TRUCK COSTS FOR OWNER/OPERATORS

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ABSTRACT

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. Sustainability for the independent trucker may reduce search costs for users of owner/operators and, at the same time, increase customer service by repeatedly using the same trucker. Economic developers need truck cost estimates to compare transportation modes and accurately estimate transportation costs. Owner/operators and users of owner/operators need truck cost information to benchmark performance against competitors and industry standards. The truck costing model developed in this study can be used by shippers and owner/operators as a negotiating tool to arrive at shipping rates. A spreadsheet simulation model was developed to estimate truck costs for different truck configurations, trailer types, and trip movements.

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CHAPTER I. INTRODUCTION

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. There are vast differences between these two segments. Local carriers include intracity delivery services such as 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. This study will focus on the intercity truckload sector and, more specifically, owner/operators.

Many small truckload (TL) firms operate in the motor carrier industry. An estimated 590,000 trucking companies operate in the United States (Coyle, Bardi, and Novak, 1994). Of the regulated carriers in the trucking industry, it is estimated that more than 95 percent are companies with 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 few trucks.

Basic to any business is the understanding and command of its costs. Understanding costs provides possibilities of efficiency gains that may increase profit or decrease costs (Casavant, 1993). Efficiency gains may reduce turnover of owner/operators and establish a positive relationship between the shipper or carrier and the owner/operator. Reducing turnover may provide better customer service through better quality deliveries. Quality deliveries are on-time deliveries with less product damage. The ever-increasing need for on-time and quality delivery of products makes it imperative for all users of owner/operators to understand their costs. A competitive advantage may be achieved for those establishing positive relationships with owner/operators through understanding or partnering (Griffin and Rodriguez, 1992).

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 model designed in this study 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.

Justification

The trucking industry is not homogenous; but, the industry approximates perfect competition because it has limited entry barriers, a large number of firms, and virtually perfect information, and its small independent truckers are mainly price takers. Cost control is essential for survival of the owner/operator. However, they may have less knowledge of the full cost of their operation than shippers, larger trucking companies, and logistics firms.

All of these entities and economic developers need accurate, reliable estimates of owner/operator costs. Shippers need accurate truck cost information to negotiate desirable rates. Cost information may allow shippers to measure truck rates with truck costs. This may supply revenue adequacy for the truckers, without sacrificing efficiency in the shippers' industry. Current cost estimates also are important for shippers to determine the appropriate mode of transportation.

Owner/operator cost information will help the larger trucking firm. In many cases, the owner/operators lease to larger firms. The lessor may not know the cost of the independent trucker, and current cost estimates may be beneficial to both parties in negotiating a lease agreement. Sustainability for the independent trucker may reduce search costs, improve quality for the lessor, and reduce turnover.

Current truck cost estimates are essential for economic developers. Current cost information again may allow intermodal transportation rate comparisons and provide transportation information vital to the location of a new facility.

Recent History

Trucks have an important role in moving commodities to market both in and out of North Dakota. Grain shipments by truck declined from 34 percent in 1978 to a low point of 21 percent in 1987 (Dooley, Bertram, and Wilson, 1988). Since 1987, the truck portion of the grain shipments have been on the increase; and in 1994, the truck portion was 24 percent (Andreson and Vachal, 1995). This increase is associated with the increasing proportion of commodities that are shipped to locations in the state. In-state shipments in the 1983-84 crop year were 8 percent of the crop compared to 1994-95 where 15 percent of the crop was shipped to in-state locations (Andreson and Vachal, 1995).

The unit train rates and subsequent changes in the elevator industry have led to a modal shift for some farm commodities (Dooley, Bertram, and Wilson, 1988). The increase in satellite elevator facilities, associated with the changes in the elevator industry, and value-added processing plants in North Dakota may give the trucking industry a competitive advantage over rail which is associated with shorter hauling distances.

Changes in the manufacturing and supply chain management have lowered inventories and created a move toward just-in-time inventory management. These new changes have increased the need for quality transportation. The owner/operator is a large part of the product movement in the supply chain. It is estimated that owner/operators move 30 to 40 percent of all intercity freight (Griffin and Rodriguez, 1992).

Technological Change

Changes in trailers and combinations of trailers continue to change the cost structure of the trucking industry. New safety requirements have affected the costs for truckers. Safety costs such as anti-lock brake systems and air ride suspension add to the price of a new tractor and trailer. However, safety features may reduce risk costs (insurance) because of fewer accidents and less damage to products hauled.

The use of cell phones and other technological changes also may create changes in the trucking industry. Cell phones can be used to seek loads, thereby reducing search time. Automatic billing and electronic data interchange (EDI) may reduce time spent billing and doing accounting procedures. EDI is direct computer-to-computer communication that can be processed by the receiver without re-keying information. EDI facilitates the move toward efficiency in supply-chain management, and motor carriers may be expected to provide EDI (Crum, Premkumar, and Ramamurthy, 1996).

Studies in the use of EDI by motor carriers discovered a low adoption rate by trucking firms. Crum, Premkumar, and Ramamurthy (1996) found that the environmental characteristics for EDI adopters focused on the dependence of the trucking firm and the transaction climate. If a firm was forced through competitive pressure or market power to use EDI, it would be adopted. Some firms recognized EDI adoption would facilitate mutual efficiency gains. The study by Crum, Premkumar, and Ramamurthy (1996) involved only larger firms, but it was found that adopter firms are twice as large as non-adopter firms. For the firms adopting EDI technology, the study found the greatest benefits in customer service and marketing.

Objectives

The primary objective of this study was to provide owner/operator cost information to more readily reflect the differences in equipment, product, and trip characteristics of the individual firm. A secondary objective was to provide additional performance measures for the different decision makers who use truck cost information. The performance measures can be used by the different entities with specific purposes. A shipper may need to know product unit costs to determine transportation costs per item. Alternatively, a lessor may want trip costs while the owner/operator may want per hour or per mile costs.

Research Method

Developing costs in the trucking industry requires use of a variety of 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 spreadsheet model was developed to link relevant truck costs to performance measures. Sensitivity analysis was conducted to determine the effects of different variables on total costs.

Paper Organization

This paper is divided into four parts. Industry cost structure and the literature are examined in Chapter II. Model development is explained in Chapter III. Model results and sensitivity analysis are presented in Chapter IV. Chapter V is the summary and conclusion.

CHAPTER II. INDUSTRY STRUCTURE

This chapter looks at the structure and economic costs related to the motor carrier industry. Economies of size and utilization are explored to determine the relationships between firm size and equipment use and their effect on costs for small trucking firms. A review of literature identifies cost variables for owner/opertors. Cost measurements also are reviewed as performance measurements for the different members of the supply chain.

