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## METHODOLOGY FOR EXPERT EVALUATION OF MULTIMODAL CARGO TRANSPORTATION ROUTES

**Summary.** The multimodal transportation of transit cargo is suitable for implementation through Bulgaria in the East-Northwest direction through the sea and river ports of the country as an alternative to the Romanian and Greek routes. Among the multimodal routes with a land leg through Bulgaria used and known so far, those via two seaports (Burgas and Varna) and three river ports (Ruse, Svishtov and Vidin) are most suitable. An expert evaluation methodology for selection of the most appropriate route is developed, including the Delphi method. A survey was conducted among 11 highly ranked and internationally recognized Bulgarian experts, known for their exceptional experience in the field of freight forwarding and international cargo transportation through Bulgaria. The results of the study show that the most suitable route for transit transportation is through the ports of Varna and Ruse with intermediate road haulage.

### 1. INTRODUCTION

To promote solutions for the efficient and balanced use of the transport modes, the involvement of maritime, inland waterway and rail transport is encouraged, including through the provision of tax incentives and funding under various programs [10]. The selection of an appropriate transport route is the basis of the permanent activity of the freight forwarders [6]. Some countries, such as Switzerland, have started to impose restrictions on the carriage of goods by road due to environmental reasons [7], high level of risk of road accidents, especially when transporting dangerous goods [22], and the impact of noise from road, rail and air transport on people through day and night [13, 18].

The development of multimodal transport technologies is part of the European transport policy and is included in the main Community strategy papers as well as in the national ones. The different modes of transport are offered in a common consolidated mode and become more integrated and coordinated [11]. Also, to facilitate the work related to document processing, information and communication technologies studied in [8] are implemented. At present, multimodal transport systems are at the heart of international trade with the aim of reducing overall transport emissions [20] and handling costs within the supply chain while meeting the demand for door-to-door freight services [2]. [5] presents an example of how the use of a combination of different transport modes underlies the development of 5PL by Contract Warehousing New Zealand Limited. Some of the main key benefits that make multimodal transport an attractive opportunity for private and public stakeholders [14], as well as for synchromodal freight transport systems [12], include saving costs and time due to the optimal use of each mode of transport at each stage of the journey [21]; greater return on infrastructure investment; better utilization of capacity as a result of optimal use of each mode; lower energy consumption; and reduction of the harmful effects of transport on the climate and environment.

A detailed comparison of railway routes enabling freight transportation from the eastern border of Poland to the west [15] has been performed based on technical parameters. An optimal road route

selection criteria system for oversize goods transportation [16] has been proposed for the Baltic Sea region based on parameters of a technical and logistic nature. Joint optimization of schedule and route in a container supply chain [17] has been developed based also on parameters of a logistic nature.

The advantages of the multimodal transport facilitate the transit cargo transportation through the Republic of Bulgaria with the use of waterway transportation. The cargo flows arriving or departing by ship through the Black Sea can be handled in the Bulgarian seaports, transshipped onto road or rail transport and continue their journey again by ship on the Danube River. In this respect, various combinations on such transit routes are possible and the most appropriate, safest and feasible one should be determined. For this purpose, a methodology was developed and a survey was conducted among a group of highly ranked experts with national and international recognition and many years of experience in the freight forwarding and transport industry to determine the most suitable bimodal and trimodal transit routes through Bulgaria.

## 2. METHODOLOGY FOR EVALUATION AND SELECTION OF MULTIMODAL ROUTES THROUGH BULGARIA

The method of expert evaluation is appropriate for assessing the multimodal transport quality. Expertise is a system of evaluation actions performed with the involvement of experts and applied to informal or weakly formalized data when the necessary evaluation information cannot be obtained experimentally [4, 19]. Expert evaluation is a multi-stage process in which the following points are determined and specified: the object of evaluation; the purpose of the expertise; the type and contents of the expert assessment; the set of allowed values of the assessments; the number of experts; and the manner and rules for conducting the expertise.

