

Performance Measures for Truck Transport

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Abstract— Truck transport is the backbone of Indian economy and a major contributor to the GDP growth. To sustain the growth and improve the performance of truck transport it is desirable to have appropriate measures of performance. The process of choosing appropriate performance measures is difficult due to the complexity of the system. This paper presents an overview and evaluation of the performance measures used in truck transport and also presents a framework for the selection of performance measures. Three types of performance measures are identified as necessary components and various flexibility measures are developed.

Keywords— Truck transport, performance measure, flexibility, resources, output.

1. INTRODUCTION

The contribution of service sector to the growing Indian economy is about 59%. One of the major constituent of the service sector is freight transport and is dominated by the truck segment that in turn is dominated by the disorganized sector with 77% of the truckers owning less than 5 trucks. The disorganized nature is one of the prominent causes for poor transport service as well as management of the resources. It is a concern that this issue is poorly addressed and is assignable to poor or inappropriate measurement of performance.

In the era of global competition, any system, whether it is operations or distribution or any other, performance measurement is desirable. Measuring performance serves several purposes. The measures of performance, indicates the current status and also assists to compare the individual performance against the competitors. The gap identification can serve several purposes such as to develop appropriate strategy, and to fill the gap in case the competitors have superior performance.

A number of characteristics desired in effective performance measurement systems are inclusiveness, universality, measurability, and consistency [1]. Apart from effectiveness, the performance measures must be capable of getting benchmarked as means of identifying the gaps and improvement opportunities [2]. Often it is difficult to measure the performance totally through single or few measures and accordingly various measures are necessary and these are categorized under cost, quality, delivery, and flexibility. To get the overall perspective of

a business it is desired to have measures of performance that cover all these dimensions at the same time there should be few measures to not to lose the overview of entire system. Prabhu et al [3] provides various efficiency and effectiveness measures for the Indian truck transport and also benchmarking the actual values. However these measures are neither categorized nor evaluated for inclusiveness, universality, measurability, and consistency. With lean management being the new mantra, the lean performance measures are the need of the hour [4].

2. EVALUATION OF AVAILABLE PERFORMANCE MEASURES OF TRUCK TRANSPORT

Transport management, analysis, and improvement are becoming increasingly important. The performance measures should be directly applicable in the real world. This section describes and evaluates various performance measures that have been used in modeling truck transportation, and discusses their applicability.

2.1 Overview

Truck transporters predominantly use the following performance measures

- 1) Cost
- 2) Combination of cost and operational performance.

Table 1 below summarizes the transport management measures used by various transporters and researchers [5-8]. These measures have their objectives as minimization or maximization subjected to various operational constraints.

TABLE 1. PERFORMANCE MEASURE IN TRUCK TRANSPORT

Measure type	Measures
Cost / Profitability	Total Cost/km; Fuel Cost/km; Tyre cost/km; enroute cost/round trip; Average Revenue/km; Average profit/km.
Quality	Price of goods damaged to the total goods transported.
Time	Promptness, Move time as a ratio of total trip time; Average round trip time; Average truck speed; No. of round trips in a year.
Flexibility	Variety of goods transported; regions covered for transport.

Other performance measures have been identified as appropriate but neither evaluated by researchers nor used and proven the utility by transporters. The qualitative measures such as customer satisfaction, networking effectiveness with various stakeholders, delivery performance, enroute management, risk management etc. are difficult to incorporate due to difficulty in measurement.

2.2 Evaluation of Measures of Performance

Cost, quality, time, and flexibility may be used in measuring performance of truck transport and other than flexibility all are being used currently but not completely. The measures used so far possess some weaknesses. This section appraises the limitations of these performance measures.

2.2.1 Single Performance Measure

The use of single performance measure is attractive due to its simplicity. However, its ability to describe the performance completely is often questioned. Inclusiveness is often the problem area. As an example: Considering the revenue per km or per trip as the single measure, does not cover the volume of the operation i.e. no. of kilometers travelled or number of trips in a year apart from not covering quality and flexibility.

