

Erasmus University Rotterdam

MSc in Maritime Economics and Logistics

2018/2019

A circular economy strategy for inland ports.

by

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Acknowledgements

First of all, I would like to thank my supervisor, Professor Dr. Elvira Haezendonck, for her help, support and patience. In addition to this fact, this study would certainly not have led to a successful conclusion without her key advices and feedbacks.

I should also like to commend all members of the friendly and close-knit team of Center Maritime Economic and Logistics.

Finally, I would like to thank my family and everyone who helps me in this research. It would not have been possible without their full and unconditional support.

Especially I would like to point out of my Woolly that supported me the most from the beginning.

Abstract

This study shows that developing strategies for a circular economy may be related to the type and functionality of the port. A circular economy strategy is the vision of a port for changing basic economic principles in the context of 3R — reuse, reduce, recycle — which are often used to implement this strategy.

As a result of multiple case study of six ports, the type and functionality of each port were determined, since this is the basis for further determining the relationship between circulation methods and port functionality.

The result of the study shows that the strategies of the circular economy of ports are dependent on the functionality of the ports. It is also worth noting that the degree of this dependence is determined by the type of the port.

Analysis of information about ports, city and region also show that inland ports, regardless of their functionality, have strong relations with the city and the local community, which determines the direction of their circulation. This fact can be explained by the historical relations of the parties. In addition, one of the results of the study is to identify the impact of nearby seaports and the impact of their circular initiatives on the circulation of the inland port. Furthermore, the study revealed a number of dependencies that affect circular economy of inland ports.

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List of Abréviations

CBS	Central Bureau Statistics Netherlands
CCNR	Central Commission for Navigation on the Rhine.
CE	Circular Economy
CEP	Circular Economy Package
CI	Circular Initiative
GDP	Gross Domestic Product
GHG	Greenhouses gases
DIPCITY	Development of Inland Ports as sustainable tools for the CITY
EC	European Commission
EFIP	The European Federation of Inland Ports
EU	European Union
INE	Inland Navigation Europe
IMO	International Maritime Organization
IS	Industrial support
SCE	Strategy Circular Economy
SRH	Rhine port of Switzerland
WTO	World Trade Organisation

Chapter 1 Introduction

1.1 Background

The planet is changing under the influence of human activity. Constant growth of industry, economy and trade results in a negative impact on the environment and a change in its environmental sustainability.

According to the World Trade Organization (WTO) (2019), about 90% of world trade is accounted for by shipping. Obviously, the international trade would be simply impossible without maritime transport. Moreover, maritime transport is the main driving force of trade and logistics industry due to the efficiency of shipping. The growth trend of trade and the maritime industry in general are increasing. In the world there are more than 50,000 merchant ships carrying all types of cargo. The world fleet is registered in more than 150 countries of the world and has more than a million sailors of almost all nationalities. This means that the shipping industry has a high level of influence on almost all spheres of human activity. Nevertheless, it should be noted that, as any coin has two sides, the marine industry, in addition to a significant contribution to the economy, also has a serious negative impact on the environment.

According to the International Maritime Organization (IMO) (2015), about 3.1% of global annual carbon dioxide emissions come from marine transport. This has a negative impact on human health and socio-economic factors, which becomes decisive in the development of the industry and other related areas. This means that this main task of modern business is changing and focuses on achieving sustainable economic development.

Moreover, current business trends show that environmental protection is becoming a very important factor influencing the strengthening of sustainable development in all business sectors, especially in the field of logistics.

Consequently, the result of negative external impact is the introduction of new management methods based on the stimulation of ecological innovations and the development of environmental initiatives that are aimed at creating an economic model that preserves commercial interests and environmental balance.

Climate change, the use of raw materials and waste management are serious problems for the global business community which define new economic methods and approach for their implementation. It should be noted that in order to reduce the negative impact of transport on the environment, numerous laws were drafted and adopted to limit the negative external impact of transport.

