Freight Transport Cost Monitoring Through Vehicle Utilization Measurements

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Abstract: Freight transport cost is the main concern of not only the trucking business companies but many business companies of Mongolia which deliver their goods besides producing them. The paper attempted introducing a model to monitor freight transport cost based on company's at-hand data, the vehicle utilization measurements. The study was done and introduced in a real carrier company which produces and delivers construction materials on site. As the model shows clear connections between cost and vehicle utilization measurements, it could be a good tool to be used in management decisions of companies which deals with freight transportation.

Keywords: cost factors, vehicle utilization measurements, cost monitoring

1. INTRODUCTION

Road transportation has been playing a major role in Mongolian transport sector in terms of the scope of the service and availability. Majority of the domestic passengers flow and near half of the domestic freight flow is carried by road. In 2015, total of near 200,000 trucks, trailers, and back-hauls registered in Mongolia and vast majority of them are owned by business companies. Besides professional trucking companies, business organizations tend to have their own fleet of vehicles to transport their goods and materials to consumers. Therefore it is concluded that organizing transportation effectively will have impact on overall business of the company. Likewise any other business, the cost could be a main indicator to measure the efficiency of transport operations.

Cost is the value of something that expended to obtain a benefit or it is the quantity of one thing that is exchanged for a service or product. In transport, the cost is a monetary measure of what the transport provider must pay to produce transportation services. There are two types of costs are used in transport: fixed and variable costs. Fixed costs describe resources such as vehicles, drivers and facilities and usually vary with time. Variable costs vary with changes in quantity or volume of goods to be transported or distance to be traveled. In order to monitor the cost and use the information for decision making, the company need to be aware of the factors that have influence on cost. Even though many of the factors are not under the control of a company's day-to-day operation, vehicle utilization is one of the main contributing factors to freight transportation cost.

In order to determine the level of truck and back-haul utilization, several inter-related and inter-influenced measurements used in practice. Those are called vehicle and equipment utilization measurement system. (Yondonsuren, 2008) There are companies using the vehicle utilization measurements (VUMs) as performance of the operation but not many of them are

using those in company's cost monitoring. In other words, companies struggling to connect vehicle utilization level to their operational cost. The assumption has been made that it is useful to examine the influence of VUMs on transport costs, since companies have traditions "(at least approach in technical education system)" to measure the operations efficiency with the VUMs in Mongolia.

This paper describes freight transport costs model based on key VUMs, such as vehicle utilization rate, capacity utilization, proportion of the run with revenue load, vehicle average operating time, time for loading and unloading, and average operational speed. The first the study covered the transport cost and VUMs and then described a model which connects operational costs to those measurements. The study was done in real company's case. The model enables improvements of vehicle utilization will reflect the cost which could influence on different management decisions.

2. TRANSPORT COSTS AND FACTORS AFFECTING

As noted above, transport cost is the monetary measurement that the companies pay in order to provide transport service and it is related to the usage of the resources. The major resources required for transporting and distributing goods are the cost of the vehicles and the costs operating those vehicles. In order to calculate and monitor the transport cost, it is important to observe the factors affecting the cost.

Freight transport cost is a function of numerous factors such as prices, freight characteristics, geography, road condition, driving behavior, vehicle specifications. (Rodrigue, 2006) According to researchers conditions and factors affecting transport costs could be grouped as shown Table 1.

Table 1. Conditions and factors affecting transport costs

Condition	Factors
Geography	Distance and accessibility
Type of product	Packaging, weight, perishable
Energy	Price of fuel
Economies of scale	Truck size and its utilization
Trade imbalance	Empty run - "back haul possibilities"
Infrastructure	Quality of road surface, terminal capacity
Competition and regulation	Competitors, tariff, labor, safety and security

Those factors could be grouped as internal and external factors. External factors are under the influence of certain market and other conditions such as fuel and spare price, insurance rate, vehicle registration fee etc. Internal factors are the factors that the companies can control or change in order to meet the objectives of it. The internal factors depend on the utilization of the company's different types of resources. The influence of these factors can be expressed by operational measurements of vehicle utilization such as coefficient of vehicle utilization, average operational speed, coefficient of available time utilization, average distance of vehicle run with revenue load etc. Since vehicle and its utilization is one of the main factors affecting the cost of road freight transport it is useful to connect the practically well known VUMs to transport cost so use these for managerial decision making.