2.3 Cost as a Truck Transport Performance Measure

Often, cost is a performance measure of choice in many operations system models. However such models have serious flaws such as lack of relevance of the cost categories, cost distortions, and inflexibility. Cost categories such as enroute expenditures are too general and the breakups as such are difficult and subjective. Enroute payments made to government officials are often distorted due to non-availability of receipt. Further many of the expenditures change with time and assigning to a particular head or benchmarking too become bottlenecks to cost calculations and year to year comparison. Unlike any other operations truck transport involve trip related costs apart from fixed costs and variable cost.

2.3.1 Strategic Goals as a Truck Transport Performance Measure

Strategy plays a major role in success of any business and so in truck transport. Measuring strategic goals assists the business to move in right direction such that the goals are achieved. Consider the strategic goals listed in the table 2 and the corresponding implied performance measures. Strategic goals are often targeted on more than single performance measure; they usually point many, and are not clearly defined. It is vital that its performance measures are colligated to the strategic goals of the organization.

To summarize, individual performance measures are often proved to be non-inclusive. Consequently, many of the performance measures that are currently in use ignore associated interactions. Measuring the use of resources and minimizing the same is of overall importance. Additionally, uncertainty must be accounted in performance measures to

ensure that the transport system responds to future changes/challenges.

TABLE 2. STRATEGIC GOALS AND PERFORMANCE MEASURES FOR TRUCK TRANSPORT

Strategic Goals	Implied Performance Measurement System
Transport Company X will provide high quality customised transport solution at the lowest possible cost.	Cost & Service Quality
Transport Company Y will transport goods type A to the goods recipient on time and at low cost.	Cost, Promptness
Transport Company Z will generate high quality transport service to meet future customer demands.	Service Quality, Flexibility

Current performance measurement systems are heavily dependent on cost as a sole measure and don't consider uncertainty. Though it is difficult to incorporate multiple measures in truck transport system modeling, the model becomes realistic when the same is done at least to some extent. In the next section a framework is developed for measuring truck transport performance.

3. FRAMEWORK FOR PERFORMANCE MEASUREMENT

As previously discussed, single performance measure is inadequate since it is not inclusive, ignore interactions among important transportation characteristics, and ignores critical aspects of organizational strategic goals. Strategic goals involve key elements that include the measurement of resources, output and flexibility. Resource measures and output measures are generally in use to some extent while flexibility is the one area that is not in use in truck transportation.

The economical use of resources, the desired output and flexibility are vital components for the success of any operations system and so in truck transport system. Therefore truck transport system emphasize on three separate measures: resource measures (R), output measures (O), and flexibility measures (F). Each of these performance measures has different goals and is illustrated in table 3.

Each of these performance measure types have important characteristics and affects each other. The inter-relationship between them is illustrated in Fig 1. To define the individual characteristics of the truck transport system, the performance measurement system must contain at least one individual measure from each of the three identified types. The three individual measures chosen from each type must coincide with the strategic goals of the fleet. Further measures shall be decided

based on the interaction between the three measurement types. Various performance measures under each type are discussed next.

TABLE 3. GOALS OF PERFORMANCE MEASUREMENT TYPE

Measure Type	Goal	Purpose
Resources	High level of Efficiency	Efficient resource management is critical to profitability.
Output	High level of customer service	Without acceptable service the goods owners and load brokers will turn to other truck owners.
Flexibility	Ability to changing environment	In an uncertain environment and changing economy, truck transportation must be able to change.