The following main tasks arise during the expert evaluation:

- Assessment of experts' competence;
- Summary assessment based on the individual assessments of experts; and
- Assessment of the reliability of the results according to the criterion for coherence of the opinions.

Depending on the object and purpose of the expertise, different assessment methods are used:

- Comparison in pairs, in which the elements are compared two by two;
- Ranking, when each element is assigned a rank determined by defined rules;
- Classification, when each element of the considered set must be allocated to one of several predefined groups; and
- Numerical coding according to a certain correspondence, when the information has non-numerical characteristics. The non-numerical nature must be taken into account in their interpretation.

When it is impossible to use other quantitative measures and experimental data (and this is the highly prevalent case), information on the state of a system can be obtained through expert evaluation. Established highly qualified specialists in the field of forwarding and logistics, suppliers and users of transport services with many years of experience are approached as experts.

To perform a generalized expert assessment, the opinions of experts can be processed by mathematical methods and aggregate quantitative values of the overall opinion can be obtained [1]. The main characteristics of the group expert evaluation are the generalized opinion of the experts, their competence and the coherence of their opinions [19].

### 2.1. Methodology for expert evaluation

The sequence of steps in the evaluation methodology is shown in Fig. 1.

#### **Determining the purpose of expert evaluation**

The objectives of the peer review may be related to the following:

- Assessment of the object on an accepted scale by summarizing the opinion of experts;

- Making a decision on an issue; and
- Increasing the validity of decisions in case of partial uncertainty, contradictions or conflicts.

#### Defining criteria for transport service quality

Depending on the goal, the evaluation criteria are defined.

#### Determining an evaluation scale

An assessment scale is defined, for example, a bimodal Yes–No scale; a 10-degree scale; a 100-degree scale, etc.

The reliability of the expertise depends on the number of experts involved. The small number does not allow sufficient statistical reliability and sustainability of the assessment and individual experts have a significant impact on the outcome of the summary assessment, which increases its subjectivity.

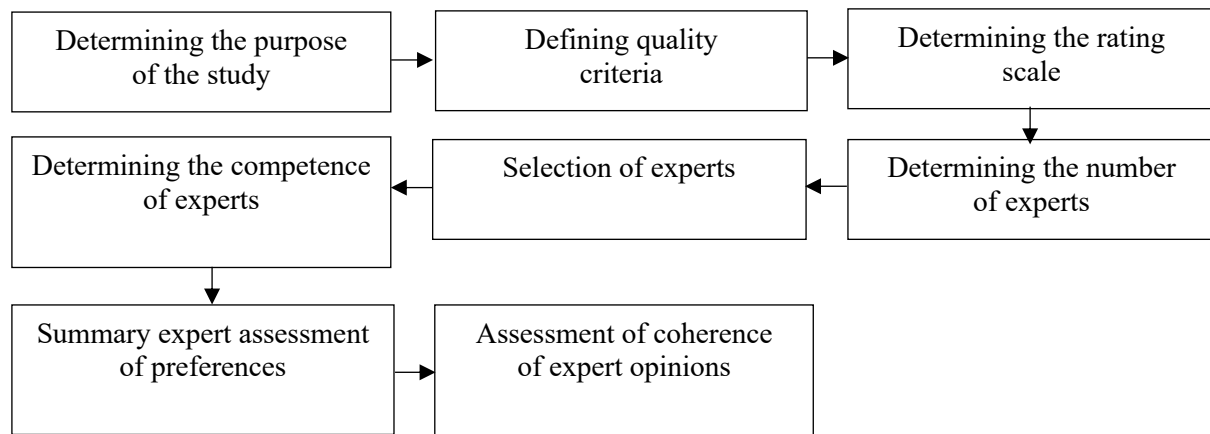


Fig. 1. Methodology for expert evaluation

The large group also has its drawbacks. It is difficult to reach an agreed opinion, the influence of the leaders and the dependence on the opinions expressed by them is growing, there might not always be a sufficient number of competent experts and organizational difficulties occur in conducting the expertise.

