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PhD THESIS

Impact factors on Danube Freight Transport Management

SUMMARY

PhD Student,
Andra Luciana TURCANU (MARCU)

Scientific coordinator,
Prof. Liliana Mihaela MOGA, PhD

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Introduction

Asia-Europe is a heavily used trade route, and its hinterland constantly expands. Public authorities responsible for developing international waterborne trade could become important facilitators of regional and international trade logistics chains that connect the region's trade to global supply chains.

Water transport is recognized worldwide as the cheapest and most environmentally friendly. At the same time, we must recognize that its main disadvantage is the long time it takes for the goods to travel from the seller to the buyer. At the same time, the volumes of goods transported on inland waterways are also based on a series of macroeconomic indicators specific to the degree of development of each country of which the port in which the transport operations take place is a part.

In the specialized literature, the research on the development of international trade in the context of the development of cargo transport operations on the Danube is in a small number, the primary specialized works dealing separately with the two aspects. Their meeting leads to the establishment of standard directions of action, the definition of economic and trade policies considering all the aspects that are the basis of the definition of the country's strategy, and strengthening of collaboration at the European level.

This doctoral thesis deals with the issues presented together, defining a harmonious relationship between a series of macroeconomic indicators and the volumes of transited goods in the context of economic development. The main argument being those essential regions in Europe, which have an outlet to the Danube, can benefit more due to their geographical position.

In this sense, in the **first chapter** of this doctoral thesis, I made a short foray into the evolution of the transport of goods on the Danube and its importance at the international level. At the same time, we also made a brief presentation of the evolution of ports and their role, starting from the 1940s, when they were intended for mechanical operations, until the 2020s, when they were recognized as an essential role in regional economic development. Their role in the performance of the transport of goods by water is a defining one.

In the **second chapter**, we dealt with the different models of port management and operation on the Danube. In addition to the port capacity in the Danube area in conjunction with the volumes of goods transported, and during the research of the specialized literature, we found that the mode of operation and management of goods differs in each port. The management of the port segment is different from the traditional methods used in large corporations. However, they are located on the course of the same navigable channel, in this case, the Danube, in fact for which I considered it necessary to briefly present the actors involved both in the port management process and in the process of transferring the goods from the seller to the buyer.

In carrying out the research which is the basis of this doctoral thesis, I considered the directives of the European Commission regarding the development of the Danube region and, implicitly, the transport of goods. In this sense, it is necessary to touch on aspects related to sustainable development, the transition to less polluting fuels, and the adaptation of concepts and technologies related to the circular economy. In this sub-chapter, we have made a short description of the situation at the European level. We also offer some good practices from the ports that have already started applying sustainable development principles and implicitly synchro modality.

Chapter three deals with the main factors influencing the performance of freight transport on the Danube. In this chapter, we touched on aspects related to the economic framework of the region of which the port is a part, as well as aspects related exclusively to port management. All sub-chapters were treated from the perspective of increasing the volumes of transported goods and the efficiency of operations specific to the transit, respectively, transshipment of goods, based on the specialized literature in the field.

Chapter Four was dedicated to analyzing the evolution of the most important influencing factors on the performance of the transport of goods by water. This fact led to the creation of several investment directions in order to make specific processes more efficient, but also to three working hypotheses, which were tested in the following chapters:

(Hypothesis 1) ***Optimizing the logistics and goods distribution process is a determining factor in the evolution of goods traffic on the Danube;***

(Hypothesis 2) ***The alignment of national strategies regarding the development of water trade with European strategies will have a positive impact on the volumes of goods transported on the Danube;***

(Hypothesis 3) ***Investments in the attraction and qualification of human resources will improve the efficiency of operations transporting goods by water.***

The following chapters were dedicated to the analysis and testing of the proposed working hypotheses, as well as the creation of a model regarding the performance of operations specific to the transport of goods on the Danube. Thus, in the **fifth chapter**, the research framework was defined for the analysis being used, Exploratory Factor Analysis. A number of 23 variables were analyzed, the data being collected from specialized websites, such as the World Bank, Eurostat, Organization for Economic Development and Cooperation, and national statistical websites, over ten years for a number of 9 countries with an outlet to the Danube and part of the European Union. SPSS and SmartPLS computer programs were used to perform the analysis in the following chapters.

Following the application of the research method in the **sixth chapter**, I extracted from the 23 variables seven main factors, which are based on a small number of variables, of different intensity, with an effect on the problem presented. To continue the research and test the relationship between the extracted factors, the first three were selected according to their degree of intensity. Linear regression was used to validate the relationships and implicitly the working hypotheses.

Since all three hypotheses were validated, they led to the creation of a model tested in **chapter seven** through Confirmatory Factor Analysis. To perform the analysis path analysis was performed through structural equation modeling. The research invalidated the initially proposed model and led to a new one, based on which predictions were made, and managerial implications were defined.

Throughout the doctoral thesis, reference was made to various national and international organizations and bodies, defining standard action policies. **Chapter eight** summarizes the main results obtained in this thesis. The most important result of the conducted research is defining the performance model of the volumes of goods transported by water in the context of developing the European economic circuit. This paper argues that the Danube ports, together with the country of which they are a part, could benefit a lot from an economic point of view from their strategic positioning on the international level.

Another significant result of the research was the presentation of the type of corporate management for the port segment and the need to implement this concept to make the entire logistics process more efficient. To establish the directions of action, aspects such as the digitization of the logistics system, the adaptation of the concept of synchro modality, and

sustainable development were considered, critical elements in accessing the funding made available by the European Commission for this activity segment.

At the same time, through the conducted research, we have demonstrated that creating a port community through clusters or other associative forms, which are made up of port actors open to communicating and collaborating proactively and effectively with each other, is a success factor in all ports. In addition, strengthening the connection between the city and the port is another aspect of communication capable of simultaneously contributing to the development of the port and the city.

Each port, transit, and transfer node must be well-governed, efficient, safe, integrated into the intermodal chain, with quality jobs, occupied by qualified labor, and maintain high environmental standards. Based on these principles, the doctoral thesis was built, and thus the managerial directions that public authorities should address in the field of research, education, and digitalization, in improving mobility and intermobility, as well as strengthening institutional capacity and cooperation, were defined.

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The results obtained from the research, recorded in the doctoral thesis, will be capitalized and continued within the Horizon Europe project, HORIZON-CL5-2021-D6-01, entitled "*Deployment and Assessment of Predictive modeling, environmentally sustainable and emerging digital technologies and tools for improving the resilience of IWW against Climate change and other extremes (PLOTO),"* no. 101069941, as a member of the research team. The project aims at increasing the resilience of the Inland Waterways (IWW) infrastructures, thereby ensuring the safe availability of the network in adverse conditions such as extreme weather, accidents, and other types of hazards. The main objective is to combine reduced climate change scenarios (applied to IWW infrastructures) with simulation tools and accurate data to provide the relevant authorities and their operators with an integrated tool to support more efficient management of their infrastructures at a strategic and operational level.

Doctoral thesis structure

The doctoral thesis entitled Impact factors on Danube freight transport management is structured into eight chapters, as follows:

- Chapter 1, **General considerations regarding Danube freight transport evolution**, introduces the field of transport of goods on the Danube, offering a brief incursion in time regarding the region's evolution, port development, and the international transport of goods. This chapter highlights the transport capacity of the Danube River in Europe and the advantages of this type of transport. Considering technological progress and the diversification of raw materials, we can say that international trade has experienced an expansion.
- Chapter 2, **Freight management transport on the Danube**, deals extensively with management models applied in the port activity and the role of the multiple organizations involved in the managerial process. The new development directions drawn by the European Commission and the specialized bodies in water transport were considered. Concepts like circular economy and sustainable development began to be implemented by the port management in the area of the Danube.
- Chapter 3, **Influence factors on the management and performance of freight transport on the Danube**, describes the main factors that influence the performance of freight transport on the Danube. Here, a theoretical presentation of the leading macroeconomic indicators of the countries bordering the Danube is made, highlighting the link between their evolution and the volumes of goods transported.
- Chapter 4, **Evolution of impact factors on the performance of freight transport on the Danube**, presents the evolution of the leading indicators in close connection with the evolution of the volumes of transported goods. From the analysis carried out, the hypotheses that were analyzed and tested in the following chapters, as well as a series of investment directions, needed to be carried out by the bodies responsible for the management of the transport of goods on the Danube, resulted.
- Chapter 5, **The measurement model of the impact factors on the freight transport management on the Danube**, presents the theoretical model for measuring the influence of the factors and the stages of application.
- Chapter 6, **Measuring the impact degree on Danube freight transport management**, focuses on measuring the impact of the factors and reducing the number of factors that influence the performance of the management of goods transport on the Danube. To apply the research method, Exploratory Factor Analysis, the SPSS statistical software program was used.
- Chapter 7, **Action directions in developing specific managerial strategies for cargo transport operations on the Danube**, highlights the results obtained in the previous chapters and focuses on validating the results obtained through the use of Confirmatory Factor Analysis. The results of the research carried out in this chapter were obtained following the use of the SmartPLS computer program.
- Chapter 8, **Conclusions, personal contributions, research limits, and further research directions**, recapitulates the main results obtained within this thesis, highlighting the elements of originality and the author's contributions. Considering that the field of research is a very dynamic one, in full development worldwide, in this chapter, several directions are pointed out that can effectively contribute to the improvement of the entire managerial process in this activity segment.

