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Statistical and economic analysis of the Rhine-Main-Danube Canal, the bridge between the North Sea and the Black Sea

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Abstract: The Rhine-Main-Danube Canal, known as the Europe Canal, is 171 km long and is the shortest navigable connection between the Black Sea and the North Sea since 1992, via the Rhine, Main, Danube-Black Sea Canal and Danube. Through the ensemble between the Rhine-Main-Danube Canal and the Danube-Black Sea Canal, a direct transport axis is created between the port of Rotterdam, the largest port in terms of freight transport, and the port of Constanta. The importance of a study on navigation on this channel is due to the economic growth and implicitly to the growth of goods and services. In this paper, a study on the economic impact of the Rhine-Main-Danube Canal was conducted due to the large flow of goods transited along it, as well as the diversification of goods transported. The main types of goods transported were identified. Also, the navigation conditions on the canal were studied and the most crowded and most dangerous areas were identified.

Keywords: navigation; economic importance; ship traffic; Rhine-Main-Danube Canal

1. Introduction

River navigation allows the transport of a wide range of goods, the most preferred being the transport of goods in large quantities, with low value, such as cereals and various materials. After maritime transport, river transport is the best way to transport goods, due to its qualities. The higher the quantity of goods, the more advantageous it is to use this method of transport, the costs being much lower, which leads to a much lower price.

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The Rhine Main Danube Canal, also known as the European Canal [1-3] or the Main Danube Canal, has been connecting the Danube with the Main for 29 years and has a total length of about 171 km. This Canal is part of the transport axis between the Port of Constanta and the Port of Rotterdam, connecting the Black Sea with the North Sea via the Danube Black Sea Canal, the Danube, the Main Danube Canal and the Main and Rhine rivers, as can be seen in Figure 1.

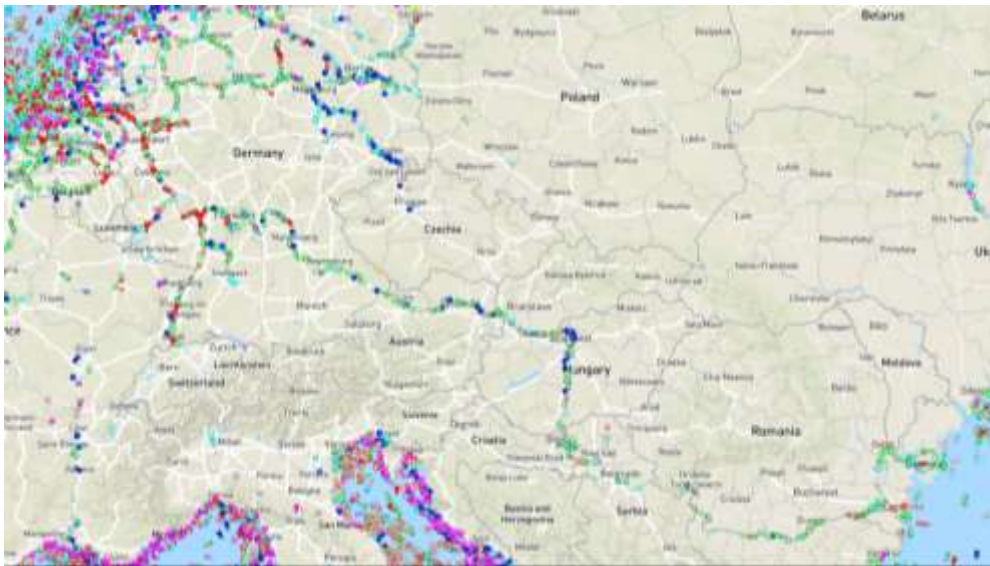


Figure 1. Naval traffic along the Rhine-Main-Danube Channel
 (<https://www.marinetraffic.com>)

The waterway crosses 15 countries and is open all year round, with certain exceptions, when the navigation conditions are not met due to the low water level depending on the season or other weather conditions. The importance of this transport axis is constantly growing, with the development of the economy and the improvement of trade in goods. The main characteristics of the Channel are presented in Table 1.

