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The Role of Short Sea Shipping Concept in Black Sea Region as a Connection between Eurasian Transport Systems

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Abstract: Despite of fluctuations in world trade as a result of economic cycles, the evolution of the political processes remains the trend of sustained growth of trade flows. This ends up in a rise in both the demand for logistics services and the requirements for them. In this sense, the critically important is the strategic development of the transport systems as a support for the improvement of competitive logistics. An important aspect is the promotion of multimodal transport, which in search of the best transport solutions will reduce the use of relatively expensive and environmentally unfriendly road transportation. This will be at the expense of the efficient combination of different modes in which the concept of short sea shipping (SSS) occupies a central place. Although this concept is widely applied in many places in the Black Sea, it still has significant potential. It was prompted by stagnation in economic relations as a result of political and economic crises in the region since the late twentieth and early twenty-first century. To evaluate the potential of the concept in the development of transport is done research on intermodal logistics network in the logistics corridor Central Asia-Central Europe. To optimize intermodal transport links a comparative analysis of the various transport alternatives on the route Tehran-Budapest is done. On this basis it is made optimization assessment on three main criteria—cost, delivery time and environmental protection and basic recommendations on strategic planning development of the Bulgarian transport infrastructure are given. An essential aspect is the encouragement of multimodal transportation, which in looking for the best transport solutions can cut back the utilization of comparatively costly and environmentally harmful road transportation. This would be at the expense of the adequate combination of different modes of transportation in which the concept of SSS has a fundamental area. Despite this concept is widely applied in various regions, in the Black Sea it still has an important future due to stagnation in economic relations as a result of political confrontations and economic crises within the region since the late twentieth and early twenty-first century. To assess the capability of the concept in the development of transport is done research on intermodal logistics network in the logistics corridor Central Asia-Central Europe. To improve intermodal transport links a comparative analysis of the various transport options on the routes Astana-Budapest and Tehran-Budapest are made. On this basis it is proposed an optimization assessment on three main criteria—cost, delivery time and environmental protection, and fundamental suggestions on strategic development of the Bulgarian transport infrastructure are proposed.

Key words: SSS concept, multimodal transportation, intermodal transportation, transport route optimization.

1. Introduction

The growing globalization of industry and commerce, which is increasingly characterized by a global territorial distribution of supply chains, is increasingly demanding for transport as a part of the logistics systems. In this sense, the different means of transport and the macro-framework, and in particular the transport and communication infrastructure, are constantly evolving to meet the increasing demands. Only with significant qualitative and quantitative changes in these structures is it possible to build and control internationally-oriented efficient supply chains.

The main focal point of this study is on the principal features of the Black Sea region and its connections with Central Europe and Central Asia, which due to their historical links can be considered as an almost

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homogeneous commercial space. This is in particular due to the development of the ancient Silk Road in the period of the 30th century BC-15th century AC, the belonging of parts of the region to various state formations and economic unions from the second half of the 20th century. During the period since 2008 continues the sharp geopolitical opposition between the US-dominated liberal-democratic world and the emerging economies. The expansion of historically established ties is accompanied by the change of traditional understanding of state borders in the context of the European Union (EU) and the Eurasian Economic Community (EAEC).

Multimodal transport plays a considerable role in the international logistics, and any progress in this direction provides important opportunities for achieving sustainable competitiveness. Thus, the focal aspects of the design of the transport corridors related to the logistics processes in the Black Sea region and the possible transport opportunities between Central Asia and Central Europe, as well the issues related to the intermodal capacities and the reduction of transport-related emissions, have been studied.

A crucial factor for the development of the transport sector in Bulgaria, and logistics in particular, is the favourable geographic position of the country, providing an exceptional opportunity to become a connecting transport link between the countries of Western and Central Europe, the Middle East, Western and Central Asia, as well as in the North-South direction.

The purpose of this study is to characterize the concept of Short Sea Shipping (SSS) in the Black Sea and to define the conditions for its implementation as an alternative to rail and road transportation and an effective mean of diversifying transport in the circumstances of the dynamically changing environment in the region [1]. To achieve this goal, similar concepts have been explored in other parts of the world (Baltic Sea Region [2], Brazil [3] and Caribbean [4]), environmental conditions and by comparative analysis is determined its implementation. The study also presents conclusions on the development of environmentally, economically, socially and politically balanced sustainable transport concepts.

This study does not provide a detailed analysis of transport services, although it would be interesting to assess their potential from a logistical, economic and environmental point of view. The results can serve operators to obtain a better assessment of the environment and price aspects.

2. SSS Concept in the Development of Links between Eurasian Transport Systems

2.1 Key Features of the SSS Concept

Traditionally, the SSS concept in EU is connected to the movement of cargo and passengers by sea between ports situated in geographical Europe or between those ports and ports situated in non-European countries having a coastline on the enclosed seas bordering Europe [5], (to some extent, covered by cabotage) is a derivation of concepts for logistics chains and intermodality, such as freight transport and the movement of people using more than one mode of transportation.

Short sea shipping is vital for the development of the industry. About 90% of imports and exports of goods in Europe are transported, at least in a part of the transport chain, using maritime transport. It is therefore important to find effective solutions for maritime transportation in order to improve the access to goods and reduce the environmental impact caused by the transport.

The main advantages of the SSS concept are low cost, potentially lower emissions, available infrastructure and significant ship capacity. However, even the maritime transportation is seen as an ecological alternative to road transportation, the SSS faces significant challenges. They are related to the high costs of fuels and harbour taxes; high risks associated with the introduction of the concept; new regulations and environmental taxes. For example, the implementation of Sulphur Emission Control Areas (SECAs) in the North and Baltic Sea provides for strict limits on the sulphur content of marine fuels, which automatically means a higher fuel price. As a consequence it means a growth in the cost of maritime transportation. The strict environmental regulations are important to achieve a significant reduction in atmospheric emissions from ships but must also take into account the desire to stimulate the shift of freight from road to sea.

The SSS concept makes special requirements for rapid and effective transshipment between sea and road or rail transport, which may be technically difficult to achieve in smaller ports. Another problem is the different infrastructure capacity in different ports, which leads to a risk of delays or increased transport time. Problems with load speed and capacity differences also have an impact on the integration of the entire transport system.