Synthesis of the thesis chapters

Chapter 1 General considerations regarding Danube freight transport evolution

The company is experiencing an unprecedented increase in world trade, with food goods, raw materials, fuels (minerals, coal, oil), and products specific to the agro-food segment (nitrates, phosphates, and other chemicals) being transited more and more often.

The need to transport goods over long distances in different areas led to the developing of that type of activity. People were increasingly motivated to discover and develop new forms of goods transport, domestically and internationally, thus facilitating access to more diversified resources through commercial exchanges. In order to be carried out in good conditions, it is necessary to choose the appropriate means of transport: road, rail, river, and sea. Each country, shipping company, carrier, and ship-owner must contribute to the organization of the process because of the aspects related to infrastructure and transport operations, respectively, transshipment of goods

Reaching ever-larger transported volumes and implicitly substantial economic growth, transporting goods by water is considered one of the most efficient and environmentally friendly modes of transport. As a result, the water transport industry is recognized for its ability to develop and adapt to new market demands through investment in infrastructure, automation of technological processes, but also improvement of working conditions. Although technological development has taken place for all types and segments of transport, water transport remains the most intensively used due to the large number of goods that can be transported simultaneously.

The Danube ports have changed significantly in the last decades, evolving from typical inland ports to modern logistics centers. Inland ports facilitate the combination of river, road, and rail transport. In an intermodal logistics chain, where rail, road, and river transport are partners, ports play a crucial interface role through the activities that occur before and after the shipment.

As ports serve as hubs for manufacturing facilities and distribution centers for goods, they are well integrated into the regional economy and contribute significantly to economic growth and job creation, as in Figure 1.4. the evolution of the services offered over the years can be observed.

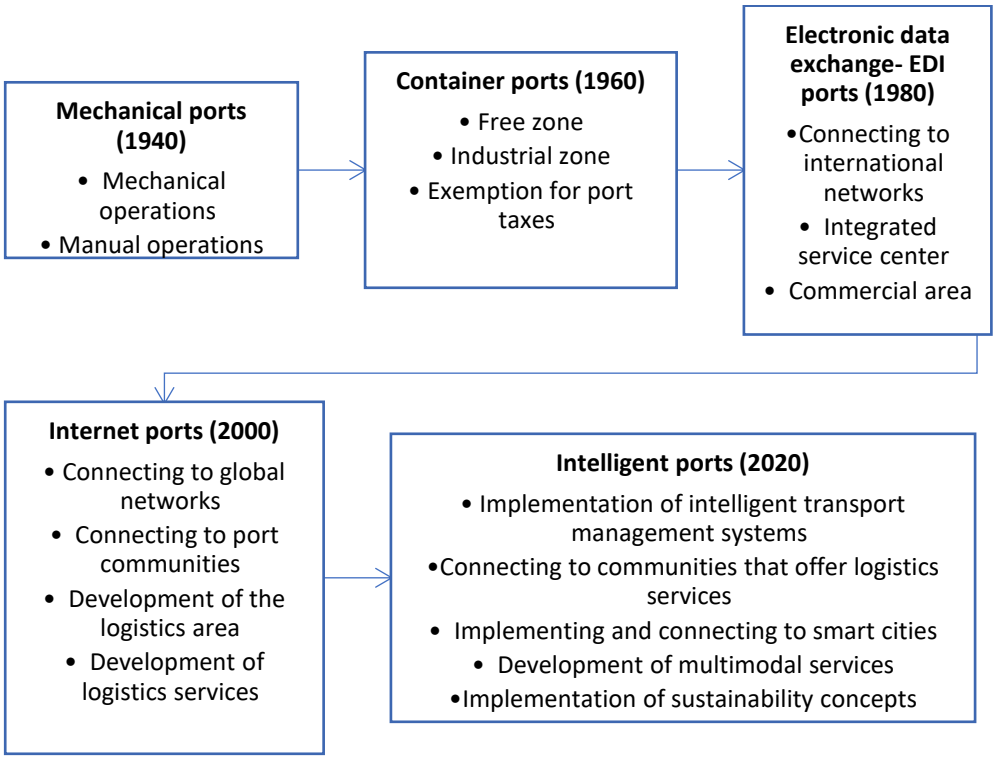


Figure 1.4. The evolution of the Danube river ports
Source: personal contribution, based on literature references

At the European level, inland ports - especially in Eastern Europe - lack adequate infrastructure to prevent inefficient handling of goods. In order to guarantee the competitiveness of inland ports, logistics processes must be organized more efficiently.

The definition of an intelligent port should be the ability to be fully automated and connected to all devices. Supply chain connectivity will help increase efficiency in the managerial process and reduce pressure on the environment. Traditional ports focused on cargo, ships and traffic should change their vision and start collecting and managing data more and more.

Chapter 2 Freight management transport on the Danube

The Danube represents the most direct connection between the rich oil and natural gas area of the Caspian Sea and Europe. The Danube region is home to the world's most significant international river, a crucial transport axis, an interconnected hydrological basin, and a world-renowned ecological corridor. Internationally, interest in using the Danube's transport potential is growing. Both opportunities and challenges, therefore, connect the region.

Congestions, in the case of this type of transport, take place within the ports. If the operations were more efficient at the transit and transshipment points, the difference between the planned time and the time traveled would be significantly reduced or perhaps even non-existent.

The evolution of international water trade and, implicitly, the development of the port segment led to the diversification of the role of a port. Over time, it has acquired different values, which leads to accelerated development of the region of which it is a part, as long as it is exploited to its true potential. Thus, the specialized literature recognizes the multiple roles

of ports and regional economic performances, which can be obtained from exploiting the potential.

Port management rules and local legislation are met under national strategies for development [1]. Ports are perceived as part of the national, respectively European transport system [2]. Knowing the actors involved in the current port activities leads to a better understanding of the operation of the ports, but also of the decision-making level.

These companies, or the interest groups that control them, tend to dominate as many transport market sectors as possible related to the port segment. However, the administration (management) of the port is responsible for adequately functioning its catchment area to increase the port's competitiveness in competition with other ports in the available market [3].

Table 2.1. Administrative composition of the port segment

Actor involved in the port management process	Description
Port land owner	Depending on the legal systems of port ownership and systems of port governance (port administration, port management) in each riparian country, land ownership in the port area may be stated, region/province, municipality, private or other entities. The land owner of the port is usually the one who manages the operation of the port and regulates the conditions and obligations related to the governance (administration) and use of the port and its facilities.
Port infrastructure owner	For simplicity of the definition, it is adopted that port infrastructure includes all port infrastructure at ground levels, such as quay walls, shore protection, harbor basins, berths, anchorages and berths, waiting areas, crane lines, infrastructure rail, and other publicly used infrastructure assets. Therefore, the ports selected for this report are examined from the point of view of infrastructure ownership. Such ownership is necessary because the owner of the port infrastructure assets sets the rules for the port infrastructure's type and scope of use. As in the previous paragraph, the owners of port infrastructure can be the state, region/province, municipality, or other entities (port authority, public infrastructure construction, management companies, etc.) to which ownership rights are granted or transferred by the supreme authority regulation.
Port authority	Each port will develop a body/entity (public company, government institution, organization) that acts as a port authority, an “umbrella” organization for all port locations in a given place (city, municipality, region, etc.). The port authority can sometimes be the same legal entity as the port operator if the administrative functions of port governance (administration/management) are not organizationally separated from the commercial activities of port operations / port exploitation.
Port operators	Port operators are present in all ports located along the Danube. Currently, port operators are usually independent companies, which can be public, private, or even with mixed ownership. In several cases in Danube ports, port operators are identical to port authorities, organized as commercial entities with governance and operational responsibilities.

Source: Law no. 235/2017, World Bank, (2007)

Increasingly, ports are integrated into global logistics chains, and their public benefits are given regional and global attributes. The value of services provided by regional ports

increasingly transcends the interests of local users and benefits businesses and communities across regional and national borders.

Developing connections with other means of transport is a continuous challenge for every port. The fast pace of development can be guaranteed by good financing opportunities and easy access to obtaining them. Easier access to financing is typical of private service ports, which can make faster decisions and apply for financing more easily. State companies have a strictly hierarchical organization of investments. This causes delays or refusals for project funding and decreases the participants' motivation.