Table 3 Main particulars of Rhine-Main-Danube Canal

Location	Europe
Spring Area	Main, Bamberg, Germany
Overflow Area	Danube, Kelheim, Germany
Branches	Rhine, Main, Main Danube Channel, Danube, Danube Black Sea Channel
Completion date	25 September 1992
The main countries crossed	Netherlands, Belgium, Austria, Germany, Hungary, Slovakia, Bulgaria, Romania

In this paper, a statistical and economic analysis of the Rhine Main Danube Canal was performed, which is considered a bridge between the Black Sea and the North Sea. A brief history of the canal was presented, as well as the initial plans for the construction of the canal. Navigation conditions, restrictions and the importance of shipping on economic improvement were also studied. Also, based on the statistical data provided by Eurostat Database (<https://www.marinetraffic.com>), an analysis was performed on the types of ships, types of goods and quantities of goods transported for the period 2010 - 2020.

2. The Channel History

The desire to connect the Rhine, Main and Danube basins has a long history. Plans for such a canal began in 793, when under the leadership of Charlemagne was built the Carol Canal, also known as Fossa Carolina, which wanted to improve transport traffic, but also for its battle fleet.

The next plan appeared in 1836, when the Ludwig Canal, named after Ludwig I of Bavaria, was built between Bamberg and Kelheim. Although inaugurated in 1846, it was damaged during World War II and was completely abandoned in 1850, due to the difficulties of the route which had many locks, a small canal width, there were problems with water levels, and the development rail transport has made this waterway unprofitable. Now there is still part of this channel, and some locks are still functional.

A third plan, also abandoned due to World War II, was the Mindorfer Line, whose construction began in 1939 and abandoned in 1942.

Planning for the existing canal at this time began in the 1950s, and the construction of the waterway began in 1960, in several segments. The works took a total of 32 years to complete, and on September 25, 1992 it was inaugurated and the final costs were estimated at USD 8 Billion (Sava, 1997), including the hydroelectric power stations, and the investment in time from the use of the canal will be recovered. , but also from the electricity supplied by hydropower plants.

3. Navigation and Restrictions

A study on the navigation conditions and restrictions along Rhine-Main-Danube Canal was performed. The total length of the canal is 171 km and the highest point above the sea is 406 m, near Nuremberg, which is the highest level that commercial boats can reach at this time. The cross section of the waterway is generally in the form of a trapezoid, with a width of 31 meters at the bottom and a width of 55 meters at the surface of the water, and the water depth is generally 4 meters. There are also a series of sections with a rectangular profile, in which the average upper and lower width is around 43 meters.

This channel connects the North Sea with the Black Sea, crossing the Netherlands, Germany, Austria, Slovakia, Hungary, Croatia, Serbia, Romania, Bulgaria and Ukraine, as can be seen in Figure 2.