Economies of Scale or Size

The terms "economies of scale" and "returns to scale" are used interchangeably in the economic literature (Dooley, 1991). Returns to scale is a return to output from a scale or proportional increase in inputs. This concept can be described with a function coefficient (ε), which shows the proportional change in output that results when all inputs are expanded by the same proportion. "The function coefficient is the elasticity of output with respect to an equi-proportional variation of all inputs" (Ferguson and Gould, 1975). Using a two-variable input bundle, (x_1, x_2), equation (2.1) results in output:

$$Q^o = f(x^o_1, x^o_2) \qquad (2.1)$$

If each input is increased by the same proportion, λ,

$$Q = f(\lambda x^o_1, \lambda x^o_2) = g(\lambda) \qquad (2.2)$$

The function coefficient (ε) is the elasticity of output with respect to λ.

$$\varepsilon = \frac{dQ/Q}{d\lambda/\lambda} = \frac{dg(\lambda)}{d\lambda}\frac{\lambda}{g(\lambda)} = \frac{d\ln Q}{d\ln \lambda} \qquad (2.3)$$

λ is the scale factor representing the proportionate change in all inputs. This function coefficient can be expressed as an elasticity, which has returns to scale which can be constant, decreasing, or increasing as ε is equal to, less than, or greater than one (Ferguson and Gould, 1975).

Although returns to scale and economies of scale are used interchangeably, they are somewhat different concepts. "Returns to scale refers to the change in output arising from scale increases in inputs, while economies of scale refers to the relationship between cost and output" (Dooley, 1991). Cost curves can be used to graphically show the relationship between cost and output. Both the short-run average cost (SRAC) and long-run average cost (LRAC) curves are depicted with a U shape (Figure 2.1).

The U shape differs for the two types of cost curves. First, the SRAC is U-shaped where the decrease in average fixed cost is outweighed by the increase in average variable cost. The rise in average variable cost occurs when the average product reaches a maximum and declines. Second, the previous argument does not pertain to the curvature of LRAC. The shape of the LRAC is formed by increasing or decreasing returns to scale in a production function and also financial economies and diseconomies of scale (Ferguson and Gould, 1975).

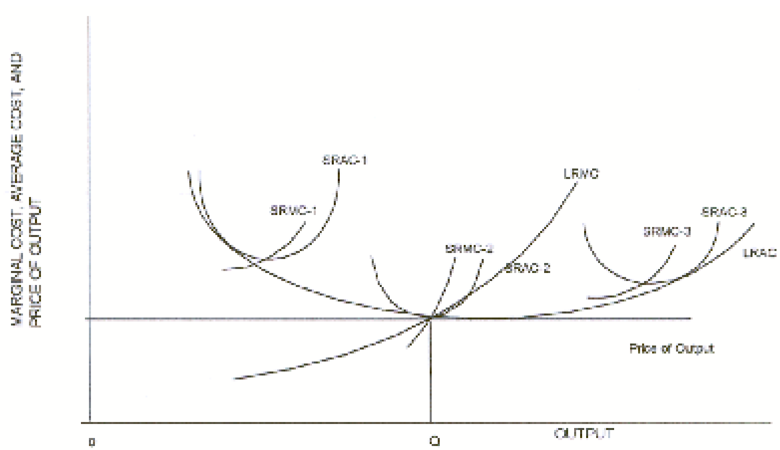
Figure 2.1. Graphical representation between cost and output. Note: LRMC = long-run marginal cost, LRAC = long-run average cost, SRMC = short-run marginal cost, and SRAC = short-run average cost (Dooley, 1991).

Figure 2.1 shows that the firm has economies of scale from the origin to Q, at which point diseconomies of scale set in. The graph shows that one, and only one, short-run plant has minimum SRAC that coincides with minimum LRAC (SRAC-2) (Maurice and Phillips, 1992). Figure 2.1 then is a representation of a long-run planning curve, LRAC, which is a locus of points and represents the least unit cost of producing the corresponding output. The entrepreneur determines the size of plant by reference to this curve and would select the short-run plant, which yields the least unit cost of producing that volume of output (Ferguson and Gould, 1975).

The long-run cost of production can be shown as a function of output,

$$LRAC = \frac{C}{Q}$$

$$\boldsymbol{C = f(Q)} \quad (2.4)$$



Long-run average cost is the cost per unit of output,

(2.5)

Long-run marginal cost is the first derivative of the long-run total cost with respect to output,

(2.6)

Let κ be the elasticity of long-run total cost with respect to output.

(2.7)

$$LRMC = \frac{dC}{dQ}$$

$$\kappa = \frac{dC}{dQ}\frac{Q}{C} = \frac{LRMC}{LRAC}$$

The elasticity of long-run average cost with respect to output, 0, is

$$\Omega = \frac{d(C/Q)}{dQ}\frac{Q}{C/Q} = \frac{LRMC \cdot Q - C}{Q^2}\frac{Q^2}{C} = \frac{LRMC}{LRAC} - 1 = \kappa - 1$$

(2.8)

A value of the elasticity of cost may be compared with unity and infer the direction of the average cost function and "thus the nature of returns to scale along the expansion path" (Dooley, 1991). Where κ is less than one, the LRAC exhibits economies of scale; and if κ is equal to one, then LRAC is at its minimum, but if κ is greater than one, the LRAC slope is positive and exhibits diseconomies of scale (Ferguson and Gould, 1975). Elasticity of total output is also related to returns to scale since total cost is equal to the reciprocal of 10 the function coefficient. Total cost elasticity is less than, equal to, or greater than unity where the function coefficient is greater than, equal to, or less than unity (Ferguson and Gould, 1975).

$$\kappa = \frac{1}{\varepsilon}$$

(2.9)

The point elasticity of total output cost is equal to the reciprocal of the function coefficient, and this is true of every point on the expansion path. This would indicate that economies of scale are referring to an output change with equal or proportional changes for all inputs. Dooley (1991) argues that changes in output are not necessarily due to scale changes in all inputs, but can be disproportional changes in inputs. Thus, the relationship between cost and output should be expressed as "economies of size" rather than "economies of scale."

An expansion path can be used to demonstrate the differences between economies of scale and economies of size. “The expansion path is the locus of input combinations for which the marginal rate of technical substitution equals the input price ratio” (Dooley, 1991). An expansion path with an equal proportion of changes in inputs is represented by a ray from the origin and is a scale line. This scale line is consistent with both economies of size and scale (Figure 2.2).

Figure 2.2 represents equal increases in X_1, and X_2 and a scale line. Figure 2.3 represents disproportional increases in inputs and the expansion path is not a scale line and may occur because of

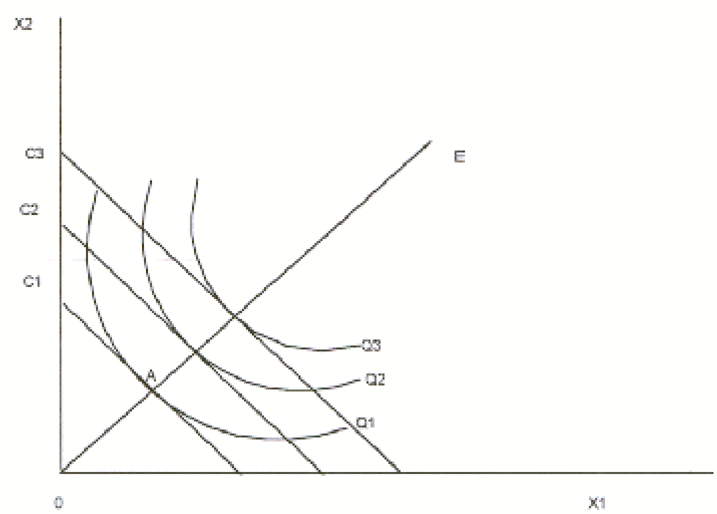


Figure 2.2. Isocost lines, isoquants, and expansion path of a homogeneous production function (Ferguson and Gould, 1975).

price changes for inputs. Thus, input adjustments associated with price changes may not be proportional. Therefore, increases in output may not be solely because of scale increases in inputs and should be referred to as “economies of size” instead of “economies of scale” (Dooley, 1991).

