established from industry experts. These prices can be changed by the user before a simulation is run. This is done by finding the cell that fits the users trailer and truck type and entering it in that cell.

Cost Summary Page

The "Cost Summary" page contains the performance measures or the output of the software model. This is separated into fixed and variable costs and also into several performance measurements. Variable costs are fuel, labor, tires, and maintenance and repair. Fixed costs are equipment costs, license and taxes, insurance, and management and overhead.
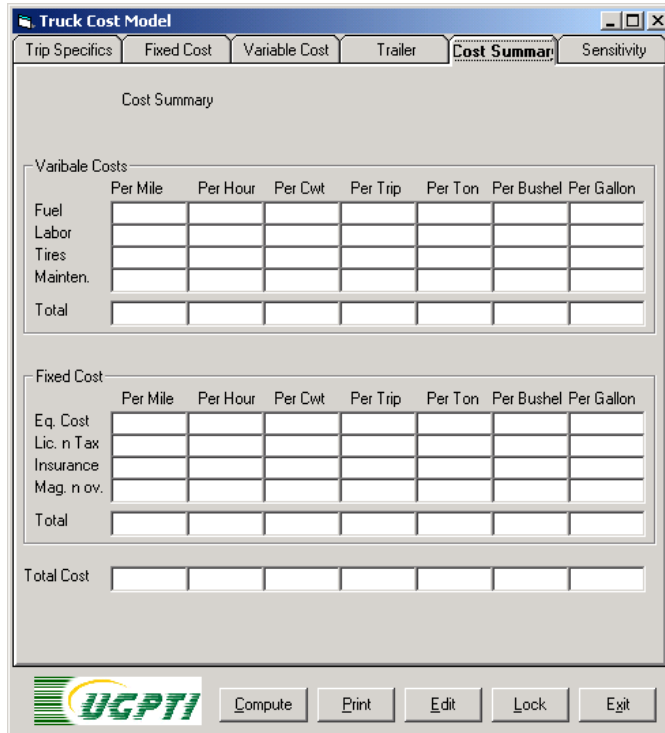
Figure 3.9. Cost Summary Page before Computing Costs.

These costs are measured in using several different performance measures. These measures are per mile, per hour, per bushel, per hundredweight, per ton, per trip, per gallon or other unit that can be designated by the user at the outset of running the model.

Sensitivity Analysis Page

The Sensitivity Analysis page lists the 12 most important parameters of the truck cost model. This page allows the user to increase or decrease (using negative sign) the value of any parameter using percentage. Pressing the analyze button displays the impact each parameter has on total cost (Figure 3.10). A negative sign refers to a decrease in total cost. If several parameters are changed simultaneously the total impact of all changes are shown in the text field of the frame at the bottom of the page. The user can clear any changes made at any time and analyze other combinations of values.
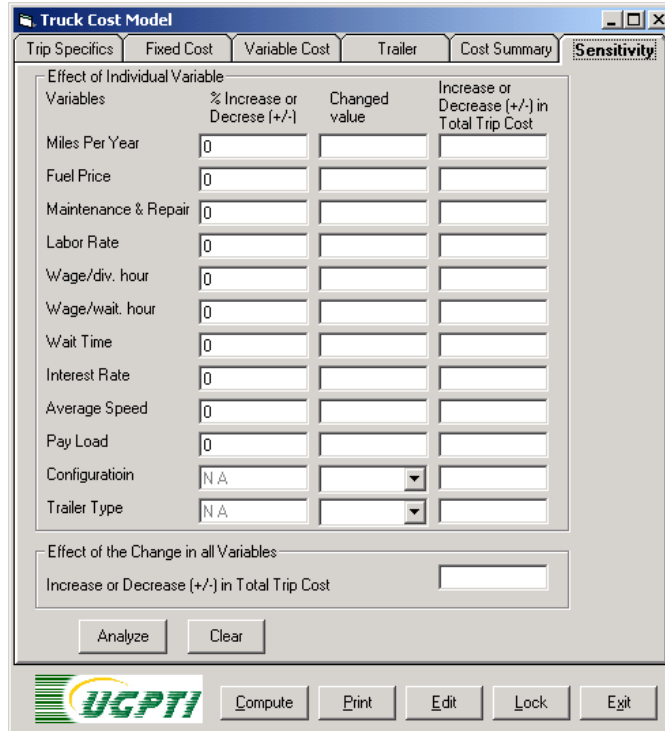
Figure 3.10. Sensitivity Analysis Page.

The change in costs are percentage effects on original costs. This provides the user with flexibility in testing variables influences on truck costs.

CHAPTER 4. SOFTWARE SIMULATION

The following example is presented to further explain the model.   The example will use arbitrarily chosen variables providing necessary information for the user to run a simulation.

Figure 4.1. Trip Specifics Page after Calculating the Truck Costs.

First the choices in all the combo boxes are entered and all input text field values remain as default or may be changed as desired. The first decision in the model is the truck configuration. Second, is the commodity type. Next is equipment ownership decision or whether equipment was leased or owned. Trailer type and labor payment are the next two combo boxes where choices are available (Figure 4.1).

Operational and trip characteristics are the next decisions to be filled by the user. First is an estimate of annual miles, then the specific trip miles are chosen including fronthaul, deadhead, and backhaul miles (total trip miles are calculated).

Next the inputs are chosen, including labor rate per mile and per hour, a wait time, an interest rate, average speed and fuel price, maintenance and repair per mile, and a salvage percentage along with a sales tax or purchase tax rate.

Now the application can calculate the transportation costs for the specific trip by pressing the "compute" button. For this example the configuration and trailer type were chosen as Rocky Mountain Double (RMD) and Van, respectively. For this combination the software calculates the values in the "Truck Costing" page of the application.

Figure 4.2 shows all inputs and calculated values in the Fixed Cost page. Purchase price of the tractor, estimated useful life, license, insurance, and maintenance and overhead costs are the only input values in this page.

Figure 4.2. Variable Cost Page after Calculating the Truck Costs.

Figure 4.2 displays the Variable Cost page. Price per tire and miles per tire for tractor and trailer are the only input values on this page, as the rest are calculated by the application. Each part of the variable cost is displayed separately for better understanding of their weight in the total variable cost.

