INDICATORS FOR THE PERFORMANCE AND FOR THE EFFORT IN TRANSPORT

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ABSTRACT

The cooperation and integration of several types of transport need special and dedicated indicators. If their definition surprises the specificity of the transport, they could be used for the benchmark of different systems of transport and also for the measurement of their relative influence into the market. Same of specific indicators for informational concepts are transformed and adapted for transport activities. This paper presents a way to generate better and more adequate indicators for getting a representation of the transport activities.

Keywords: *inter-modality, multimodality, entropic level, equivocation, trans-information, informational factor.*

1. INTRODUCTION

We will consider the transport as a system included into the logistic. The sub-systems of the transport system are the means of transport: by road, by sea, by railroad or on air Multimodal transport is not only the reunion of several types of transportation. The management of multimodal transportation involves the entire transport infrastructure: terminals, consolidation warehouses, ports, airports or something else, which requires the highest extent of coordination from all of those involved in the logistics process.

The cooperation and integration of several types of transport need special and dedicated indicators. If their definition surprises the specificity of the transport, they could be used for comparison of different systems of transport and for the measurement of their relative influence into the market.

2. INTER-MODALITY AND MULTIMODALITY

The term of inter-modality was used for a system of transport which consists of modules of transport more different than similar. The method involves the transportation of freight in an inter-modal vehicle or container, using multiple modes of transportation (rail, ship, and truck), without any handling. This reduces cargo handling, and so improves security, reduces damages and loss, and allows freight to be transported faster. As a consequence, each mode of transport will have its own development and the differences between them will increase.

They are two different approaches of the inter-modality:

- the inter-modal system consists of hubs (ports, airports, terminals, warehouses) and the network or
- the inter-modal system consists of hubs (ports, airports, terminals, warehouses) only.

It is obvious that nothing exists completely independent; anything is included in the wholeness.

Multimodal transport means the simultaneous or alternative use of the different ways of the transport. It solves a big part of cargo mobility problems. The multimodal transport refers to a transport system usually operated by one carrier with more than one mode of transport under control or ownership of one operator. It involves the use of more than one means of transport such as a combination of truck, railcar, railways, aeroplane or ship in succession. The most important advantages of multimodal transport could be considered the followings: coordinated and planned as a single operation, minimized the loss of time and risk of loss, pilferage and damage to the cargo at trans-shipment points. The markets is psychically reduced by faster transit of goods, the distance between origin or source materials and customers is getting to be insignificant.

2.1 Inter and multimodal characterisation of a system of transport

A system of transport could be in one of the 'm' states.

Shannon [3] characterised the multimodal diversity of such a system by its entropic level:

$$H = -\sum_{i=1}^{m} p_i \lg p_i \tag{1}$$

This formula is not related to the tendency of the system to change its state from the state i to the state j, where i, j $\in \{1,2,\ldots m\}$. For this reason, the average entropy H_m of the system under a transitory matrix is

$$H_M = \sum_{i=1}^{m} p_i H_i \tag{2}$$

where
$$H_i = -\sum_{j=1}^{m} p_{ij} \lg p_{ij} \tag{3}$$

and
$$H_{M\max} = \lg m \tag{4}$$

If the system laid in the state i it could pass to any state j. The entropy H_i only considers the incertitude of the change of the state without a suggestion about its nature.

Let T_{ij} be the transition of the system to a state j with a certain level of efficiency (done by the indicators e_{ij}).

$$E_i : \begin{pmatrix} T_{i1}.......T_{im} \\ p_{i1}........p_{im} \\ e_{i1}.........e_{m1} \end{pmatrix}, \quad e_{ij} \geq e_{i,j+1}, \ j=1,2,\ldots m \tag{5}$$

Let consider now the transitions are in the decreasing order of the level of efficiency.

Let E_i denote the fact that the system is in the state i and is doing the transition T_{ij} with the probability p_{ij}. If E will normally unfold, the outcome will be the transition T_{ij} to the state with the maximum of efficiency (j=1).