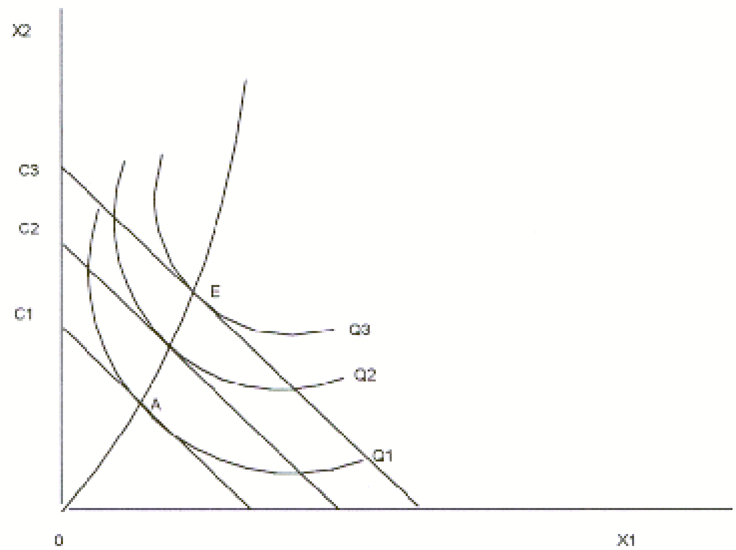


Figure 2.3. Graphical representation of the expansion path with economies of scale, but not returns to scale.
Source: Adapted from Dooley (1991).

Within the framework of Figure 2.3, equation (2.9) shows that the firm with that particular input mix is on the expansion path. Thus, the point elasticity of total output cost is equal to the reciprocal of the function coefficient. This is true of every point on the expansion path. Real-life firms rarely have increasing returns to scale resulting from scale increases in inputs. Firms are likely to add inputs at disproportional rates instead of scale increases resulting in increased output. Therefore, the relationship between cost and output is attributed to plant size (Dooley, 1991).

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. Fixed costs are short-run costs that cannot be avoided and do not vary with output (Hirschey and Pappas, 1993). 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. The strategy of increased equipment use may decrease total costs per unit of output. Figure 2.4 shows the cost relationship with increased use. As usage increases, average fixed cost per unit decreases.

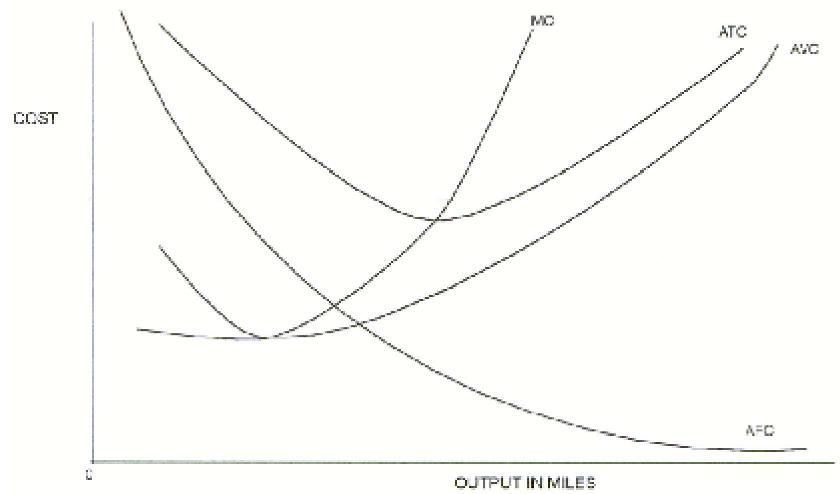


Figure 2.4. Cost curves. ATC = Average Total Cost, AVC = Average Variable Cost, AFC = Average Fixed Cost (Maurice and Phillips, 1992).

Figure 2.4 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 2.4 depicts the concept of increased equipment use to minimize average fixed cost.

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 (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. The details of the costs are discussed in the Chapter III.

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 react differently to changes in truck configuration, product characteristics, or input price changes. The model developed in this study measures costs on a per mile, per ton mile, per hour, per hundred weight, and per trip. The flexibility of the model allows for changes in performance measurements to fit individual needs.

Data

Some data from Faucett and Associates (1991) were used to build the truck cost spreadsheet model. The data included truck prices (updated via the Producer Price Index for June, 1996), equipment weights, maintenance and repair information, and fuel economy coefficients. Dooley, Bertram, and Wilson (1988) provided data for management and overhead expense and characteristics of owner/operators.

Insurance cost information was received through an interview with West Fargo Insurance, and interest rates were provided by First Bank of Fargo. The North Dakota Motor Vehicle Department provided license, fees, and tax cost information. Tire prices and wear information were furnished by OK Tire of Fargo, and fuel prices were surveyed at Petro Serve of Fargo. Kearny (1994) provided a labor rate for the default value. Truck data and cost relationships were constructed in a spreadsheet model, which is presented in Chapter III.

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 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 zero. 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. Chapter III presents the model development, including input costs and formulas used to construct the spreadsheet truck cost model.

CHAPTER III. MODEL DEVELOPMENT

Bierman, Bonini, and Hausman (1991) describe a model as a "simplified representation of an empirical situation." This spreadsheet 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 (Bierman, Bonini, and Hausman, 1991). 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, Bonini, and Hausman, 1991). Exogenous and intermediate variables are represented in various places throughout the model.

Truck Cost Spreadsheet Model

The spreadsheet model developed for trucking costs was constructed with five linked sheets. Sheet one contains decision and exogenous variables. Variables represented on sheet one of the model include the initial capital investment in equipment, interest rate, fuel price, payload, trip distance, maintenance and repair, and revenue. Sheet two has performance measures, which are the cost and revenue summary for a particular movement. The third through fifth sheets contain data, sensitivity analysis, and linkages for the costing and revenue associated with a particular truck movement.

Firm Characteristics

Sheet one of the spreadsheet model contains decision and exogenous variables. These variables are characteristics of a particular firm and are classified as equipment characteristics, operational characteristics, and input prices associated with a particular movement. The decision variables depend on the analysis being performed. Variables can be varied to determine their effect on cost.

Equipment Characteristics. The first group of variables on sheet one of the model reflects three decisions made at the outset of operations by the firm. The first decision is whether equipment is owned or leased. The second decision is the tractor or truck configuration. In the model, it can be a conventional (single trailer) or a Rocky Mountain Double (RMD) (double trailer configuration). Other truck configurations may be added to fit an individual need. The third decision is the type of trailer, which can be a dry van, hopper, flatbed, or tanker (Table 3.1).

