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EFFICIENCY AS AN ASSESSMENT MEASURE OF WAREHOUSE FACILITIES LOCATION IN LOGISTICS NETWORK

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Abstract

The paper presents an approach to the assessment of the location of facilities in the warehouse logistics network with the efficiency of its operations. Determination of efficiency of complex systems of this type should take into account wide range of issues. The system efficiency results on the one hand from the efficiency of its action and on the other hand from the ability to use available system elements to achieve the objectives. Efficiency is a main criterion to the evaluation of the activity both at the level of the whole system, as well as in its subsystems or components. Most often, it refers to the principle of rational management formulated in two variants: performance (maximization effect) and economical (minimizing effort). The article poses the thesis that based on studies of speed and reliability of execution of tasks it is possible to assess the potential locations of warehouse facilities in the studied logistics network. Were also presented factors affecting the efficiency of the functioning of individual cells of the logistics network. Was pointed to the technical, economic, organizational and reliability aspects affecting the efficiency and reliability of the logistics network in terms of both supply and distribution. It was also presented a modular block diagram of an assessment method for localizing logistics facilities in the logistics network.

Keywords: *efficiency, logistics network, location*

1. Introduction

Economic activity at every level of management (micro, meso, macro) and in every sector of the economy (private, public) is most commonly assessed in terms of efficiency. Wherein efficiency is defined differently. Very often, the efficiency is identified with the effectiveness in terms of achieving the goal or productivity without reference to the effective operation or focus the efficiency on resource allocation in the sense of Pareto optimum [21].

In contrast, in the theory of system efficiency is defined as the adaptation of the system to perform tasks [6]. Typically during systems analysis are taken into account:

- the potential efficiency of the system, expressing the rated capacity of the system, allowing the achievement of the objectives of functioning,
- realized efficiency, expressing a degree of capacity utilization of the system in the process of implementing specific purposes and under certain conditions,
- obtained efficiency, expressing the value of the results obtained in the process of implementation of specific objectives, as a result of realization of a particular system function.

Speaking about the operational efficiency of the logistics network, we mean both characteristic a total logistics system and process of its operation, expressing the assessment of the impact of the functioning of the system. Efficiency of the technical system which is the logistics network, in terms of normative is however the degree of implementation of tasks given to system, taking place in certain operating conditions and for a specific period [6]. As it is known, the location of logistics network elements, which are warehouse facilities, affects both the costs and the quality of action of the whole logistics network. For this reason, it appears advisable to take into account the level of efficiency of the completely logistic network during the location of new warehouse facilities.

In the literature can be found the following division of efficiency [25] (Fig. 1):

a) **organizational** concerning the functioning of the system – is defined as the adaptability of the system to changes in the environment and productive use of its resources to set objectives,
b) **technical** associated with maximizing the volume of production using given expenditures to its leading. Wherein on the choice of technology affects two components: to maximize production volume and minimize manufacturing costs.,
c) **economic** (allocative) concerns rational management, its measures are relationships between increments effects and inputs, or a total effects to partial expenditures:

- productive (in production sphere),
- allocative (in production and structure sphere).