The increase in the number of experts in the general case leads to an increase in the reliability of the expertise. At the same time, it should be borne in mind that the number of experts can be reduced without compromising reliability and objectivity if specialists with higher competence are selected.

In the theory of expert evaluation, it is accepted that the optimal number of experts is in the range  $7 \div 20$ .

#### Selection of experts

The requirements for the experts for their competence are defined in advance. One of the criteria that can be used as a summary is the length of service in the subject field. The main requirements for the experts are as follows: high level of general erudition; scientific and vocational training and experience in the evaluated field; good information about the level of quality of the object of assessment; intuition and ability to think ahead; common sense; ability to reason by analogy; receptivity to innovation; absence of conflict of interest; and impartiality in evaluation. An extended list of  $N$  experts is created, the number of which is more than the required  $M$  experts.

The *expert competence factor*  $k_o$  can be expressed as follows:

$$k_o = f(d_i, k_z, k_a), \quad (1)$$

where  $d_i$  is the reliability of the expert's judgments;  $k_z$  is the degree of knowledge on the issue under consideration; and  $k_a$  is the justification factor.

The *reliability* of the expert's judgments can be determined on the basis of information about his/her past experience in solving problems relevant to the subject of the expertise  $d_i$ .

The *degree of knowledge*  $k_z$  of the discussed problem (the object of the expertise) by the expert is reported in the general expert competence factor  $k_o$ , and test methods can be used to establish this value.

The structure of the arguments, on which basis the expert forms his/her opinion, is presented by the justification factor  $k_a$ , which is determined by his/her familiarity with the sources of information and argumentation and taking into account the influence of the source. This can also be determined by an appropriate test. The values given below correspond to:

$k_a = 1$  - high degree of influence of the source on the expert's opinion;

$k_a = 0.8$  - average degree of influence; and

$k_a = 0.5$  - low degree of influence.

There are various methods for determining the competence of experts and some of them are as follows:

- Subjective: self-assessment; mutual evaluation; and differentiated method.
- Objectified: test methods (when experts are "tested" for competence) and deviation method.

The test methods can be applied alone or as a supplement to the subjective ones.

The subjective methods take into account the above-mentioned components of the competence and the necessary qualities of the expert, but there are no objective measures for this and it is the responsibility of the experts themselves.

Among the subjective methods, the method of mutual evaluation known from the literature is considered to be the most adequate here. The method has some disadvantages:

- Attempt to eliminate opponents;
- Manifestation of interpersonal relationships;
- Unawareness of the competence of some of the participants, etc.

Despite these weaknesses, the method of mutual evaluation is superior to other methods, such as the self-assessment method. Combined with test methods, it can yield good results, which is why it is offered with significant changes.

#### **Determining a summary assessment of the object based on or by comparing individual assessments of experts**

For this purpose, average values are used: arithmetic mean or, very often, median.

#### **Evaluation of the reliability of the results according to the criterion for coherence of the opinions of the experts**

A dispersion factor of concordance is used to assess the degree of coherence of the experts' opinions. This ratio compares the variance of expert opinions  $S^2 = \frac{\sum_{j=1}^n (r_j - \bar{r})^2}{n-1}$  with the maximum possible variance  $D_{\max} = \frac{N^2(n^3-n)}{12(n-1)}$  and is calculated by the following formula:

$$W = \frac{12 \cdot \sum_{j=1}^n (r_j - \bar{r})^2}{N^2 \cdot (n^3 - n)}, \quad (2)$$

where  $N$  is the number of experts;  $n$  is the number of statements; and  $r_j$ ,  $j=1, 2, \dots, n$ , are numbers showing the sum of the ranks of the statements awarded by the experts. From these, as a result of the evaluation, average ranks of the statements are calculated as  $d\bar{r}_j = \frac{\sum_{j=1}^N r_j}{N}$ .