The "Cost Summary" page summarizes the costs and each component of fixed costs. Variable costs are displayed separately (Figure 4.3). The bottom row below the table shows total cost per unit (Figure 4.3). Many units are included for ease of reading. Those requiring different measurements can quickly see the results without further calculation. This total cost per mile is $1.31 where fixed cost is $0.87 (66 percent) and variable cost is $.44 (34 percent). A major component of variable cost is fuel at $0.32 per mile (37 percent of total variable cost). Similarly major components of fixed costs are equipment at $0.24 per mile (53 percent of total fixed cost) and management and overhead costs $0.11 per mile (23 percent of total fixed cost). Thus the cost summary not only provides unit cost per mile or bushel, but also states the major components contributing to total cost.
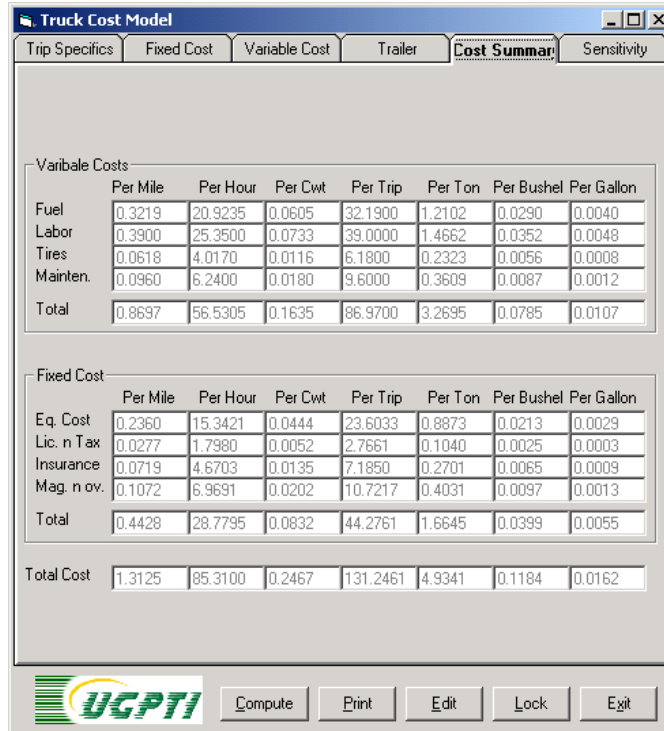
Figure 4.3. Cost Summary Page.

The "Sensitivity" page provides a powerful feature of the application. Figure 4.4 shows the list of parameters the application allows to change for sensitivity analysis. In this example miles per year is increased by 20 percent and the changed value column shows the increased value as 120,000 miles per year and the original value was 100,000 miles per year (Figure 4.4). The model's sensitivity to increasing miles per year decreased total truck costs by 5.62 percent. Again decreasing (indicated by negative sign) the fuel price by 20 percent reduced the total truck cost by 4.91 percent. Similarly increasing the average speed by 30 percent increased truck cost by 23.32 percent and changing the configuration from a RMD to a Spread Tandem decreases total truck cost by 6.35 percent. Considering the combined impact of all the changes mentioned above, it increases the total price by 0.66 percent. This combined impact does not necessarily become the algebraic sum of all percentage increments for each individual change.

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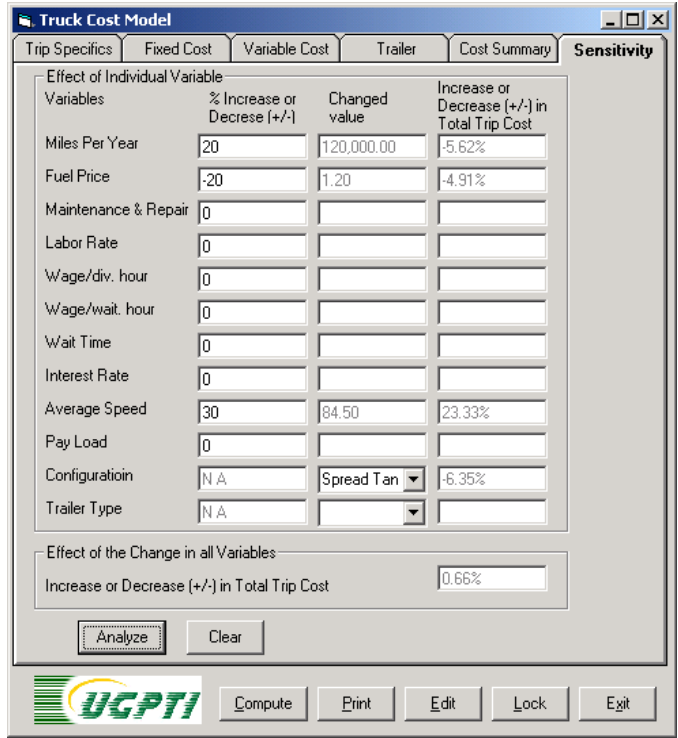
Figure 4.4. Sensitivity Analysis.

CHAPTER 5.   INPUT PRICES

Owner/operators face a competitive labor rate, which can be hourly, by the mile, or some combination. In the software application, labor cost also can include wait time for loading and unloading. Wait time might be considered as an opportunity cost of operations and may be overlooked by many owner/operators. Owner/operators may not consider wait time or loading and unloading as a cost because of U.S. DOT rules that limit driving and on-duty time.

The interest rate is used for equipment purchase and leasing and also for return on investment (ROI). The rate varies in the case of lease, or purchase, depending on the market rates and the risk factor foreseen by the lender. The rate can vary in the case of ROI depending on the return expected by the owner/operator.

The fuel price is an exogenous variable that depends on the current market rates for fuel. Fuel price may vary depending on geographical location, and supply and demand conditions. The default value is $1.50 per gallon.

Maintenance and repair costs are estimated at nine cents per vehicle mile and weight adjusted by .097 cents for each 1,000 pounds above or below 58,000 pounds (Faucett and Associates, 1991). Technological improvements and long warranties for trucks may lessen repair costs but individual firms will have different maintenance and repair costs depending on equipment and operating conditions. The default is set at nine cents and can be changed by the user.

Speed is a function of engine horsepower, terrain, wind, and weight. The model bases fuel economy on weight and speed. Ryder (1994) found that for every one mile-per-hour gain in speed above 55 miles per hour, fuel economy drops 2 percent. As of the winter of 2002, industry experts concur that the fuel economy of the new trucks are similar to results of the formulas developed for this software model. Many input fields have a default value and the user is allowed to change these defaults before run time. The text fields for the values to be computed are kept empty and disabled (The page displays values in black which are input values and the values in gray are computed values).