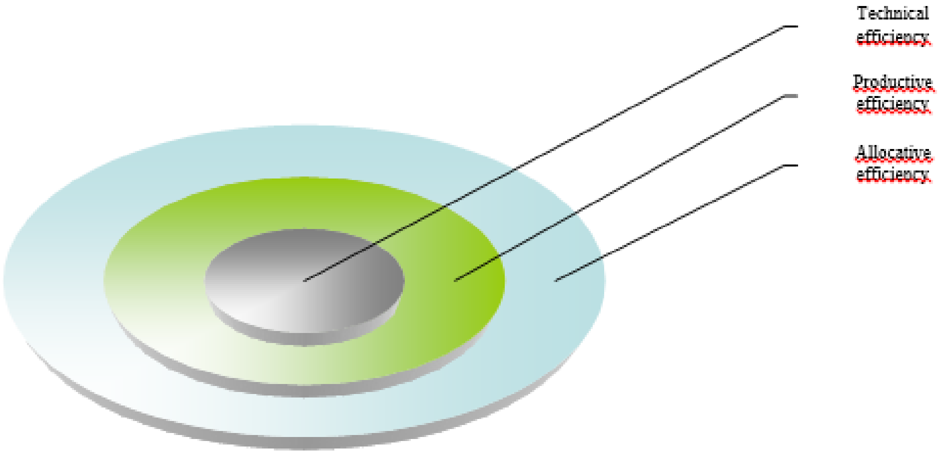

Fig. 1. The relationship between technical, productive and allocative efficiency

In assessing the operation of the logistics network should therefore take into account both economic efficiency, which expresses the relationship between expenditures and results achieved, and is also its evaluation, as well as technical, which is determined by the difference between the results obtained (or expenditure) and the result of such a relationship for the "best model" (which may be determined theoretically or empirically) [21]. Technical efficiency can be expressed as the potential to reduce inputs used to generate a given amount of results or the potential to increase the number of results at a given amount of expenditures.

To sum up, the system efficiency results on the one hand from the efficiency of its action, namely the achievement degree of the objectives of system operation, on the other hand from the ability to use available system elements to achieve the objectives. Whereby the degree of realization of set goals can be defined as the system effects, while expenditures correspond to the size of the resources involved in achieving the objectives [3]. Thus, the system efficiency also expresses the assessment of its operations.

2. Logistics network

According to [3, 5, 8, 23] logistics network is cooperating in various functional areas of mining, production, trade and service companies and their clients, between which flow streams of products, information, and financial resources (Fig. 2).

Modern logistics networks are becoming increasingly complex, thereby increases their exposure to noise and danger. As a result, decreases the efficiency of given logistics network.