In order to better understand the particularities of the different management models applied in port management, it is essential to analyze in detail how the operation and management structure is established in the different ports located on the inland waterways. There are five main management models applied in the management of the port activity, based on the responsibility of the public and private sectors, according to Ordinance 22/1999 and the report developed by the World Bank "Alternative Port Management Structures and Ownership Models" [4,5], as can be seen in table 2.2.:

Table 2.2. Management models applied in the management of port activity

Port type	Characteristics
Ports of public services	Public Service Ports Port Authority performs the full range of port-related services and owns all the infrastructure. They are usually a branch of a government ministry, and most of their employees are civil servants. Some ancillary services can be left to private companies. In recent years, however, public service ports have decreased.
Ports of instruments	Similar to a public service port, the tool port differs only in the private management of its cargo operations, although the port authority still owns the terminal equipment. In many cases, such a port is a transitional form between a public service and a proprietary port.
Owner ports	It represents the most common management model where the infrastructure, especially the terminals, is leased to private operating companies, with the port authority retaining ownership of the land. The most common form of leasing is a concession agreement in which a private company is granted a long-term lease in exchange for rent that is typically a function of the size of the facility as well as the investment required to build, renovate, or terminal extension. The private operator is also responsible for providing terminal equipment to maintain operating standards.
Corporatized ports	The port authority behaves like a private enterprise. It concerns ports that have been almost entirely privatized, except that ownership remains public and often assumed to be the majority shareholder. This management model is unique because it is the only one where ownership and control are separated, which lessens the "public good" pressures faced by the owner port authority and the "shareholder value" pressures faced by private ports.
Private service ports	The result of a complete privatization of the port facility with the mandate that the facilities retain their maritime role. The Port Authority is fully privatized, with almost all port functions under remote control, with the public sector retaining standard regulatory oversight. However, public entities can be shareholders and thus steer the port towards strategies in the public interest.

Source: Ordinance 22/1999, World Bank, (2007)

The corporatized port management model is characterized by public land ownership, leading to investments in public infrastructure. We can see a direct relationship between the

development of the transport infrastructure, the development of the port, and the economic development of the region of which it is a part. When European and national programs are available that can develop water transport infrastructure, the application of this model is remarkable for the success factor that can attract significant investments that are difficult to find in the private sector in ports that do not involve emerging development, as can be seen in table 2.3.

Table 2.3. Characteristics of corporatized ports

Characteristics	Description
Financial self-support	Revenues for port authorities come from fees charged for shipping operators (port charges) and land concessions. The corporatization of the port allows access to capital markets, thus reducing or eliminating the need for state infrastructure investment.
Investments in port development based on commercial needs	In countries such as Belgium and Germany, much of the investment in port infrastructure is financed by government authorities. In a corporate port, investments are made based on commercial reasoning. This consideration includes that the port authority does not access necessary financing for development (mainly in infrastructure) from the authorities at the national or international level.
Operated by landowner	The central role of the port landowner is to develop a set of cluster activities within the port. Port authorities need the technical capacity to provide all necessary port services, but most can be outsourced. The port authorities must decide the size of the outsourced services so that the land owner can focus on exploiting the port property.
Ability to negotiate long-term lease/concession contracts	Corporatized ports sign leases and concessions with operating companies that may include clauses for minimum performance levels. The port authority treats concessionaires as customers because they often share a strong interest in attracting more cargo to the port.

Source: adapted from the World Bank, (2017)

The corporatized port management model extends the tasks of the port administration to direct involvement in the promotion, application, and implementation of transport infrastructure development projects to improve the connection with other means of transport. Private port service providers themselves have become increasingly globally present. Several strategic alliances have recently been formed within the global maritime and port services industries. These alliances affect how ports are financed, regulated, and operated.

Chapter 3 Influence factors on the management and performance of freight transport on the Danube

Over time, it has been noticed that there are close relations between the development of the transport of goods on the Danube and the economic growth of the countries bordering the Danube, especially in the areas adjacent to the port segment. These relationships are visible through the lens of export and import volumes and a series of macroeconomic indicators to be analyzed in the following chapters.

The continued growth of world trade and the desire of many countries to accelerate the pace of integration into the global trading system will depend not only on maintaining an open

global economic system but also on improving the quantity and efficiency of support structures such as logistics services [6]. Logistics services are considered to be poor when there are:

- limited coordination between countries regarding border procedures;
- the inefficiency of the customs clearance process in the ports;
- fragmentation and poor quality of transport-related infrastructure;
- costly and infrequent maritime transport (with long and indirect maritime routes);
- delays in tracking shipments;
- delays in terminal handling and customs clearance of goods;
- the absence of cold storage facilities in ports;
- and the inability to certify product quality;

may cause significant obstacles to international trade.

Water transport accounts for 90% of world trade, with cargo ships forming the backbone of the global economy. Internationally, it was found that the level of transported cargo has an estimated value of 4.5 trillion dollars annually and is expected to increase by approximately 4.7% in the coming years, states the Water Quality Assurance Union (2020) [7].

Therefore, the relationship between transporting goods by water and economic development is bidirectional. This research thesis is designed to study the management of the transport of goods on the Danube, as well as the impact of the factors that influence the performance of this type of transport.

Intelligent transport management systems (ITS) apply information and communication technologies to road transport, including infrastructure, vehicles, and users, traffic and mobility management, and interfaces with other transport modes [8]. The continuous development of logistics chains and their network system is possible due to the developed node-link system, where the most critical nodes are seaports and integrated logistics centers [9].

To implement innovative systems in ports, it is necessary to have a collaborative approach. A port authority needs more resources to develop technological innovation. Therefore, the port authority must coordinate initiatives that will allow the development of this type of intelligence, either through a research and development network or through hackathons or meetings – that is, events that bring together specialists in computer programming [10]. In table 3.1., we can see the internal and external services that port administrations can apply.

Table 3.1. Services that can be integrated into the intelligent management systems of goods transport on the Danube

Services	Role
PCS – Port Community System	Message exchange tool in the port environment, having a commercial and logistic character, which has a B2B (Business to Business) character.
PSW - Port Single Window System	A tool that provides local ship information to port authorities is B2G (Business to Government).
S&S- Security and Safety services	IMO regulations such as ISM or ISPS apply to maritime transport or technical standards such as ISO 28000 (Specification for Security Management Systems for the Supply Chain) to improve security in international supply chains. IMO conventions are binding on ports worldwide.
VTMIS: Vessel Traffic Management and Information System	The intelligent maritime traffic system based on satellites, radar, AIS (Automatic Identification Systems), and related services such as e-maritime and e-navigation aims at integrating all traffic management systems: VTMIS (Vessel Traffic Management and Information System), ATM (Air Traffic

	Management), ERTMS (The European Rail Traffic Management System): maritime, air, rail, and road, respectively.
E- freight	It was defined in 2007 in the Logistics Action Plan as a result of the interaction of transport services with ICT and the Internet. It describes the processes, actors, and data flows to enable the exchange of information in electronic formats - paperless - across all modes of transport.
Synchro modality	The concept defines the widespread use of the Internet and tracks and traces technologies to logistics and transport management: production, transport, and distribution: 3 types of logistics are currently defined: production, transport, and delivery. All must be synchronized to avoid bottlenecks, overproduction, stock outs, or shortages in industries or businesses.

Source: Yan Alix (2019)

One of the main objectives of the European Union and the countries that have agreed on their vision is to contribute to creating a single European market. To achieve this, a sustainable and interconnected transport network is necessary. Intelligent transport management systems refer to a range of digital traffic management and information systems covering multiple modes of transport. The Commission has recognized that the successful coordinated implementation of such systems is vital to achieving a pan-European, convenient, and truly integrated transport system that forms an intrinsic part of future transport [11].

One solution to mobility problems is intelligent transport. The development of port infrastructure is only worthwhile if the entire transport system benefits and there are no bottlenecks for another element within the system [12]. An intelligent port strategy should contain at least three primary long-term goals to be achieved:

- advanced port technologies;
- intelligent port system;
- ecological technologies.

With advanced port technologies in mind, we mean automated yard cranes that can load and unload containers with computer-aided precision, intelligent sensors, cameras, driverless and battery-powered self-guided vehicles to transport containers, drones to inspect equipment ports, and to help debug with remote video streaming.

Regarding the intelligent port system concept, I specify the one-stop digital portal for a seamless and more efficient port clearance intelligent planning system to optimize the turnaround time of ships in the port and berths.

One of the advantages of sea-river ports is that they have become part of European policies, strategies, and programs aimed at developing the core network until 2030. The development of sea and river transport as a sustainable mode of transport is expected to be achieved through the sources of non-reimbursable financing from European funds, which can be directed in this direction.

The necessary conditions for the development of river-sea ports consider good cooperation between all members of the port community, consisting of:

- Port administrations;
- Port authorities;
- Customs commissioners;
- River commissioners;
- Transport operators;
- Terminal operators;

- Logistics service providers;
- Quality control companies;
- Maritime companies;
- Shipbuilding companies.

Optimizing cargo traffic for river seaports is much more important today due to the demands of global trade, which means a large volume of fast-moving cargo, large-capacity vessels, increasingly complex that are increasingly faced with: geopolitical issues, operational congestion, safety and security issues.

Chapter 4 Evolution of impact factors on the performance of freight transport on the Danube

In terms of management, organization, and monitoring, the managerial process within the port segment is critical and sometimes challenging to optimize, as several factors are involved. Regardless of the type of raw material transported, the factors mentioned in the previous chapter are found in all the countries bordering the Danube.

Handling goods is the most expensive and challenging, as it involves coordinating special equipment, machines, tools, and devices and skilled labor in their handling. This process becomes all the more complex, the more economic actors are involved, from ship-owners to equipment owners and customs authorities.

These operations are carried out in all ports, and the most difficulties are encountered in transporting heavy goods. This fact led to the specialization of ports and the implementation of a series of investments in the specialization of the use of technological equipment at terminals to ensure the facilitation of specific handling operations.