Fixed Cost

Page two or the "fixed cost" page of the model includes the purchase price of the tractor, estimated useful life, license, insurance, management and overhead costs all as an input. The trailer cost is from the trailer cost table. Values related to the fixed cost are calculated by the program (Figure 5.1). The fixed cost of truck load transportation includes equipment costs either based on lease or owned costs. The owned equation includes the equipment depreciation and return on investment (ROI), which may represent an interest cost on borrowed funds. (Equation 1).

Figure 5.1. Fixed Cost Page before Computing Costs (shows only the default input values).

Depreciation

The cost of using a capital asset is the definition of depreciation (Fess and Warren, 1990). Literature revealed that, in the trucking industry, depreciation is the portion of useful life of a truck used during the accounting period. Allocating depreciation over the useful life of the investment, a manager can measure the economic contribution of the investment (Casavant, 1993).

Tractors and trailers are depreciated on the straight-line basis. The model calculates depreciation by subtracting the salvage value from the purchase price and dividing this figure by the estimated useful life. Salvage values are difficult to determine. Salvage value primarily depends on mileage and condition of the equipment (Dooley, 1996). The default salvage value used is 30 percent, which can be changed by the user at run time. An estimated useful life (EUL) of five years for the tractor and 10 years for the trailer is the consensus of experts in the industry. This estimate is based on the 100,000 mile annual use. A higher annual utilization will shorten the EUL of equipment.

Return On Investment

Equipment return on investment (ROI) constitutes another portion of equipment costs. ROI is considered to be either interest on debt capital or return on equity investment. Therefore, Interest can be the desired return of the manager or the rate paid on debt capital. The default value for interest is 11 percent and was estimated as the interest rate a owner/operator may have to pay on borrowed capital for equipment (Equation 5.1).

Equation 5.1. Return on Investment.

$$\left(\frac{PP\text{-}V}{2} + SV \right) * I$$

where,

PP is purchase price, SV is savage value, and I is interest.

The program considers only one ownership cost or lease cost depending on the choice made on the Truck Costing page. Because the costing is for a particular trip, in the short run, truckers own or lease based on their decision at the time of acquiring the truck (Equations 5.2 and 5.3).

Equation 5.2. Total Equipment Cost (tractor and trailer)

Equipment ownership cost =
Equipment depreciation + Equipment Return On Investment (ROI)

Equation 5.3. Total Equipment Lease Costs

Let:

C = Cash Flow Payment
P = Principal (amount of loan of purchase price)
I   = yearly interest rate in decimal
N = Number of years (period of lease)

Therefore,

C = (Pi) / [1 - (1 / (1 + I) N)]

License Fees Insurance and Sales Tax

Other fixed costs associated with equipment are license fees and insurance. License fees and insurance are a factor of trade area, miles traveled, weight, and product characteristics. Both have some characteristics of variable costs, but generally are treated as fixed costs (Casavant, 1993). License fees and fuel tax were obtained from the N.D. Motor Vehicle Department in Bismarck and were prorated at $1,126. This fee is for both North Dakota and Minnesota, where a vehicle would be used equally in both states. Insurance costs were estimated to be $7,185 (Kleingartner, 2001). Estimates were obtained for a 350-mile radius of Fargo for movements in North Dakota and Minnesota. The model default is set at the aforementioned levels, but can be changed in the model to reflect the user's needs.

Sales tax also is a factor in the purchase of a new truck and trailer. This estimate is based on a percentage and the purchase price of equipment. This is an entry the user can change in the model and the default is set at 5 percent. This percentage varies on a per state basis.

Management and Overhead Costs

The literature described management and overhead costs as short-run fixed costs not directly attributable to a unit of output (Casavant, 1993). Dooley, Bertram, and Wilson (1988) identified management costs as management and administration staff and overhead costs as advertising and communications equipment, office space, and office equipment. For owner/operators, management and overhead costs may be minimal because the operator may be the manager and other costs are not applicable.

Management and overhead costs include costs for management and administrative help. Dooley, Bertram, and Wilson (1988) reported that many owner/operators fail to allocate cost for management or administration. Overhead costs would include advertising and communications. Other costs included in management and overhead are dispatch, sales, management, and accounting.

The default estimate for management and overhead is based on a Dooley, Bertram, and Wilson (1988) survey. The weighted average cost totaled $10,721 annually. Advances in technology may have lowered the costs of communications and accounting. Cell phones can reduce the time spent in search for loads and dispatch, while computers and electronic data communication can reduce time spent on accounting. This cost can be changed to reflect a company's management cost.

Variable Cost Page

Page three of this model displays the default price of each tire and tire life in miles as input for tractor and trailer tiers. The program calculates all other related values based on the entries made on page one of the Truck Cost Analysis Program. The tire prices and life can be changed (Figure 5.2).

Figure 5.2. Variable Cost Page before Computing Costs (shows only the default input values).

Trailer

The fourth or "Trailer" page has two tables, the Trailer weight table and trailer purchase price table. The program picks the appropriate value from these tables according to the user's choice made for trailer and truck configuration. These tables provide the user the option to change any value before the run time (Figure 5.3).
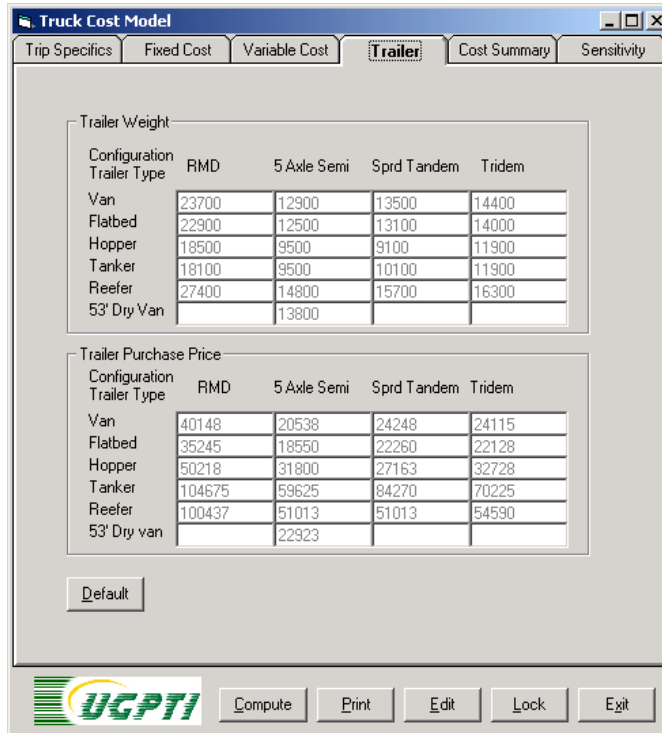
**Figure 5.3. Trailer Weight and Purchase Price
Tables in Trailer Page.**

