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THE MEASUREMENT OF THE PERFORMANCE OF FREIGHT TRANSPORTATION

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Abstract

This paper analyses the present role and use of the traditional transportation measurement, namely the (freight)tonne-kilometre. It is argued that this measurement has some limitations to assess properly the real transportation work, and not to characterise the importance of transport modes. Other measurement methods should have to taken into consideration. Monetarisation of transport services or derivative measurement could be the key to properly characterise differentiated freight transport activities and support decision making on both macro- and microeconomic level.

Keywords: freight transportation performance, work, measurement, tonne-kilometre.

1. Introduction

Analysing logistics and freight transportation processes four main areas can be determined. The parameters of transportation performance, vehicle fleet parameters, parameters of infrastructure and statistical parameters of transportation process. This paper focuses on the definition of transportation performance and work, analysing present methods and exploring new possible procedures. Nevertheless, any areas can not be examined exhaustively without the knowledge of connected areas. Logistics as an integrated and interdisciplinary science provide the effective tools for both practical and theoretical approach.

2. Concepts

A certain kind of uncertainty can be experienced relating to performance and work. In every day use we also mix the notions of work and performance. The transportation work and performance has a unique and different meaning from the physical definition. In fact it would be more accurate to use the expression achievement instead of performance. With the help of performance one can compare and describe the material flow i.e. in statistics.

Inside transportation we use performance and outputs as a work characteristic and measure it in (freight)tonne-kilometres.

The transportation work deviates from physical work only by a constant multiplier namely the gravity acceleration (g); nevertheless it is essentially a work quantity.

The transportation output is the work per time unit ($P = W/t$). It is expressed in tonne- km/year or kg-meter/hour, etc.

3. The Classical Characteristic of Material Flow

In analysing and optimising transport systems, it is essential to describe and characterise the actual material flow.

3.1. The Basic Characteristics of Material Flow

The main characteristics of material flow are:

- quantity (Q)
- distance (d)
- time (t).

The distance references, such as the route, the line and length depend on the spatial situation of starting and end point of the transshipment.

The time factor plays a role as the time of a single event, and on the other hand the duration of the process.

The quantity of materials can be expressed as follows:

- in case of bulk materials in mass (weight?) or volume unit (kg, t or m^3);
- in case of piece goods in movement unit (pieces).

3.2. Transportation Work and Performance

Transportation work and performance are average characteristics.

The transportation work (W) is defined by multiplication of material quantity (Q) and transportation distance (d): $W = Q \times d$.

The transportation performance, output is the work per time unit: $P = W/t$. It is expressed in tonne-km/year or kg-meter/hour, etc.

Considered the measure of the two factors:

Material quantity:

- weight (g, kg, tonne),
- volume (l, hl, m^3),
- movement unit (pieces).

Distance (length):

- meter,
- kilometre.

Various measurement units are obtained by combining the above factors (i.e. tonne- km, kg-meter, etc.).

4. The Critical Analysis of Transportation Work

For analysing given different systems adequate and essential (performance-) measurements should be selected. According to GLOBERSON [1] the principles of selection are the followings:

1. The conditions related to measurements must be well and clearly formulated;
2. Numerical measurements should be preferred to non-numerical ones;
3. Comparative, relative measurements should be preferred to absolute ones, since these are suitable to compare two or more factors.

Regarding the last phrase one could remark that absolute measurements could not be always substituted for relative ones because they have limitations.

The advantages of the traditional measurement of the transportation work can be summarised in the following:

- simple, easy to understand,
- the factors are deterministic, measurable, statistics are available,
- comparable to previous data, longer time series are available.

The disadvantages of traditional measurement are as follows:

- The material quantity is not necessarily in proportion to real, actual work, expenditure.
- Neglects the time factor.
- Disregards the value of the transported goods.
- Ignores the special property of products (i.e. perishable, fragile, hazardous goods).
- Disregards the quality issues (quality of the product, transportation process).
- Does not represent at all the value-added, logistic services during the transportation, haulage.

Regarding the material quantity the weight and volume of the products can vary between extreme values depending on different groups of goods. The density combines the weight and volume of cargo. In transport the reciprocal of density (volume/weight) characterise the extensity. Each transport modes define extensity in different ways. For example a given product which is voluminous in road haulage could be a heavy cargo in air freight traffic.