For many efficient trucking operations the typical proportion of transport costs for operations in low- and medium-income countries found as shown in Table 2. (Archondo-Callao,2009)

Table 2. Proportion of costs in transportation

CLASSIFICATION	COST ITEMS	PROPORTION OF OPERATING COSTS (%)
Variable Costs	Fuel	20-30
	Lubrication Oil	1-5
	Tires	10-15
	Spares	15-20
Fixed costs	Driver and other cab staff	10 – 20
	Other labor	About 5
	Depreciation and Interest	15 – 20
	Overheads and other costs	10 – 15

In transport, major internal factors that drive fixed and variable cost are capacity of the vehicle fleet and distance to be covered to complete transport work. Capacity refers to the size and numbers of the vehicles. The distance will affect how much and how many vehicles will be used. The fixed cost doesn't vary with the vehicle run rather it is the cost of having vehicles. But variable costs vary with the volume of goods to be distributed and the distance to be covered in order to deliver those goods. For example fuel and lubrication costs would be considered variable costs. Although distinction is made between fixed and variable costs, those two types of costs are interdependent. For example, usage of larger vehicle (higher price) will affect the fuel cost (variable cost) of making delivery. Also the some factors will affect both costs in different ways. For example increasing the service points will increase fuel cost and also if it needs to add the number of the vehicle which means pay for fixed costs.

In general the following measurements are used to measure the costs.

- For capacity:
    - the number of vehicle-days
- For distance:
    - total kilometers run for certain period
    - total operating days to cover the distance

In the next section we describe the variables that influence the cost factors. In practice the companies use VUMs to describe the influence of many of those variables.

3. RELATION OF TRANSPORT COSTS TO VUMs

Vehicle-days quantifies the capacity by referring the number of days a vehicle available for the operation and the number of days the vehicle actually has been in operation in a given period of time. For the fleet, vehicle-days of each vehicle need to be summed up. It will depend on the type, carrying capacity, number of vehicle, number of days vehicle is available for operation, vehicle maintenance days and holidays, the number of hours drivers operate a vehicle in a given day, number of available drivers. It is possible to pre-determine this factor.

Total kilometers measure the distance based on location of delivery points, distance to the points, distance between the points, frequency of the delivery, capacity of the vehicle and other boundaries. Total operating days will depend on total kilometers to be covered, vehicle speed, time required to perform the delivery including the time of loading, unloading, inspection goods and the number of hours drivers operate a vehicle in a given day.

In order to indicate vehicle and back-haul utilization several inter related and inter influenced measurements are used in practice. Those are called VUMs. (Yondonsuren, 2008)

The measurements are divided as quantitative and qualitative as the following:

1. Qualitative

- Utilization coefficient of the vehicle - α_{line} (proportion of days when the vehicle is actually working in line and total available days in a certain period);
- Capacity utilization coefficient – γ (proportion of tons carried and total capacity of the vehicle);
- Route utilization coefficient - β (proportion of kilometers with revenue load and the total kilometers);
- Average operational speed - V_{oper} (proportion of average kilometers with revenue load and total working time in line)
- Time utilization coefficient – ρ (proportion of vehicle time working in line and 24 hour of the day)

2. Quantitative

- Number of vehicles - N
- Total kilometers - L_{total}
- Kilometers with revenue load - L_{load}
- Vehicle capacity - q
- Lost time for loading, unloading and other idling- T_{lost}
- Total working time in line - T_{total}

Since all of these measurements are used to describe how efficient the transportation is being organized, VUMs also express road freight transport costs.

Table 3 outlines the major factors, influencing variables in the forms of VUMs and cost components, and the type of the cost.

Table 3. Cost factors, measurements, component, and type & VUMs referred

Cost factor	Measurements	Cost component	Cost type	VUMs
Capacity	Number of vehicle-days	Depreciation cost	→ Fixed	α_{line}
		Vehicle owning cost (licensing, insurance, taxes, parking)	→ Fixed	γ ρ
		Salary cost	→ Fixed	q
		Vehicle leasing or contracting costs	→ Fixed	
Distance	Total kilometers	Fuel costs	→ Variable	β
		Maintenance cost (tire, oil change)	→ Variable	q γ V_{oper}
	Total operating days	Travel allowance	→ Variable	T_{lost}
		Nights and extra hours	→ Variable	L_{load} V_{oper}

4. MODELLING TRANSPORT COSTS BASED ON VUMs

It is useful to examine the influence of VUMs on the transport costs.
Therefore considering the meanings of the VUMs, as discussed in previous section, transport costs per ton-kilometer (ton km) can be expressed as the following:

$$C_t = X * [YC_f + C_v(Z + F)] \frac{₮}{\text{ton km}} \quad (1)$$

Where,

C_t :total transport costs,

C_f :fixed transport costs,
C_v :variable transport costs, and
X :factor which expresses the influence of vehicle capacity and its utilization;

$$X = \frac{1}{\gamma q} \qquad (2)$$

γ- capacity utilization coefficient;
q - vehicle capacity;
Y- factor which expresses the influence of available fleet and time utilization.