In addition, the legal framework is a crucial factor in the implementation of new economic approaches. The circular economy is one of these methods, which provides the main driving force for updating business processes in the context of introducing new ways of green growth. Obviously, the introduction of a circular economy strategy opens up new opportunities for maritime industry, creation new visions and business models, especially in the port sectors, both in deep-sea ports and in inland ports.

1.2 Problem statement

The logistics industry is one of the main industries in the European countries. The ports of this region have a great potential. For instance, the Le Havre – Hamburg region includes a wide range of different ports which handle millions of tons of cargo and affect almost all spheres of human life. A powerful and well-developed transport

infrastructure helps to ensure efficient port operation. Moreover, various types of infrastructure are ready to ensure the achievement of different types of business goals and improve a relationship between industries. In addition to the above, the transport industry has a serious social and economic effect, since qualified personnel are required to ensure the efficiency of the logistics system. In other words, the transport industry is the prime mover for staff development and employment.

However, as noted earlier, one of the problems of transport is the negative impact on the environment, which can be defined as a critical factor in the conditions of growth in transport activity. This means that this aspect can be the basis for changing the business model and should ensure balance between the modes of transports that are used as a foundation for international trade in the conditions of its constant growth. In other words, the use of inland waterways will increase and, as a result, the role of inland ports becomes an important point for cargo handling.

Furthermore, the port is an ideal place for the development of circular economy; the reason for this is that inland ports are logistics centres for the accumulation of industrial flows and waste. In addition, the inland ports are suitable for the placement of industrial complexes that process, collect and send waste. Accordingly, it stimulates the occurrence of closed loops. In addition to the above, it should be noted that the strategy of circular economy is a powerful motivator for innovation, which aims to facilitate circular initiatives.

However, it should be assumed that the port circularization depends on a wide range of factors, influencing the development of the circular economy. Consideration of a number of them will be presented in this research.

1.3 Research objective

The main objective of this research is to study and determine the dependences of the development of circular economy strategies on the type and functionality of the inland ports as well as the orientation of the port to sustainable development. In addition, it is necessary to identify stable relationships with all participants involved in the processes of circulation and dependence on them.

For this purpose, the strategies of the circular economy in the selected ports will be studied. Then, the comparison of circularization will be conducted, based on which we will be able to identify any trends and determine the dependencies of circular economy on the type of the inland port. It should be noted that the barriers, potentials and driving forces that determine the circulation strategy will also be discussed.

1.4 Research question

The fundamental objective of this research is formulated as follows: A circular economy strategy for inland ports.

The main research question addressed in this thesis is: Are there different ways to apply circular economy to inland ports in Northwest Europe and why?

In order to answer the main research question, the following sub-research questions are formulated:

- What are the advantages of circular economy for inland ports?
- What is a circular activity and with which organizations are connected to inland ports?
- What is the role of port policies for the development of circularization?

- Scope of inland ports: the definition of functionality and types of inland ports.
- What is the economic business potential of circular initiatives for inland ports?
- What are the incentives, barriers and drivers of circular initiatives in hinterland ports?

1.5 Methodological approach

The purpose of the study is to use a multiple case study. This method will provide a complete study of why and how the functional features of inland ports affect the development of a circular economy strategy. The secondary data will serve as the basis for the analysis and will lead to a complete answer to the research question.

Chapter 2 Literature review

This part presents the relevant literature on the strategies of a circular economy in ports and inland ports, a typology of inland ports depending on the functionality of the port as a theoretical framework that can be applied to research questions previously formulated.

Firstly, linear and circular models will be explained. In addition, the explanation will be given of the reasons for the circularization of the economy model.

Secondly, the definition will be given for the circulation model of the port, the role of the port in the region's economy and the region's benefits from the port and its circularization.

Thirdly, the differences in the types of inland ports will be made depending on their functional features. Then, the connections between the city and the inland port (urban mining) will be determined. The definition of a circular economy approach in the inland port and the difference between these approaches depending on the type of port will also be given.