Cost Summary

Page 5 summarizes the costs. Each major component of fixed cost and variables cost are displayed in two tables. The bottom row of each table contains total cost for each column. At the bottom of the page below the tables summation of the fixed cost and variable cost equates the total cost. Costs are calculated and displayed for per mile, per hour, per Cwt (100 pounds), per trip, per ton (2000 pounds), per bushel, and per gallon (Figure 5.4). Density values are used to convert pounds to bushel (Appendix A, Table 5). The table shows the density of different commodities in the program.
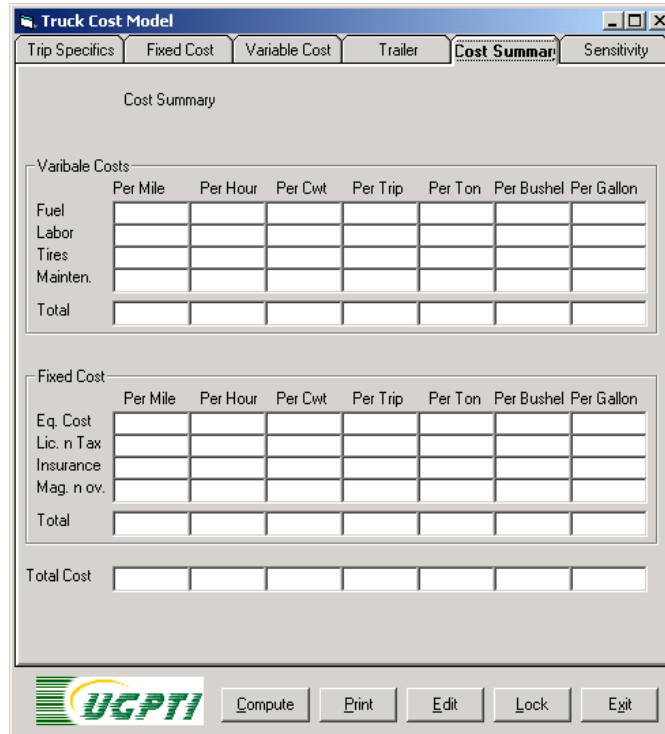
Figure 5.4. Cost Summary Page before Computing Costs.

Sensitivity Analysis Page

Sensitivity analysis is used to determine how changing variables in the model affect total cost. The sensitivity analysis page allows the user to determine how changing a parameter or combination of parameters change total cost for a particular simulation. This analysis allows the user to evaluate changes without running multiple simulations.

Twelve parameters or variables are listed for the sensitivity analysis (Figure 5.5). The page allows the user to increase or decrease (using negative sign) the value of any parameter using percentage. Pressing the analyze button displays the individual impact each parameter has on total cost (Figure 5.5). A negative sign refers to a decrease in total cost. If a number of parameters are changed simultaneously the total impact of all changes is shown in the text field of the frame at the bottom of the page. The user can clear changes at any time and analyze other combinations of values.

Figure 5.5. Sensitivity Analysis Page.

CHAPTER 6. CONCLUSIONS

Differences that exist among truck configurations, trip and product characteristics, and input prices influence costs for individual owner/operators. Obtaining cost estimates for individual motor carrier movements is difficult. The increasing need for on-time quality delivery of products makes it imperative for all users of owner/operators to understand their costs. Shippers who understand that sustainability for the independent trucker may reduce search costs for transportation and at the same time increase customer service by repeatedly using the same trucker. Also large trucking companies and or brokers who use owner/operators need truck cost information to benchmark performance against competitors and industry standards. The Truck Costing Software Model developed also may be used by shippers and owner/operators as a negotiating tool to arrive at equitable shipping rates.

An Owner/Operator Spreadsheet Costing Model developed in 1996 has been useful, however it is based on a spreadsheet and is not a stand alone model or software product. The software model developed is to be a stand alone product that does not require any specific software applications except for Microsoft Windows. The model includes many truck configurations, freight options, and performance measures.

Performance Measures

Previous motor carrier cost studies focused on per mile costs. Users of independent truckers may use different performance measures for the same movement. A shipper may measure costs in units, while the trucker measures in miles. This study differs from the previous studies in the performance measures provided and also flexibility of the model.

The objective of this study was to provide truck cost information to reflect differences in equipment, product, and trip characteristics of an individual firm. The secondary objective was to provide additional performance measures for decision makers who need owner/operator cost information. The measures include, but are not limited to:
- cost per mile
- cost per bushel
- cost per hundredweight
- cost per ton
- cost per trip
- cost per hour
- cost per gallon
- cost per unit

Development and Data

The model is implemented using Visual Basic, a widely used programming language. Visual Basic allows a programmer to develop applications with graphical user interfaces that run in Microsoft's Windows without the complexity generally associated with Windows programming. This application includes three forms; a splash screen form, a main form, and a small pop up form used to add new commodity type or unit.

Data used to build the model came from a combination of previous studies, interviews, and journal articles. Information used from previous studies was updated and verified through interviews of industry experts. Estimates on license fees and taxes came from the N.D. Department of Motor Vehicles. Estimates on insurance were received from West Fargo Insurance. Equipment quotes came from Wallwork Truck Sales and Johnson Trailer Sales. Tire cost estimates were received from OK Tire, with costing and wear information.

Assumptions and Operating Characteristics

The operating characteristics of the firm assumed 100,000 mile equipment usage. A simulation of the model used an equipment configuration of an RMD setup pulling a 48-foot van with a 28-foot pup trailer and a GVW of 90,800 pounds and a payload of 53,200 pounds. Capital equipment costs were estimated to be $84,739 for the tractor and $40,180 for the trailer, with an estimated useful life of five years for the truck and 10 years for the trailer. The equipment was assumed to be purchased rather than leased.