Table 3.1. Equipment characteristics from sheet one of truck cost spreadsheet model

Column		
Row	**A**	**B**
9	Equipment Characteristics	
10	Equipment Ownership vs. Lease	Own
11	Truck Configuration	Conventional
12	Trailer Type	Dry Van
13	# Tractor Tires	10
14	# Trailer Tires	8

Initial trailer decisions for the owner/operator determine the types of products that can be transported. Thus, equipment decisions limit backhaul opportunities. Opportunities may exist for the owner/operator in leasing where other trailer configurations can be pulled using the lessor's equipment.

This variable would then become trip specific. The number of tires is automatically adjusted in the model for the different trailer configurations. The default is conventional, so the trailer tire number is eight. However, the number of tires changes from 8 to 16 if an RMD is specified.

Operational and trip characteristics. The second group of decision variables in sheet one of the model are the operational and trip characteristics. These decision variables depend upon the characteristics of the firm and a particular movement. Characteristics of the firm determine equipment use. A common measurement of equipment use is annual miles per truck. The annual mileage is 100,000 miles in the base case scenario for the model (Table 3.2). Annual mileage varies with different firm characteristics. One expert estimates that the typical owner/operator's annual mileage is around 100,000 miles per year (Dooley, 1996).

Size of the service area is a characteristic that can determine equipment use. Local hauling may limit mileage because of time spent loading and unloading. Long distance hauling may increase mileage because of less time loading and unloading. Variations to this concept may include multiple shift hauling to increase hours of service. Team driving for longer trips can increase annual mileage.

Table 3.2. Operational and trip characteristics from sheet one of truck cost spreadsheet model

Column		
Row	**A**	**B**
18	Miles Per Year	100,000
19	Trip Distance	350
20	% Time Loaded	71%
21	Backhaul Miles	75
22	Deadhead Miles	100
23		
24	Payload (lb.)	53,200
25	GVW	80,000

26	Tare Weight	26,800

Owner/operator driving hours are limited by U.S. Department of Transportation (DOT) hours of service regulations. These rules state that no driver shall work more than 70 hours in eight days or drive more than 10 hours in one day (Griffin, Rodriguez, and Lantz, 1992).Work time is classified as fueling, loading, and unloading. A driver is limited to no more than 15 hours of duty in one day, but only 10 hours can be driving time. There must be at least 8 hours of off duty between on-duty times (Griffin, Rodriguez, and Lantz, 1992).

Trip distance is the miles beginning with one revenue trip and ending with the next revenue trip. Trip distance includes the total trip, deadhead miles, and backhaul miles. Backhaul miles are the loaded revenue miles on a return trip. Deadhead miles are the empty miles needed to get to a load from the fronthaul to a backhaul for the return trip.

A manager must determine the trade-off between fuel economy and time. For some managers, fuel economy is a critical variable because routing limits driving hours. Some believe that fuel economy can be an important strategy for operating a profitable trucking firm (Dooley, 1996).

The next decision variables in the operational and trip characteristics portion of sheet one include truck weight and payload. Payload is determined from other variables. Weight regulations, truck configuration, trailer type, and product characteristics all are factors that affect payload (Coyle, Bardi, and Novak, 1994). The model determines the gross vehicle weight from the different configuration choices, trailer types, and the entry of payload weight. Table 3.2 shows the entries as they appear in the model.

Input prices. The final group of variables on sheet one are the input prices (Table 3.3). Owner/operators face a competitive labor rate, which can be hourly, by the mile, or some combination. In the model, 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 (Dooley, 1996).

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. In the model, there is one interest rate for both purposes, with a default value of 11 percent.

Table 3.3. Assumed input prices from sheet one of truck cost spreadsheet model

Column		
Row	**A**	**B**
29	Labor Rate/Mile	$0.29
30	Wages/Hour	$10.00
31	Wait Time/Hour	0
32	Interest Rate	11%
33	Average Speed (MPH)	45
34	Fuel Price/Gallon	$1.25
35	Maintenance & Repair/Mile	$0.09

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 $1.25 per gallon.

Maintenance and repair costs are estimated at nine cents per vehicle mile and weight adjusted by .097 cents for each thousand pounds above or below 58,000 pounds (Faucett and Associates, 1991). The trend of technological improvements and longer warranties for trucks will lessen repair costs in the future.

Individual firms will have different maintenance and repair costs depending on operating conditions. The base case is set at nine cents and can be changed for a specific case.

Speed is a function of engine horsepower, terrain, wind, and weight. The average speed of 45 miles per hour (Table 3.3) was specified for the base case scenario because of a fuel economy study reported by Faucett and Associates (1991). This study based fuel economy on weight but speed also affects fuel economy. Ryder (1994) found that for every 1 mile per hour gain in speed over 55 miles per hour, fuel economy drops 2 percent.

Cost Information

Formulas in sheet four of the model link the operating and trip characteristics and input prices from sheet one and compute the performance measures on sheet two. Sheet four also links sheets one and five, which contain the data for equipment pricing, fuel coefficients, maintenance and repair, and vehicle weights. Variable and fixed costs and formulas are determined by linking the three sheets. The cost information sheet also includes insurance costs, license and taxes, and tire cost information.

Fixed Costs

The first part of sheet four represents the operating characteristics of the owner/operator. This portion of the spreadsheet contains information on owned or leased equipment. Leasing is more difficult for owner/operators than for larger firms because of the perceived risk of failure of truckers by leasing companies (Hesh, 1996). Table 3.4 shows the ownership cost versus lease cost.

An @IF function linking sheets one, two, and four of the Truck Cost Spreadsheet Model determines whether the decision maker is leasing or owns equipment. This link automatically determines the equipment costs displayed at the bottom of Table 3.4. These costs are different depending on the equipment decisions made by the manager. The variations include lease versus buy, the type of trailer, the estimated useful life, and the interest rate of an owner/operator.

Table 3.4. Annual equipment costs and lease vs. own from sheet four of truck cost spreadsheet model

Column			
Row	A	B	C
11		Per Tractor	Per Trailer
12	Purchase Price	84,739.2	20,537.5
13	Salvage Price	25,421.76	6,161.25
14	Estimated Useful Life	5	10
15	Equipment Depreciation	11,863.49	1,437.63
16	Equipment ROI	6,058.85	1,468.43
17	Equipment Ownership Costs	17,922.34	2,906.06
18	Interest Rate	11.00%	11.00%
19	Lease Cost	22,927.91	3,487.3
20	Percent Ownership	100.00%	100.00%
21	Percent Lease	0.00%	0.00%
22	Ownership Cost	17,922.34	2,906.06
23	Lease Cost	0	0
24	Equipment Cost	17,922.34	2,906.06

Equipment costs. Costs for equipment are based on a 1988 study by Dooley, Bertrum, and Wilson, a 1991 study by Faucett and Associates, and interviews with industry experts. Costs from the earlier studies were updated to 1996 prices using the Producer Price Index for June 1996. The interviews with experts established ranges of costs and verified default values. The default values represent typical values for one type of tractor and four types of trailers. The values can be changed to reflect actual price, salvage value, and EUL of any owner/operator.