#### **Delphi method**

The Delphi method is for expert prediction through factor analysis, statistical processing and correction after each cycle of processing of results [3]. The method aims to iteratively reconcile the opinions of experts if the concordance factor is not high enough. The opinion of each expert is compared with the overall result obtained from the model. The results are not reported in order to avoid the distorting effect of the suggestion or adjustment to the opinion of the majority. A consultation is conducted in several rounds (usually two or three) and, after each round, a discussion is held to clarify the reasons for the evaluation. The Delphi method has been successfully applied in risk assessment by experts in multimodal transport and subsequent optimization of freight delivery routes in large logistic companies in Thailand and Vietnam [9].

#### **Algorithm for increasing the degree of coherence**

Based on the considered methods, an algorithm for increasing the level of coherence between experts is proposed (Fig. 2). An evaluation model is chosen, which determines the aggregate value of

the expert evaluation. The concordance factor  $W$  is calculated and it is established whether its value is acceptable for verification of the assessment. If not, the Delphi method is applied and the coherence is checked again. Thus, coherence should be reached after a few cycles.

## 2.2. Expert assessment of the transport operator/forwarder for the service quality in multimodal transport

The study had the following stages:

Stage 1. Development of a work plan for evaluation of the quality criteria for multimodal transport.

Stage 2. Determination of the number of experts: it is planned to invite 20 experts.

Stage 3. Defining of a requirement for the qualification of the experts: to attract highly qualified specialists as experts from forwarding and logistic companies as well as specialists engaged in logistics in trading companies. Experts had to have at least 20 years of experience in the field.

Stage 4. Defining the task: Development of a system of criteria, together with their weight, comprehensively reflecting the interests of operators and customers in the transport and logistics chain. More radical approaches can also be sought, excluding the most remote expert assessments.

Stage 5. Determination of an evaluation scale: A scale from 0 to 100 is selected.

Stage 6. Questionnaires with the defined criteria are sent; the purpose of the research is explained.

Stage 7. Experts wishing to participate in the study prepare their answers. 11 of 20 invited experts participated in the study. The respondents have many years of experience in forwarding and transport and work at the management level in companies, organizations or government institutions as described below.

1. In the working group on road transport at the International Federation of Freight Forwarders Associations (FIATA) and the National Association of Bulgarian Freight Forwarders (NSBS).
2. Ship broker in the Balkan Shipping and Crew Agency and long-term commercial director of the former state-owned shipping company BRP.
3. In the European Association for Forwarding, Transport, Logistics and Customs Services (CLECAT), FIATA, NSBS and Trans Express EOOD.
4. In the department of "Strategic Development, Port Services and Ecology" within the State Enterprise "Port Infrastructure" (DPPI) of the Ministry of Transport, Information Technologies and Communications.
5. In the freight forwarding company Unishipping International.
6. In the freight forwarding company Veslam Shipping EOOD and NSBS.
7. In the freight forwarding company SIKO Trans AD and NSBS.
8. In the freight forwarding company Alog EOOD and NSBS.
9. In the international company Cargill.
10. In the freight forwarding companies Etna Cargo EOOD, Etna Transport OOD and NSBS.
11. In the freight forwarding company Scorpion Shipping EOOD, FIATA and NSBS.

The obtained answers are presented in Table 1.

Stage 8. Complex assessment.

The median and average of each of the criteria were determined depending on the assigned grades by the experts. The results are presented in Table 2.

Stage 9. Coherence of expert opinions.

- 1) Determination of the concordance factor.

$$W = 0.14.$$

- 2)  $W < 0.8$ ; therefore, there is a low degree of coherence between expert opinions.

- 3) Assessment of the significance of the concordance factor.

The following statistical hypothesis is tested:

$H_0$ : Disagreement among experts, or

$H_1$ : Unanimity of experts.

Pearson's criterion  $\chi^2$  is applied.