The SSS concept includes the transport of cargo between ports and intermodal port hubs with a fixed timetable [6]. Accuracy and frequency are essential factors as they allow the transport at sea of time sensitive goods which are currently transported by other means of transport. The growing importance of maritime transport in future transport systems means increasing requirements for efficiency, sustainability and economic stability. Implementation of this concept may in the future lead to problems related to the capacity of rail and/or road infrastructure and to open up additional markets [7].

SSS is an integral part of a larger transport chain that requires a link between existing road and rail systems and shipping (see Fig. 1). This allows transport users to have better access to global markets, adapt their logistics systems and better planning. SSS can duplicate existing road and rail routes, thus providing a better cost-effective and environmentally friendly alternative to consumers (Table 1). SSS also creates conditions for intermodal transport solutions, combining maritime transportation with inland, road and rail transportation [7].

Sea shipping has a high degree of segmentation, as ship owners face different demand conditions. SSS aims to combine intra-regional freight flows with interregional connections and to connect between homogeneous and heterogeneous transport systems. The idea is to combine different concepts and to offer a more integrated maritime transport chain.

2.2 Conditions for the Development of the SSS Concept in the Context of Maritime Logistics in the Black Sea

The development of the transport infrastructure in Bulgaria is directly related to the multilateral policy in this area. The first among these factors is the European Union [8]. The membership of Bulgaria in the EU is a dominant factor in the socio-economic development of the country. In the transport sphere, it influences in four main ways:

- through the trade of the country with other members states (over 70% of the foreign trade turnover is with the EU countries);
- through the EU grants for the construction of core transport infrastructure (these funds are crucial for the construction of a new one and the modernization of existing infrastructure);
- through the Union’s transport and trade policy, which is binding on Member States [9];
- attracting FDI (Foreign Direct Investment) in the construction of transport infrastructure.

The second factor is the international investment projects forming a part of the regional business environment:

- in the energy sphere—the natural gas pipeline running from the Russian Federation to Turkey “Turkish Stream”, which will change not only the energy but also the transport map of Bulgaria and the region;
- in the transport sphere—the infrastructure projects of the Struma and Hemus motorways, the construction of the railway connection with Macedonia,

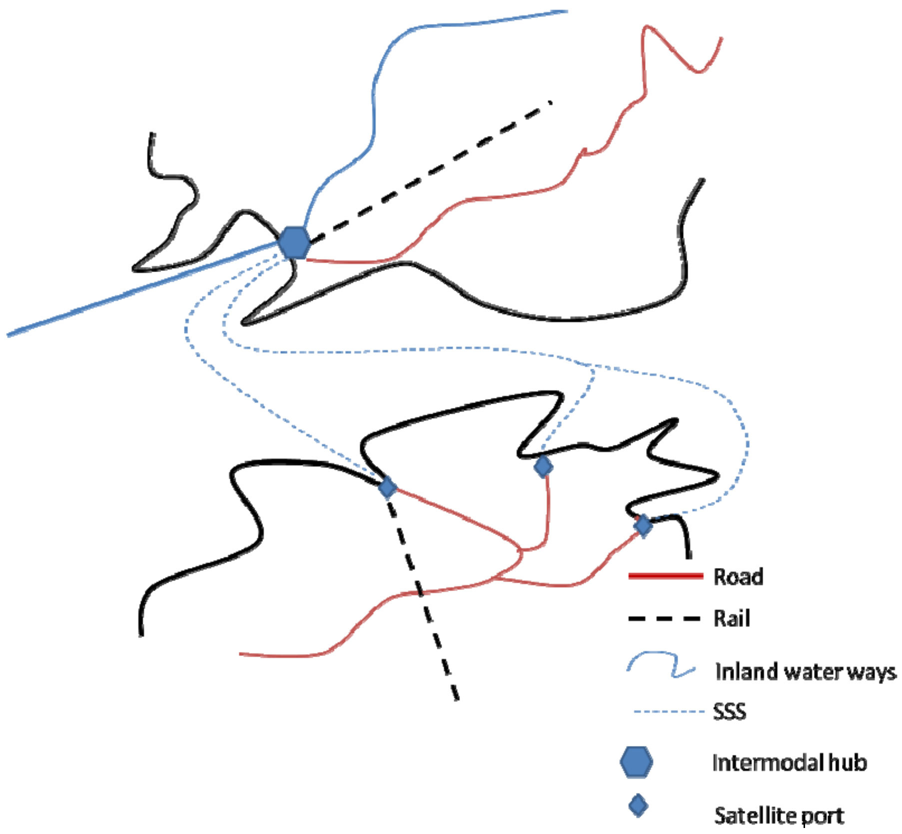

Fig. 1 SSS conceptual scheme.

Table 1 Characteristics of the different concepts.

	Short sea shipping	Rail transportation	Conventional (bulk) shipping
Timetable	Fixed	Fixed	Semi-fixed (frequent short-term changes)
Frequency	At least 1/week	Up to several times/week	Variable
Punctuality	High (deviation up to 1 hour)	High (deviation up to 1 hour)	Low (deviation up to 1 week)
Perspective	Long-term (months to years)	Long-term (months to years)	Short-term (weeks to months)
Degree of integration in transport chains	High	High	Low-average

the construction of terminals and distribution warehouses of transnational chains;

- in the industrial sphere—the construction of new ones and the modernization and enhancement of the existing production capacities in the mining industry, metallurgy, chemical industry, construction materials, etc. [9] and attraction of FDI in the transport machinery.

The third factor is the international crises, the military conflicts and the commercial sanctions in which Bulgaria participates or is their object. These are the crisis in the Middle East, the sanctions against the Russian Federation after the accession of the Crimea, the frozen conflicts in the Caucasus and the Transnistria and the crisis in Ukraine [9].

The fourth is the significant change in global and regional freight flows by building new and changing the capacity and purpose of the existing elements of the transport infrastructure with a direct relation to the Bulgarian transport system:

- the construction of a container terminal in Tekirdag as an expression of the general trend of limiting the growth of freight flows through the Bosphorus;

- the Russian-Iranian project to build a transport corridor from the Indian Ocean through Iran and the Caspian Sea to Astrakhan and Khazan;
- the Russian-Chinese project for the construction of the Beijing-Kazan-Moscow high-speed railway along the Transsiberian railway;
- the expressed by China and supported by Russia initiative to restore the "silk road";
- the modernization and extension of Russian ports and other major transport infrastructures in the Black Sea region [9].