2.1 Circular economy

2.1.1 Linear economy

The current economy is largely determined by the use of business methods resulting from the industrial revolution. This, in turn, led to a linear approach based on the principle: resource extraction, production of goods and services, and disposal of waste after use.

In a linear economy, companies extract materials that are used to produce a product. A customer buys a product that will be disposed of when he stops fulfilling his goals (MacArthur, 2014). This leads to the formation of a take-make-dispose mentality (Figure 1).



Figure 1: Linear economy, take – make – dispose scheme. Source: Waste reduction week in Canada

It should be noted that this model of economy is based on the constant use of raw materials, the amount of which is limited. Moreover, using this economic model leads to environmental problems and inefficient waste management.

2.1.2 Shift to circularization from linearity.

It is obvious that the main problem with using this model is the lack of raw materials, and this problem is becoming more and more serious from day to day. In addition, the limited numbers of raw materials affect their price and leads to a significant increase in prices.

According to MacArthur, over the past ten years, the price of goods has grown by more than 150 percent.

Moreover, MacArthur Foundation experts note that consumers are changing their consumers' behaviour. As a result, they are ready to share products with someone else or use a previously used product instead of their own product. (MacArthur 2014). This means that the transition to circularization of economy is a very important step for both business and society.

For the first time, the vision of the circularization of the economy was proposed by the American economist K. Boulding (1966) as a solution to the problem of environmental degradation. Boulding (1966) analysed the main causes of environmental problems; on the basis of this, he proposed changing the linear economy to a circular one. The bottom line is that the circular economy assumes that within the framework of the production system, a traditional linear economy, the development of which depends on the consumption of resources, transforms to an economy whose development depends on recycling and reusing.

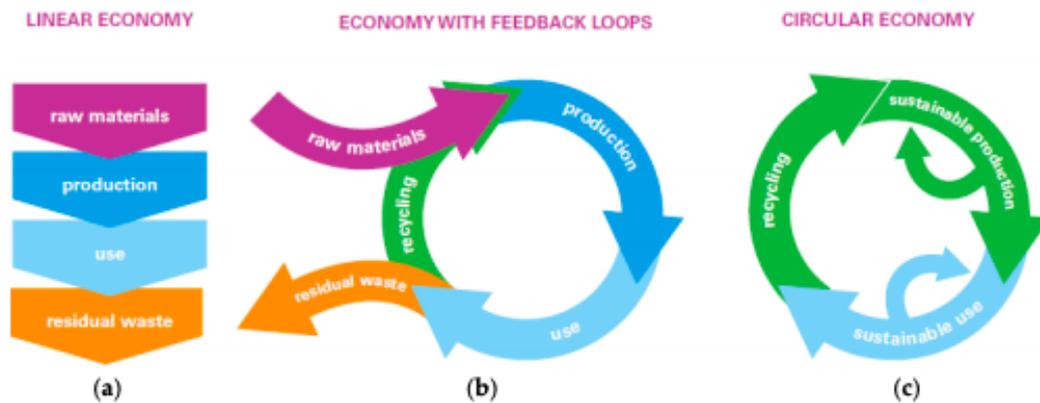


Figure 2: Differences between linear economy (a), economy with feedback loops (b), and circular economy (c) Source: RLi (2015) Van Buren et al. (2016).

In addition, circular methods of the economy become attractive to all business participants because these methods give a greater degree of freedom of companies from the market and can smooth out its instability, as well as reduce the geopolitical component of the business, especially international business. It is also worth noting that the transition to circular management methods is stimulated and motivated by governments at all levels, which is a very important initiative for popularizing the circular economy.

Thus, the transition to circularization is a necessity for the further development of business, which is supported by governments, societies and industries. Moreover, this is the basis for sustainable development in general.

2.1.3 Principles of circular economy

According to the MacArthur (2013), a circular economy is an industrial system that is restorative or regenerative by intention and design Figure 3. It replaces the 'end-of-life' concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse, and aims for the elimination of waste through the superior design of materials, products, systems, and, within this, business models.