The movement unit also covers different quantities. The packaging of transported goods can be also different, hence it would influence the work and expenditure.

The distance is not a questionable factor, and generally acts without any correction. Nevertheless, crossing certain physical and geographical borders, barriers can result in a sudden work growth, concerning at least expenditure, and cost. Similarly, there could be distance to cover, which do not raise the level of the performed work due to the unnecessary extra kilometres (i. e. detour to custom clearance place). On the other hand the fact that a certain product is custom cleared, however, can result in a work growth without any distance covered. So the performed work is not necessarily a linear function of the distance. This is illustrated on the following figure.

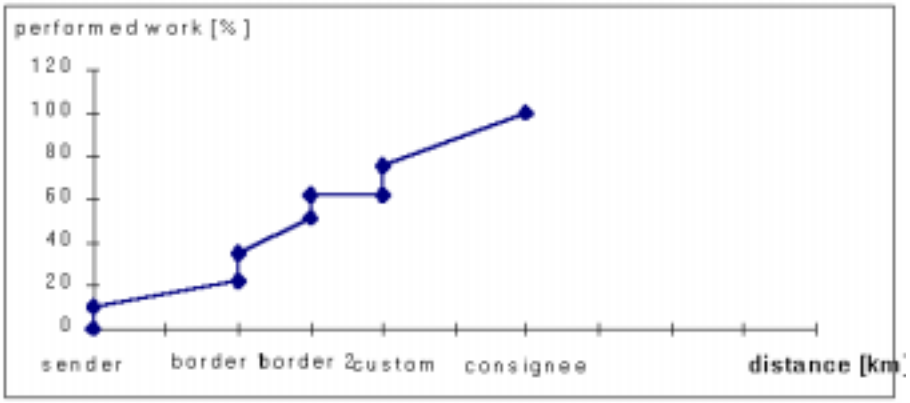

Fig. 1. Work/distance function

The time is not represented directly in transportation work, although it is a very important basic characteristic of material flow. Of course it influences the performance, however, the performance is not able to express the magnitude of the performed work. It is the biggest contradiction related to work; namely it disregards the time factor. The time usually has an effect upon the quality of the service when the real time deviates from the planned/agreed time-window. Most often the delay causes change in the judgement of the transportation work. In case of JIT an earlier delivery also could result in a non-conform work by need for storage.

In the modern logistic and the JIT system, the time duration of the transport is extremely important because it can replace storage and inventory expenditure, hence it has a work enlarger role. While distance and material quantity are deterministic, time is a stochastic one. Two transportation tasks, which are same in other parameters, could result in different time performance.

The value of the product has a significant impact on the real transportation work. Value-density means the relative price compared to weight or volume. Value-density correlates with logistics costs, so it influences the entire logistic process.

In case of high value-density the transportation and inventory costs grow because of security and strategic issues. The following figure illustrates the connection between transport rates and value of the goods.

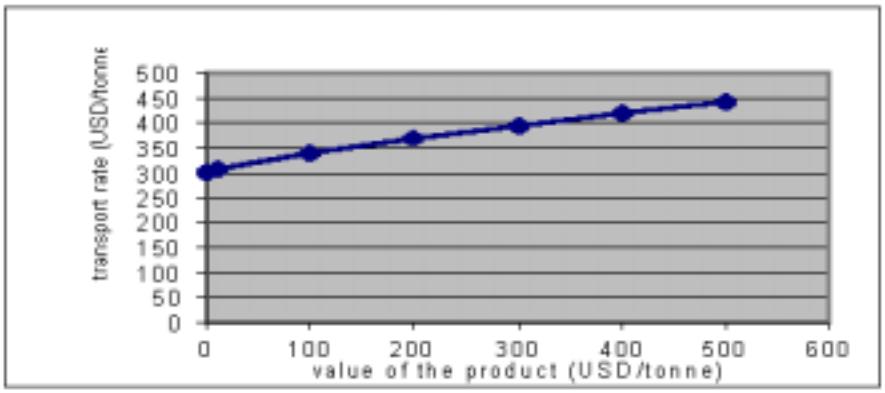

Fig. 2. Transport rates/product value function

Special characteristics (perishable, fragile, and hazardous) require special conditions and the way of transport and handling. Only considering these extra-expenditures could the transportation process properly be estimated. In this case the human- expenditures could be much higher.