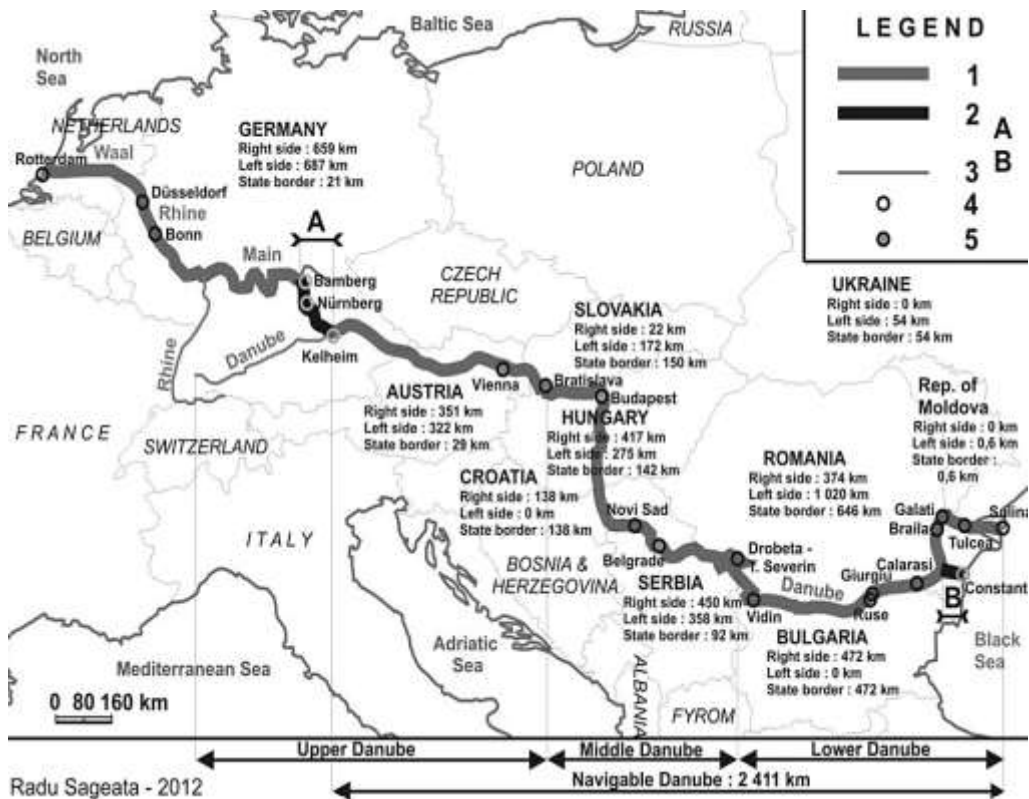


Figure 2. The Rhine-Main-Danube Channel waterway: 1. Navigable rivers, 2. Navigable channels, 3. Other rivers, 4. Cities, 5. Capitals

Source: (Sageata, 2012, pp. 157-166)

Along the course of the canal are 16 locks with heights of up to 25 meters. The 16 locks are managed from four centres, which were upgraded from 2001 to 2007, and the cost was about 1.3 million dollars per lock. Thirteen of them are designed to save water and require about 30 minutes to pass a lock. The locks are presented in Table 2.

Table 2. Locks along the Rhine-Main-Danube Canal

Location	Completion Date	Economy Lock	Level difference [km]	Lock Length [m]	Lock Width [m]
Bamberg	1967	Yes	10.94		
Strullendorf	1967	Yes	7.41		
Forchheim	1964	No	5.29		
Hausen	1968	Yes	12.00		
Erlangen	1970	Yes	18.30		
Kriegenbrunn	1970	Yes	18.30		
Nürnberg	1971	Yes	9.40		
Eibach	1978	Yes	19.49		
Leerstetten	1980	Yes	24.67	190	12
Eckersmühle	1985	Yes	24.67		
Hilpoltstein	1989	Yes	24.67		
Bachhausen	1989	Yes	17.00		
Berching	1991	Yes	17.00		
Dietfurt	1984	Yes	17.00		
Riedenburg	1982	No	8.40		
Kelheim	1981	No	8.40		

Depending on the type of vessel, an estimated calculation (Table 3) was made for the Rotterdam Constanta route, based on the travel computer provided by Danube Logistics Portal (<https://www.danube-logistics.info/travel-time-calculator/>).

Table 2. Travel Time between Rotterdam and Constanta via Rhine-Main-Danube Channel

Vessel Type	Operation Mode	Distance [km]	Locks	Time Rotterdam - Constanta	Time Constanta - Rotterdam
Motor cargo vessel 1.350 to. Tonnage				11 days 18 hours	14 days 3 hour
Motor cargo vessel 2.000 to. Tonnage	24 hours	3253	70	11 days 7 hours	12 days 11 hours
2-unit pushed convoy				11 days 20 hours	14 days 2 hours
4-unit pushed convoy				-*	-*

*Not operating due to restricted maximum dimensions of vessels and pushed convoys.

4. Naval Transport

River navigation is used for the transport of goods and materials, as well as containers. Although it is a slow and less punctual means of transport compared to rail, road or air transport, the low costs and large quantities that can be transported in a single trip, make this method the most popular, after maritime transport.

The international pandemic situation, due to the Covid-19 virus, had different effects depending on the type of goods transported, if in the case of grain shipments it increased considerably, in terms of iron ore transport it was much lower than the previous year. However, this industry was not affected and continued to thrive even during the pandemic.

Naval traffic on the Rhine-Main-Danube Canal was studied for the period 2010-2020 from several perspectives.