Industry estimates for labor rates of non-refrigerated, non-union wages at 29 cents per mile. Default labor cost was 29 cents per mile. The interest rate estimate of 11 percent may be on the high end of the range of rates a new owner/operator may have to pay because of the risk factor associated with independent truckers. Only one interest rate was used in the model. The rate of 11 percent was used for return on investment and computing lease payments. Functions of fuel costs include fuel price, weight, speed, terrain, and truck configuration. Fuel costs are determined from a coefficients table for different truck configurations and trailer types developed by David Knapton (Faucett and Associates, 1991). The assumptions made in using the table are for level terrain 55 miles per hour and fuel-efficiency options in use in 1985. Ryder (1994) confirmed that not only is fuel efficiency weight sensitive, but also speed sensitive. The estimation in the article is that for every mile per hour over 55, there is a 2 percent loss in fuel efficiency. The embedded formula in the model uses the coefficients table for weight and adjusts automatically for speed over 55 miles per hour. The base case for the RMD at 65 miles per hour results in miles per gallon of 4.15 loaded and 5.34 empty. This estimate was confirmed to be a good estimation of fuel economy by industry experts. The model estimates fuel mileage for a five-axle semi at 80,000 GVW and 55 mph at 7.73 miles per gallon empty and 5.72 miles per gallon loaded.

The base maintenance and repair costs are nine cents per mile with a load factor of plus or minus .097 cents per mile per 1,000 pounds of weight over or under 58,000 pounds. Faucett and Associates (1991) estimated maintenance and repair costs at 10 cents per mile with a .108 cents per mile change per 1,000 pounds change in gross vehicle weight. Better warranties have brought repair costs down for many trucking firms. The age of the equipment and operating conditions directly impact maintenance and repair costs. The model was simulated with a base maintenance cost of nine cents. All variables can be changed by the user to reflect operating conditions and actual available data.

Tire costs were weight adjusted with different mileage estimations for tractor and trailer tires. Tractor tires are estimated to cost $400 with estimated mileage of 204,500 miles, while trailer tires are estimated to cost $262.50 with expected mileage of 100,000 miles. Tires wear more with more weight, and some trailer configurations have more tire wear. Data suggest that for a five-axle semi above 3,500 pounds per tire, tire life decreases by about .7 percent for each 1 percent increase in weight (Faucett and Associates, 1991). For the base case scenario, tire costs are estimated at 4.5 cents per mile, which includes the load factor.

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Flexibility of the Model

The model was designed for ease of use and can quickly provide results for different configurations and body types. "SStabs" were used in programming to provide for ease of jumping back and forth among the pages in the model.

The decision maker can choose the interest rate, fuel price, labor rate, payload, and trip design. These variables all are easily changed to compensate for different truck and trip characteristics. The model is easily updated. Equipment costs and other factors, such as tire price or insurance costs, can be changed. All parts of the model easily are changed to specific applications. Performance measures can be added to fit different situations.

Results

The end results of running a simulation are the performance measures in costs per mile, hour, bushel, hundred weight, ton, and trip. These costs are separated into fixed and variable cost categories. Variable cost categories include fuel, labor, tires, and maintenance and repair. Fixed costs categories include equipment, license fees and taxes, management and overhead, and insurance.

Sensitivity

Sensitivity analysis can be performed on variables that may change. Variables, such as wages, fuel price, maintenance and repair, or equipment utilization, may be different or changing for individual owner/operators. Analysis can easily be run by using the sensitivity analysis section of the model to quickly access an increase or decrease in fuel prices or a change in equipment usage.

Summary

Truckers face different input prices, product characteristics, truck configurations, geographical characteristics, firm size, and driving practices. Thus, obtaining current estimates of costs for particular independent owner/operators is difficult. The software that was developed determines costs for a variety of truck configurations, product characteristics, and input prices. A firm's costs are determined by its equipment, characteristics of products hauled, and input prices associated with a typical movement for that firm.

The truck costing software may provide information to many in the trucking and or shipping industry. Anyone estimating transportation costs needs reliable estimates of owner/operator costs. Also some shippers need accurate truck cost information to negotiate desirable rates and determine the appropriate mode of transportation.

A stand-alone Truck Costing Model was developed using Microsoft Visual Basic for Windows. The model in this study has many useful features. Costs can be obtained for many different configurations and trip characteristics. Important conclusions can be drawn from running simulations include the sensitivity of costs and equipment use, wait time and trip distance, labor, and fuel price. The relationships of these variables and the cost of operations are important for trucking interests.

The simulations and sensitivity analysis determined the truck cost model's flexibility and inadequacies. Factors influencing costs of owner/operators include annual miles, trip distance, and truck speed for fuel efficiency. Decreasing annual miles may be critical for the trucker debating on waiting for a better revenue load. The opportunity cost of waiting may more than make up for the additional revenue received. Another interesting factor in the model is the wait time. Initial assumptions exclude wait time, but loading and unloading time for short movements are the driving force of increased costs. The shorter the trip, the greater the impact of loading and unloading time on cost.

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APPENDIX A. DETAILED CALCULATIONS OF THE MODEL

This section will show calculations in the Truck Cost Analysis Software, which determines variable and fixed costs. The costs are segmented in fixed and variable costs by their components. The calculations will be shown by those components.

Variable Cost Components

The components making up variable costs, as mentioned previously are fuel, labor, tires, and maintenance and repair. The calculations for these individual components will be explained. In order to provide an example for variable cost components the derivation of gross vehicle weight is explained.

GVW

INPUT:
Pay Load   = 53,200 lb (determined by the user of the model)
Tractor weight   = 13900 lb
Trailer weight   = 23700 lb (Appendix I)

CALCULATE:

Tare weight   = Trailer weight + Tractor weight
                               = (23700 + 13900) lbs
                               = 37,600 lb

Gross Vehicle weight, GVW   = (Pay Load + Tare weight)
                                     = (53,200 + 37,600) lb
                                     = 90,800 lb

Fuel

The fuel price is an exogenous variable that depends on the current market rates. Fuel price may vary depending on geographical location and supply and demand conditions. Fuel economy is a function of engine horsepower, speed, terrain, wind, and weight. At the same time speed is a function of engine horsepower, terrain, wind and weight. This study based fuel economy on weight and speed. Ryder (1994) found that for every one mile per hour gain in speed over 55 miles per hour, fuel economy drops 2 percent. Knaptons Formula is based on the co-efficient table and may be adjusted for speed. The following procedure shows the calculations.