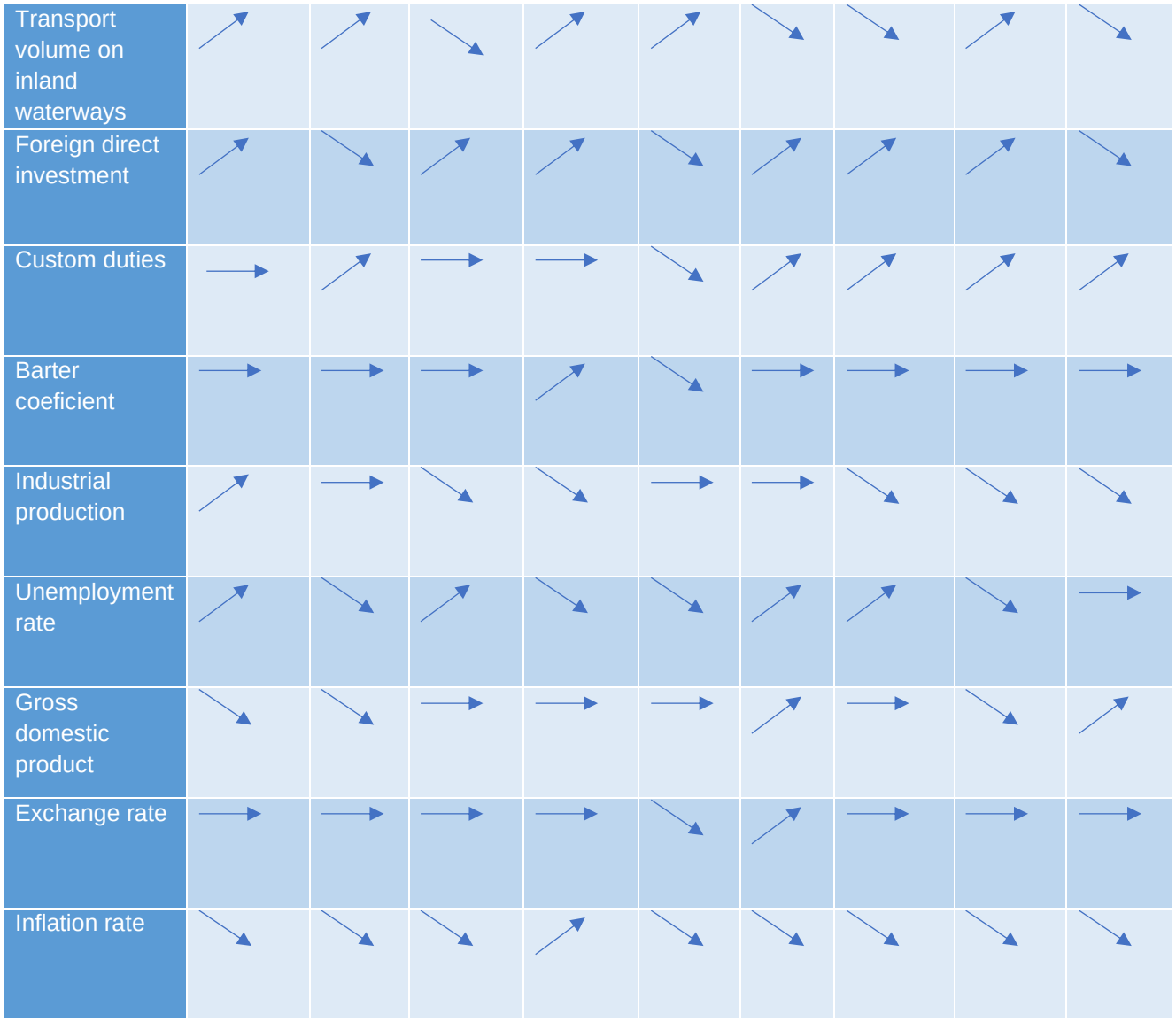
The port assumes a complex organization, with many defining actors in its activity involved in the management process, leading to establishing a more significant number of performance indicators. A few indicators may not provide a sufficient basis for performance analysis. Specialists recommend fixing a set of fundamental indicators so that they can then be developed into other secondary indicators so that as many details and aspects can be touched as possible. The secondary and primary actors must be consistent [13].

The way indicators are tracked can be permanently or punctually, depending on the purpose. As a rule, the permanently monitored indicators refer to the activities developed inside the port and refer to the port as an isolated entity.

In the previous sub-chapters, we presented the evolution of the leading indicators selected for building the model for measuring the impact of influencing factors on the performance of the management of goods transport on the Danube. Table 4.1. the evolution of each analyzed indicator is summarized.

Table 4.1. Analysis of the evolution of indicators that influence the performance of goods transport on the Danube

	Germany	Austria	Slovakia	Hungary	Croatia	Serbia	Romania	Bulgaria	Ukraine
Logistic performance index	↘	↘	↗	→	↘	↗	↗	↗	→



Source: own creation based on the specialized literature studied and the analyzed indicators

Legend symbols:

Symbol	Meaning
	Increasing
	Decreasing
	Constant evolution

Following the analysis carried out in chapter 4 on the influencing factors on the performance of freight transport on the Danube, we can draw the following conclusions:

- The logistics performance index, an indicator introduced by the World Bank and analyzed every two years, is composed of the efficiency of customs procedures, the quality of the logistics infrastructure, the competitiveness of prices, and the quality of logistics services, taking into account the estimated delivery time and the time performed, is in a slight decrease in countries such as Germany and Austria. The ports of these two countries are known for their logistics performance at the European level, especially in the context of the digitalization of the entire process. They were among

the first countries to allocate a considerable budget for the development of the digitization of the port segment. However, this indicator is decreasing, as are the gross domestic product and the inflation rate. The growth or stagnation of the other analyzed indicators leads to the need for investments in port development. The ports in this area are occupied at maximum capacity, which prevents a logistic performance regarding the handling and storage of goods. At the same time, growing industrial production and a high level of goods volumes lead to managerial measures regarding environmental protection, the development of synchro modality, and the identification of new transport routes, respectively, of demand for goods and from areas other than the traditional ones.

- In the case of Croatia, the decrease in the logistics performance index combined with the other decreasing indicators indicates an increase in the volumes exported from the country's domestic production. We observe a weak international collaboration but a stable industrial production involving the domestic workforce. In order to capitalize on the potential of the port segment, a series of managerial measures are required to strengthen international cooperation through the development of public-private partnerships, prioritizing projects aimed at port investments in terms of port construction and modernization.
- In the case of Slovakia, the logistics performance index is increasing, as is foreign direct investment, but also the unemployment rate. In contrast, the volume of goods handled and industrial production is decreasing. This direction of the analyzed indicators indicates a transit of goods made of imports and less of exports. Government measures to increase industrial production would lead to a decrease in the unemployment rate. Therefore, a series of managerial decisions and measures are required to improve the port infrastructure, attract new port operators, attract funds to improve access to synchro modality, increase public-private partnerships, and improve access to education and training in the field of the available workforce.
- Hungary has stagnated the logistics performance index, but it has an increase in the volumes of goods handled. Industrial production is down, but foreign investment is up. These differences between the indicators assume a weak domestic production ready for export. However, the decrease in the logistics performance index indicates poor efficiency of the operations that are the basis of the logistics services. Thus, the management of the port sector must pay special attention to the container and ro-ro businesses in the ports. Joint promotion through partnerships, the exchange of good practices, and port-specific training of the workforce can lead to improved and better positioning on the river transport market in terms of logistical efficiency.
- Romania and Bulgaria are enjoying an increase in logistics performance, as well as in foreign direct investments. Industrial production is declining in both countries, a fact that leads to the traffic of goods from import and not from export. The increase in customs duties and the decrease in industrial production led to a decrease in the volumes of goods handled and an increase in the unemployment rate. In order to reduce the negative impact of the indicators on the logistics performance, a series of managerial measures are required regarding the digitization of the logistics process, investments in synchro modality, the implementation of corporate management directions, the attraction of investments from the private sector, as well as know-how, the implementation of a specialized education and training system for port staff.
- As reported in subchapter 4.7. a central component of the gross domestic product is the volume of transported goods. If a higher value of exports suggests a trade surplus,

a higher value of imports suggests a trade deficit. Therefore, the decrease of this indicator in countries such as Germany, Austria, and Bulgaria suggest a decrease in consumption expenditures, as well as those for investments, and an increase in imports. In order to develop the economy and implicitly export, a series of measures must be taken in the context of the government granting funds for its production and infrastructure development. Keeping under control the inflation rate and the exchange rate by government factors leads to an improvement in the access of goods to the foreign market.

In addition to the objective of ensuring a high quality of accessibility, European and national transport policies are increasingly striving to create favorable conditions for sustainable and efficient transport. Starting from these considerations, a first research hypothesis was formulated **(Hypothesis no. 1). Optimizing the logistics and distribution process of goods is a determining factor in the evolution of goods traffic on the Danube**.