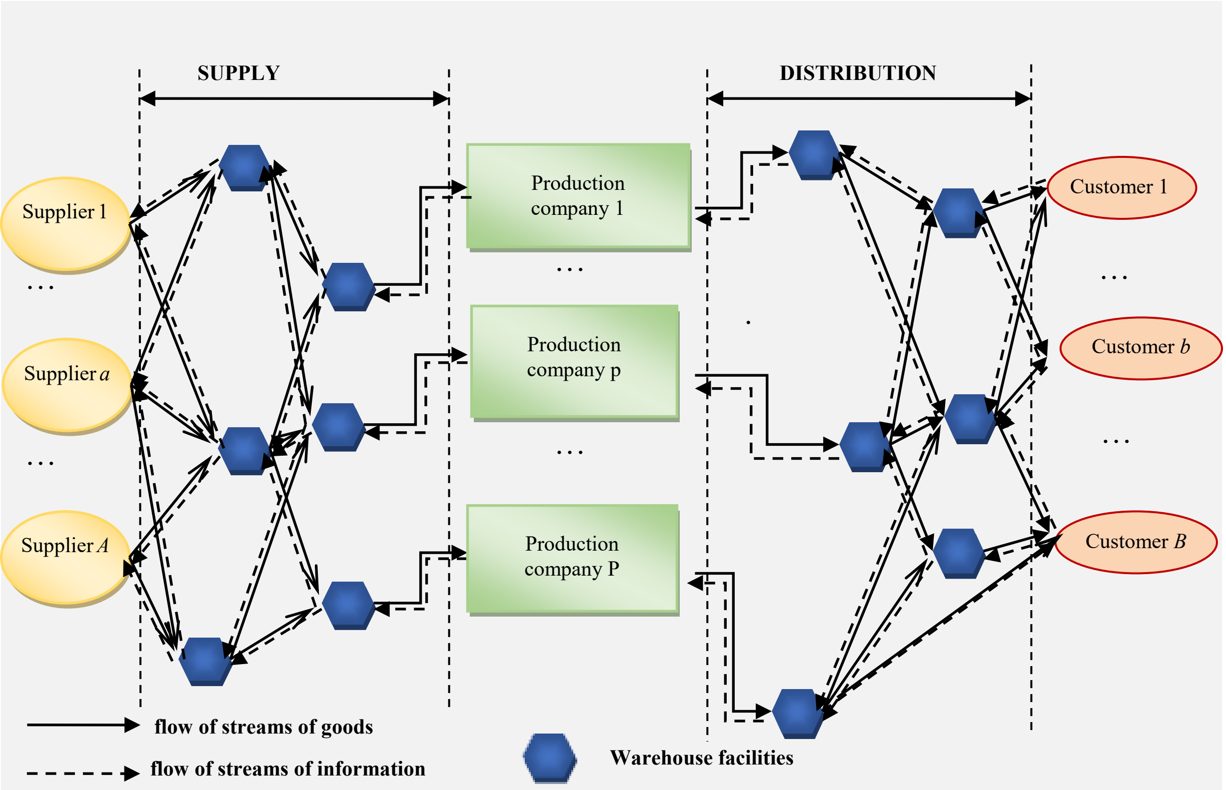

Fig. 2. Logistics network

Changes of functioning, resulting e.g. from the increase in moving cargo or a new network configuration, of existing logistics networks cause that it is justified to assess their efficiency and their comparison to ideal solutions in given market conditions. At the same time, in the case of new warehouse facilities location, it is necessary to identify the cost of reconfiguration of existing logistics networks to their more efficient form.

3. Efficiency as location assessment measure

Efficiency studies can be made depending on the time horizon in which the analysis is made, and by this different understanding of business objectives. The long-term prospect of defining the ability to grow and develop is called dynamic whereas static efficiency (in short-term horizon), focuses on avoiding wastage of owned (currently) resources and their best allocation.

The static economic efficiency of the logistics network activity is analysed in two aspects: productive and consumption. Productive efficiency is an economical expression of technical efficiency, does not guarantee, however, that maximize customer satisfaction of logistics services. Achieving this state requires allocative efficiency in the sphere of consumption and in the sphere of the production structure. Full allocative efficiency therefore means that of all the solutions of effective warehouse location were selected only those provide the greatest satisfaction for recipients of services. That full allocative efficiency is identified with the total economic efficiency, which means that from given resources has been, achieved the highest possible level of satisfaction. In addition, because satisfaction comes from the consumption of services, then economic efficiency requires the greatest possible level of production, i.e. technical efficiency.

Efficiency is a main criterion to the evaluation of the activity both at the level of the whole system, as well as in its subsystems or components. Most often it refers to the principle of rational management formulated in two variants: performance (maximization effect) and economical (minimizing effort) [24]. Efficiency is understood as the relationship between expenditures and effects can be defined as:

1) the difference between effects and expenditures (Present Value, PV). The desired result should be greater than zero, which means that the results achieved are greater than the expenditures,
2) dividing effects to expenditures (Benefit-Cost Ratio, B/C ratio). The desired result should be greater than one, which means that expenditures are lower than achieved effects,
3) expressed as a percentage quotient of the difference between effects and expenditures to expenditures (return on investment ROI). [25]

Measures of efficiency can be divided into:

– **indicators**. Indicators analysis comes down to constructing the relationship between various magnitudes. The choice of indicators depends on the purpose of research. Can be used single or set of indicators or develop synthetic measures,
– **parametric**. Parametric methods are based on appropriate solving of optimization problem. Parametric methods are used for models with well-defined structure. From the form of the structure depends an adequate number of estimated parameters. For parametric efficiency measurement are used both deterministic and stochastic models,
– **nonparametric**. These methods do not require knowledge of the functional relationship between expenditures and outcomes. They are characterized by greater flexibility, because the structure of models is not fixed, but is adjusted according to data. The non-parametric approach uses linear programming procedure, however is not taken into account the effect of the random factor on the efficiency of facilities and potential errors of measurement.

Methodical concepts concerning research of the logistics system efficiency are characterized by different ranges, levels of detail and the split criteria. Especially important is the mechanism of indicators construction.

Fairly wide range of indicators and measures of logistics systems assessment can be found in [2, 7, 18, 20, 24, 25]. As a quantitative assessment indicators of transport subsystem authors suggest tonne-kilometres performed, the number of consignments, the actual working time of means of transport, the amount of goods carried, transport costs per tonne-kilometre and per consignment, degree of utilization of working time and transport possibilities of available transport resources.

Interesting approach taking into account proecological aspect when constructing measures can be found in positions [1, 15, 18, 19].