$$Y = \frac{1}{\alpha_{line}\rho} \qquad (3)$$

α_{line} – utilization coefficient of the vehicle;
ρ - time utilization coefficient;
Z - factor which expresses the influence of route utilization and operational speed;

$$Z = \frac{1}{\beta V_{oper}} \qquad (4)$$

β - coefficient of route utilization
V_{oper} - average operational speed;
F- factor which expresses the influence of lost time and distance of transport with revenue load;

$$F = \frac{T_{lost}}{L_{load}} \qquad (5)$$

T_{lost}- lost time for loading, unloading and other idling;
L_{load} - kilometers with revenue load;

The equation (1) expresses total transport costs as a function of VUMs. X, Y, Z, and F represent the groups of similar VUMs. X expresses the right selection of the vehicle type (vehicle capacity and its utilization). The value Y reflects quality of the company's management activities such as maintenance scheduling, organization of drivers roster, consideration of the season etc. The value Z and F express the optimal utilization of back-haul, optimal location, route selection, capacity of loading and unloading equipment etc.

5. THE CASE OF REAL COMPANY "TEGSH PLANT"

"Tegsh plant" is a company which grinds mountain stones and produces and delivers gravels and concrete to construction sites. Since 2013 the company is selected to supply construction materials to newly constructing international airport site and working to supply 208000 ton gravels within 3 years. The career is located in Altanbulag sum, 100 kms from Ulaanbaatar and 21 kms from the international airport construction site. Figure 1 shows the fleet composition and the number of each vehicle. We conducted the study of determining vehicle utilization and variable and fixed cost of the single trip between the gravel plant and new international airport site. Table 4 shows VUMs average data of the fleet.





15 1 3 1 3

Figure 1. Fleet composition of the company "Tegsh plant"

From the data we could find X, Y, Z, and F factors using the equations (2), (3), (4), and (5). After the calculation X, Y, Z, and F will be as in the Table 5.

Table 4. Data of VUMs and costs of the company "Tegsh Plant"

VUMs	α_{line}	β	γ	ρ	V_{oper} (km per hour)	q (ton)	L_{load} (km)	T_{lost} (hour)	C_f (₮ per hour)	C_v (₮ per hour)
Value	0.61	0.61	0.50	0.72	35	15	21	1.0	9600	15400

Table 5.Value of the factors

Factors	X	Y	Z	F
Value	0.093	2.28	0.046	0.047

If we apply the data from Table 4 to the equation (1) the truck transport costs will be as following:

$$C_t = 0.093*[2.28*9600+(0.046+0.047)*15400]= \ 3367.53 \frac{₮}{\text{ton km}}$$

Values of each factor are calculated for a different combination of operational parameters. So the changes in operational parameters will impact the changes in the factors. In order to illustrate, the Z values in accordance with operational parameters β, V_{oper} are given in Table 6.

Table 6. Value of the Z in accordance with β and V_{oper}.

β / V_{oper}	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
10	0.200	0.182	0.167	0.154	0.143	0.133	0.125	0.118	0.111	0.105	0.100
15	0.133	0.121	0.111	0.103	0.095	0.089	0.083	0.078	0.074	0.070	0.067
20	0.100	0.091	0.083	0.077	0.071	0.067	0.063	0.059	0.056	0.053	0.050
25	0.080	0.073	0.067	0.062	0.057	0.053	0.050	0.047	0.044	0.042	0.040
30	0.067	0.061	0.056	0.051	0.048	0.044	0.042	0.039	0.037	0.035	0.033
35	0.057	0.052	0.048	0.044	0.041	0.038	0.036	0.034	0.032	0.030	0.029
40	0.050	0.045	0.042	0.038	0.036	0.033	0.031	0.029	0.028	0.026	0.025
45	0.044	0.040	0.037	0.034	0.032	0.030	0.028	0.026	0.025	0.023	0.022
50	0.040	0.036	0.033	0.031	0.029	0.027	0.025	0.024	0.022	0.021	0.020
55	0.036	0.033	0.030	0.028	0.026	0.024	0.023	0.021	0.020	0.019	0.018
60	0.033	0.030	0.028	0.026	0.024	0.022	0.021	0.020	0.019	0.018	0.017

Calculated the rest of the factors also and drew graphics on MS Excel. The relationships of

each factor and the corresponding VUMs are shown in Figure 2.