The level of inefficiency is done by the non dimensional indicator
$h_{ij} = (e_{i1}-e_{ij})/e$, where $e = (|e_{i1}|,\ldots,|e_{im}|)$.
If $h_{ij} = \lg w_{ij}$, we arise to the weighted entropy

$$H_i^{\ p} = -\sum_{j=1}^{m} p_{ij} \lg \frac{w_{ij}}{p_{ij}} \tag{6}$$

or

$$H_i^{\ p} = \alpha \sum_{j=1}^{m} p_{ij} h_{ij} + H_i \tag{7}$$

introduced by Theiler, Tovissi [4].

For the usual entropy, if p_{ij}=1 (doubtless transition) H_i=0 (the disorder is at minimum, for any j).

For the weighted entropy, if there exists doubtless transition (p_{ij}=1), there $H_i^{\ p} = \lg w_{ij} = h_{ij}$ or the minimum disorder is expressed by the inefficiency h_{ij} of the transition from i to j, or the disorder is at minimum if the transition h_{ij} is inefficiency.

The maximum value is :

$$H_{i\max}^{\ p} = \lg \sum_{j=1}^{m} \lg w_{ij} \text{ and is fulfilled for} \tag{8}$$

$$p_{ij} = \frac{w_{ij}}{\sum_{i=1}^{m} w_{ij}}, \ j=1,2,\ldots m$$

The weighted entropy for the entire system [2] is:

$$H_M^{\ p} = \sum_{i=1}^{m} p_i H_i^{\ p}$$

and

$$H_{M\max}^{\ p} = H_{i\max}^{\ p} \tag{9}$$

In the case of a transhipment platform for goods, we could consider the following three different possible situations [5]:

1. containerised
2. united (i.e. palletised goods)
3. bulk.

The transitions between this could be described as follows: a part of the bulk merchandise should be united and going from the state 3 to the state 2, the units could pass into a container (from the state 2 to the state 1) and so on. It is possible to define the matrix of these passages.

In the inter-modal freight transport, the goods lie into a state *i* and could pass into a state j with the probability p_{ij}, where j=1, 2, 3. The entropy H_i for each state *i* give us the possibility to understand the incertitude of transition from *i* to *j*.

The margin between the real values and the maximum value of the entropy shows if there still exist possibilities of improvement of the activities of the transhipment platform for goods.

2.2 The characterisation of a inter-modal system of transport in uncertainty conditions

Let M be the matrix and its elements p (x_i, y_j) representing the probability of transmission of signals from the entry $i \in X$ to the exit $j \in J$.
Using the following:
- $p(x_i)$ as the probability the signal x_i come in the system and
$p(y_j)$ as the probability the signal y_j come out from the system, then:
A. the entropy of the entering field will be:

$$H(X) = -\sum_{i=1}^{m} p(x_i) \lg p(x_i) \tag{10}$$

B. the entropy of the going out field will be:

$$H(Y) = -\sum_{j=1}^{n} p(y_i) \lg p(y_i) \tag{11}$$

C. the entropy of the total field will be:

$$H(X,Y) = -\sum_{i=1}^{m} \sum_{j=1}^{n} p(x_i, y_j) \lg p(x_i, y_j) \tag{12}$$

and trans-information in absolute value T and relative value T_r is:

$$T = H(X) + H(Y) - H(X,Y) \tag{13}$$

$$T_r = \frac{T}{H(X)} \tag{14}$$

Let we consider now the equivocation

$$H(X/Y) = H(X,Y) - H(Y) \tag{15}$$

as a measure of the equivoque on the come in field X when is known the come out field Y. In dynamic interpretation this represents the equivoque of the passed modal distribution starting from the present modal distribution. A static interpretation is that H represents the equivoque of the traffic generators distribution starting from the present modal distribution off the traffic.