The fifth is development of the concept of an integrated transport system. Effective use of existing infrastructure is becoming the dominant principle for the development of integrated transport systems, including railways, highways, airports, inland waterways, seaports and pipelines. This is illustrated by the *Ashgabat Declaration* adopted at the International Conference in 2014, the *Almaty Declaration* and the *New Coastal Development Action Program 2014-2024* which aim to build systematic collective efforts to overcome barriers to transport and trade [10].

Sixthly, the development of the concept of cross-border logistics is of utmost importance. The idea is to shorten the time for crossing the borders of the respective freight flows. This requires, first of all, synchronization and simplification of customs procedures. This task, in itself, is a serious challenge given the strategic contradictions between the EU and the Asian partners. Second, build a highly efficient, innovative and flexible intermodal transport infrastructure. And thirdly, stimulate the development of multimodal transport to optimize logistics corridors.

2.3 Transport Hubs in the Black Sea Region

From the point of view of integration in the transport system, the built infrastructure and the existing traffic (Fig. 2), we can conclude that the ports of Istanbul, Bourgas, Varna, Constanta, Odessa, Novorossiysk (Caucasus), Poti, Batumi and Samsun can be considered as regional transport hubs in the SSS concept (Fig. 2).

From a historical point of view, the Balkans and the Black Sea play an important role as the link between Central and Western Europe and the Middle East. As a bridge between Europe, Africa and Asia, they have become an important geostrategic region for carrying out a number of transport projects. Five transport corridors pass through their territory, incl. transport corridor VII (Rhine-Main-Danube). Thus, the SSS concept allows the economies of this region to derive maximum positive results from the development of Eurasian transport links in the east-west direction.

Through the territory of Bulgaria, two major transport corridors along the East-West axis pass, serving the trade between Europe and Asia. These are the "North Corridor" linking China, Mongolia, North and South Korea and Japan along the Trans-Siberian highway to the European countries, and "South Corridor" from China, Pakistan, India and Indochina through Iran to the Middle East, Turkey, North Africa and Europe. These corridors intersect the territory of Bulgaria with its branches through the Caspian region and the Caucasus, joining the route of the ancient Silk Road (TRACECA corridor) connecting China in Central Asia with the Balkans and Europe in the past [5].

In this sense, the SSS concept in Black Sea (also in the Caspian Sea) serves to integrate the already described transport systems (Fig. 3).

Applying the SSS concept is of interest to different stakeholders whose interests differ. When the benefits and costs of introducing a change are unevenly distributed among them or the decision making in different structures is poorly synchronized, changes can never be made easy. It is logical for SSS service to be offered by the established ship operators [7] due to the high degree of uncertainty.

Unlike other areas where the development of the concept depends on the overseas lines, in the Black

Fig. 2 **Ro-Ro, ferry services and transport hubs in the Black Sea [11].**

Fig. 3 **The SSS concept in Black Sea in the integration of transport systems.**

Sea, it is a function of the development of the transport corridors between Western Europe and Asia as a link between European and Asian transport systems. In this sense, it offers opportunities for new business models at both operational and commercial levels.

Given the built transport infrastructure, rolling stock and prospects for the development of ports in Georgia (Batumi began to lose its significance as a merchant port), the initial analysis of market conditions for the implementation of the SSS concept shows the presence of the following segments:

- Ro-Ro railway ferry lines are serviced by four companies with a total capacity under the current schedule of around 29,000 wagons per year:

(1) Varna-Poti;
(2) Varna-Caucasus;
(3) Varna-Ilichovsk;
(4) Ilichovsk-Poti;
(5) Ro-Ro ferry lines;
(6) Ro-Ro ferry lines operated by twelve companies [11];
(7) Burgas-Poti;
(8) Constanţa-Poti;
(9) Container lines;
(10) Constanţa-Poti;
(11) Varna-Poti;
(12) Burgas-Poti.

This is primarily about using the infrastructure of the railway ferry connections from Varna to Ilichovsk (Ukraine), Port Caucasus (Russia) and Poti (Georgia). Potential is also the Ro-Ro line from Bourgas to Poti (Georgia) and Novorushiysk (Russia), and especially after increasing uncertainty about the political situation in the Republic of Turkey. After the construction of the Hemus highway in Bulgaria, an increase in the importance of Varna Port [5] is expected. The Constanta port also has its high intermodal capabilities, with the built highway in the west and the connection with the Danube.

2.4 Development of the Concept of SSS in the Black Sea Region and Integration of Transport Systems

The requirement for high frequency and capacity utilization means that ships cannot be too large. Considering the potential of the market (transit cargo flows in the broad Black Sea region) this is from 350 to 500 TEU for containers and ferries with a load capacity of up to 100 wagons/900 cars/100 trucks. At present, available ships can provide a frequency of four ships per week in the Varna-Ilicovsk-Poti direction (one ship at 1.75 days) and three ships a week in the Varna-Caucasus direction (one ship at 2.34 days). It is possible that a precise analysis of the freight flows and the frequency of transport schedules will require a larger number of smaller vessels (the Varna-Caucasus line is served by ships with a capacity of 45-50 conventional wagons).

A comparison with similar concepts around the world shows that no shipping service is available that meets all the theoretical requirements of the SSS concept. Nevertheless, they have some common characteristics with it—frequency of the schedule, level of integration, type of ships or type of transported goods.

On March 3, 2009, the new ferry line Varna-Caucasus to Ferryboat Complex Varna is opened, which shortens the distance between Bulgaria and Russia by 800 km and decreases with 40% the delivery time at 36 hours of average transit time (Fig. 4) [2].

The Avangard ferry (CNF06 project) with a capacity of 45 standard wagons runs along the line. In the autumn of 2010, a second ferry—"Slavyanin" (CNF09 project, 50-wagon capacity) was launched on this line. From Russia to Bulgaria on the ferry railroad are driven compressed gas, petroleum products, oils, glass and chemical products. All this goes to the port by rail. Bulk and mass consumption goods are transported from Bulgaria.

On import in 2014, 4,187 wagons or 125,373 tonnes of freight were transported. Ninety-three percent (93%) of the cargoes are LPG and petroleum products, and the rest of the goods are equipment, cereals, glass, fertilizers and others. In total 4,020 wagons or 32,378 tonnes were transported on export, including 3,387 empty gas tanks and 633 full wagons with magnesite, machinery, equipment, building materials, food products, cosmetics, and more. The expected increase in transport in 2015 compared to 2014, with the inclusion of the Bulgarian ferry Varna to the two Russians [12] was not realized [13].