Administrative barriers in the logistics of goods on the waterway of the Danube and its navigable tributaries represent a significant obstacle to the efficient and sustainable use of the Danube as the central transport axis of the region. The abundant existence of the administration reduces its economic and environmental potential, having a negative impact on the economic growth and social well-being of the entire region. Alleviating significant administrative barriers in a coordinated transnational manner is the primary step towards better governance of this mode of transport. It reduces the logistics costs of large industries that depend on inland waterway transport. Therefore, a new hypothesis resulted, **(Hypothesis no. 2). The alignment of national strategies regarding the development of water trade with European strategies will positively impact the volumes of goods transported on the Danube**, which will be tested in the following chapters.

Following the analysis carried out on the factors that significantly contribute to the performance of the transport of goods on the Danube, the need for qualified labor in several ports was made visible. In this context, a new working hypothesis became visible, which is to be tested, namely, **(Hypothesis no. 3) Investments in the attraction and qualification of human resources will lead to the efficiency of operations specific to the transport of goods by water.**

Chapter 5 The measurement model of the impact factors on the freight transport management on the Danube

Over time, the relationship between macroeconomic factors and the state of the water transportation industry has been studied [14]. Studies have concluded that there is a close relationship between the two considerations. By analyzing the risk factors that affect the efficiency of water transport [15], the variables that impact performance can be highlighted, and a series of mechanisms can be developed to reduce their impact.

The research focuses on analyzing the indicators, presented in table 4.1., from the countries along the Danube, especially those located on the IV and VII Pan-European corridors. This paper argues that the Danube ports could benefit a lot from their strategic positioning internationally.

The selection of countries for this study was based on European integration policies. Thus, the countries that are part of the European Union and, on the course of the Danube, were selected in table 5.1., which can be viewed together with the analyzed macroeconomic indicators and the time range.

Table 5.1. Indicators selected for analysis

No.	Analyzed indicators	Countries	Years
1	Core Consumer Price Index (CPI)	Germany Austria Slovakia Hungary Croatia Serbia Romania Bulgaria Ukraine	2011- 2020
2	Exchange rate		
3	Impact of fees related to customs clearance procedures		
4	Industrial production		
5	The stock market		
6	Unemployment rate		
7	Gross domestic product		
8	Transport volume on inland waterways		
9	The volume of goods transited in container vessels		
10	Export of high technology		
11	Logistics performance index		
12	Export of goods and services		
13	Import of goods and services		
14	Inflation rate		
15	Employed labor force		
16	Export of fuel		
17	Exports of ores and metals		
18	Foreign direct investments		
19	Average delivery time for export		
20	Average delivery time for import		
21	The commercial coefficient applied to international barter operations		
22	Transport depending on the nationality of the vessel		
23	Modal division of freight transport by country		

Source: personal contribution, based on the specialized literature studied

Efficient ports are essential for national, regional, and international logistics. In this sense, it is necessary to research the performance of the entire logistics chain based on a series of factors considered necessary to analyze international trade performance.

Therefore, in the framework of this research, we analyzed, for ten years, a series of 23 indicators, with data collected from 9 countries located along the entire course of the Danube, from the perspective of the performance of the entire logistics chain, based on a series of factors considered necessary in the analysis of the performance of goods transport on the Danube. The analyzed data were collected from the websites of specialized institutions such as the World Bank, Eurostat, the Organization for Economic Cooperation and Development, and the National Institutes of Statistics.

The application of Exploratory Factor Analysis in marine research is extensive because most of the factors involved are not quantifiable, and therefore many indicators are required. Several authors [16-18] specify in their works that the main factors that cannot be quantified are those that measure the quality of services in ports, the selection criteria in the choice of container transport, those that evaluate the expectations of travelers when we refer in passenger transport, as well as those that strengthen the competitive position of carriers. These factors can be observed through several variables.

This study aims to provide a systematization of the number of indicators that are the basis of the above analyses using the widely varied factorial analysis. This paper will extract the factors with an influence degree of more than 60% in the performance of water freight transportation. In the scope of this study, an Exploratory Factor Analysis will be carried out by applying the principal component analysis (PCA) method, which is based on three main stages:

- extraction of variables,
- retention of the main variables,
- rotating the factors and obtaining several factors that will be the basis of the following analyses.

Users of Exploratory Factor Analysis must choose the appropriate factor model in the analysis of the chosen indicators by the purpose of the analysis. The most used and effective method is Principal Component Analysis. This method will reduce the number of variables, keeping only the essential ones [17]. Among the main advantages of principal component analysis, we mention:

• Improve understanding of variables by extracting mean, median, minimum, and maximum values, etc.

• Errors, outliers, and missing values in the data can be discovered.

• Patterns can be identified by viewing data in graphs such as box plots, scatter plots, and histograms.

This method is used to identify principal components, that is, different linear combinations of performance variables so that the principal components can be multiplied by their eigenvalues to obtain a weighted measure of the variables.

The Statistical Package for the Social Sciences (SPSS) software program was used to apply the ACP method, and the EXCEL program was used to describe the internal and external interpretation of the descriptive statistics of the ACP results.

Chapter 6 Measuring the impact degree on Danube freight transport management

The congruence relationship between the evolution of macroeconomic indicators and the evolution of the volumes of goods transported by water was demonstrated in the analysis carried out in chapter 4. All the indicators included in this analysis can be influenced by a country's government policies, which lead to an increase, respectively, a decrease in the transport of goods on the Danube.

Any pair of variables with a value greater than 0.5 will be considered excluded from the analysis, and the analysis will be repeated. In an ideal model, the off-diagonal elements (the values to the left and right of the diagonal in the table below) should all be minimal (close to zero). Correlations with a high value, according to Table 6.1., over 0.7 was observed between the variables “Commercial coefficient applied to international barter operations” - “Logistics performance index,” “Modal division of freight transport by country,” as well as between “Employed labor force” and “Modal division of freight transport by country.”

Table 6.1. The variables with the highest degree of correlation

	Exchange rate	Volume of goods transited in container vessels	Logistics performance index	Export of goods and services	Import of goods and services	Employed labor force	Commercial coefficient applied to international barter operations	Modal division of freight transport by country
Exchange rate	1,000	0,076	-0,031	0,417	***0,639***	0,012	0,027	-0,075
The volume of goods transited in container vessels	0,076	1,000	0,064	-0,207	-0,002	***0,631***	0,289	0,557
Logistics performance index	-0,031	0,064	1,000	0,081	0,166	0,380	**0,777**	0,569
Import of goods and services	***0,639***	-0,002	0,166	***0,689***	1,000	-0,052	0,212	0,151
Employed labor force	0,012	***0,631***	0,380	-0,138	-0,052	1,000	0,540	**0,720**
The commercial coefficient applied to international barter operations	0,027	0,289	**0,777**	0,017	0,212	0,540	1,000	**0,840**
Modal division of freight transport by country	-0,075	0,557	0,569	-0,024	0,151	**0,720**	**0,840**	1,000

Source: personal contribution, based on results from SPSS software

The next item in the output is a table of common points that shows how much of the variance is contributed to the factors to be extracted. At this analysis stage, the variables that have a value below 0.5 are eliminated from the following analyses.

Regarding the collinearity of the variables, it can be seen that the lowest value is 0.578 and belongs to the “average delivery time for import” variable. However, it will be maintained for the following analyses as it exceeds the minimum acceptable threshold. In table 6.3. the variables with a value above 0.9 are particularly highlighted, namely “Export of fuel,” “modal division of freight transport by country,” and “commercial coefficient applied to international barter operations.”

Table 6.3. Collinearity of variables

Variables	Extraction value
Core Consumer Price Index (CPI)	0,816
Exchange rate	0,631
Impact of fees related to customs clearance procedures	0,794
Industrial production	0,778
The stock market	0,612
Unemployment rate	0,830
Gross domestic product	0,645

Transport volume on inland waterways	0,740
The volume of goods transited in container vessels	0,749
Export of high technology	0,741
Logistics performance index	0,825
Export of goods and services	0,770
Import of goods and services	0,853
Inflation rate	0,624
Employed labor force	0,884
Export of fuel	**0,916**
Exports of ores and metals	0,882
Foreign direct investments	0,673
Average delivery time for export	0,636
Average delivery time for import	0,578
The commercial coefficient applied to international barter operations	**0,906**
Transport depending on the nationality of the vessel	0,814
Modal division of freight transport by country	**0,913**

Source: personal contribution, based on results from SPSS software

Considering the subject of the present research and the values above the average resulting from the analysis of common points, analysis preceding the retention of factors leads us to conclude that the selection of the variables subject to the analysis was carried out correctly, and the research can be continued.

The next step is to determine the number of factors needed to determine the underlying structure of the data. Factors with a value < 1 will be omitted from further analysis.

The eigenvalue reflects the number of extracted factors whose sum should equal the number of items subjected to factor analysis. Table 6.3. shows all the factors that can be extracted from the analysis, along with their eigenvalues.

For purposes of analysis and interpretation, we are only concerned with the initial eigenvalues and the sums extracted from the quadratic deviations. Because the requirement to identify the number of components or factors declared by the selected variables is the presence of eigenvalues greater than 1. Table 6.4 shows seven components with values above 1, so for the first component, the value is 4,790 > 1, the second component is 3.817> 1, the third component is 2.684 > 1, and the eighth component is 0.913 < 1. Thus, the set of 23 variables declared represents seven components.