Where:

FC is a fixed co-efficient
GVW is gross Vehicle Weight
VC is a variable co-efficient
INPUT:

MPH = average speed = 65 miles/hour
Fuel Price= 1.50

Calculate Loaded Truck:
For RMD and Van FC   = 0.1203 (From Table, Appendix I)
For RMD and Van VC   = 0.0008 (From Table, Appendix I)
Loaded GVW   = 90,800 (calculated)
Empty GVW   = Tare weight = 37,600 (From Table, Appendix I)

Calculated For Empty Truck:
Speed = 65 MPH; [0.02*(MPH -55)] = 0.2

For loaded truck   = 5.182985(1 – 0.2) miles/ gallon
                          = 4.1464 miles/gallon

For empty truck   = 6.64982(1 – 0.2) miles/ gallon
                          = 5.3199 miles/gallon time loaded = 50% [previous input]
% time Empty = 50 %

Cost/mile for fuel (Loaded truck)   = (Fuel Price/ gallon)/ (miles/gallon)
                                           = 1.5/4.1464
                                           = 0.3618 / mile

Cost/mile for fuel (Empty truck)   = (Fuel Price/ gallon)/ (miles/gallon)
                                           = 1.5/5.3199
                                           = 0.2820 / mile

Average fuel cost/mile   = (Loaded cost*Time Loaded + Empty cost*time empty)
                                           = 0.3618*0.5 + 0.2820*0.5
                                           = 0.3219 /mile

Labor

Rates for labor is a readily known variable for paid drivers and is accounted for in the model by per time and per mile. The user of the model can choose per mile, per hour, or both.
The model is designed to recognize wages through the initial entry on sheet one. If functions are used to place labor costs into the performance measures:

If(LM>0andWT=0,LM)
If(LM>0andWT>0,(LM+((TD/S)+WT)*LH))/TD))
If(LM=0,((TD/S)+WT)*LH)/TD))

where:

LM=Labor Rate Per Mile
TD=Trip Distance
WT=Wait Time
LH=Labor Rate Per Hour
S=Speed

=(.29+(((100/65)+1)*10))/100)
=$.39/mile

Tire Cost

The combination of tire price and tire wear make up tire costs. Tires are weight sensitive and wear more with more weight. Tire life is independent of weight below 3,500 pounds per tire (Faucett and Associates, 1991). Weights above 3,500 pounds result in a .7 increase in wear for each 1 percent increase in weight.

INPUT:

Tractor tires cost/ tire   = 400.00
Trailer tires cost/ tire   = 262.50
Tractor tires miles/ tire   = 204500.00
Trailer tires miles/ tire   = 100000.00

Tire cost is independent of weight below 3500 lb/tire

GVW/(number of tractor tires + number of trailer tires) > 3500
0.7 % increase in cost for each 1% increase in weight

Tire cost increase/mile   = (GVW/tire – 3500)/3500*100*0.007*Tractor tire cost/mile

Increased Tire cost/mile = (Tire cost/tire)/(Tire miles/tire) + [Increment if GVW/tire>3500]

Tire cost/ truck = (Loaded tire cost/mile/time)*(Num of tires)*Percent time loaded
                 + (Empty tire cost/mile/time)*(Num of tires)*Percent time empty

In this example:

Empty tire cost/mile/tire for tractor   = 400.00/204500 = 0.00195599
Empty tire cost/mile/tire for trailer   = 265.50/100000 = 0.002625
For RMD & Van
Number of Tractor Tires   = 10
Number or Trailer Tires   = 16
Number of Total Tires   = 26

Loaded GVW   = 90800
Empty GVW   = 37600

                                    90800/26   = 3492.3 < 3500

So no increment
Loaded tire cost/mile/tire for tractor   = 0.00195599
Loaded tire cost/mile/tire for trailer   = 0.002625
Percent Loaded = 50%   [Previously calculated]
Percent Empty = 50%   [Previously calculated]

Tire cost/vehicle/mile for Tractor
= (Loaded tire cost/mile/time)*(Num of tires)*Percent time loaded
                + (Empty tire cost/mile/time)*(Num of tires)*Percent time empty
                = 0.00195599*10*0.5 + 0.00195599*10*0.5
                = 0.00195599

Tire cost/vehicle/mile for Trailer
                = 0.002625*16*0.5 + 0.002625*16*0.5
                = 0.042

Total Tire cost /vehicle/mile
                = Cost for tractor tire + Cost for Trailer tires
                = 0.00195599 + 0.042
                = $.06155/mile

Maintenance and Repair Cost

Maintenance and repair is based on a formula from Faucett and Associates (1991) where a scaling procedure was used. The formula is weight sensitive and is based on a gross vehicle weight (GVW) of 58,000 pounds. Service costs are nine cents per vehicle mile and weight adjusted by .097 cents for each 1,000 pounds above or below 58,000 pounds (Faucett and Associates, 1991). Long warranties exist for major components on tractors, so maintenance and repair costs vary depending on the age of the equipment, weight and operating conditions.

Base cost   = 0.09 per mile

Weight adjustment: +-0.097 cents for each 1000 pounds above or below 58,000

Maintenance and repair

cost/mile   = 0.09 + adjustment

Adjustments:
For Loaded truck   = ((Loaded GVW - 58000)/1000)*0.00097* Percent time loaded
For Empty truck   = ((58000 – Empty GVW)/1000)*0.00097* Percent time empty

In this example: Loaded GVW = 90800
                           Empty GVW   = 37600

Percent time loaded   = 50%
Percent time empty   = 50%

Maintenance and repair cost/mile   = 0.09 + ((90,800 – 58,000)/1000)0.00097*0.5
                                                  + ((37600 – 58000)/1000)0.00097*0.5
                                                  = 0.09 + 0.015908 – 0.009894
                                                  = 0.096014

Total variable cost/mile
                 = Maintenance and repair cost + Fuel cost + Labor cost + Tire cost
                 = 0.096014 + 0.3219 + 0.39 + 0.06155
                 = 0.869464

Fixed Costs

Components making up fixed costs are equipment costs, license fees and taxes, insurance, and management and overhead. The make-up of fixed and variable costs are similar for many trucking firms but differences exist in the areas of management and overhead and those firms employing terminals. Some fixed costs for trucking companies have characteristics of variable costs therefore, those components with the characteristic of costing whether or not the truck is moving is considered a fixed cost.