The problems associated with the operation of this line are not an exception to the problems of applying

Fig. 4 Opening of the railway line Varna-Caucasus.
Source: Ref. [4].

the SSS concept. On the one hand, after the accession of the Crimea to the Russian Federation, the capacity of the Caucasus port is insufficient. On the other hand, there is unfair competition between companies operating the line, which grows into an economic confrontation involving government institutions. In this case, the common interests of a port and an operator from the Russian side, expressed in their unified ownership and accordingly coordinated actions against the Bulgarian operator, are also a problem [14]. In the end, the result is almost a double reduction in freight turnover, from which both sides do not benefit.

However, the Varna-Caucasus railway-ferry line has significant potential, creating significant advantages over business, shortening the distance between Bulgaria and Russia by 800 km and delivery time reduced by about 40% [11].

2.5 Intermodal and Multimodal Transport in the Black Sea Region

Nodes in the transport system provide not only the starting and ending points in transportation flows but also the basis providing new business opportunities in the flow of material flows to the organizations concerned. The broad opportunities for creating a new business is becoming the priority of multi-modal transport chains in intercontinental and transcontinental logistics chains [15, 16]. The focus is on a two- and three-modal combination of different modes of transport with expanded opportunities for logistics services such as warehousing and distribution.

3. Development of the SSS Concept in the Context of the Development and Optimization of Logistics Corridors in Black Sea

The development of the SSS concept is directly dependent not only on the development of transport corridors but also on the development of logistics infrastructure. These are:

- seaport container terminals (SCT), which essentially function as international hubs with intermodal or multimodal connections [17], thus dominating the Black Sea region from the port of Constanta, with its infrastructure links and the port of Poti, as a natural geographic intermodal hub;

- rail and automotive terminals in seaports which, by their physical nature, also represent intermodal (multimodal) nodes. These are the ports of Varna, Burgas, Constanta, Poti;
- regional and local container, rail and car terminals—Caucasus, Ilichovsk;
- inland waterway terminals with capability to use and river-sea shipping (RSS);
- inland terminals with supra-regional functions—in the region of Sofia, Bucharest, Plovdiv, Budapest, where there are mega hubs or can be formed for overloading and distribution [18];
- regional and local terminals with bi- or intermodal capabilities, and in particular access to rail transport.

In order to operate a system with a certain return, the scale of investments is critical. This applies particularly to local and regional logistics facilities. Often, such terminals have a low load and therefore do not operate with the required economic efficiency. This is reflected in reducing their potential for intermodal opportunities and ultimately restricting access to road and rail transport. To some extent, these problems are solved by introducing highly efficient multi-modal innovation systems [19] for horizontal cargo handling such as Mobiler, Cargo Domino [20] or IDIOMA [21]. The extremely promising is so-called rail highways (the ModaLohr project [22]). Further improvement of the transport system can be sought in its complex integration [23, 24], covering:

- freight villages [1] which should serve as a basis for European freight transport [25];
- regional distribution centers for partial consolidation and division of goods [26];
- urban consolidation centers (UCCs) together with distribution centers oriented to the main urban areas [27].

Thus, we can define the corresponding logistic corridor (Fig. 6). In doing so, it is crucial to target investments in the most efficient chains, taking into account their complex economic and environmental sustainability.

3.1 Intermodal Logistics Network in the Central Asia-Central Europe Logistics Corridor

3.1.1 Optimizing the Intermodal Transport Links

In order to be able to determine optimal intermodal transport links, we will look at their options between two specific endpoints. For example, Teheran and Astana are used as core nodes in Central Asia with links to China and India, and Budapest—in Central Europe, where high-performance multimodal transport links have been developed across Europe (Figs. 5-7).

The estimates applied in Table 5 show that the fastest is the link 1.4.a Astana-(track) -Aktau-(ferry)-Baku-(track)-Poti-(ferry)-Constanta-(track)-Budapest. The best price and the least harmful emissions are the connection link 1.3 Astana-(rail)-Aktau-(ferry)-Baku-(rail)-Poti-(ferry)-Varna-(rail)-Ruse-Budapest.

Table 6 shows the ranking by the three criteria. If they have the same weight, we can assume that the sum of the rankings for each of the listed routes determines their complex effectiveness. Thus optimal intermodal transport chains according to the criteria value, time and quantity of CO_2 emissions are 1.3 Astana-(rail)-Aktau-(ferry)-Baku-(rail)-Poti-(ferry)-Varna-(rail)-Ruse-(river ferry)-Budapest. Quite a bit, the chains 1.3.c Astana-(rail)-Aktau-(ferry)-Baku-(rail) -Poti-(ferry)-Varna-(track)-Rouce-(ferry river)-Budapest and 1.4 Astana-(rail)-Aktau-(ferry)-Baku-(rail)-Poti-(Ferry)-Constanta-(rail)-Budapest. It follows that the Varna port has an absolute competitive advantage over the Constanta and Burgas ports in the Astana-Budapest connection in the logistic version 1.3 Astana-(rail)-Aktau-(Ferry)-Baku-(rail)-Poti-(Ferry)-Varna-(rail)-Russe (Ferry river)-Budapest.

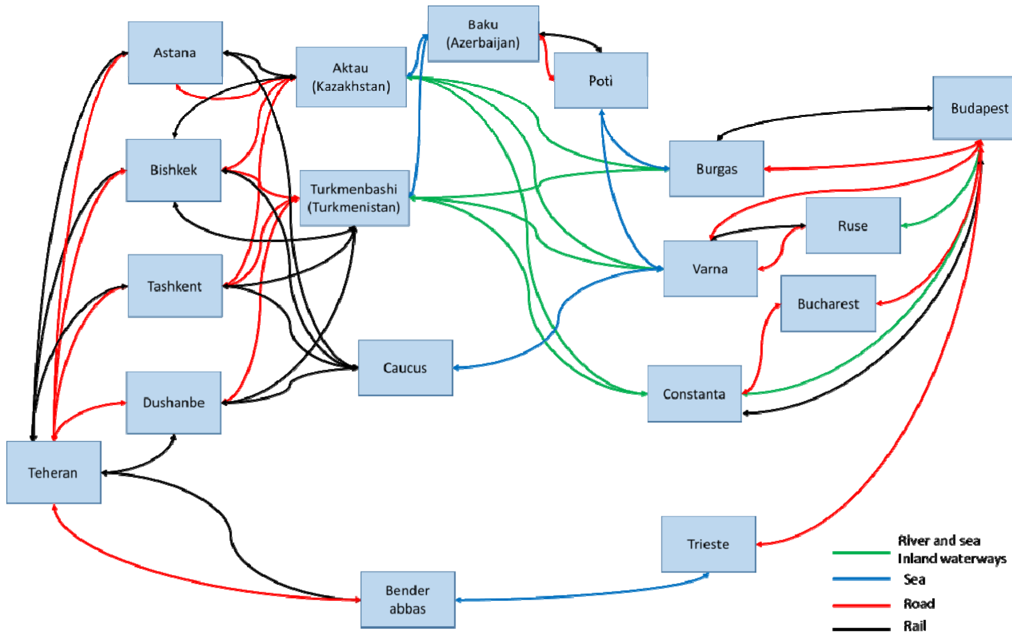

Fig. 5 Logistics transport network Central Asia-Central Europe.