Table 6.4. The degree of variance of the variables

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	% Cumulative	Total	% of Variance	% Cumulative	Total	% of Variance	% Cumulative
1	4,790	20,824	20,824	4,790	20,824	20,824	4,170	18,130	18,130
2	3,817	16,596	37,420	3,817	16,596	37,420	3,033	13,188	31,318
3	2,684	11,667	49,087	2,684	11,667	49,087	2,599	11,301	42,620
4	1,875	8,152	57,239	1,875	8,152	57,239	2,193	9,534	52,154
5	1,490	6,477	63,716	1,490	6,477	63,716	1,965	8,543	60,697
6	1,328	5,772	69,488	1,328	5,772	69,488	1,694	7,364	68,061
7	1,151	5,005	74,493	1,151	5,005	74,493	1,479	6,432	74,493
8	0,913	3,971	78,464						

9	0,855	3,716	82,180						
10	0,791	3,439	85,619						

Source: extract from the SPSS program

The extracted sum of the square holding a percentage share of the variance shows that the first factor represents 20.824% of the various characteristics of the mentioned observations, the second 16.596%, the third 11.667%, and the smallest of the seven extracted factors 5.005%. Thus, seven components are effective enough to represent all the characteristics or components highlighted by the 23 mentioned variables.

In Annex C, we have highlighted all the variables with a load greater than 0.5 and figure 6.5. the degree of intensity can be observed before performing the Varimax rotation. It can be seen that seven variables contribute to factor 1, 4 variables contribute to factor 2, 2 variables contribute to factors 3 and 5, while only one variable contributes to factor 3. At the same time, it is observed that for factors 4 and 7, the component variables do not have a substantial loading.

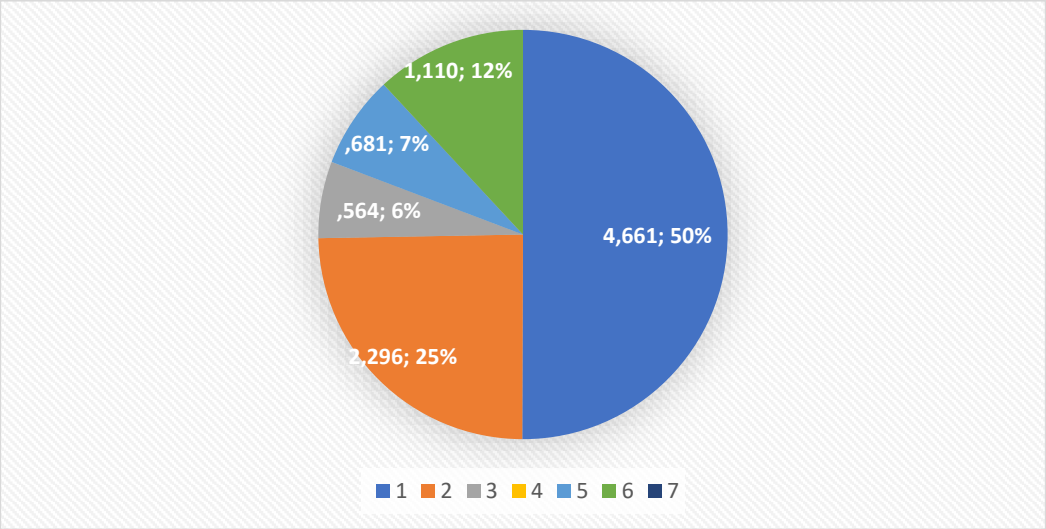


Figure 6.5. Factor loadings before performing Varimax rotation
Source: personal contribution, based on results from SPSS software

In Appendix D, we have highlighted all the variables with a load greater than 0.5, and in figure 6.6. the degree of intensity can be observed after performing the Varimax rotation. Following the redistribution of the variables, it can be seen that for factors 1 and 2, 4 variables each contribute; for factors 3 and 5, 3 variables each contribute; for factors 4 and 2, variables contribute; and for factors 6 and 7, only one variable contributes. The variables may load on several components, and then it is recommended to exclude them from further analyses, but this is not the case in the present research.

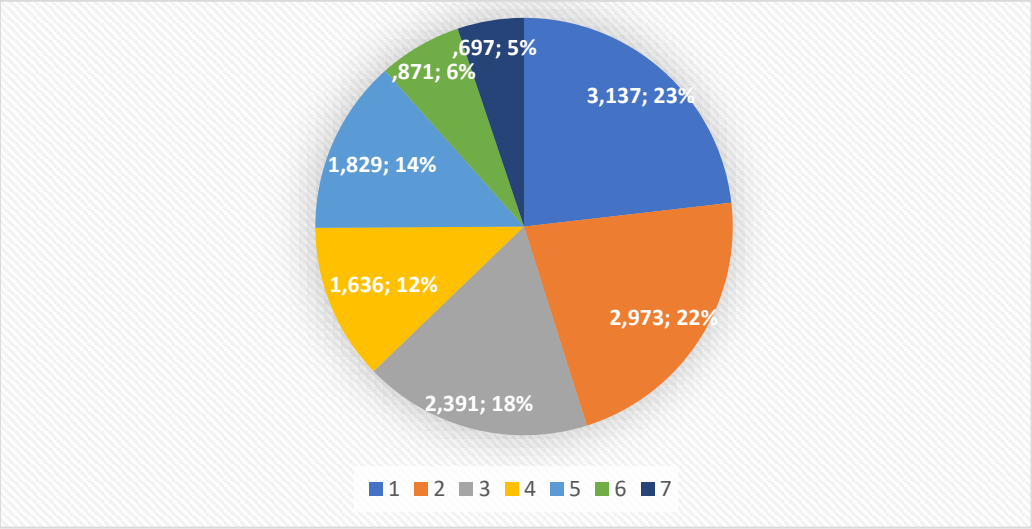


Figure 6.6. Factor loading degree after Varimax rotation
Source: personal contribution, based on results from SPSS software

In the present research, according to Appendix D and Figure 6.6, each factor has a substantial load of more than 0.5 on different components so that they can be subjected to the following analyses. It is noted that after performing the Varimax rotation with Kaiser normalization, the distribution of the variables was performed homogeneously, with each factor having at least one component variable. At the same time, the degree of loading, according to figure 6.6., does not show significant differences between the factors, and no more cross-loading variables were identified.

Applied analysis methods, Exploratory Factor Analysis, allowed the exploration of the data selected for analysis, the selection and understanding of critical variables, and the elimination of those that do not significantly influence the issue presented. After applying all the stages in table 6.5. extracted factors can be observed, along with the component variables and their degree of loading.

Table 6.5. The degree of contribution of the indicators on the factors

Factors	Variables				Cumulative contribution
Factor 1	Logistic performance index	Average delivery time for the export	Average delivery time for the import	The commercial coefficient applied to international barter operations	
	0.884	0.778	0.648	0.827	3.137
Factor 2	Exchange rate	Export of goods and services	Import of goods and services	Transport depending on the nationality of the vessel	
	0.745	0.802	0 .869	0 .556	2.973
Factor 3	The volume of goods transited in container vessels	Employment labor force	Modal division of freight transport by country		

	0.861	0.826	0 .705		2.391
Factor 4	Unemplyment rate	Export of fuel			
	0.758	0.879			1.636
Factor 5	Core Consumer Price Index	Industrial production	Foreign direct investments		
	0.738	0.543	0 .547		1.829
Factor 6	Exports of ores and metals				
	0.871				0.871
Factor 7	Inflation rate				
	0.697				0.697

Source: personal contribution, based on results from SPSS software

In the continuation of the research and for testing the hypotheses mentioned in chapter 4, it is necessary to establish the intensity of the degree of connection from the variables, considering the dependent variant, the resulting factor, and the predictors of the variables that led to their creation. Our attention is particularly drawn to the first two factors, which have a similar degree of intensity, each composed of 4 variables. The third factor will be subject to further research, as the factor loading value is above average. We observe that both variables specific to the management activity of goods traffic on the Danube and variables specific to the macroeconomic segment are grouped in the same factor, so there is an interdependent relationship between them.

Therefore, for the following analyses, only the first three factors are tested, as they have the highest loading, respectively 3.173 for the first factor, 2.973 for the second factor, and 2.391 for the third factor.

The coefficient of determination (R^2) shows the total proportion of the change in the dependent variable explained by the change in the independent variables and, therefore, the estimated regression model.

In our case, in table 6.6., it can be seen that for all three relationships, R2 has values very close to 1. Hence, there is a strong relationship between the independent and dependent variables. In these cases, the errors are close to 0. The higher the value of R^2, the better the estimated regression function explains the observed values.

In order to test the quality of the model regarding the working hypotheses, the analysis of variance (ANOVA) will be used. In table 6.6., it can be seen that the MSR value is significantly higher than the MSE value. The F distribution is for the value 1, so the independent variables affect the dependent variable. So, considering what was exposed in the previous subchapter, all three models are statically valid.