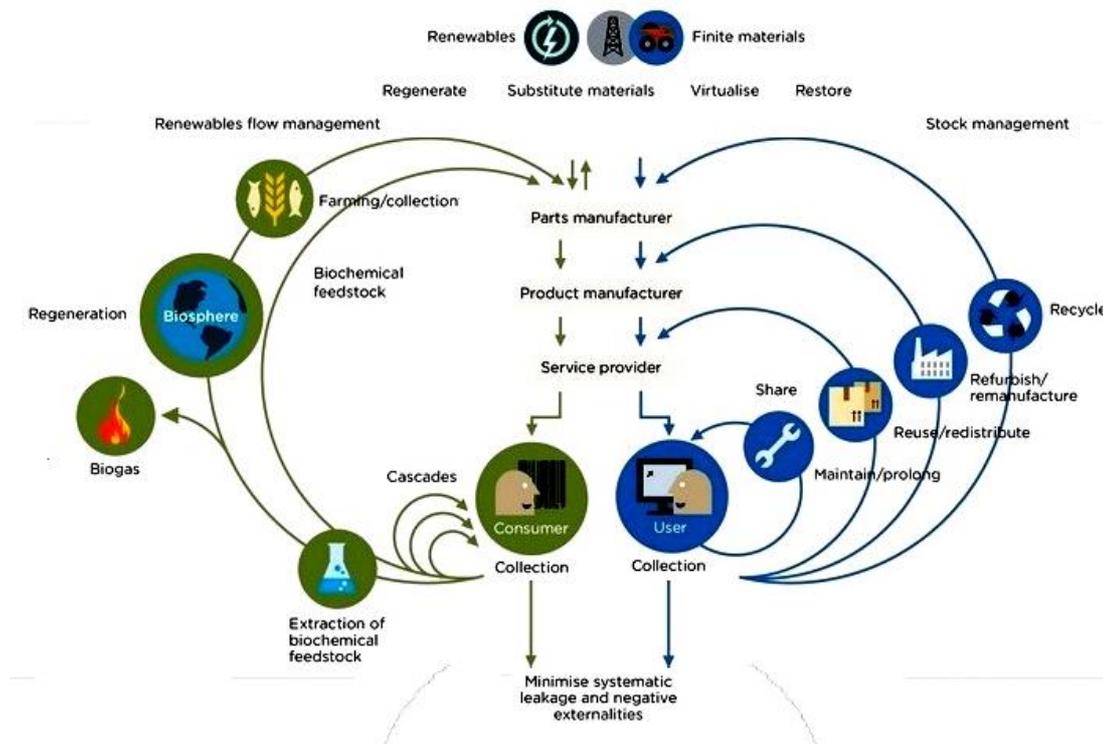


Figure 2: Circular economy systems diagram. Source: European Journal of Sustainable Development (2016), 5,4, 511

The circular economy is an alternative to the linear model, the basis of which is the minimization of primary resources and the use of waste products in accordance with the 3Rs principle (reduction, reuse, recycling). This means that the circular economy is becoming one of the main strategies for sustainable development, and the introduction of the circular economy is a serious challenge for the business environment today.

The circular economy has inevitable consequences for production, employment, finance and also motivates a shift in public policy and taxation. The economic advantage of this model is the development of waste, providing access to materials that increase the utility of resources, with the prospect of recovery natural capital. (K. Webster, 2013)

Over the past few years, this fact has given impulse to a change in the model of the economy in almost all spheres of human activity.

Currently, when leading companies are innovating, embracing the use of new approaches in the field of recovery and reuse of materials in the production process. It should be assumed that now one can observe the evolution of circular business models that seriously affect the linear economy. (K. Webster, 2013)

2.1.4 The forces and barriers of circular economy

For this study, it is necessary to understand the barriers and motivational factors for the implementation of circular initiatives.

K. Govindan and M. Hasanagic (2018) divided the driving forces into internal and external. Internal motivators are factors aimed at introducing circular initiatives related

to the organization's resources, while external driving forces include motivational factors outside the company that facilitate the introduction of a cyclical economy.