Table 2 Transport chains Central Asia-Central Europe.

	Intermodal transport chain
1.1.	Astana-(rail/track)-Aктay-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-(track)-Budapest
1.2.	Astana-(rail/track)-Aктay-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail/track)-Budapest
1.3.	Astana-(rail/track)-Aктay-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.4.	Astana-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(rail/track)-Budapest
1.5.	Astana-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(track)-Bukharest-(track)-Budapest
1.6.	Bishkek-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-(track)-Budapest
1.7.	Bishkek-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail/track)-Budapest
1.8.	Bishkek-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.9.	Bishkek-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(rail/track)-Budapest
1.10.	Bishkek-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(track)-Bukharest-(track)-Budapest
1.11.	Bishkek-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-(track)-Budapest
1.12.	Tashkent-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-Burgas-(track)-Budapest
1.13.	Tashkent-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail/track)-Budapest
1.14.	Tashkent-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.15.	Tashkent-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(rail/track)-Budapest
1.16.	Tashkent-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(track)-Bukharest-(track)-Budapest
1.17.	Tashkent-(rail/track)-Aktau-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-Budapest
1.18.	Dushanbe-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(rail/track)-Budapest
1.19.	Dushanbe-(RAIL/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(track)-Bukharest-(track)-Budapest
1.20.	Dushanbe-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-Budapest
1.21.	Dushanbe-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(rail/track)-Budapest
1.22.	Dushanbe-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(track)-Bukharest-(track)-Budapest
1.23.	Dushanbe-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-Budapest
1.24.	Astana-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-(track)-Budapest
1.25.	Astana-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail/track)-Budapest
1.26.	Astana-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.27.	Astana-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(RAIL/track)-Budapest
1.28.	Astana-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(track)-Bukharest-(track)-Budapest

(Table 2 continues)

	Intermodal transport chain
1.29.	Bishkek-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-(track)-Budapest
1.30.	Bishkek-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail/track)-Budapest
1.31.	Bishkek-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.32.	Bishkek-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(RAIL/track)-Budapest
1.33.	Bishkek-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(track)-Bukharest-(track)-Budapest
1.34.	Bishkek-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-(track)-Budapest
1.35.	Tashkent-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-Burgas-(track)-Budapest
1.36.	Tashkent-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail/track)-Budapest
1.37.	Tashkent-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.38.	Tashkent-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(rail/track)-Budapest
1.39.	Tashkent-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(track)-Bukharest-(track)-Budapest
1.40.	Tashkent-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-Budapest
1.41.	Dushanbe-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(rail/track)-Budapest
1.42.	Dushanbe-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(track)-Bukharest-(track)-Budapest
1.43.	Dushanbe-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-Budapest
1.44.	Dushanbe-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(rail/track)-Budapest
1.45.	Dushanbe-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Constanta-(track)-Bukharest-(track)-Budapest
1.46.	Dushanbe-(rail/track)-Turkmenbashi-(Ferry)-Baku-(rail/track)-Poti-(Ferry)-Burgas-Budapest
1.48.	Bishkek-(rail/track)-Caucasus-(Ferry)-Varna-(rail/track)-Budapest
1.49.	Bishkek-(rail/track)-Caucasus-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.50.	Bishkek-(rail/track)-Caucasus-(Ferry)-Constanta-(track)-Bukharest-(track)-Budapest
1.51.	Bishkek-(rail/track)-Caucasus-(Ferry)-Varna-(rail/track)-Budapest
1.52.	Astana-(rail/track)-Caucasus-(Ferry)-Varna-(rail/track)-Budapest
1.53.	Astana-(rail/track)-Caucasus-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.64.	Astana-(rail/track)-Caucasus-(Ferry)-Varna-(rail/track)-Budapest
1.65.	Tashkent-(rail/track)-Caucasus-(Ferry)-Varna-(rail/track)-Budapest
1.66.	Tashkent-(rail/track)-Caucasus-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.67.	Dushanbe-(rail/track)-Caucasus-(Ferry)-Varna-(rail/track)-Budapest
1.68.	Dushanbe-(rail/track)-Caucasus-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.69.	Astana-(rail/track)-Teheran-(rail/track)-Bander Abbas-(Ferry)-Trieste-(track)-Budapest
1.70.	Bishkek-(rail/track)-Teheran-(rail/track)-Bander Abbas-(Ferry)-Trieste-(track)-Budapest
1.71.	Tashkent-(rail/track)-Teheran-(rail/track)-Bander Abbas-(Ferry)-Trieste-(track)-Budapest
1.72.	Dushanbe-(rail/track)-Teheran-(rail/track)-Bander Abbas-(Ferry)-Trieste-(track)-Budapest

Table 3 Distances and times in transport chains Central Asia-Central Europe.