For this purpose, the empirical value  $\chi_{emp}^2$  is calculated based on the concordance factor, the number of experts and the number of different questions in the survey.

$$\chi_{\text{emp}}^2 = 19.12.$$

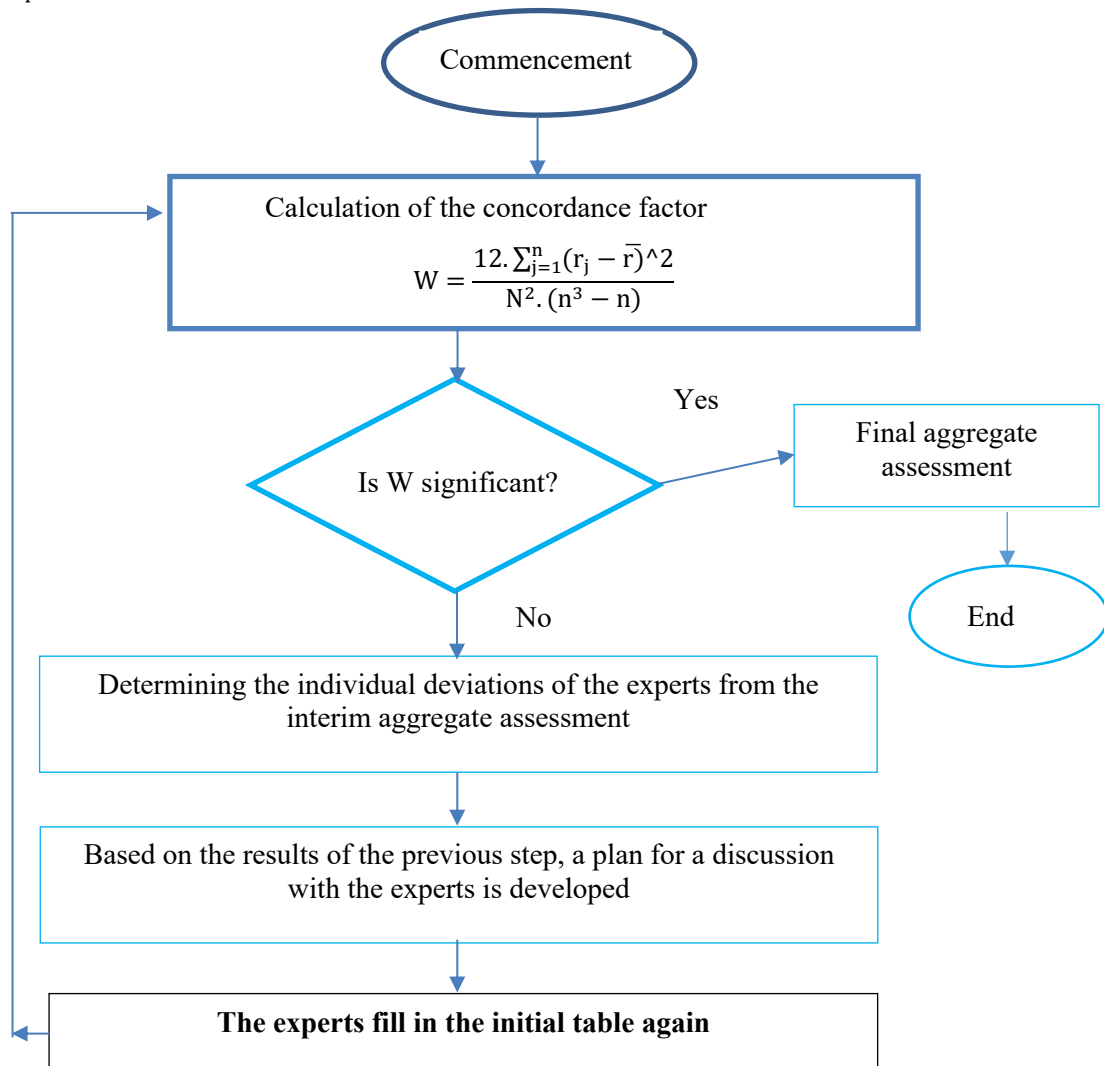


Fig. 2. Algorithm for increasing the degree of coherence of the expert decision

The obtained value is compared with the tabular (theoretical) value  $\chi_t^2$  at 12 degrees of freedom (13-1) and significance level  $\alpha = 0.05$ . Since the empirical  $\chi_{\text{emp}}^2 = 19.12$  is smaller than the tabular (theoretical)  $\chi_t^2 = 21.02607$ ,  $W = 0.14$  is a statistically insignificant value. This means that at this stage, it cannot be stated that there is unanimity in the opinion of experts.