The purchase price for the tractor in Table 3.4 represents a conventional tractor with a sleeper and a 400 horsepower engine. Tractor price can vary depending on configuration, options, horsepower, and wheelbase. The price range could vary from $60,000 to more than $100,000 (flesh, 1996). Equipment prices were derived using the Producer Price Index (PPI) for June 1996 and equipment prices from

Faucett and Associates 1988 prices. The PPI multiplier is 145.6 for tractors and 130.6 for trailers. The default tractor price is $84,739. Trailer price varies with configuration. Equipment information was used from Faucett and Associates (1991) for two different truck configurations and four trailer types.

Depreciation. The cost of using a capital asset is the definition of depreciation (Fess and Warren, 1990). The 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 were depreciated on the straight-line basis. Depreciation was calculated 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 truck (Dooley, 1996). The default salvage value used is 30 percent (Dooley, Bertram, and Wilson, 1988). An estimated useful life (EUL) of 5 years for the tractor and 10 years for the trailer is the consensus of experts in the industry. This is shorter than the study by Dooley, Bertram, and Wilson (1988) because lessors now require newer equipment. 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 (Casavant, 1993). Interest can therefore 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 would pay on borrowed capital for equipment (Benson, 1996). ROI was determined as

$$\left(\frac{PP-SV}{2}+SV\right)*I, \qquad (3.1)$$

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

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 are generally treated as fixed costs (Casavant, 1993). License fees and fuel tax were obtained from the North Dakota 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, 1996). Estimates were obtained for a 350 mile radius of Fargo for movements in North Dakota and Minnesota.

Sales tax also is a factor in the purchase of a new truck and trailer. The estimate for a truck trailer combination costing $107,000 would be $5,350. Sales tax was included with the license fees and taxes portion of the model and annualized over the EUL.

Management and overhead costs. The literature described management and overhead costs as short-run fixed costs that are 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 (Casavant, 1993).

In the costing portion of the model, the 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.

Variable Costs

Variable costs include labor, fuel, tires, and maintenance and repair. Maintenance and repair costs vary with the operator and are difficult to quantify. Inputs prices for fuel, tires, and labor are easily obtained and can be readily estimated. The values for variable inputs were observed on Nov. 1, 1996.

Maintenance and repair. Within the costing portion of the model, 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 1000 pounds above or below 58,000 pounds (Faucett and Associates, 1991). The Faucett study estimates service costs to decrease by 10 percent from 1988 to 1995 because of technological advances and also the trend for longer warranties in the truck industry. The formula for maintenance and repair is

$$\text{Loaded Truck} = ((\text{GVW}-58{,}000)/1{,}000)*.00097)*\text{Percent time loaded.} \tag{3.2}$$

Empty Truck = -((58,000-GVW)/1,000)*.00097)*Percent time empty.

Fuel costs. Fuel prices are easily obtained by surveying truck fueling facilities. Fuel prices fluctuate with supply and demand factors. The fuel default price in the truck cost model is $1.25 per gallon. Fuel economy is a function of weight and speed. Fuel consumption varies between loaded and unloaded movements. The model represents fuel economy through a formula developed by Knapton (1981). Knapton's estimates for fuel consumption are estimated for level terrain and use of all fuel-efficiency options expected to be in use by 1985. Knapton's study estimated fuel economy on a 45-mile-per-hour speed. Improvements in fuel efficiency and an increase in the speed limit would have offsetting effects on fuel economy. Coefficients were developed for 14 configurations and body types.

The formula based on the coefficient tables is

$$[\frac{1}{(FC \bullet (\frac{GVW}{1000}) + VC)}] + [.02 \bullet (MPH - 55)] \qquad (3.3)$$

where FC is a fixed coefficient, GVW is gross vehicle weight, and VC is a variable coefficient.

Fuel economy also is a factor of speed (equation 3.3). For every 1 mile per hour over 55 miles per hour, fuel economy drops an estimated 2 percent (Ryder, 1994). The fuel economy was adjusted to accommodate the speed factor using an If Statement.

In the model, different truck configurations are connected to cost through the use of a series of embedded @IF functions. This procedure automatically connects the proper configuration, body type, GVW, and speed to the corresponding coefficients and determines fuel economy. The mileage estimate is weighted for loaded and empty movements and estimates fuel costs.

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 default labor rate in the truck cost spreadsheet model is 29 cents per mile, which is estimated to be the rate for non-union drivers operating non-refrigerated equipment (Kearny, 1994). Driver cost estimates for non-refrigerated single trailer equipment is 30 cents per mile (Faucett and Associates, 1991). 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:

(3.4)

@If(SheetA:B29=0,(SheetA:B19/SheetA:B33)+(SheetA:B31*SheetA:B30/SheetA:B29+((SheetA:B31*
SheetA:B30)/SheetA:B19)).

where SheetA:B29 equals the labor rate per mile, Sheet A:B 19 equals the trip distance in miles, Sheet A: B33 equals the average speed, SheetA:B31 equals the wait time, and SheetA:B30 equals the labor rate per hour.

Tire costs. 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. Formula 3.5 shows the @IF function of weight sensitivity for tractor and trailer tires:

(3.5)

@If(SheetA:B25/(SheetA:B 14+SheetA:B 15)>3500,(SheetA:B25-3500)/3500)* (.007 * SheetD:D57), 0.

where SheetA:B25 is the gross vehicle weight, SheetA:B 14 is the number of tractor tires, SheetA:B 15 is equal to the number of trailer tires, and SheetD:D57 is equal to tractor tire cost per mile.

Tire costs were estimated at $400 for tractor tires and $262 for trailer tires (Heggeness, 1996). Wear estimates for tractor tires are 204,500 miles on average considering steering tires will wear faster than drivers. Trailer tires wear faster than tractor tires and have an estimated life of 100,000 miles (Heggeness, 1996).

Summary

Truck costs are categorized by variable and fixed costs. The model provides performance measures in cost per mile, per hour, per hundred weight, and per trip. Other measures may be used for specific routing decisions and include, but are not limited to, per ton, per ton mile, per month, and per year. Different performance measures can be used by a decision maker for specific purposes. Performance measures and sensitivity analysis are presented in Chapter IV.

CHAPTER IV. SENSITIVITY ANALYSIS

The spreadsheet truck costing model was built with assumptions for operational characteristics, including equipment and trip characteristics and a set of input prices. The strength of the spreadsheet truck costing model is the flexibility for the user. The user has the option to enter a wide range of data for operational characteristics, trip-specific information, and input prices reflecting the characteristics of a specific firm. This flexibility, which allows the decision maker to specify data associated with a specific operation or trip, differs from previous studies. A second strength of this model is its ability to update the data. Using the PPI and personal interviews to obtain current information, the model can be updated without duplicating this study. Another strength is the ease of changing performance measures. Dooley, Bertram, and Wilson (1988) provided performance measures on a per mile basis, while Faucett and Associates (1991) use per mile and per ton-mile. Performance measures easily can be changed to fit a given situation.