Link	Distance	Duration (hours)
Astana-(rail/track)-Aktau (km)	2,666	33
Aktau-(Ferry)-Baku (nm)	200	17
Baku-(rail/track)-Poti (km)	910	12
Poti-(Ferry)-Burgas (nm)	627	52
Burgas-(track)-Budapest (km)	1,161	14
Poti-(Ferry)-Varna (nm)	611	50
Varna-(rail)-Ruse (km)	260	4
Ruse-(Ferry river)-Budapest (nm)	608	113
Poti-(Ferry)-Constanta (nm)	582	49
Constanta-(rail/track)-Budapest (km)	1,077	14
Bishkek-(rail/track)-Aktau (km)	2,642	38
Varna-(rail/track)-Budapest (km)	1,080	13
Tashkent-(rail/track)-Aktau (km)	2,051	29

(Table 3 continues)

Link	Distance	Duration (hours)
Tashkent-(track)-Budapest (km)	4,903	64
Astana-(track)-Budapest (km)	4,500	56
Astana-(rail/track)-Teheran-(RAIL/track)-Bander Abbas (km)	4,185	54
Bander Abbas-(Ferry)-Trieste (nm)	4,196	350
Bishkek-(rail/track)-Teheran-(rail/track)-Bander Abbas (km)	3,620	51
Dushanbe-(rail/track)-Teheran-(rail/track)-Bander Abbas (km)	2,652	34
Tashkent-(rail/track)-Teheran-(rail/track)-Bander Abbas (km)	2,739	36
Teheran-(rail/track)-Poti (km)	1,464	20
Teheran-(rail/track)-Bander Abbas (km)	1,276	14

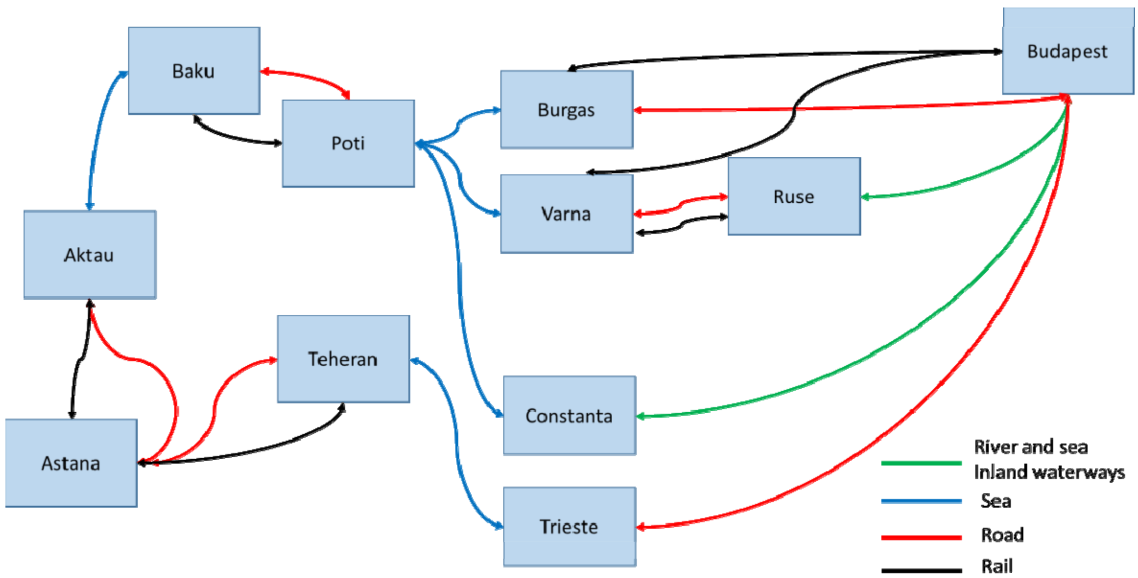

Fig. 6 Logistic transport network Astana-Budapest.

Table 4 Transport chains Astana-Budapest.

	Intermodal transport chain
1.1.	Astana-(track)-Aktau-(Ferry)-Baku-(track)-Poti-(Ferry)-Burgas-(track)-Budapest
1.1.a	Astana-(rail)-Aktau-(Ferry)-Baku-(rail)-Poti-(Ferry)-Burgas-(track)-Budapest
1.1.b	Astana-(rail)-Aktau-(Ferry)-Baku-(track)-Poti-(Ferry)-Burgas-(track)-Budapest
1.2.	Astana-(track)-Aktau-(Ferry)-Baku-(track)-Poti-(Ferry)-Varna-(track)-Budapest
1.2.a	Astana-(rail)-Aktau-(Ferry)-Baku-(rail)-Poti-(Ferry)-Varna-(rail)-Budapest
1.2.b	Astana-(rail)-Aktau-(Ferry)-Baku-(track)-Poti-(Ferry)-Varna-(rail)-Budapest
1.2.c	Astana-(rail)-Aktau-(Ferry)-Baku-(track)-Poti-(Ferry)-Varna-(track)-Budapest
1.3.	Astana-(rail)-Aktau-(Ferry)-Baku-(rail)-Poti-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.3.a	Astana-(track)-Aktau-(Ferry)-Baku-(track)-Poti-(Ferry)-Varna-(rail)-Russe-(Ferry river)-Budapest
1.3.b	Astana-(track)-Aktau-(Ferry)-Baku-(track)-Poti-(Ferry)-Varna-(track)-Russe-(Ferry river)-Budapest
1.3.c	Astana-(rail)-Aktau-(Ferry)-Baku-(rail)-Poti-(Ferry)-Varna-(track)-Russe-(Ferry river)-Budapest
1.4.	Astana-(rail)-Aktau-(Ferry)-Baku-(rail)-Poti-(Ferry)-Constanta-(rail)-Budapest
1.4.a	Astana-(track)-Aktau-(Ferry)-Baku-(track)-Poti-(Ferry)-Constanta-(track)-Budapest
1.4.b	Astana-(rail)-Aktau-(Ferry)-Baku-(track)-Poti-(Ferry)-Constanta-(track)-Budapest
1.4.c	Astana-(rail)-Aktau-(Ferry)-Baku-(track)-Poti-(Ferry)-Constanta-(rail)-Budapest
1.69.	Astana-(rail)-Teheran-(rail)-Bander Abbas-(Ferry)-Trieste-(track)-Budapest
1.69.a	Astana-(track)-Teheran-(track)-Bander Abbas-(Ferry)-Trieste-(track)-Budapest

Table 5 Research results of transport chains Teheran-Budapest.

	Distance					Sum (h)	Sum price ($)	CO_2 emissions (kg/t·km)
	Track (km)	Rail (km)	Barge (river-sea) (km)	Ferry (морски) (nm)	Sum (km)			
1.1.	4,737			827	6,269	148	7,470	335.47
1.1.a	1,161	3,576		827	6,269	207	5,753	246.07
1.1.b	2,071	2,666		827	6,269	192	6,190	268.82
1.2.	4,656			811	6,158	145	7,341	329.67
1.2.a		4,656		811	6,158	223	5,106	213.27
1.2.b	910	3,746		811	6,158	208	5,543	236.02
1.2.c	1,170	2,666	608	811	5,946	237	5,152	220.66
1.3.		3,836	608	811	5,946	256	4,590	191.41
1.3.a	3,576	260	608	811	5,946	197	6,307	280.81
1.3.b	3,836		608	811	5,946	192	6,431	287.31
1.3.c	260	3,576	608	811	5,946	252	4,715	197.91
1.4.		4,653		782	6,101	220	5,087	212.1
1.4.a	4,653			782	6,101	143	7,320	328.5
1.4.b	1,987	2,666		782	6,101.264	187	6,041	261.86
1.4.c	910	3,743		782	6,101	205	5,524	234.9
1.69.	556	4,185		4,196	12,512	489	7,339	343.41
1.69.a	4,741			4,196	12,512	350	9,348	448.04

Table 6 Bringing the results of the Astana-Budapest transport chain survey to the best choice.