By applying the Delphi method, a discussion should be held with the experts to discuss the objectives of the study, the criteria and their quantitative evaluation (metric expression).

Stage 10. A discussion on the criteria is held and the experts give answers again.

Stage 11. Completion of the answers by the experts after the discussion.

Stage 12. The implementation of stage 9 is repeated with the new data and in case of coherence in the opinions of the experts; stage 8 is performed for the complex assessment.

The recalculated values are as follows:

$$W = 0.18;$$

$$\chi_{\text{emp}}^2 = 24.2; \text{ and}$$

$$\chi_t^2 = 21.02607.$$

It is obvious that  $W = 0.18 < 0.8$ , i.e., again, it is relatively small, but from verification of its statistical significance  $\chi_{\text{emp}}^2 > \chi_t^2$ , it follows that it cannot be ignored, i.e., there is a slight but statistically significant consolidation in the opinion of experts.

Table 1

Answers of the experts

Criterion	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11
1. Low total cost	75	99	50	95	40	100	90	50	60	100	90
2. Sustainability of cost over time	50	80	80	90	60	50	90	70	80	100	80
3. Accurately predictable cost for pricing purposes	50	90	50	80	50	35	70	100	80	90	80
4. Reliability of the route	75	70	80	85	65	100	20	100	90	100	90
5. Guaranteed delivery term	70	80	50	80	55	35	10	95	70	30	80
6. Minimum transshipments	30	85	30	85	70	35	10	10	70	95	90
7. Lower risk of loss and damage	60	85	50	80	50	35	10	10	90	100	90
8. Flexibility of the route – options for temporary interruption, acceleration or delay of the delivery	30	80	90	90	45	100	60	90	50	30	80
9. Minimum storage time	30	90	50	90	50	35	10	90	60	45	70
10. Minimum stay of the engaged vehicles	40	90	90	90	70	100	90	90	70	45	70
11. Minimum number of modes of transport involved	20	95	50	90	70	35	30	85	60	45	90
12. Synchronization between separate operations/stages in the transportation process	60	85	90	85	50	100	70	100	70	90	80
13. Lower harmful emissions	50	80	90	95	50	100	50	90	90	95	90

**New complex assessment, performed in accordance with stage 8, by determining the average and median.**

The average and median of the answers for each criterion are determined. The ranking of the first five criteria is made in the following order:

Low total cost (in both cases) - Criterion 1;

Reliability of the route (in both cases) - Criterion 4;

Minimum stay of the involved vehicles (in both cases) - Criterion 10;

Lower harmful emissions - Criterion 13;

Synchronization between the separate operations/stages in the transportation process (in both cases) - Criterion 12;

Sustainable cost over time - Criterion 2.

To formulate the model, the weighting factors  $k_j$  are determined, formed by the arithmetic mean estimates of the values of the criteria

$$k_j = \frac{\bar{r}_j}{\sum_{j=1}^{13} \bar{r}_j}, (j = 1, 2, \dots, 13). \quad (3)$$

The variables  $X_j$  take the value 1 if the respective factor is included in the complex estimation of the model and 0 if it is not included.

$$F_{cp} = 0.09(X_1 + X_4 + X_{10}) + 0.08(X_2 + X_3 + X_{12}) + 0.07(X_5 + X_6 + X_7 + X_8 + X_9 + X_{11} + X_{13}) \quad (4)$$

Similar to the median

$$F_M = 0.09(X_1 + X_4 + X_{10} + X_{12} + X_{13}) + 0.08(X_2 + X_3 + X_8) + 0.07(X_5 + X_6) + 0.06(X_7 + X_9 + X_{11}) \quad (5)$$