Equipment Costs

Equipment costs are a function of: purchase price, ownership type (lease versus own), interest rates (including lease, or return on investment), estimated useful life, annual miles, and salvage value. These components all make up equipment costs and decisions by the user of the Truck Cost Model may make changes to all the variables before analyzing the costs. The calculations of equipment costs are:

INPUT:

Trailer Owned	= 100%
Trailer Leased	= 0%
Tractor Owned	= 100%
Tractor Leased	= 0%
Estimated Useful life Tractor	= 5 years
Estimated Useful life Trailer	= 10 years
Salvage Price	= 30 % of purchase price
Miles per year	= 100,000
Purchase Tax rate	= 5 %
Interest rate	= 11 %

CALCULATE:

Purchase price of Trailer   = \$40147.50 (From Appendix I)
Purchase price of Tractor   = \$84739.00 (Fixed Cost Page)
Salvage price Tractor   = 0.3*84739.20 = 25421.76
Salvage price Trailer   = 0.3*40147.50 = 12044.25
Equipment depreciation   = (Purchase price – Salvage price)/Estimated useful-life
For Tractor   = (84739.20 – 25421.76)/5   = 11863.49
For Trailer   = (40147.50 – 12044.25)/10 = 2810.33

Equipment Return on Investment (ROI)
ROI   = ((Purchase price – Salvage price)/2 + Salvage price)* Interest rate
For Tractor   = ((84739.20 – 25421.76)/2+ 25421.76)*0.11 = 6058.85
For Trailer   = ((40147.50 – 12044.25)/2 +12044.25)*0.11 = 2870.55
Equipment own-ship cost   = Equipment depreciation + Equipment ROF
For Tractor   = 11863.49 + 6058.85 = 17922.34
For Trailer   = 2810.33 + 2870.55 = 5680.88

Lease Cost
Derivation of the equation to get the lease cost
Let:
x   = payments on a loan
A   = principal (amount of loan or purchase price)
i   = yearly interest rate in decimal
n   = no of periods (years)

Solution:

A_1 = Remaining amount after the first payment at the end of the first period
          = $(A+ Ai) – x = A(1+i) – x$
Similarly,
A_2 = $A_1(1+i) – x$
          = $\{A(1+1) – x\}(1+i) – x$
          = $A(1+i)^2 – x(1+i) – x$

A_2 = $A_2(1+i) – x$

          = $A(1+i)^3 – x(1+i)^2 – x(1+i) – x$

A_n = $A(1+i)^n – x(1+i)^{n-1} – x(1+i)^{n-2} – \ldots\ldots\ldots\ldots x(1+i) – x$
          = $A(1+i)^n – x\{1 + (1+i) + (1+i)^2 + \ldots\ldots\ldots\ldots+(1+i)^n\}$
A_n = Remaining amount after the last payment at the end of last period
          = 0

Therefore:

For this Example
Given:

i   = 0.11
$A_{tractor}$ = $ 84739.2
$A_{trailer}$ = $ 40147.5
$n_{tractor}$ = 5 years
$n_{trailer}$ = 10 years

CALCULATE:

In this example tractors and the trailers are all owned:

Firm equipment cost for Tractor   = Equipment own ship cost for tractors
                                            = 17922.34

Firm equipment cost for Trailers   = Equipment own ship cost for trailers
                                            = 5680.88

Annual Equipment Cost   = Firm equipment cost for (Trailer + Tractor)
                                            = (17922.34+5680.88)
                                            = 23603.22

Annual Sale Taxes   = (Purchase price / Estimated Useful Life) * Sales tax rate
                                            = Sales tax for tractor + Sales tax for Trailer
                                            = (84739.2/5 + 40147.5/10)+0.05
                                            = 1048.13

License Fees and Taxes =(Annual Fee)/Annual Miles
                                    =1718/100,000
                                    =$.017/mile

Management and Overhead   =(Annual Cost)/Annual Miles
                                    =10,721/100,000
                                    =$.107/mile

Insurance   =(Insurance Premium)/Annual Miles
                                    =7185/100,000
                                    =$.072/mile

Fixed cost is a function of the total of license fees and taxes, equipment, management and overhead, and insurance. These are simply totaled and can be attributed on a per mile or other unit basis.

Total Firm Cost or Fixed Cost per year
                = $44276.02

Miles/year   = 100,000 Total Fixed cost/mile

= 44276.02/100000
= 0.44

TOTAL Cost/Mile
= Fixed cost + Variable cost
= 0.44 + 0.869464
= 1.3122242= $ 1.31 Cost in other units

Total cost/mile   = 1.3122242/mile

Total cost/hour   = Total Cost/mile*average speed
                         = 1.3122242*65
                         = $ 85.29

Total cost/trip   = Total Cost/mile*Trip distance
                         = 1.3122242*100
                         = $ 131.22

Total cost/cwt(100 lb)   = ((Total Cost Trip)/(Pay Load/100)
                         = ((131.22242/(53200/100))
                         = $ 0.25

Total cost/ton   = ((Total Cost/Cwt)*20)
                         = 0.2467*20
                         = $ 4.93

Total cost/bushel   = ((Total Cost/Trip)/Pay Load)*Pounds in Bushel
                         = (131.22242/53200)*60   [assuming wheat
                         = $ 0.147   1 Bushel = 60 lb]

Total cost/gallon   = ((Total Cost/Trip)/Pay Load)*Pounds in gallon
                         = (131.22242/53200)*6.550348   [assuming oil
                         = $ 0.016   1 gallon = 6.55 lb]

APPENDIX B.   TABLES FOR CALCULATIONS

Table B.1. Trailer Weight

Configuration	RMD	Conventional	Spread Tandem	Tridem
Trailer Type				
Van	23700	12900	13500	14400
Flatbed	22900	12500	13100	14000
Hopper	18500	9500	9100	11900
Tanker	18100	9500	10100	--
Reefer	27400	14800	15700	11900
53' Dry Van	--	13800	--	--

NOTE:
RMD   = Conventional + 28-foot single-axle + 2,800
Tractor weight   = 13,900 (Constant)
Tare weight   = Tractor weight + Trailer weight

Table B.2. Trailer Purchase Price

Configuration	RMD	Conventional	Spread Tandem	Tridem
Trailer Type				
Van	40148	20538	24,248	24,115
Flatbed	35,245	18,550	22260	22128
Hopper	50218	31800	27163	32728
Tanker	104675	59625	84270	70225
Reefer	100436	51013	51013	54590
53' Dry Van	--	22923	--	--

Table B.3. Fuel Consumption Fixed Co-efficient

Configuration	RMD	Conventional	Spread Tandem	Tridem
Trailer Type				
Van	0.0008	0.0008	0.0008	0.0008
Flatbed	0.0009	0.0009	0.0009	0.0009
Hopper	0.0008	0.0008	0.0008	0.0008
Tanker	0.0009	0.0009	0.0009	0.0009
Reefer	0.0008	0.0008	0.0008	0.0008
53' Dry Van	--	0.0008	--	--

NOTE:
Conventional   = Spread Tandem
Tridem   = (RMD + Conventional)/2
Reefer   = Vans = 53' Dry Van = Hopper

Table B.4. Fuel Consumption Variable Co-efficient

Configuration	RMD	Conventional	Spread Tandem	Tridem
Trailer Type				
Van	0.1203	0.11068	0.11068	0.1155
Flatbed	0.113592	0.1045	0.1045	0.1090
Hopper	0.1203	0.11068	0.11068	0.1155
Tanker	0.113592	0.1045	0.1045	0.1090
Reefer	0.1203	0.11068	0.11068	0.1155
53' Dry Van		0.11068		

NOTE:
Conventional = Spread Tandem
Tridem = (RMD + Conventional)/2
Reefer = Vans = 53' Dry Van = Hopper

Table B.5. Commodity Density

Commodity	Pounds Per Bushel
Barley	48
Corn	56
Oats	32
Rye	52
Wheat	60
Flax	56
Soybean	60
Sunflower Seeds	28

NOTE: A user defined freight unit may also be used.