The role of quality is difficult to handle. It undoubtedly influences both the expenditures and judgement of the performed work. Because of the complexity of quality it is desirable to handle this issue later.

The transport performance could be treated less and less separately nowadays. With the spreading of the logistic approach the transportation is getting more and more integrated into the logistic process with other services. The above-mentioned factors themselves comprehend this issue. Nevertheless, the work of storage, material handling, package, etc. and transport work occur as an organic part of logistic work. It seems justified to take the logistic work into account.

It follows from the above mentioned that, certain constraint should be taken into consideration referring to the exact comparison by freight tonne-kilometres, not only between different transport modes but inside a given transport mode (i.e. inside the road transport sector), due to the special, differentiated transport solutions.

For example between transport modes one can hardly compare mass bulk transport to long distances (waterway, railway) and short distance road transport. Within road transport it is also complicated to compare the transport of low density, voluminous goods with the transport of high density, heavy goods.

5. The Present Use of the Transportation Performance and Work, Applied Solutions

The transportation performance expressed in tonne-kilometres is used in the following areas:

- demonstration of transportation's role in the national economy,
- determination of the importance of each transport mode,
- exploration of the distribution by traffic nature (exports, import, etc.),
- determination of the distribution by goods type,
- distribution of transport organisations,
- distribution of transport vehicles by countries,
- capacity rate,
- determination of specific operational, vehicle associated costs,
- distribution of trucking modes (i.e. at railways).

The above areas are indispensable, fundamental factors to set the principles of freight-transport politics, still support the short and medium decisions of transport organisation and management.

Regarding the present fashionable transport topicality: externalities, it can be argued that the weighting by tonne-kilometres distorts the judgement of transport modes [3]. When we are talking about fair and efficient pricing in transport we also should have to compare the importance, environment friendship, etc. of transport modes by a fair and efficient way with an adequate measurement [2].

The following model helps us to understand the environment of transport activities and to estimate correctly both the real work and the damage in environment (externalities).

Concerning the applied areas it is argued that transport performance and work are used by state or transport service suppliers to make transport politics, economic decisions. In other words *the consumers, the users of the transport do not use this* for making their decisions.

To investigate and criticise tonne-kilometres it is necessary to learn the other existent apparatus and procedures.

Assessing transport activity statistics use the following techniques and measurement besides tonne-km:

- mass (weight) of the transported goods,
- transport distance,
- transport tariff revenue,
- transported units (i.e. containers),
- number of vehicles,
- capacity measurements,
- operation time/haulage time,
- fuel, energy consumption,
- utilisation/crowd indexes,
- other artificial indexes.

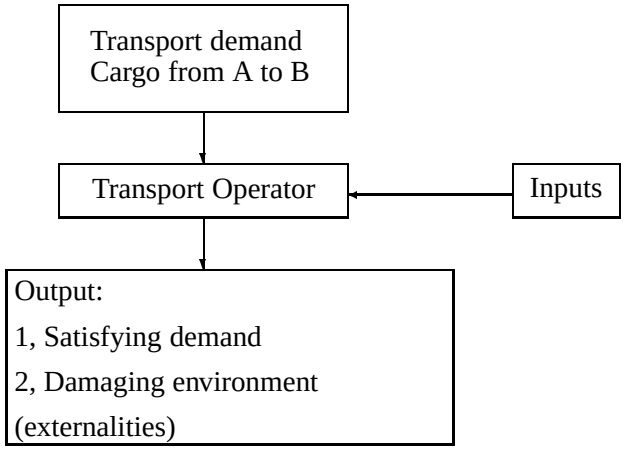

Fig. 3. Model of freight transportation

6. Transportation Work from the User's Point of View

As we mentioned earlier consumers of the transport services do not use traditional measurements (i.e. tonne-km).

Let us look through the decision-factors, which help for the users to choose between alternative services:

- cost,
- time,
- quality.

It is remarkable that distance and quantity of the goods are not decision factors, since these are basic features of the transport task, which have to be performed anyway.