	Ranking in terms of duration	Ranking in terms of price	Ranking in terms of CO_2 emissions	Ranking
1.1.	**1.48**	7.470	3.3547	12.3047
1.1.a	2.07	5,753	2.4607	10.2837
1.1.b	1.92	6,190	2.6882	10.7982
1.2.	**1.45**	7,341	3.2967	12.0877
1.2.a	2.23	**5,106**	2.1327	9.4687
1.2.b	2.08	5,543	2.3602	9.9832
1.2.c	2.37	5,152	2.2066	9.7286
1.3.	2.56	**4,590**	**1.9141**	9.0641
1.3.a	1.97	6,307	2.8081	11.0851
1.3.b	1.92	6,431	2.8731	11.2241
1.3.c	2.52	**4,715**	**1.9791**	9.2141
1.4.	2.20	5,087	**2.121**	9.408
1.4.a	**1.43**	7,320	3.285	12.035
1.4.b	1.87	6,041	2.6186	10.5296
1.4.c	2.05	5,524	2.349	9.923
1.69.	**4.89**	7,339	3.4341	15.6631
1.69.a	3.50	**9,348**	**4.4804**	17.3284

The estimates applied in Table 8 for the Logistics transport network Tehran-Budapest (See Fig.7 and Table 7) show that the fastest is the automobile transport link. An optimal price has the chain 2.1.a Tehran-(Rail)-Poti-(Ferry) -Varna-(Railway)-Ruse-(Ferryboat)-Budapest, and the least harmful in emission terms is the link using the river-sea concept and the connection Caspian Sea across the Volga River, the Don, the Black Sea and the Danube River [26]. The different cargo has a different "appetite" for these criteria, and at the company level there are no mechanisms to impose the implication the most environmentally friendly options. This requires cooperation actions at regional and interregional level to establish regulatory mechanisms in this direction.

Table 9 shows the ranking by the three criteria. If they have the same weight, we can assume that the sum of the rankings for each of the listed routes determines their complex effectiveness. Thus, optimal intermodal transport chains according to the criteria value, time and amount of harmful emissions are 2.4.a Tehran-(Railway)-Poti-(Ferryboat)-Constanta-(Railway)-Budapest and 2.5.a Tehran-(Railway)-Poti-(Ferryboat)-Constanta-(Ferryboat)-Budapest. The 2.2.a Tehran-(Railway)-Poti-(Ferryboat)-Varna-(railway)-Budapest and 2.3.a Tehran-(Rail)-Port-(Ferryboat)-Burgas-(Truck)-Budapest are just a bit behind. It follows that the ports of Varna and Bourgas must set their strategic

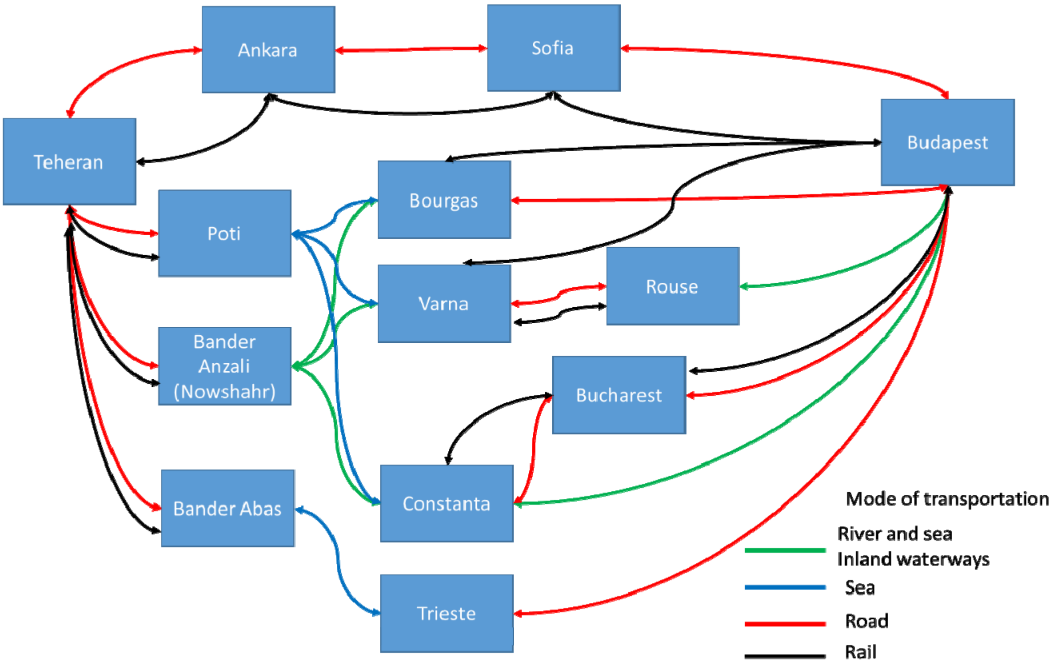

Fig. 7 Logistics transport network Tehran-Budapest.

Table 7 Transport chains Tehran-Budapest.