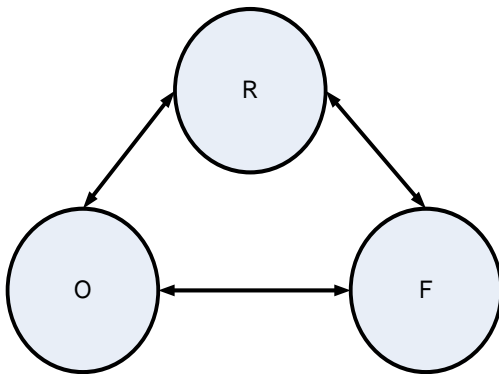


Fig.1: The Truck Transport Measurement System

3.1. Resources

Resources are major contributor to the total cost and hence are desired to be measured and controlled effectively. Resource measures in truck transport include the vehicle utilization, fuel and tyre consumption, crew requirements, and other costs. Efficiency measures the utilization of resources in the system that is used to meet the system objectives. Resource measurement is very critical as inefficient use of them makes the transport operation uncompetitive while scarcity of resources leads to opportunity costs arising from the low capacity utilization. Resource minimization for a given level of operation is the objective of truck transportation. The minimization objectives are to be achieved without deteriorating the output service and flexibility in the transport operation. The following is an example list of resource performance measures:

- **Total Cost/km:** Total cost of resources used and generally measured per km.
- **Return on Investment (ROI):** Measures profitability of the organisation as a fraction of investment.

- **Variable cost per km:** This cost indicates the level of resource consumption and hence beneficial in controlling the costs. The resources such as fuel, tyre, maintenance etc are covered by this cost.
- **Trip related Cost:** This cost is a semi-fixed cost and involve costs incurred for a round trip. Costs such as loading/unloading charges, brokerage paid to get the load, enroute expenses are covered under this measure.

3.2. Output

Transport service is the output of truck transportation. Output measures include: customer responsiveness, quality of transport service, and the number of tonne- kilometers of goods transported. Many of these measures are easily represented numerically, such as:

- Tonne-kms of goods transported in a year
- Number of on-time deliveries
- Number of round trips in a year
- Average round trip distance

However there are many other output performance measures that are much more difficult to express numerically, such as

- Customer satisfaction
- Service quality

A minimum level of output is often specified, and it is necessary to assess these performance measures in the light of associated costs. For example, increasing the number of tonne-kms in a year may lead to overloading that in turn leads to penalties paid to the government, increased maintenance costs etc. Many questions that are to be answered, which are given below:

- What is the added value or cost of delivering the goods early?
- What are the costs associated with the late delivery?
- What are the minimum and maximum tonne-kms /day in this month?
- Which resources affect the output of the transport system?

Output performance measures must correspond to the fleet goals as well as the customers' goals and values. Often customers value reliable on-time delivery than early delivery. The following are examples of truck transport output performance measures.

- **Total hire charges:** Total revenue and often they are expressed per trip or km.
- **Profit:** Total revenue less expenses
- **On-time deliveries:** Measures the delivery performance of the truck and the crew together.
- **Customer Complaints:** Number of customer complaints registered.
- **Transport Lead Time:** Total amount of time for a trip and measured from receipt of the documents at the source to the handing over the documents to the goods recipient at the destination.
- **Number of Dead kms:** It quantifies truck travel without generating revenue.

3.1.3 Flexibility

Flexibility, which is seldom used in truck transport, can measure a fleet's ability to accommodate volume, variety, and schedule fluctuations from various stakeholders. Flexibility is vital in uncertain environment that the truck transport undergoes. The two types of flexibilities commonly used are range flexibility and response flexibility [9]. Range flexibility changes the extent to which the volume of operation can be changed i.e. amount of tonne-kms that can be varied. Response flexibility is the way in which the operation itself can be changed. In truck transport it may be that ability to change the region of operation, type of goods transported etc. Though there are limits to the range and response flexibility, the transport operations and trucks are desired to be designed and operated to adapt adequately in uncertain environment.

4. FLEXIBILITY MANAGEMENT

Numerous studies are available describing the measures for flexible manufacturing systems [10, 11]. However the measurement of flexibility for complex systems such as truck transport has not been addressed.

TABLE 4. SYSTEM FLEXIBILITY TYPES

Flexibility Type	Characteristics
Volume Flexibility	Ability to transport goods for variation in tonne-kms
Delivery Flexibility	Meeting the delivery dates when they are revised as per customer requirements.
Mix Flexibility	Ability to transport different goods in a single trip
New Service Flexibility	Ability to transport goods for varying customer requirements and to different regions.