APPENDIX C. FIXED AND VARIABLE COSTS

Costs identified in the literature review include fixed and variable costs components for an owner/operator. Fixed costs are costs that do not change with output and cannot be changed quickly or in the short run. The short run is a period in which a firm cannot change its factors of production. Variable costs change with output and may be easily changed (Ferguson and Kreps, 1965). The distinguishing characteristic between fixed and variable cost is time. In the long run, all costs are variable, or can be changed.

Dooley, Bertram, and Wilson (1988), Casavant (1993), and Faucett and Associates (1991) identified costs incurred by trucking firms. Variable costs are costs that can be attributed to mileage, or running time (Dooley, Bertram, and Wilson, 1988). The literature revealed that owner/operator variable costs include maintenance and repair, fuel, labor, and tires. Fixed costs are incurred whether or not a truck is logging miles (Dooley, Bertram, and Wilson, 1988). Items of fixed costs include equipment costs, license fees and taxes, insurance, and management and overhead.

Operational trade-offs exist between large and small carriers. Small firms may be free from many costs associated with larger firms such as terminal operations, administrative and management specialists, and information systems; but larger firms may enjoy an advantage in purchasing sophisticated technology, equipment, and other inputs where large volume discounts may exist (Coyle, Bardi, and Novak, 1994).

Even though it appears economic gains from size are minimal, there are many small companies owning more than a single power unit or trailer. It would be intuitive to assume that some economies could be gained in the form of volume discounts for some inputs used in the trucking industry for those operating more than one power unit. However, in the truckload sector of the trucking industry, there does not seem to be any major economies due to the size of a company (Coyle, Bardi, and Novak, 1994). The large number of small firms operating in the motor carrier industry should attest that economies of size are not extensive.

Economies of Utilization

Owner/operators may not incur some fixed costs associated with larger firms. While economies of size are minimal for the owner/operator, economies of utilization are possible.   Cost minimization for the owner/operator encourages high usage of equipment. The concept of economies of utilization is allocation of fixed costs over increased output and is realized by increasing the use of those fixed assets. Equipment usage for owner/operators may be limited by the hours of service allowed by federal regulations (Griffin, Rodriguez, and Lantz, 1992).

Opportunity exists for the entrepreneur who employs a strategy of increased equipment use. Increased equipment usage may be accomplished by adding a driver and using a team concept. Additional revenue from increased equipment use may more than offset higher labor and other increased costs by decreasing fixed costs and total costs per unit of output. Figure 1 shows the cost relationship with increased use. As usage increases, average fixed cost per unit decreases.

Figure 1 shows the average fixed cost curve slopes downward throughout the entire range. As output approaches zero, average fixed cost becomes larger and larger, but as output increases, average fixed cost becomes smaller and smaller. Thus, Figure 1 depicts the concept of increased equipment use to minimize average total costs.
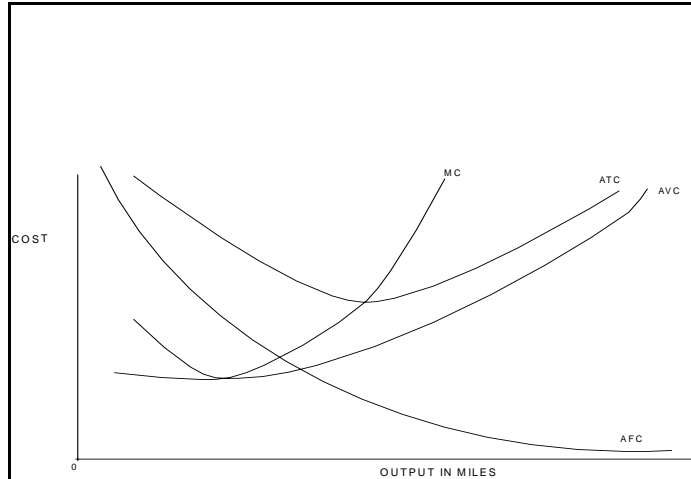
**Figure C.1. Cost Curves. ATC=Average Total Cost,
AVC=Average Variable Cost, AFC= Average Fixed
Cost (Maurice & Phillips, 1992).**

Cost Measurements

In reviewing the literature, it was found that cost measurements, or performance measures, are limited to cost per ton, cost per mile, or per ton mile. Faucett and Associates (1991) used cost per mile and cost per ton mile. Dooley, Bertram, and Wilson (1988) measured costs only on a per mile basis. The Battalle Team (1995) measured cost per mile and cost per ton. Different cost measurements are important for the different entities using truck costs or transportation comparisons. Alternative performance measures may differ due to changes in truck configuration, product characteristics, or input price changes.   Performance measures can be stated on a per mile, per ton, per ton mile, per hour, per hundred weight, per trip, or other unit basis. The flexibility of the model allows for using performance measurements to fit individual needs.

Data

Data used to build the original truck cost spreadsheet model came from a variety of sources including interview and secondary data sources. Some data has been updated from the Spreadsheet Truck Cost Model and all data has been verified for reliability. The new software model also allows for the change of any data that does not reflect a particular input, equipment cost, or trip characteristic.

Cost Summary

Factors affecting costs in the trucking industry include economies of size, economies of utilization, and the makeup of variable and fixed costs. Economies of size for small firms and owner/operators may be minimal, and the cost structure of owner/operators may vary somewhat from larger firms because management and overhead costs may be low or negligible. Small firms or owner/operators may increase size by adding power units to take advantage of volume discounts. Utilization is the most important factor affecting owner/operators. High use lowers average fixed costs for the owner/operator. It would be expected that small changes in equipment use would have a large impact on costs for the owner/operator.