Base Case

Initial assumptions for the base case scenario were developed. The tractor/trailer configuration consisted of a conventional tractor pulling a dry van (Table 4.1). Annual miles were set at 100, 000. A typical trip was assumed to be 350 miles with 75 miles of backhaul and 100 miles of deadhead at an average speed of 45 miles per hour. Gross vehicle weight (GVW) was set at 80,000 pounds and reflects a typical five-axle semi. Input prices include labor at 29 cents per mile, fuel price at $1.25 per gallon, an interest rate of 11 percent, and maintenance and repair of 9 cents per mile. All assumptions could reflect practices of typical owner/operator firms.

Table 4.1. Assumptions and options for the base case scenario from sheet one truck cost spreadsheet model.

Characteristics	Initial Assumptions	Range (or alternative)
Truck Configuration	Conventional	Conventional or RMD
Trailer Type	Dry Van	Dry Van, Hopper, Flatbed, Tanker
Own	Own	Own or Lease
# Tractor Tires	10	10
# Trailer Tires	8	8 or 16
Annual Miles	100,000	No Limit
Trip Distance	350 miles	No Limit
Percent Time Loaded	71 percent	0 to 100 percent
Backhaul Miles	75	Maximum Trip Distance
Deadhead Miles	100	Fronthaul Minus Backhaul
Payload (pounds)	53,200	No Limit
Gross Vehicle Weight (pounds)	80,000	Payload Plus Truck Weight
Labor Rate/Mile	29 cents	No Limit
Wages/Hour	$10.00	No Limit
Wait Time	0	No Limit
Interest Rate	11 percent	No Limit
Average Speed	45 MPH	No Limit
Fuel Price	$1.25 Per Gallon	No Limit
Maintenance & Repair/mile	0.09	$.01 to $.15

Performance Measures

The quantitative expressions of objectives that managers are trying to achieve are performance measures (Bierman, Bonini, and Hausman, 1991). Sheet two in the spreadsheet truck costing model is labeled cost summary and provides five different performance measures. Table 4.2 displays the breakdown of cost measurements including cost per mile, per hour, per hundred weight, per trip, and per ton mile.

Table 4.2. Performance measures for truck costs, 1996, from sheet two of truck cost spreadsheet model

Column						
Row	A	B	C	D	E	F
7	Variable Costs	Per Mile	Per Hour	Per Hundred	Per Trip	Per Ton Mile
8	Fuel	$0.19	$8.60	$0.13	$66.85	$0.010
9	Labor	$0.29	$13.05	$0.19	$101.50	$0.015
10	Tires	$0.04	$2.02	$0.03	$15.75	$0.002
11	Maintenance	$0.10	$4.35	$0.06	$33.81	$0.005
12	Total Variable Costs	$0.62	$28.02	$0.41	$217.91	$0.033
13						
14	Fixed Costs					
15	Equipment Cost	$0.21	$9.37	$0.14	$72.90	$0.011
16	License Fees and Taxes	$0.03	$1.20	$0.02	$9.34	$0.001
17	Insurance	$0.07	$3.23	$0.05	$25.15	$0.004
18	Management and Overhead	$0.11	$4.82	$0.07	$37.53	$0.006
19	Total Fixed Costs	$0.41	$18.63	$0.27	$144.91	$0.022
20						
21	TOTAL COSTS	$1.04	$46.65	$0.68	$362.82	$0.055

Source: Cost Summary of Truck Cost Spreadsheet Model.

Truck costs also are categorized by variable and fixed costs. Other performance measures may be used for specific cost decisions and include, but are not limited to, per ton, per ton mile, per unit, per month, and per year. Different performance measures can be used by a decision maker for specific purposes including modal comparisons or benchmarking.

Configuration comparison. As compared with prior work, the output of the spreadsheet model generates multiple performance measures (Table 4.2). Different cost measures are important because of the relationships among variables in the model. A cost comparison using the same payload is displayed in Table 4.3. Performance measures shown in Table 4.3 are the results of simulations using two different truck configurations, and three trailer types including conventional and RMD pulling either a dry van, flatbed, or hopper. The assumptions are the same as in Table 4.1 except for the truck configuration and trailer type.

Table 4.3. Base case performance measures by equipment type, 1996

	Cost Per Mile	Cost Per Hour	Cost Per Cwt	Cost Per Trip	Cost Per Ton Mile
Conventional					
80,000 GVW					
Van	$1.04	$46.65	$0.68	$362.82	$0.055
Flatbed	$1.03	$46.16	$0.67	$359.02	$0.054
Hopper	$1.05	$47.06	$0.68	$366.04	$0.054
RMD 80,000 GVW					
Van	$1.11	$50.04	$1.00	$389.16	$0.080
Flatbed	$1.10	$49.32	$0.97	$383.57	$0.077
Hopper	$1.13	$50.85	$0.92	$395.53	$0.073

Source: Simulations, Truck Spread Sheet Costing Model, 1996.

The performance measures displayed in Table 4.3 relate the higher costs of pulling an RMD over a conventional configuration at the same GVW. Comparing the conventional van with an RMD van, cost per mile increases by 7 cents and cost per weight unit increases by 32 cents as a larger payload is carried in the conventional van because of less truck weight. The next section will show the advantage of an RMD when payload is increased.

Cube out. When trailer volume is filled before the weight limit is reached, it is refered to as "cube out." Product characteristics cause cube out. For example, sunflowers are light, and a trailer filled to volume capacity does not reach the weight regulation limit. Larger trailer configuration or an RMD can be used to lower per weight unit costs. Table 4.4 demonstrates the classic case where a conventional truck and trailer combination cubes out and an RMD is used to increase weight and load capacity. An assumption is made that gross vehicle weight can be increased from 60,000 pounds to 80,000 pounds by changing from a conventional to an RMD. All assumptions are the same as in Table 4.1 except for truck configuration, trailer type, and GVW.

Table 4.4. Comparison of truck configurations and the cube out effect

	Cost Per Mile	Cost Per Hour	Cost Per Cwt	Cost Per Trip	Cost Per Ton Mile
Conventional GVW 60,000					
Van	$0.99	$44.41	$1.04	$345.39	$0.085
Flatbed	$0.98	$43.92	$1.02	$341.63	$0.083
Hopper	$1.00	$44.81	$1.02	$348.49	$0.083
RMD GVW 80,000					
Van	$1.11	$50.04	$1.00	$389.16	$0.080
Flatbed	$1.10	$49.32	$0.97	$383.57	$0.077
Hopper	$1.13	$50.85	$0.92	$395.53	$0.073

Source: Simulations, Truck Spread Sheet Costing Model, 1996.

The costs increase on a per mile, per hour, and per trip basis for the RMD, but decreases on a per weight unit and on a per ton mile basis (Table 4.4). In the case of cube out, the conventional van is 12 cents per mile less than the RMD van, but 4 cents more per unit weight (Table 4.4). This same scenario may exist when regulations allow an RMD increased GVW because of truck length and number of axles. State regulations allow an RMD to exceed 80,000 pounds on many roads, but regulations vary on a state-to-state basis. For example, North Dakota allows an RMD to operate up to 105,500 pounds on many state and federal highways and only is restricted by axle weight limits.

Sensitivity Analysis

Sensitivity analysis shows the change in the performance measures by varying a decision or exogenous variable (Bierman, Bonini, and Hausman, 1991). The truck costing model's sensitivity analysis helps the decision maker to understand what happens to costs as variables change. Understanding cost relationships may help a manager to minimize costs.