Flexibility measures are distinctly different from the other two measure types. They are potential behaviour of the system rather than the actual behaviour. Therefore flexibility is not demonstrated to exist. Generally the flexibilities used for supply chain measurement [12] has been adapted for truck transportation and as given in the table 4:

4.1.1 Volume Flexibility, F_v

It is the range of volumes in which the organization can run profitably. When applied to truck transport, it is the flexibility in tonne-km that can be met when demanded by the customer. The fleet can have more flexibility when there are several vehicles and vehicle types are in the fleet. Another way to increase tonne-km is to have more professional drivers per truck to run the truck for more duration per day. Keeping the OEE of the truck high by using TPM is also can render high volume flexibility. Minimum volume flexibility is decided by the break-even tonne-kms the truck has to transport. Lesser

the costs involved lesser will be the breakeven tonne-km and more will be the volume flexibility. Assuming the normal distribution of the demand (D) for the transport, volume flexibility is expressed as,

$$F_v = P\left(\frac{mtkm_{\min} - \bar{D}}{S_D} \leq D \leq \frac{mtkm_{\max} - \bar{D}}{S_D}\right)$$

or

$$F_v = \phi\left(\frac{mtkm_{\min} - \bar{D}}{S_D}\right) - \phi\left(\frac{mtkm_{\max} - \bar{D}}{S_D}\right)$$

Where

$$F_v \in [0, 1]$$

\bar{D} is the tonne – kms available to the fleet

S_D is the standard deviation of the tonne- kms available

$mtkm_{\min}$ & $mtkm_{\max}$ are the minimum and maximum profitable million tonne- kms.

4.1.2 Delivery Flexibility, F_D

The ability to move planned delivery dates forward may be important for truck transportation. Often, transportation being part of the supply chain, it is desired to cut short the transportation time to make up for the delay in manufacturing and / or other areas of the supply chain. This ability of truck transport allows the supply chain to accommodate rush orders and special orders. Delivery flexibility will be expressed as the percentage of slack time by which delivery can be reduced. The delivery flexibility defined for the supply chain [12] as such suits the truck transportation. For any transport trip the delivery flexibility may be expressed as

$$F_D = \frac{L_j - E_j}{L_j - t}$$

Where

L_j and E_j are the latest and earliest delivery times respectively for the j^{th} trip.

't' is the current transportation time for the trip.

4.1.3 Mix Flexibility, F_M

Mix flexibility is similar interchangeability for specific application of the trucks. Currently, trucks in India are interchangeably used. However, this does not mean that the trucks are flexible. Current trucks are equally inflexible for all type of goods. Mix flexibility may be classified as simultaneous flexibility and changeover flexibility. Simultaneous flexibility is defined as ability of trucks to multiple goods type in a single trip. This makes truck to avoid part load operation and thereby improving

profitability. Changeover flexibility may be defined as the ability to transport goods of different variety in different trips based on the availability. This flexibility tries to reduce the waiting time for getting the load.

4.1.4 New Service Flexibility, F_N

New service flexibility is defined as the ease with which the news goods can be transported by the system. This flexibility targets to avail the benefit of additional loads by responding to the customer requirements faster than others. These are more applicable to trailer trucks, which transport items such as machines and other huge structures of manufacturing, construction industry.

5. CONCLUSIONS

Performance measurement is a crucial element of performance management of any system. Though there are several measurement systems available to measure the product related system, there are few service measurement systems such as truck transportation. The dominating disorganized sector of truck transport is currently in need of appropriate performance measures that measures the resource utilization, output and flexibility.

This paper discusses various performance measures under all these categories. Resource measures are discussed to measure the efficient utilization of resources, while the output measures were focused on both quantity and quality of outputs that leads to customer satisfaction as well as profitability of the fleet. Finally flexibility measures discussed focused on building fleets' ability to respond to changing requirements of the customer that leverage available opportunities to enhance the business as well as profitability.

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