In terms of the total number of goods transported (Figure 3), Netherland registered 3,919,518 thousand tons of goods in the period 2010-2020, occupying the first place with a percentage of 43% and being followed by Germany with 26% and Belgium with 21%. Every year, the percentages are similar, around 9%, except for 2020, where we have 8.5%.

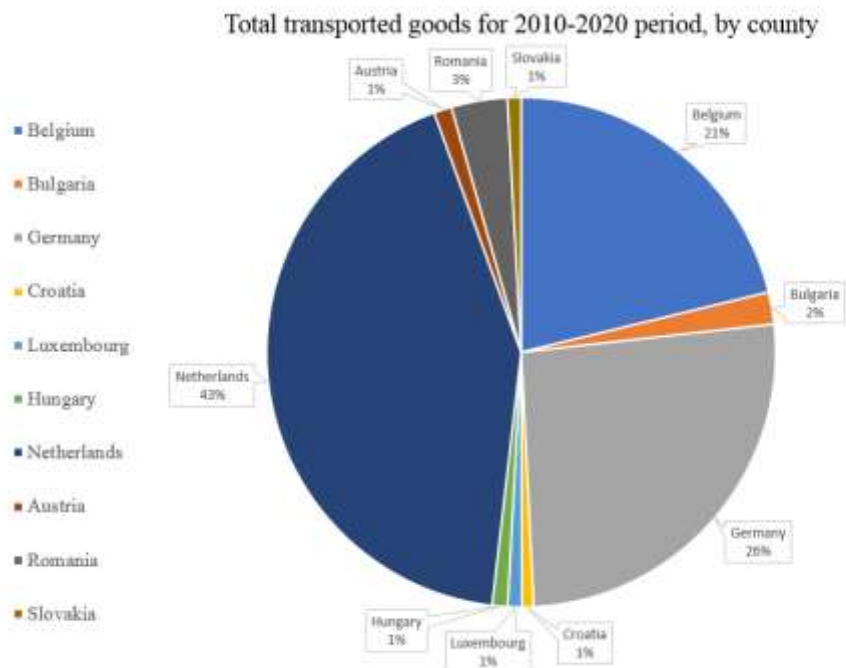


Figure 3. Total Transported Goods for 2010-2020 Period

In terms of ship types (Figure 4), the Netherlands, Germany and Belgium remain in the top 3 for all types of vessels, both self-propelled and not self-propelled vessels.