Let we consider now the average error

$$H(X/Y) = H(X,Y) - H(X) \tag{16}$$

as a measure of incertitude of the come out field Y, when is known the come in field X. . In dynamic interpretation this represents the incertitude of the future modal distribution knowing the initial present modal distribution. A static interpretation is that H represents the incertitude of the future modal distribution as a result of the initial known distribution of the traffic generators.

Trans-information T is also equalled to:

$$T = H(X) - H(X/Y) = H(Y) - H(Y/X) \quad (17)$$

and represents the average value of the mutual information related to the field X obtained from the field Y, or the average of the information passing throw the system.

Based on the trans-information, the systems could be in the following situations:

1. There exists a one-to-one function between X and Y, there isn't equivoque on the come in signals and there isn't error on the come out signals, T_r=1. The traffic on each transport mode is provided by only one traffic generators or sender.
2. For any signal from Y corresponds only one signal in X, so there no exists equivoque on the signal x_i come into the system when is known the signal y_j to the exit.

At the same time, for the same signal x_i entered into the system they are generated many signals y_j at the exit and this facilitate the genesis of some errors during the process.

For the transport, this is the situation of a dispatch started by car, divided into many pieces and some of them will continue the way by another mod of transport.

3. A signal entered into the system generates only on signal to the exit, so there is no error. But, if the signal from the exit is known there exists equivoque on the entering signal:

$$T_r = H(Y)/H(X) \quad (18)$$

4. There exists an equivoque related to the entered signals and error on the exit signals. This created an uncertin situation about the work inside the system and:

$$T_r = H(X) + H(Y) - H(X,Y)/H(X) \quad (19)$$

5. If all the signals: entered, leaved or the reunion of them have the same probability in their category

$$p(x_i, y_j) = \frac{1}{mn} \quad \text{and}$$

$$p(x_i) = \frac{1}{m},\ p(y_j) = \frac{1}{n},\ i = 1...m,\ j = 1...n \quad (20)$$

then the entropies will have the maximum values and it results the followings:

$$H(X) = \lg m, \quad H(Y) = \lg n, \quad (21)$$

$$H(X,Y) = \lg mn = H(X) + H(Y) \quad T_r = 0,$$

The significance of this situation is the possible connexion of each entered signal to any signal arrived to the exit, so the uncertainty is dominant.

The relative trans-information could define the quality of the connexions entrance-exit through the system as follows:

$T_r = 0$ maximum complexity

$T_r = 1$ correspondence on-to-one between entrance and exit,

$T_r \neq 0, T_r \neq 1$ random connexion between entrance and exit.

Into an intermodal terminal, during an interval of time come in a number of transport units from different modes of transport x_i. The same units will go out from the terminal using the vehicles y_j of other types of transport. Immediately could be know H(X), H(Y), H(X,Y), T_r. If the relative trans-information has a small value, the conclusion is that the change of the mode of transport is very complex and it requires a lot of diver logistic and multimodal operations.

Relative trans-information represents an indicator of the degree of specialisation of freight in relation with the modes of transport served by the terminal and allows a comparison between transport terminals. In the same time the trans-information could be used for define the optimal solution for the classical problem of transport in Operational Research, where x_i represents the supplier and y_j represent the consumer.

3. INDICATORS FOR THE PERFORMANCE AND FOR THE EFFORT IN TRANSPORT

The classical indicators are not very adequate to the complexity and the real value of the performance into transport. For example, if the route between the expedition points x_i i=1…m and final point y_j is denoted by TK_{ij} (tkm)

$$TK = \sum_{i=1}^{m} \sum_{j=1}^{n} TK_{ij} \quad (22)$$

do not indicate the real effort for the transport.

This effort is bigger if:

- the number of the sender/ reception points is bigger
- the weight of the dispatch points done by their probabilities p_i (dispatched tones from x_i / dispatch tones from all points) is more uniform and the same for the receiving points.
- there exists a large diversity of goods
- the complexity of the connexions is important, so that the matrix of the connexions has a lot of positive elements.