Table 2

Ranking of criteria by both methods, average and median

Criterion	Average	Criterion	Median
12. Synchronization between separate operations/stages in the transportation process	80.00	1. Low total cost	90
4. Reliability of the route	79.55	10. Minimum stay of the engaged vehicles	90
1. Low total cost	77.18	13. Lower harmful emissions	90
10. Minimum stay of the engaged vehicles	76.82	4. Reliability of the route	85
2. Sustainability of cost over time	75.45	12. Synchronization between separate operations/stages in the transportation process	85
13. Lower harmful emissions	75.45	2. Sustainability of cost over time	80
3. Accurately predictable cost for pricing purposes	70.45	3. Accurately predictable cost for pricing purposes	80
8. Flexibility of the route – options for temporary interruption, acceleration or delay of the delivery	67.73	8. Flexibility of the route – options for temporary interruption, acceleration or delay of the delivery	80
11. Minimum number of modes of transport involved	60.91	5. Guaranteed delivery term	70
7. Lower risk of loss and damage	60.00	6. Minimum transshipments	70
5. Guaranteed delivery term	59.55	7. Lower risk of loss and damage	60
9. Minimum storage time	56.36	11. Minimum number of means of transport involved	60
6. Minimum transshipments	55.45	9. Minimum storage time	50

### 2.3. Expert assessment of the preferences for the used transport modes in a multimodal route

The questionnaires filled in by the experts indicate a number of combinations of modes of transport in multimodal transport routes, arranged according to the preferences of each expert. In order to quantify the priority, we accept the principle that the selected routes in import, export and transit modes should be scored with 1, 2, 3 or 4 points.

The results of the questionnaires are summarized in tabular form (Table 3 and Table 4), arranged in descending order. Due to the many combinations obtained, the two directions, i.e. the mirror transport routes for export, import and transit, are combined in Table 3 for the bimodal routes (import and export) and in Table 4 for the trimodal routes (predominantly in transit and import modes).

The following color highlighting of the export, import and transit regimes was used: export in green color; import in red color; and transit in blue color.

The main (preferred by the experts) bimodal routes are sea-road/road-sea, 43%, river-road/road-river, 20%, and sea-rail/rail-sea, 18%. In the trimodal routes, the preferences are, respectively, for the



different combinations of sea, road and river, 28%, combinations of river, railway and sea, 25%, and combinations of river, railway and road, 14%. Among the different transport modes, according to the scoring of the routes in which they participate, road remains the most preferred transport mode, 32%, followed by sea transport, 29%.

Based on these results, it can be concluded that the combinations of sea, road and river transport, i.e., sea-road-river and river-road-sea routes, are the most preferred multimodal routes for transit or re-export cargo (temporary import for export in unchanged form) through the Republic of Bulgaria.

When choosing a route for the passage of these cargo flows through the country, factors such as the geographical location of our country, respectively, the geographical location of our main sea and river ports, their capacity and the connecting infrastructure should be taken into account.

The ports of Varna and Burgas have similar capabilities and cargo turnover with certain predominance in the capacity and turnover of the port of Varna, if the liquid bulk cargo is not taken into account. On the Danube River, the port with the largest capacity and cargo turnover is Ruse.

The road connection between the ports of Ruse and Varna is in a relatively better condition and is shorter: 200 km from Ruse to Varna or 178 km to Varna-West. As a comparison, the distance between the ports of Ruse and Burgas is 250 km. The Ruse-Burgas route is not only longer but also more difficult to drive on due to the crossing of the Stara Planina mountain. For this reason, the calculated average speed on the Ruse-Varna route is 24% higher than that on the Ruse-Burgas route (Fig.3).

Given the above and the analysis of the results of the expert survey, it follows that research on multimodal transport of re-export and transit cargo needs to be conducted for the sea-road-river and river-road-sea routes through the ports of Varna and Ruse (Fig. 3).

### 3. CONCLUSIONS

A methodology for quality assessment and selection of an appropriate route for multimodal transport using the method of expert assessment is proposed. The methodology also includes the Delphi method for iterative coherence of the opinions of experts, with insufficient concordance factor. With the proposed methodology, a survey was conducted among 11 leading Bulgarian experts in freight forwarding, international transport and logistics.