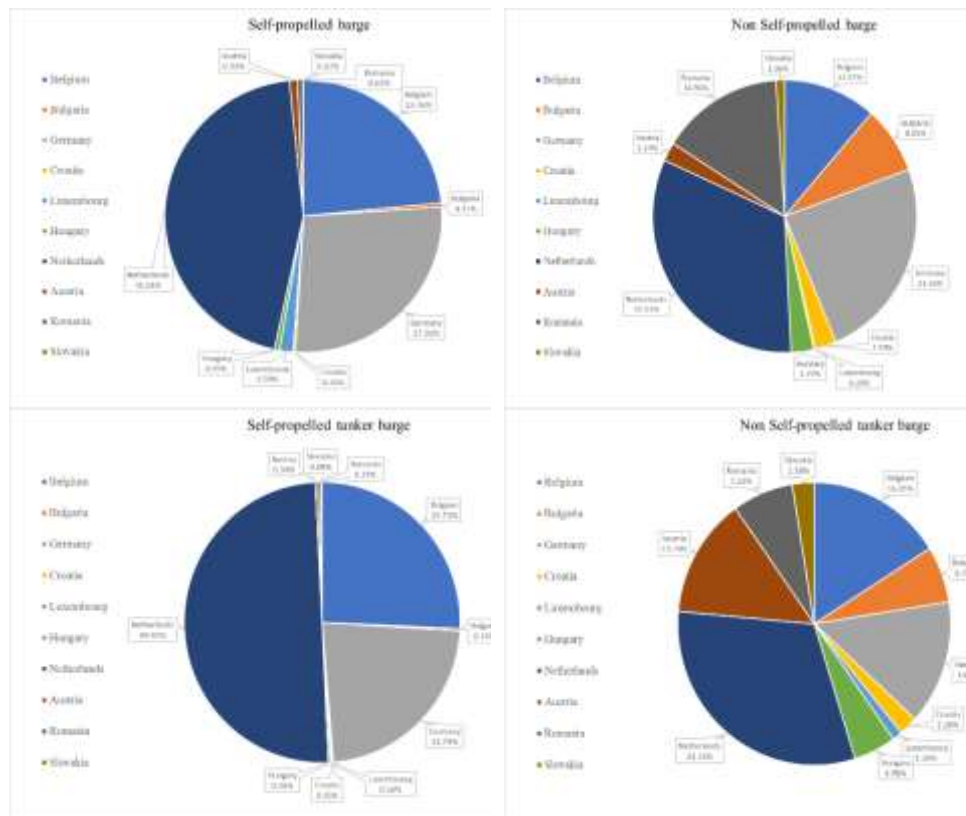


Figure 4. Total Transport for 2010-2020 period, by types of vessel

The most popular types of goods transported for the period 2010-2020 are presented in Figure 5. It can be seen that the most popular goods transported are metal ores and other mining and quarrying products, being followed at a difference of 20% by coke and refined petroleum products.

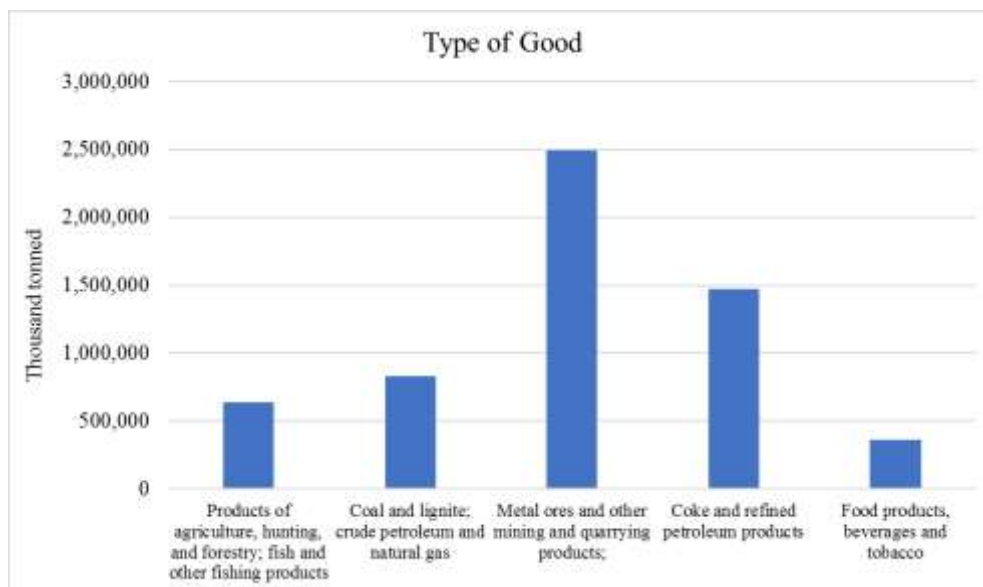


Figure 5. Total Transport for 2010-2020 Period, by Type of Good

5. Conclusions

River transport has become quite complex and is constantly evolving due to increasing market requirements, but also due to the many advantages it offers, as well as the convenient prices of services.

The main advantages of this method of transport are the much lower investment costs compared to road, rail or air transport, as well as the fact that the waterways are natural routes and do not generally require expensive landscaping. Also, another important advantage is the importance of transport safety, the risks being much lower even compared to maritime transport.

A study on navigation conditions, restrictions and shipping along the Rhine Main Danube Canal was conducted. The main types of goods transported were identified, as well as types of ships for the period 2010 – 2020.

The Rhine-Main-Danube Canal is one of the largest civil engineering projects carried out to date and is a major freight route that connects the North Sea with the Black Sea and has the highest chances to remain an important European transport corridor given the multitude cities crossed, including four capitals.

The main types of goods transported are cereals, agricultural, forestry, as well as coal, crude oil and natural gas and the largest quantities of goods were registered in the Netherlands, Germany and Belgium.

In conclusion, the Rhine Main Danube Canal has a special economic importance, opening new markets for the countries it passes through, and improving the conditions of port infrastructure and updating the fleet will increase trade in goods, both in terms of transported capacity and transport distances.

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