Based on this, they classified the following motivating factors:

- Politics and economics: laws relating to economic growth, improving the environmental situation and others.
- Health: improving community health and animal welfare.
- Protecting the environment: climate change, agricultural quality and protecting renewable resources.
- Society: population growth, urbanization, job creation potential and consumer awareness.
- Product development: increasing the efficiency of using materials and energy and increasing cost of production.

The result of joint research of Utrecht University and Deloitte was the identification of barriers to the transition to a circular economy (Kirchherr et al., 2017). In accordance with these studies, four main types of barriers to the use of a circular economy are identified:

- Cultural barriers associated with the lack of necessary knowledge and the desire to participate in a circular economy
- Market barriers associated with the unwillingness of market participants to circularize due to many circular business models lack economic viability.
- Regulatory barriers related to laws and rules that slow down and complicate the transition to a circular economy.
- Technological barriers lying in the absence of proven technologies for the implementation of circular economic principles, the risk of using new technologies without a guaranteed result.

2.2 Circular economy of the port.

2.2.1 What is the contribution of circular economy to the port value chain?

Tendencies to a change in the economic model are evident in all the areas of economic activity.

In accordance with the resolution of the Paris Climate Conference (World Maritime News 2015), the marine industry has a high level of environmental pollution (3% of global warming). It is obvious that the maritime industry is facing this problem and is forced to reduce these figures. Since ports are transport hubs and locations for logistics and processing, circular economy initiatives are the basis for ensuring compliance with these commitments and rules.

Sustainable development is one of the tasks of the European Commission (EC). Undoubtedly, the circularization of economy can be considered as a basis for sustainability. In order to promote the circular economy model, the European Union (EU) Commission adopted the Circular Economy Package (CEP). This contributes to the creation of an innovative climate in the field of circular economy through the harmonization of waste legislation and safety requirements.

To begin with, it is worth noting that ports are points where sea and land routes meet and commercial, legal and many other interests intersect. A port is a complex mechanism geographically related, but also dependent on many factors, such as a portfolio of operations, management structures, and port value chains. In other words, the main function of the port is the connection between different modes of transport.

Moreover, in the most cases, the port is the beginning of the land transport infrastructure of a country, continent and so one.

This factor can be called decisive, since additional services appear in this place that are associated with the handling and storage of goods, as well as with the subsequent shipment of goods by other type of transport to final consumers.

In addition, the port affects the region and provides direction for the development business of parallel ports, which helps provide port functions. These are energy support, terminal and warehouse operators, towage, mooring, stevedoring companies and many others.

This factor should be taken into account since it is the basis for clustering ports and port-dependent enterprises. This means the concentration in one place of various industries associated with the port and with each other. They are sensitive to delivery times and transportation costs, and are also intermediaries and facilitators in the activities of the port. It can be called an industrial port ecosystem, where a wide range of business activity is collected, while the main goal is to create a unique logistics product.

The European Union Commission notes that the core of a circular economy lies in ecosystems that unite various companies and industries. Thus, the presence of industrial zones in ports contributes to the circular and more sustainable use of waste and resources, since they provide the advantages of existing synergies between industries. (M. Kyllönen 2017)

2.2.2 Circularization in different part of the value chain of the ports.

2.2.2.1 Port as a driver for circularization of logistics.

Port and industrial zones are particularly suitable for the formation of a circular economy. Moreover, this is a specific way in which ports can become more sustainable (Van Dooren & Braam, 2015).

According to the vision of the port of Rotterdam, the circular economy is important for the ports because:

- The main function of the port is to create a link between the manufacturing and processing industries for the reuse of energy.
- Ports work in industries that handle waste and stimulate the emergence of innovative circles.
- Ports are ideal places for the further development of a circular economy because they are the intersection points of all types of waste and industrial flows and serve as logistics centres.