The first two features are reflected into the entropy H(X) of the dispatch/receive points, related to the maximum value $H(X)_{max}$=lg m.

For he third feature will proceed by analogy related to the weight of each category of goods in the total displacement.

The fourth feature could use the new concept of trans-information introduced by Cuncev…as follows:

Let consider now the stochastic matrix Z=(z_{ij}) i=1,2…n, j=1,2…n of the probabilities to have a transfer of goods between the points x_i and y_j:

$Z_{ij} = TK_{ij} / TK$

The probability to arrive same goods in y_j could be expressed by

$$q_j = \sum_{i=1}^{m} p_i z_{ij} \quad (23)$$

The average value of the mutual transferred into the information system is the trans-information T

$$T = H(X) + H(Y) - H(X,Y) = H(X) - H(X/Y) \quad (24)$$

where H(X,Y) means the entropy of the reunite in/out field.

Considering the relative trans-information Tr = T/H(X) as a characterisation of the complexity of the connexions (i, j) we get:

$T_r = 0$ maximum complexity
$T_r = 1$ correspondence on-to-one sender-receiver
and $T_r \neq 0$, $T_r \neq 1$ for a random correspondence .

We introduce now a new concept, the informational factor $C(T_r)$, for the complexity of factors that are influencing the effort of transport.
Using this new concept, the total transport activity could be expressed by:

$$CTK = TK \cdot C(T_r). \tag{25}$$

The evaluation of this factor $C(T_r)$ is very difficult to be done. In order to have a method to calculate it, I propose the following algorithm:
Step 1: the identification of all factors that are influencing the effort of transport;
Step 2: to establish the empirical probability of involvement of each of the previous factors;
Step 3: to allocate to each factor a measurable magnitude of its involvement;
Step 4: to build the synthesis function of all this factors.

It is a similarity between this operation and the building of the synthesis function for the multi-criteria optimisations problems [1], in linear programming.

In a similar way a lot of specific indicators for informational concepts could be transformed and adapted for transport activities. This way will allow to have a better and more aquarate representation of the transport activities.

4. THE OPTIMAL DECISION UNDER RISK CONDITIONS

Let we consider that the decision maker will adopt a strategy i if he knows the complete field of probability related to the behaviour of the concurrent:

$$(A, J, p_{ij}), p_{ij} \geq o, \sum_{i,j=1}^{m} p_{ij} = 1 \tag{26}$$

where p_{ij} represents the probability that the concurrent will adopt the alternative j when the decision maker will choose the variant i. The problem is to determine the optimal strategy for the decision maker such as he will obtain at least the utility U_{ij} .

Usually for this problem is used the method of the minimisation of the lost. But this method applied for the criteria of the minimisation of the average lost U

$$U = \sum_{i,j=1}^{m} U_{ij} p_{ij} \tag{27}$$

do not take into consideration the unpleasant surprise generated by the concurrent who could choose an unfavourable variant for the decision maker, with a great probability.

The distribution of the probability of loss takes into consideration the surprise effect. If the homogeneity of the distribution increases the predictability of the events decrease.

For such a situation, taking into consideration the well-balanced entropy

$$H_G = -\sum_{i=1}^{m} U_{ij} p_{ij} \lg p_{ij} \tag{28}$$

it will be considered also the unpleasant surprise generated by the concurrent who could choose an unfavourable variant for the decision maker with a great probability.

5. CONCLUSIONS

The movements of goods from supplier to receiver imply the change of different modes of transport and a lot of inter-modal and logistic operations. The complexity of the transport activities is well to be measured using different indicators.

The indicators are also necessary for ranking the different systems of transport, for characterize the informational and operational connexions in the hubs and in junction's points.

There is not only one possible system of indicators.

The proposed indicators do not completely cover the multimodal transport problems, but each of them clarifies same important and new aspects.

The suggested algorithm achieves a connexion from the multimodal transport problems and the multi-criteria linear optimisation problems.

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