Quality, as a factor is complex itself and contains the following classical attributes:

- ability for use,
- efficiency,
- reliability,
- safety and security,
- conformity to environmental/social prescriptions.

In transport quality can be explained in the followings:

- accessibility,
- availability,
- speed,
- flexibility,
- tracking,
- service level,
- reliability,
- safety,
- complex service.

Of course the above list is incomplete, the point can be grouped different and several other ways and it depends on the transport solution.

Naturally, the three fundamental factors (cost, time, quality) are in close relation.

7. Alternative Solutions to Measure Transport Work

7.1. Measurement in Value:

The most homogenous and thus the most comparable measurement would be the value of the transport services. Namely each factor: goods, distance, time and quality of the service could be monetarised.

However, several issues should be answered regarding this monetarisation.

The value of the products theoretically can be determined or it is known. It raises some problems which value of the product can be accepted.

The contract (invoice) value

- between seller and buyer,
- between trader and trader,
- between trader and consumer.

Market value, price

- commodity Exchange rate,
- price by custom of trade,
- pure market price.

Generally, the price is to be considered because of its intimacy and because the contract value is not known, sometimes manipulative, speculative and thus a certain kind of distortion, uncertainty has to be taken into consideration.

The transport distance – beside quantity of the goods – is a deterministic characteristic, so monetarisation could easily be solved. The question is what kind of multiplier could be applied. In the European Union a lot of guiding principles exist according to fair and efficient pricing, and there are some determined distance prices (Euro per kilometre). These specific values have to be properly selected

for different transport solutions, roads, time so it brings some difficulties into the calculation and modelling.

The transport time is a stochastic factor, however, through the Value of Time figures and the real or estimated transport time, the value of it can be calculated [4].

The special features and value added logistic services could be monetarised, taken into account by the (extra)price of these services. Further investigations seem to be necessary in this field.

Last but not least *the quality of the service*, which is the most difficult to deal. It is problematic to find a functional relationship between each quality criterium and the value of them. One can take the market judgement, prices. It is also possible to assume that other factors determine a certain, average level of quality, hence – because of the difficulties on modelling – we disregard this factor during monetarisation.

Also further investigations are necessary to explore the correlation between the items above mentioned (i.e. value and special features) and identify other factors which have an impact on transport performance.

The advantage of monetarisation that one can compare the calculated value of transport with the market prices determined by demand and supply and no significant difference is possible. It would be a universal and unified method allowing dynamic and not static evaluation of transportation work, which could adapt itself to changing market conditions. The unified measurement allows us to investigate time series exploring the changing in time.

7.2. Derivative Measurements

The factors in chapter 4. could be used and with weight numbers a derivative unit can be elaborated. Further investigations are necessary to discover this area and to find adequate functions, which describe the connection between real work and the factors mentioned in chapter 4. Nevertheless, one has to consider, that a too complex derivative measurement – because of the difficulties on understanding the meaning of it – could not be widely used.

7.3. Analysing Expenditures to Elaborate Transportation Performance and Work

To tackle the real transportation work it seems to be useful to analyse the expenditures. Of course the market-based methods are more important, nevertheless, cost analysis gives some points of reference, especially because of externalities and deformed market conditions.

To do that the European principle on road pricing and pricing transport use mentioned earlier provides efficient tools and methods.

8. Conclusions

Freight tonne kilometres as a traditional and universal measurement is widely used but due to its universality, it is too homogenous. It follows from this that it is not able to characterise properly the transport performance with special regard to differentiated transport solutions of our time. This is why it could cause some distortions during the assessment of the weight of the transport modes. Concerning the applied areas it is argued that transport performance and work expressed in tonne kilometres are used by state or transport service suppliers to make transport politics, economic decisions, so it used only on macroeconomic level. In other words *the consumers, the users of the transport do not use this* for choosing transport solutions.

Concerning the measurement of transport activities there is a need for change, need for elaborate fair and efficient method measuring transport performance and work. In this paper two alternative solutions are discussed: *monetarisation* and derivative artificial measurements. The earlier is rather a universal and easy to understand and compare method. Several issues have to be considered (e.g. the role of the quality) relating to monetarisation, nevertheless it seems to be a better and manageable solution. Regarding the later further investigation is necessary or other solutions should be explored and elaborate.

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