Given the above, it can be concluded that to the assessment of adaptation different structures of the logistics system, including the logistics network is necessary systematized arrangement of values. Included together parameters, measures and quantified measurable factors, subordinated to the assessment criteria and their weights and hierarchy, form a layout of values to evaluate the system. The layout of values should contain:

– technical and economic parameters, and methods for their identification,
– measures of assessment and assignment of particular parameters,
– factors difficult to measure (not measurable),
– criteria for evaluation and selection of variants.

As criteria for assessing, the efficiency of logistics processes can be used: the criterion of time of flow of materials and information, the criterion of level of service quality and service, the criterion of minimizing costs and the criterion of operability of operation. With regard to assessing the efficiency of supply, chains can be distinguished:

1) technical indicators, including among others:
   – number of means of transport,
   – number of means of transport working hours,

   - number of driven km,
   - number of km per means of transport,
   - number of failures of means of transport.
2) economic indicators, including among others:
   a) absolute measures:
      - transport costs,
      - value of the means of transport,
      - depreciation cost of mean of transport,
      - personnel costs of transport department.
   b) relative:
      - the share of transportation costs in total costs.
      - transport costs per unit of value of transported goods and products,
      - maintenance costs of means of transport per month, a year,
      - costs per tonne kilometre.

Efficiency measurement can have many uses. Among them can be distinguished among others: selection of means of transport to tasks, the choice of applied technologies, increasing productivity of logistics processes, reducing the execution time of tasks, reducing the cost of e.g. reduction in fuel consumption, etc. To compare the efficiency of the functioning of the variants of location choice of warehouse facilities is necessary to define and determine the implementation effects of processes for each of the variants. The result is a gain (or loss) arising from the used variant location of warehouse facilities in logistics network. This can also be a difference between the values of measures obtained for different variants. Therefore for a single warehouse object *v*, $v \in \boldsymbol{V}$ efficiency can be determined as the quotient of difference of the values of measures (criteria) for a potential object and the value of measure of variant set as standard (e.g. existing), i.e..:

$$\forall k \in \boldsymbol{K} \ , \forall v \in \boldsymbol{V} \qquad \Delta\Xi(k,v) = \frac{\left|\Xi(k,v) - \Xi(k,v_b)\right|}{\Xi(k,v_b)} \cdot 100\% , \tag{1}$$

where:

$\Delta\Xi$ – the efficiency of operation of *v*-th object due to the *k*-th criterion, $k \in \boldsymbol{K} \ , v \in \boldsymbol{V}$

$\Xi\Phi$ – value of *k*-th operating efficiency measure of *v*-th object,

$\Xi(k,v_b)$ – standard value of *k*-th operating efficiency measure of *v*-th object due to the *k*-th criterion.

Calculation of the value of efficiency $\Delta\Xi(k,v)$ allows answering the question how much a percentage due to the *k*-th measure the value of efficiency of potential location differs from the standard value $b\Xi\Phi$.

In Fig. 3, was presented a modular block diagram of an assessment method for localizing logistics facilities in the logistics network.

As mentioned earlier in assessing the efficiency usually must take into account more than one measure therefore in assessing the choice of location should be taken into account other criteria, and as a result we get vector of efficiency assessments, i.e.:

$$\forall v \in \boldsymbol{V} \qquad \Delta\Xi(v) = \left[\Delta\Xi(1,v),...,\Delta\Xi(k,v),...,\Delta\Xi(K(v),v)\right], \tag{2}$$

where:

K(*v*) $\Delta\Xi$ – number of measures used to measure the efficiency of operation of *v*-th object, $v \in \boldsymbol{V}$.

At the same time should not be forgotten that the warehouse facility location also affect the efficiency of other elements of the logistics network and thus the efficiency of the entire logistics network. Therefore, when deciding on the choice of location, you have to select an object that meets the criteria of efficiency due to its location (e.g. the position due to the access to the road or the low cost of rental) and in the next step, to analyse the chosen variant due to the efficiency of the whole network.