The results of the research show that the Varna-Ruse-Varna route is the most preferred connection through Bulgaria between the Black Sea and the Danube River in the transit multimodal transportation on the sea-road-river and river-road-sea routes, 28%, because the speed is relatively high and passage through the Balkan Mountains is avoided.

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Table 3

Summarized results for the combined bimodal transport routes preferred by experts in export, import and transit modes

Bimodal routes	Score	Share
sea-road/road-sea	58	42.96%
river-road/road-river	27	20.00%
sea-rail/rail-sea	24	17.78%
road-rail/rail-road	16	11.85%
river-rail/rail-river	9	6.67%
river-sea/sea-river	1	0.74%
Total	135	100.00%

Table 4

Summarized results for the combined trimodal transport routes preferred by experts in export, import and transit modes

Trimodal routes	Score	Share
sea-road-river/river-road-sea/road-river-sea	31	28.18%
sea-rail-road/road-rail-sea	28	25.45%
river-rail-road/road-rail-river	16	14.55%
sea-rail-river/river-rail-sea	15	13.64%
sea-rail-river-road	4	3.64%
road-rail-road	4	3.64%
sea-rail-road	3	2.73%
sea-river-rail	3	2.73%
road-sea-road	3	2.73%
sea-road-rail	2	1.82%
river-road-rail	1	0.91%
Total	110	100.00%

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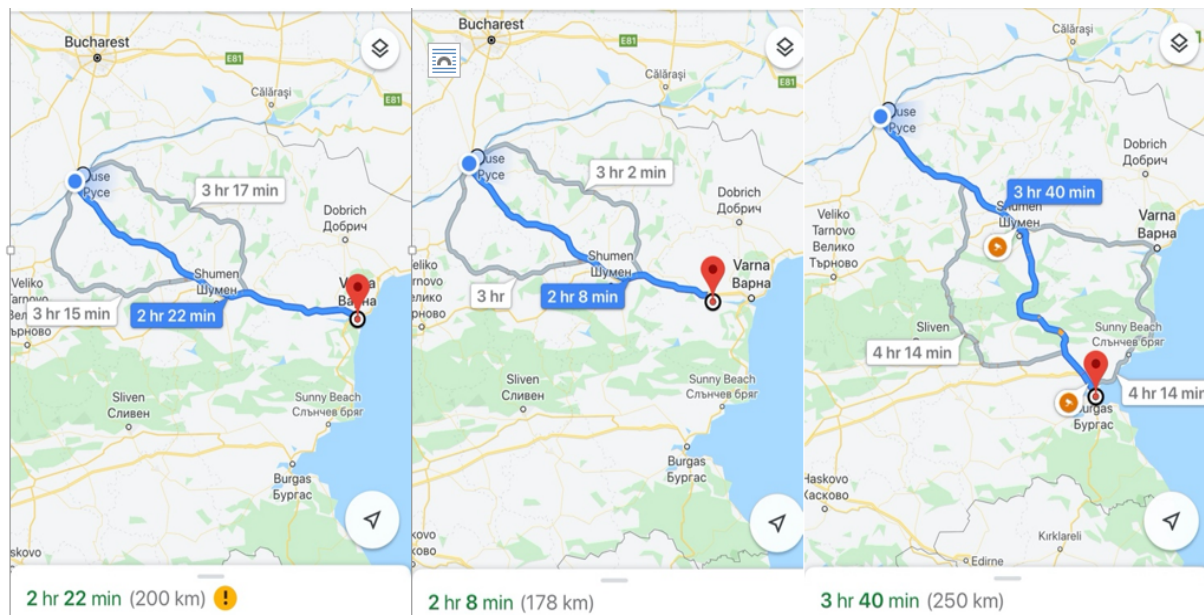


Fig. 3. Recommended Google Maps routes between the ports of Ruse, Varna and Burgas

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