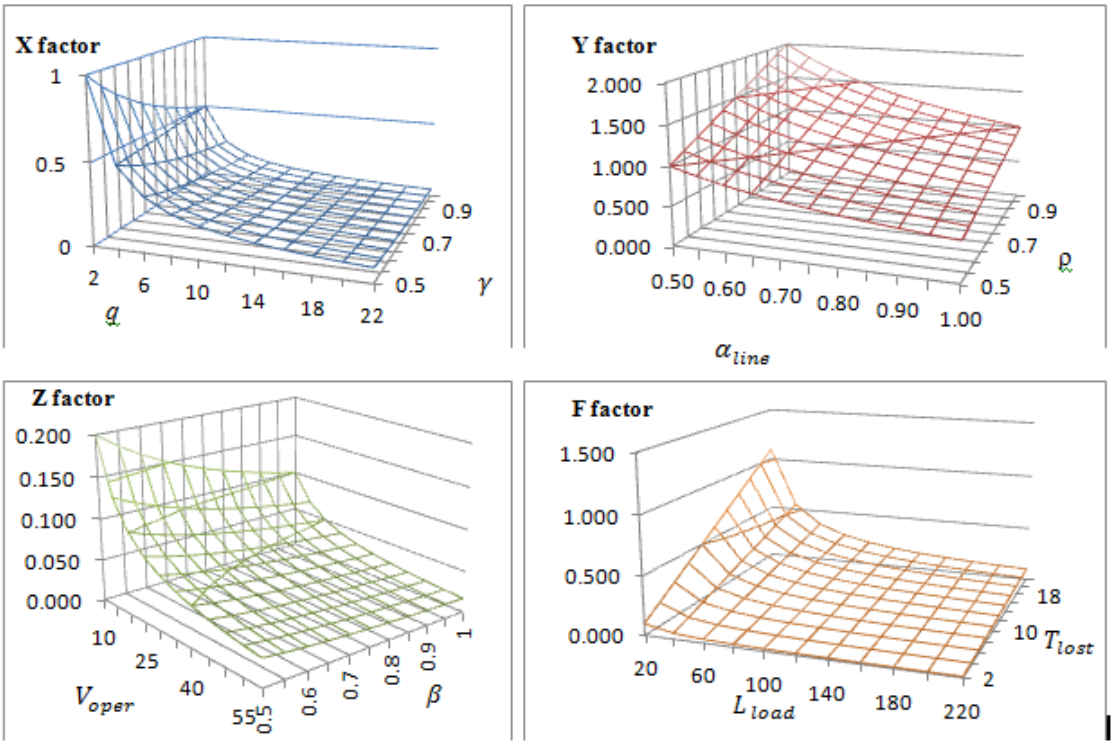

Figure 2. Relationship of the factors and VUMs

Figure 3 shows graphically the relationship between transport costs and X, Y, and Z factors. The factor F has great influence on the transportation costs - proportion of lost time and average distance with revenue load. For constant distance of travel lost time has decisive influence on the transport costs.

From this illustration we could see any increase in VUMs will decrease the transport cost. Therefore it is practically beneficial for a company to use this model in operational cost monitoring.

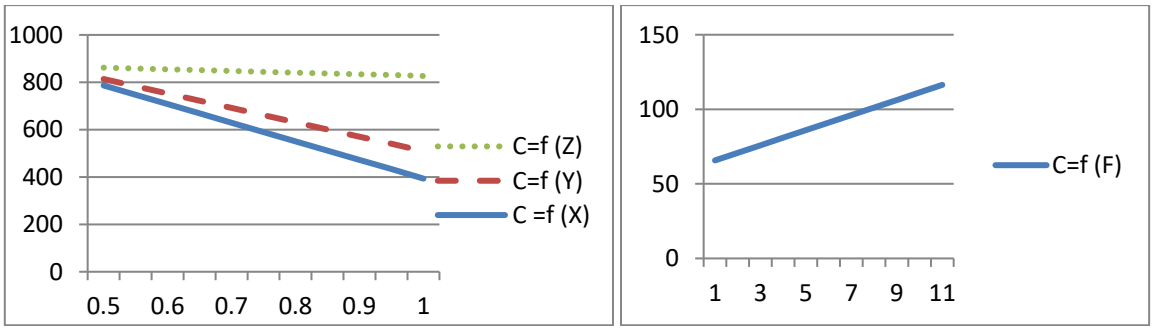

Figure 3. Relationship of the VUMs and transportation cost

5. CONCLUSION

Cost issue is the main concern of not only trucking but other businesses. Differentiating accurately and monitoring transport cot is even more sophisticated. Since many companies register and count on vehicle utilization measurements, it is useful to use VUMs for cost monitoring. The influence of the internal factors of a company on transport cost can be

expressed by VUMS such as coefficient of vehicle utilization, average operational speed, coefficient of available time utilization, average distance with revenue load etc. The VUMs have decisive influence on transport costs per ton-kilometer. In order to monitor transport cost change and make decisions the companies could use the available data of VUMs.

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