Table 6.7. ANOVA analysis results

	Factor (dependent variable)	Variable (independent variable)	Correlation repport (R)	Determination coefficient (R^2)	Mean of squares (MS)		Statistics (F)
					Regression (MSR)	Error (MSE)	
Hypothesis 1	Logistic system optimization (OSL)	V1, V2, V3, V4	0.974	0.949	20.882	0.053	392.173
Hypothesis 2	Economic European circuit (CEE)	V5, V6, V7, V8	0.953	0.908	19.979	0.096	207.575
Hypothesis 3	Labor force availability (DFM)	V9, V10, V11	0.938	0.880	25.809	0.124	207.471

Source: own creation, based on the results from the SPSS computer program

Following the application of simple linear regression, according to table 6.6. the following is observed:

Hypothesis 1 The optimization of the logistics process and distribution of goods is a determining factor in the evolution of goods traffic on the Danube: The value of the correlation coefficient is 0.974, which means that there is a strong link between the index of logistics performance, the average delivery time to export, the average import delivery time, the commercial coefficient applied to international barter operations. Regarding the coefficient of determination, its value is 0.949, very close to the maximum value of 1, so the errors are minimal. Since the average of the squares of the deviations of the adjusted values of the dependent variable from their selection average indicates a high action of the regression factors, comparable to the sum of the squares of the residuals, since the value of F is 392,173, it is considered that hypothesis 1 is validated and can be subjected to further research.

Hypothesis 2 The alignment of national strategies regarding the development of water trade with European strategies will have a positive impact on the volumes of goods transported on the Danube: The value of the correlation coefficient is 0.953, which means that there is a strong connection between the exchange rate, the export of goods and services, import of goods and services, transport according to the nationality of the vessel. Regarding the coefficient of determination, its value is 0.908, very close to the maximum value of 1, so the errors are minimal. Since the average of the squares of the deviations of the adjusted values of the dependent variable from their selection average indicates a high action of the regression factors, comparable to the sum of the squares of the residuals, since the value of F is 207,575, it is considered that hypothesis 2 is validated and can be subjected to further research.

Hypothesis 3 Investments in the attraction and qualification of human resources will improve the efficiency of operations transporting goods by water: The value of the correlation coefficient is 0.938, which means that there is a strong connection between the volume of goods transited in container-type vessels, the force of employed work, the modal split of goods transport by country. Regarding the coefficient of determination, its value is 0.880, close to the maximum value of 1, so the errors are minimal. Since the average of the

squares of the deviations of the adjusted values of the dependent variable from their selection average indicates a high action of the regression factors, comparable to the sum of the squares of the residuals, since the value of F is 207,471, it is considered that hypothesis 3 is validated and can be subjected to further research.

Chapter 7 Action directions in developing specific managerial strategies for cargo transport operations on the Danube

Confirmatory Factor Analysis was used to validate the previously obtained results and create predictions to optimize the management activity specific to the transport of goods on the Danube. In order to validate the obtained model and create predictions, the SmartPLS software program was used. Using this software, it was possible to validate the results obtained by applying exploratory factor analysis. Structural equation modeling (SEM) and partial least squares path modeling were used. The results were subjected to Confirmatory Factor Analysis to validate the econometric model created.

The model being tested is as follows: **The lack of an entirely digitized logistics process, standard economic policies, and qualified labor for operations on the Danube leads to a decrease in the volume of goods transported on the Danube**.

The variables subject to analysis were selected following the research exemplified in the previous subsections, following the application of Exploratory Factorial Analysis, Multiple Regression, and ANOVA. The main difference between the previously applied techniques and path analysis is that this type of analysis focuses on the decision about the whole model: it can be accepted, modified, or rejected.

Confirmatory factor analysis (CFA) models, a particular case of structural equation modeling (SEM), are widely used in measurement applications for various purposes. Designs for construct validation and scale refinement, measurement invariance can be assessed by CFA testing. In each component, measurement error and structural error are included in the analysis. Compared to path analysis only has a structural error, SEM includes both errors in the analysis [19].

SEM analysis with the structural model will be used to test the model. Other terms used for path analysis include causal modeling and covariance structure analysis. A “Path Analysis” type analysis will also be performed, representing the response of the dependent variable to a unit change in an explanatory variable when other variables in the model are held constant. The analysis was performed using the SmartPLS software application.

For the interpretation of the path coefficients resulting from running the proposed research model, it is essential to note that the values obtained for the path coefficients are not the same as the values of the correlation coefficients. We will mainly analyze the relationship between the impact factors selected to be the most important in influencing the volumes of goods transported on the Danube, according to figure 7.3.

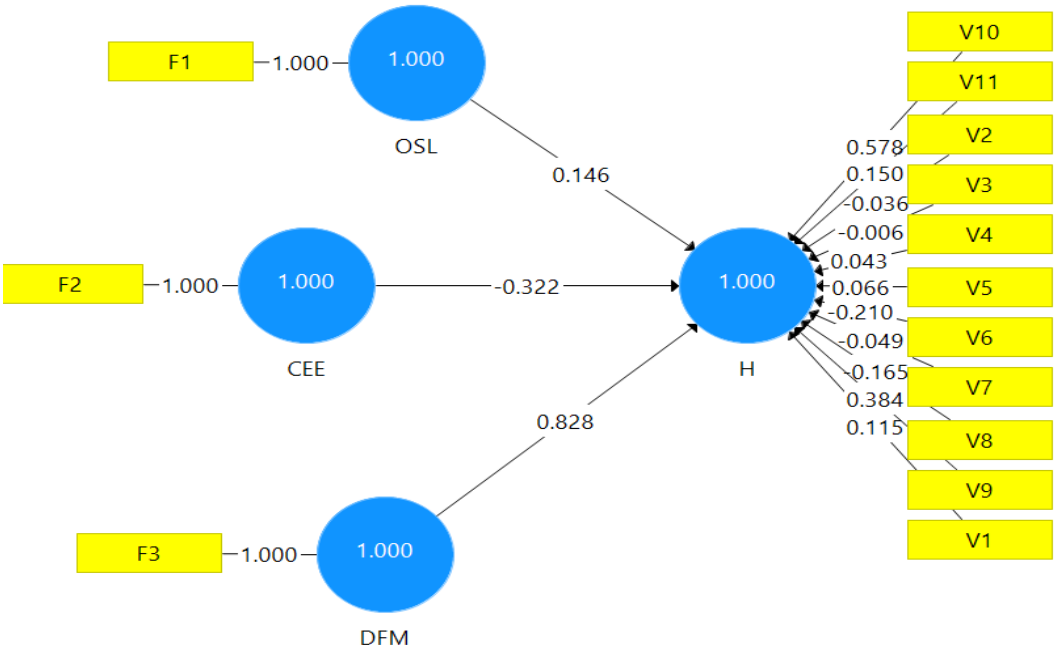


Figure 7.3. The resulting structural model after running it in the SmartPLS program
Source: Extracted from the SmartPLS software program

In the model presented above, F1, F2, and F3 represent the factors resulting from the Exploratory Factor Analysis and will take over the role of leading indicators for the latent variables OSL (logistics system optimization), CEE (European economic circuit), DFM (labor availability). The composition of the latent variables is given by the previously obtained research results as follows:

- F1- factor resulting from the Exploratory Factor Analysis through the SPSS software program. It comprises the following indicators: the logistics performance index, the average export delivery time, the average import delivery time, and the commercial coefficient applied to barter operations.
- F2- factor resulting from the Exploratory Factor Analysis through the SPSS software program. It comprises the following indicators: Exchange rate, Import of goods and services, Export of goods and services, and Transport according to the vessel's nationality.
- F3- factor resulting from the Exploratory Factor Analysis through the SPSS software program. It comprises the following indicators: the volume of goods transited in container vessels, the employed workforce, and the modal split of goods transported by country.

Thus, after running the SmartPLS software program, the following resulted:

- The first relationship occurs between the optimization of the logistics system, denoted by “OSL,” in the graphic representation, and the volumes of goods transited, denoted by “H” in the graphic representation. The significance of the path coefficient is 0.146, which means that if OSL has a standard deviation from the mean of 0.146, the standard deviation of H increases in direct proportion.
- We notice that the following relationship is negative. It occurs between the European economic circuit, denoted by “CEE” in the graphic representation, and the volumes of transited goods, denoted by “H” in the graphic representation. The negative path

loading, -0.322, represents that when H increases, CEE will decrease, so the influence relationship will be in the opposite direction.

- The last relationship subject to analysis is the one between the availability of the labor force, denoted by "DFM" in the graphic representation, and the volumes of goods transited, denoted by "H" in the graphic representation. This relationship is positive, with the path coefficient value being 0.828. This relationship shows that when the available workforce is increasing, there will also be a significant increase in the volumes of goods transported on the Danube.

It is highlighted in the graphic representation, figure 7.3. Moreover, the interpretation of the path coefficients and the relationship between CEE and H. Considering that by using the software program chosen for the analysis, another relationship of influence was detected, different from the one initially foreseen, the model was reinitialized.