Variables chosen for sensitivity analysis include fuel price and economy, wages and wait time, interest rate, equipment utilization, and maintenance and repair. Sensitivity analysis included changing variables by 10 percent and determining the effect on total trip cost (Table 4.5).

Table 4.5. Conventional dry van sensitivity analysis, 1996

Variable	10% Increase From Base Case	Percent Increase or Decrease Total Trip Cost
Equipment Use	10,000 Miles	-3.6%
Fuel Price	$0.13	+1.9%
Maintenance & Repair	$0.01	+0.9%
Labor	$0.03	+2.8%
Interest Rate	1%	+.7%

Speed over 55 mph	6 mph	+2.5%

Model Sensitivity to Utilization

Minimal changes in annual miles for an owner/operator greatly impact total cost. Changing annual miles spreads fixed costs over more miles, thereby reducing average total costs. A 10 percent change in equipment usage results in a 3.6 percent change in total costs (Table 4.5). This relationship of equipment usage and costs are important for the owner/operator who is trying to minimize costs (Figure 4.1).

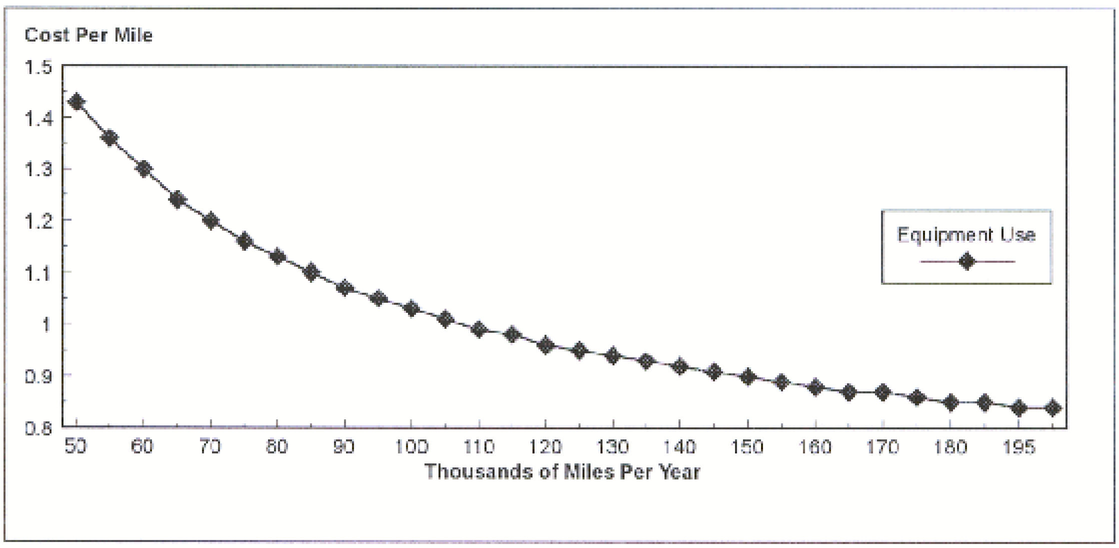


Figure 4.1. Equipment usage and costs per mile from sheet three of truck cost spreadsheet model.

Most owner/operators are trying to operate at or above 100,000 miles per year (Dooley, 1996). Conditions that affect utilization include experience in the industry, geographical size of the market area, size of the company, and regulatory status (Dooley and Wilson, 1991). The owner/operator is at a disadvantage in obtaining a backhaul. Regulated truckers obtained a backhau172 percent of the time while firms operating without authority obtained a backhaul only 45 percent of the time (Dooley and Wilson, 1991).

Model Sensitivity to Fuel Price

Trucking costs are sensitive to fuel price. A small movement in price greatly impacts costs and may erode margins for the owner/operator. A 10 percent change in fuel price changes total cost by 1.85 percent (Table 4.5). Owner/operators contemplating leasing to another company should attempt to tie rates to fuel prices through an escalator clause.

Fuel economy also is a factor of weight and speed. The trade-off for speed and time may be a factor of the hours of service regulations. Trip speed of a particular trip movement may be regulated by how long it takes for the movement and how much driving time the trucker is allowed. Traffic congestion in urban areas, weather, road construction, and road conditions also may slow trip speed. These reasons indicate why multiple performance measures are needed to determine costs.

A 10 percent increase in speed over 55 miles per hour results in a 2.3 percent increase in total costs (Table 4.5). Cost is increasing at an increasing rate as speed increases from 55 miles per hour. The trade-off truckers face is fuel economy versus time. Assuming that a truck drives 100,000 miles annually at 55 miles per hour instead of 70 miles per hour would save $8,184 per year in fuel costs.

Model Sensitivity to Maintenance and Repair

Costs of maintenance and repair are the most difficult to estimate. High mileage warranties exist for new equipment and lead to lower maintenance and repair cost for an owner/operator. Advances in equipment design have lowered repair costs 10 percent (Faucett and Associates, 1991). A trucker using older equipment may have higher repair costs. However, this may be offset by lower capital investment in equipment (Casavant, 1993). The estimated useful life (EUL) for a tractor is now only five years. Many lessors now hire only newer equipment for reliability and image (Dooley, 1996).

Maintenance and repair costs in the model are weight sensitive with higher weights having higher costs. The model was designed to account for the load factor. Weights above or below 58,000 pounds change maintenance and repair costs by .097 cents per mile per 1,000 pound change in gross vehicle weight (Faucett and Associates, 1991). Sensitivity analysis was conducted for cents per mile. Costs increase rapidly by adding weight; and Table 4.6 shows that at nine cents per mile, an increase of 50,000 pounds adds 3.9 percent to total per mile costs.

Table 4.6. Maintenance and repair per mile and weight from sheet three of truck cost spreadsheet model

GVW (Pounds) >	60000	70000	80000	90000	100000	110000
Cents Per Mile Main. & Repair	Total Cost Per Mile					
$0.01	$0.93	$0.94	$0.95	$0.95	$0.96	$0.97
$0.03	$0.95	$0.96	$0.97	$0.97	$0.98	$0.99
$0.05	$0.97	$0.98	$0.99	$0.99	$1.00	$1.01
$0.07	$0.99	$1.00	$1.01	$1.01	$1.02	$1.03
$0.09	$1.01	$1.02	$1.03	$1.03	$1.04	$1.05
$0.11	$1.03	$1.04	$1.05	$1.05	$1.06	$1.07
$0.13	$1.05	$1.06	$1.07	$1.07	$1.08	$1.09
$0.15	$1.07	$1.08	$1.09	$1.09	$1.10	$1.11

Model Sensitivity to Wait Time

Wait time or loading and unloading time is the relationship between labor and cost change. The sensitivity analysis counted wait time at a labor rate of $10 per hour. Wait time influences costs more with shorter movements and longer wait times (Figure 4.2). Owner/operators many times do not consider wait time because it is an opportunity cost, not an out-of-pocket expense. The opportunity cost may involve