	Intermodal transport chain
2.1.	Teheran-(lorry)-Poti-(Ferry)-Varna-(Railway)-Ruse-(Ferry)-Budapest
2.1.a	Tehran-(Railway)-Poti-(Ferryboat)-Varna-(Railway)-Ruse-(Ferryboat)-Budapest
2.2.	Tehran-(truck)-Poti-(Ferry)-Varna-(truck)-Budapest
2.2.a	Tehran-(Railway)-Poti-(Ferryboat)-Varna-(Railway)-Budapest
2.3.	Tehran-(truck)-Poti-(Ferryboat)-Burgas-(truck)-Budapest
2.3.a	Tehran-(Railway)-Poti-(Ferryboat)-Burgas-(truck)-Budapest
2.4.	Tehran-(truck)-Poti-(Ferryboat)-Constanta-(truck)-Budapest
2.4.a	Tehran-(Railway)-Poly-(Ferryboat)-Constanta-(Railway)-Budapest
2.5.	Tehran-(truck)-Poti-(Ferryboat)-Constanta-(Ferryboat)-Budapest
2.5.a	Tehran-(Railway)-Poti-(Ferryboat)-Constanta-(Ferryboat)-Budapest
2.6.	Tehran-(truck)-Bander Anzali-(Ferryboat Sea-River)-Constanta-(Ferryboat)-Budapest
2.7.	Tehran-(truck)-Bander Anzali-(Ferryboat sea-river)-Varna-(truck)-Budapest
2.7.a	Tehran-(Railway)-Bander Anzali-(Ferryboat sea-river)-Varna-(Railway)-Budapest
2.8.	Tehran-(truck)-Bander Anzali-(Ferryboat sea-river)-Burgas-(truck)-Budapest
2.8.a	Tehran-(Railway)-Bander Anzali-(Ferryboat Sea-river)-Burgas-(truck)-Budapest
2.9.	Teheran-(truck)-Bander Abbas-(Ferryboat)-Trieste
2.9.a	Tehran-(Railway)-Bander Abbas-(Ferry)-Trieste
2.10.	Tehran-(Rail/Truck)-Ankara-(Rail/Truck)-Sofia-(Rail/Truck)-Budapest

Table 8 Results of the study of the transport chains Tehran-Budapest.

	Distance					Duration (h)	Cost ($)	CO_2 (kg/t·km)
	Track (km)	Rail (km)	Ferry (river-sea) (km)	Ferry (nm)	Sum			
2.1.	1,464	260	1,127	611	3,982	186	3,330	146.21
2.1.a		1,724	1,127	611	3,982	186	**2,627**	109.61
2.2.	2,544			611	3,676	83	4,105	185.73
2.2.a		2,544		611	3,676	83	2,883	122.13
2.3.	2,625			627	3,786	86	4,233	191.53
2.3.a	1,161	1,464		627	3,786	86	1,812	154.93
2.4.	2,541			582	3,619	83	4,084	184.57
2.4.a		2,541		582	3,619	83	2,864	121.04
2.5.	2,541			582	3,619	83	4,084	184.57
2.5.a		2,541		582	3,619	83	2,864	121.04
2.6.			4,541		4,541	**423**	4,541	**81.74**
2.7.	1,080		3,234		4,314	302	3,161	128.40
2.7.a		1,080	3,234		4,314	302	2,697	101.40
2.8.	1,161		3,289		4,450	310	3,305	134.67
2.8.a		1,161	3,289		4,450	310	2,806	105.64
2.9.	1,276			4,196	9,047	364	4,220	222.82
2.9.a		1,276		4,196	9,047	364	3,607	190.92
2.10.	3,770				3,770	**54**	**5,580**	**245.05**

Table 9 Bringing the results of the study of the Tehran-Budapest transport chains to choose the best option.

	Ranking in terms of duration	Ranking in terms of Cost	Ranking in terms of CO_2 emissions (kg/t·km)	Ranking
2.1.	3,446	1,268	1,789	6,503
2.1.a	3,446	**1,000**	1,341	5,787
2.2.	1,537	1,563	2,272	5,372
2.2.a	1,537	1,098	1,494	**4,129**
2.3.	1,597	1,612	2,343	5,552
2.3.a	1,597	0,069	1,185	**4,183**
2.4.	1,528	1,555	2,258	5,341
2.4.a	1,528	1,090	1,481	**4,099**
2.5.	1,528	1,555	2,258	5,341
2.5.a	1,528	1,090	1,481	**4,099**
2.6.	7,825	1,729	**1,000**	**10,554**
2.7.	5,586	1,203	1,571	8,361
2.7.a	5,586	1,027	1,241	7,854
2.8.	5,741	1,258	1,648	8,664
2.8.a	5,741	1,068	1,292	8,101
2.9.	6,735	1,606	2,726	**11,067**
2.9.a	6,735	1,373	2,336	**10,444**
2.10.	**1,000**	2,124	2,998	6,122

priorities to improve their competitiveness in these areas.

At a national level, a source of competitive advantage may be the continuous improvement of administrative services and the reduction of bureaucratic procedures. To some extent, this can be solved by deepening multimodality in freight, where mergers and acquisitions will not only result in economies of scale but also in the use of complex optimization models at a company level. Last but not least, there is the investment potential of the large international logistics companies. Thus, the dynamic development approach enables investment in highly efficient innovative methods and tools for handling and transporting cargo.

4. Conclusions

A crucial element of the Central Asia-Central Europe logistic corridor is the development of SSS concept in the Black Sea which combines intra-regional freight flows with interregional connections and links homogeneous and heterogeneous transport systems. It is a connecting link between Europe's and Asia's transport systems with increasing importance in the context of evolving integration processes. The idea is to combine different concepts and mode of transportation to offer a more integrated highly effective transport chain. Its development is related to the transport infrastructure.

The development of the transport infrastructure directly depends on the regional business environment and therefore the further expansion of the SSS concept derives from political, economic and financial stability of the region and neighboring Middle East, Central Asia and Central Europe.

The history of the region is a datum for the development of the SSS concept which allows its economies to derive maximum positive results from the development of Eurasian transport links in the east-west direction. The territory of the Republic of Bulgaria occupies a central position on the Bolkans and hence has an important role for SSS effectiveness.

The role of SSS will also increase with increasing environmental requirements to the transport system. Therefore the planning of intermodal transport chains cannot be achieved as a result of unambiguous criteria, as it is based on a multi-criterion management approach in which compromises are often made or multiple quality criteria are taken into account. The examinated links between Central Asia and Central Europe prove that the best intermodal transport chain according to the criteria value, time and quantity of CO_2 emissions is 1.3 Astana-(rail)-Aktau-(Ferry)-Baku-(rail)-Poti-(Ferry)-Varna-(rail)-Ruse-(river ferry)-Budapest. Therefore Varna port has an absolute competitive advantage over the Constanta and Burgas ports in the Astana-Budapest connection. Concerning the link Teheran-Budapest the optimal intermodal transport chain according to the same criteria is 2.4.a Tehran-(Railway)-Poti-(Ferryboat)-Constanta-(Railway)-Budapest. It follows that the ports of Varna and Bourgas must reconsider their strategic priorities to improve their competitiveness in these areas.

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