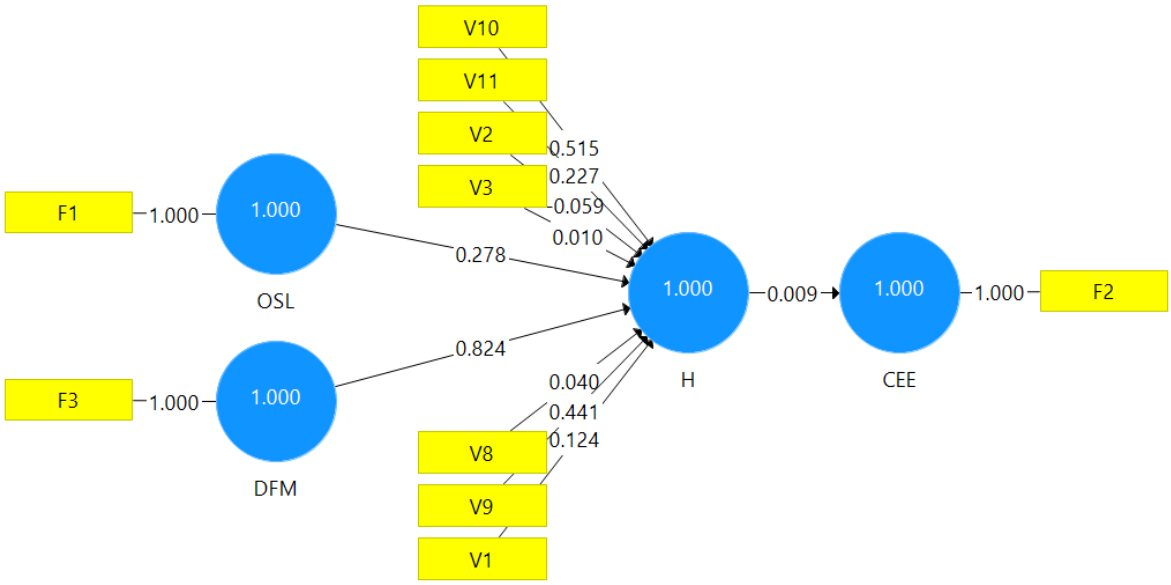


Figure 7.4. Structural model resulting from reinitialization in the SmartPLS program
Source: Extracted from the SmartPLS software program

According to figure 7.4. we notice that the path coefficient value between "H" and "CEE" is positive, with a value of 0.009. At the same time, there is an increase in the value of the path coefficient between OSL and H and a slight decrease in the path coefficient between DFM and H. Suppose the first variable increases implicitly; the latter increases with the related sub-indicators. This relationship confirms that the volumes of goods transported on the Danube influence the European economic circuit factor.

Through the path analysis, another relationship of influence was detected, which led to the realization of another structural model, namely: **The lack of an entirely digitized logistics process and qualified workforce for the operations carried out in the transport of goods on the Danube, lead to a decrease in the volumes of transported goods with direct implications on the European economic circuit**, as can be seen in figure 7.4.

The Confirmatory Factor Analysis carried out with the help of the SmartPLS software program by integrating structural equation analysis methods, as well as path analysis, led to three main directions from a managerial point of view:

1. The main directions of investment from the authorities involved in the management of the logistics chain should be in its digitization in order to optimize delivery times for both import and export, as well as the improvement of the processes underlying the logistics

performance index, such as: streamlining customs procedures, improving infrastructure, price competitiveness, tracking transport throughout the logistics chain.

2. Investments in the improvement of the processes mentioned above will positively influence the exchange rate, the import of goods and services, and the export of goods and services.

3. Human resource development by improving access to education and training. Congestion often occurs inside ports, which can be improved by qualifying the human resource and ensuring access to training programs on developing digital skills.

PLS-SEM is prediction-oriented, and most applications focus on the Stone-Geisser (Q^2) test [20,21] and the Q^2 effect size. Cepeda et al. (2016) [20] recently introduced samples to assess the predictive validity of PLS-SEM models, and the predictive validity measurement of our model is based on these ideas. This model includes an exogenous factor (volumes of goods transported on the Danube) with direct and theorized links with three dependent variables (logistics system optimization, European economic circuit, and labor availability).

The results are presented in table 7.2. indicates whether digitalization of the logistics chain and labor availability predict the volumes of goods transported on the Danube and the European economic circuit. If the differences between the PLS-SEM values and the mean values (linear model (LM) regression) are negative, the PLS-SEM error is smaller than linear regression. This demonstrates that using the proposed model with PLS improves the predictive relevance of the available indicator data, and compared to the LM results; the PLS-SEM results have a lower prediction error (RMSE and MAE) than the LM. Regarding Q^2, the differences between PLS-SEM and LM should be positive [22].

Table 7.2. Predictive validity scores obtained

	PLS-SEM			**LM**			**PLS-LM**		
	RMSE	MAE	Q^2_predict	RMSE	MAE	Q^2_predict	RMSE	MAE	Q^2_predict
F2	95950,039	70831,134	-0,015	96981,615	72465,623	-0,037	-1031,58	-1634,49	**0,022**
V2	42,216	12,176	-0,006	42,721	16,251	-0,031	-0,505	-4,075	**0,025**
V11	140,713	90,756	0,256	134,694	90,006	0,318	6,019	0,750	-0,062
V1	1120612,118	725657,358	-0,006	1126126,769	725473,142	-0,016	-5514,65	184,216	**0,010**
V8	276,74	250,651	-0,002	251,215	215,505	0,175	25,525	35,146	-0,177
V3	56,592	17,354	-0,007	56,585	18,107	-0,007	0,007	-0,753	**0,000**
V9	131,136	94,742	0,498	120,541	89,065	0,576	10,595	5,677	-0,078
V10	141,89	105,556	0,601	142,209	105,352	0,599	-0,319	0,204	**0,002**

Source: Own creation from using SmartPLS Predict

The results suggest that the European economic circuit positively affects the volumes of goods transported on the Danube. The results also show that the leading indicators of logistics chain optimization, in this case, the logistics performance index, the average export delivery time, and the average import delivery time, influence this relationship, and the available workforce influences the volumes of goods transported on the Danube.

Given that the observations, their predictions, and the predictive error are specific and identifiable, the predictions could be used to isolate and identify specific aspects. Thus, we can say that the analysis carried out led to the conclusion that in order to improve the traffic of goods on the Danube, the following managerial directions must be taken into account:

1. Due to the growing demand for efficient ports, ports need to improve their ability to attract more users and increase efficiency. From an economic point of view, efficient handling of containers at terminals is essential in reducing transportation costs, maintaining shipping schedules, and maximizing profits.
2. Keeping the unemployment rate under control and investing in the training of port staff will contribute considerably to the efficiency of the total loading and unloading process. A workforce specialized in specific fields of interest contributes to attracting foreign investments, a determining fact in the development of any state located along the Danube.
3. Centralized management is a vital factor preventing the Danube ports from increasing efficiency. It is recommended to harmonize legislation along the entire course of the Danube and eliminate bureaucracy.
4. The study also showed strong national policies and investment dominance. Each country must maintain control over the exchange rate, inflation, and, implicitly, the level of taxes related to import-export operations so that the level of demand is not affected.
5. At the same time, the level of foreign direct investments considerably influences the level of operations specific to river-sea transport. The more developed and attractive the country, the more the volume of demand will increase and, implicitly, the level of exports.
6. Investments in infrastructure, especially those aimed at maintaining the level and quality of water, improving mobility and synchro modality, and digitizing each port, will have a positive impact in reducing the time allocated to the delivery of exported and imported goods.

Chapter 8 Conclusions, personal contributions, research limits, and further research directions

This research was designed to highlight the impact of macroeconomic indicators on the management of freight transport on the Danube. Through the conducted study, we showed a harmonious relationship between the European economic circuit and the level of goods transported on previous waterways. Even more, the congruence relationship is found in a series of indicators, a fact that leads us to the conclusion that any investment in keeping under control one of the indicators resulting as determining factors spills over into the performance level of the others.

The resulting prediction from running the program serves two primary purposes: generating theory-based predictions and measuring the predictive validity of theoretical models. After running the software program, it turned out that many four variables have a significant predictive capacity in the European economic circuit and implicitly in the volumes of goods transported on the Danube, according to the previously validated congruence relationship. The chosen software program's specificity also offers a set of predictive validity scores.

The results of this study will help formulate and implement appropriate policy, both within the ports and national policy level, to achieve increased operational efficiency. While there are essential questions for port and terminal operators regarding the efficiency of

domestic operations, there are even bigger ones for the government to establish an enabling economy so that an enabling environment is created for investors and industry operators.

In further research, cases where the predictions strongly deviate from the known observations can be analyzed. Cases with inferior predictive performance can be investigated to identify why they conform poorly to the model, possibly allowing a survey or further questions to be conducted and refinement of the theory.

Given the growing expansion of cargo transport operations on the Danube, the subject of this doctoral thesis allowed the foundation of the concept of corporate management at the level of the port segment, as well as the effects of this type of transport on the economy of the country of which it is a part. In this context, the thesis contains ideas and concepts that can transform into new research directions in the future.

The results obtained from the research, recorded in the doctoral thesis, will be capitalized and continued within the Horizon Europe project, HORIZON-CL5-2021-D6-01, entitled “Deployment and Assessment of Predictive modeling, environmentally sustainable and emerging digital technologies and tools for improving the resilience of IWW against Climate change and other extremes (PLOTO),” no. 101069941, as a member of the research team.

Based on the results obtained in the first and second years of doctoral studies, the author was included in the project POCU/380/6.13/123847 “Academic excellence and entrepreneurial values - scholarship system to ensure opportunities for training and development of entrepreneurial skills of doctoral students and post for Ph.D. students” - ANTREPRENORDOC, focused on supporting researchers from “Dunărea de Jos” University in Galati, with high scientific potential.

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