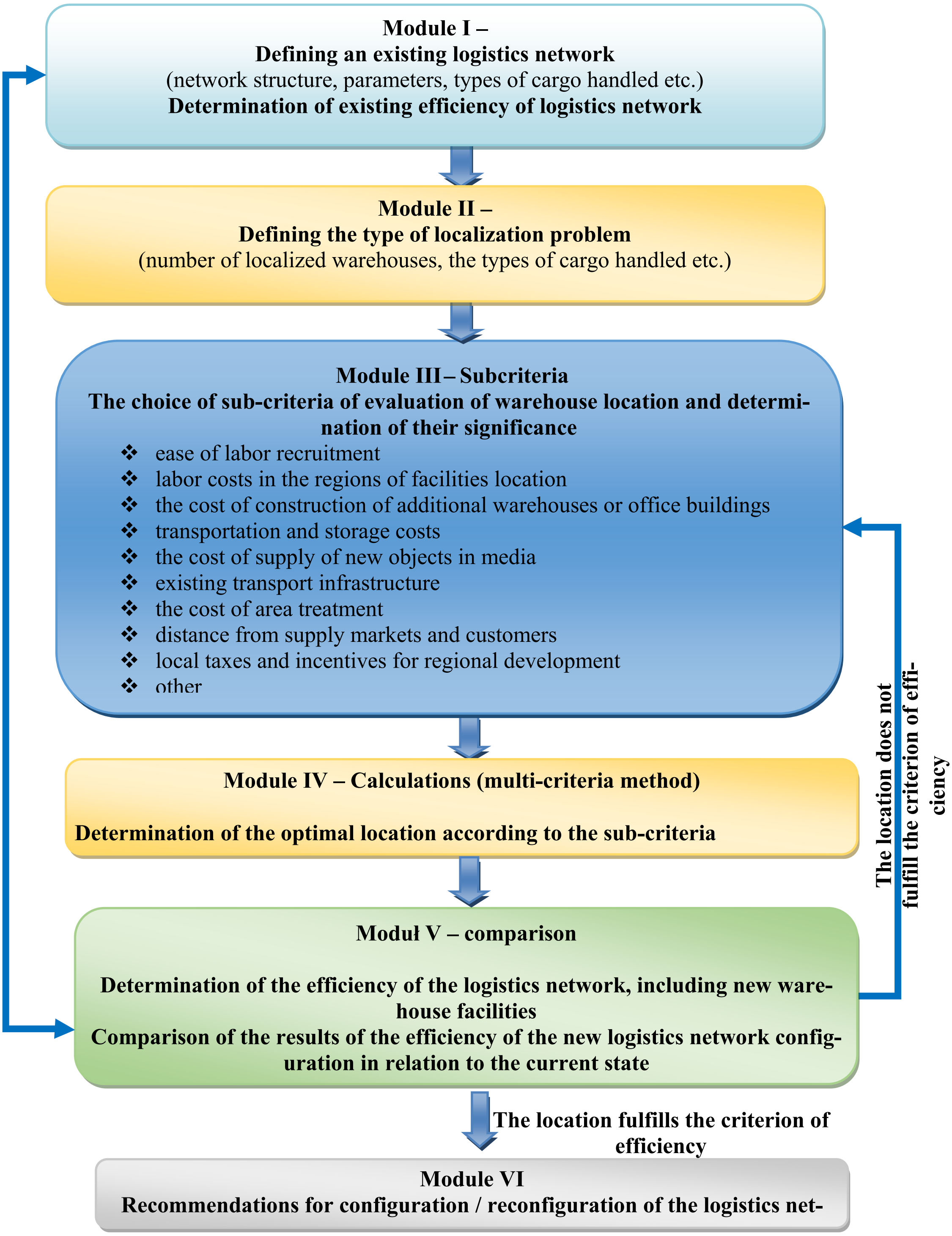

Fig. 3. A schematic flow diagram of an algorithm for the method for assessing the location of warehouse facilities

Conclusions

Assessment of efficiency of the logistics network action may relate to the degree of use of its components and the entire network. For this reason, proposed in the article indicators and criteria can be used both to evaluate the entire system, and after minor modifications for evaluation of its subsystems or components. The proposed criteria for assessment of proecological transport systems enable an assessment of the efficiency of action of transport system taking into account various limits on the ecology. The inclusion of environmental aspects in the assessment of the transport system, including variants of its shape, it is necessary, among others, in the analysis of innovative technologies and legal instruments enforcing proecological activities.

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