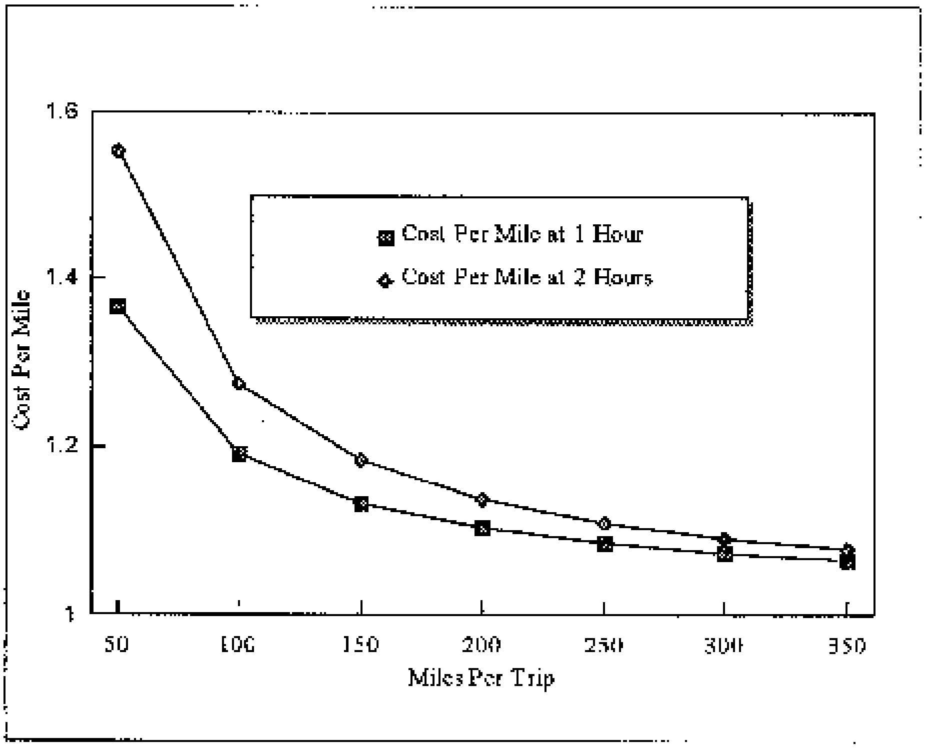


Figure 4.2. Sensitivity of total costs to loading and unloading time from sheet three of truck cost spreadsheet model.

more than the labor rate of $10 per hour. The usage example showed the relationship between total cost and use. Every idle hour may be an opportunity to lower costs through higher equipment use.

Many owner/operators do not consider wait time as a cost because of the laws regulating driving time (Dooley, 1996). If an assumption is made that wait time is included in the model and a per hour wage rate of $10 per hour with 1 hour wait time and distance is extended from 50 to 350 miles, per mile costs decrease by 22 percent (Figure 4.2). Wait time was not included in the base case scenario of the truck cost spreadsheet model.

The truck cost spreadsheet model provides the user with a range of alternatives that can be easily adapted for a particular equipment configuration or product or trip characteristic. The model provides the decision maker with a wide range of performance measures that can be easily changed to fit a specific use. Data in the model can be quickly updated by using the PPI and renewed industry interviews to gather equipment and input prices. Sensitivity analysis can be performed through the use of what-if tables in Lotus 1-2-3 and readily provide cost information about single and dual variable changes. The model performs well over a wide range of entries and provides performance measures that would be expected with those entries.

CHAPTER V. CONCLUSIONS

Summary

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. Sustainability for the independent trucker may reduce search costs for users of owner/operators and, at the same time, increase customer service by repeatedly using the same trucker. Users of owner/operators need truck cost information to benchmark performance against competitors and industry standards. The truck costing model developed may be used by shippers and owner/operators as a negotiating tool to arrive at equitable shipping rates. Economic developers need truck cost estimates to compare transportation modes and accurately estimate transportation costs. A spreadsheet simulation model was developed to estimate truck costs for different truck configurations, trailer types, and trip movements.

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 the flexibility of the model.

The objective of this study was to provide truck cost information to reflect the 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 hundred weight
- ! Cost per ton-mile
- ! Cost per hour
- ! Cost per trip

Data

The spreadsheet model consisted of five stacked sheets. Data used to build the model came from a combination of the previous studies, interviews, and journal articles. Information used from previous studies was updated via the Producer Price Index and verified through interviews from people in the industry. Estimates on license fees and taxes came from North Dakota 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

A base case for a particular configuration and movement was used to demonstrate the model. The operating characteristics of the firm assumed 100,000 mile equipment usage. The model was based on an owner/operator. The base case equipment configuration was a conventional setup pulling a 48' van with a GVW of 80,000 pounds and a payload of 53,200 pounds. Capital equipment costs were estimated to be $84,739 for the tractor and $20,537 for the trailer with an estimated useful life of 5 years for the truck and 10 years for the trailer. The equipment was assumed to be purchased rather than leased.

Kearny (1994) estimated non-refrigerated, non-union wages at 29 cents per mile. The default labor cost was 29 cents per mile. The interest rate estimate from First Bank of 11 percent was in the middle of the range of rates a new owner/operator would 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 both 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. The base case for a five-axle semi pulling a 48-foot van at 55 miles per hour results in miles per gallon of 6.15 loaded and 7.81 empty. This estimate was confirmed to be a good estimation of fuel economy by Ron Hesh of Wallwork Truck Sales. 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 spreadsheet model adjusts automatically for speed over 55 miles per hour.

The base maintenance and repair costs are 9 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 thousand pounds change in gross vehicle weight. An estimate from Tom Dooley and Ron Hesh of Wallwork truck sales confirmed that nine cents per vehicle mile may be in line with the Faucett estimates.

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.

Flexibility of the Model

The model was designed for ease of use and can quickly provide results for different configurations and body types. Dialog boxes were used in the configuration portion of the model so a decision maker can easily choose a configuration and keep decisions within the confines of the model. The first decision was between own and lease. A dialog box was developed for the decision maker to choose between conventional and Rocky Mountain double. Another dialog box was developed to choose the type of trailer among van, flatbed, hopper, and tanker.

The decision maker can choose the interest rate, fuel price, labor rate, payload, and trip design. These variables are all 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 are easily changed to specific applications. Performance measures also can be changed to fit different situations. For example, costs per unit or cost per year can quickly be added to fit a decision maker's specific criteria.

Results

The end results of running a simulation are the performance measures in costs per mile, hour, hundred weight, ton mile, and trip. These costs also 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 was performed on variables that may change. Variables such as wages, fuel price, maintenance and repair, or equipment utilization may be different for individual owner/operators. Analysis can easily be run by using spreadsheet what-if tables to quickly access an increase or decrease in fuel prices or a change in equipment usage.

Conclusions

The model in this study has many useful features. Costs can be obtained for many different configurations and trip characteristics. Important conclusions 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 the owner/operator and users of owner/operators.

The simulations and sensitivity analysis determined the spreadsheet truck cost model's flexibility and inadequacies. Factors influencing costs of owner/operators include annual miles, trip distance, and truck speed or 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 driving 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. Fuel efficiency is another factor driving the model. Revenue adequacy may result by driving 55 miles per hour rather than 70 miles per hour. However, the trade-off may be that more revenue will offset higher fuel costs.

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