In other words, this is a place with a high concentration of raw materials and residual flows from numerous industrial and logistic activities. In addition, a high level of accessibility provides an excellent basis for the widespread use of circular initiatives for production and consumption. Thus, the port will become a good place for value-added activities (Kuipers, et al., 2015). This opens up broad opportunities for the development and implementation of a circular economy strategy in seaports. This factor is decisive because the implementation of circular initiatives will also affect development perspectives of the cities, since the port plays a significant and evolutionary role in the region.

2.2.2.2 The role of ports for regional economy

In modern conditions, effective management is a significant factor in accelerating economic growth in the regions. Obviously, it is impossible to achieve anything without affordable and high-quality transport.

A. Smith (1776) argued: “As by means of water-carriage, a more extensive market is opened to every sort of industry than what land-carriage alone can afford it, so it is upon the sea-coast, and along the banks of navigable rivers, that industry of every kind naturally begins to subdivide and improve itself ...”

Accessible transport infrastructure is a determining factor for creating a competitive environment in the region, especially if the region has access to extensive transport infrastructure, including developed road, rail and water capacities. In this case, the port will be the location of traffic activity.

The development of the port has a stimulating effect on the economic growth of territorial entities, entrepreneurial activity and competition in the market, the inflow of investments and qualified personnel, and the development of innovative technologies.

Based on the constant interest of business representatives, the port becomes a point to stimulate integration and the formation of logistics platforms, clusters and others. This means that enterprises are emerging and developing around the port aimed at strengthening the supply chain, which, in turn, strengthens the economic situation in the region. Modern transport technologies and innovative transport and logistics systems significantly reduce the time of delivery of goods and reduce transport costs, increase the competitiveness of products manufactured in the region. In addition, it affects the increase of the socio-economic role of ports in the region, since it is an employer and tax payer of the budget.

In other words, the economic consequences of the port can be of two types: direct and indirect.

Direct effects relate to the business environment. These are companies operating in the port and creating traffic flows. For example, shipping lines, transport companies, terminal companies, manufacturers. The income depends on the activity of the port; the direct effect applies to companies that are associated with the main activity of the port because they create a transport flow, whereas the companies that do not create the transport flows have an indirect effect on the performance of the port. Thus, the impact of the port has a significant regional effect and affects the economic, social, technical, innovation and other areas.

In other words, the port has a serious impact on the region entirely, both directly and indirectly, which becomes an even more serious motivator for the implementation of circular initiatives in the port.

In other words, the port shows a serious impact on the region entirely, directly and indirectly, which becomes an even more serious motivator for the implementation of circular initiatives in the port. Moreover, the port zones are the core of the creation of a new economic approach to the organization of a city, the aim of which is to reduce the reduction of energy consumption and emissions, waste and costs. Connecting the port with the city motivates new approaches in business and planning on the basis of a “circular design” (Fusco Girard, L. 2010).

2.2.3 The main circular initiatives in port

Circular initiatives in ports focus on: minimizing the use of productive resources in order to eliminate waste and pollution; value maximization at each stage; restoring non-renewable resource flows in a closed cycle as well as managing biological resource flows; and establishing mutually beneficial relationships between the companies in each circular chain (Van Dooren & Braam, 2015).

Thus, circular economy in ports is a synergistic approach that combines economic, logistic and industrial activities with the cultural heritage of the port and the creative potential of its wider community, which leads to a dynamic, complex and sustainable system (Girard, 2013).

In other words, historically, ports are located in populous districts, with stable growth rates of city population and industries, which negatively affects the ecological situation in the region. Therefore, circular initiatives become the basis for the realization of the ambitious port development goals that can be achieved through the joint efforts of the port and the city administration. In addition, start-ups aimed at addressing the bottlenecks of the port, provide diversification and innovation, focused, among other things, on accelerating the circular transition.

2.3 Circular economy in inland port

2.3.1 Introduction

Apparently, one of the main factors of the work of the port is the transport component allowing to ensure a high level of cargo handling in the port. However, it should be noted that in order to achieve this goal it is necessary to reach a high level of accessibility of transport. Therefore, the interconnection and interaction between the inland seaport provide great opportunities for achieving this goal. Inland and seaports complement each other since seaports depend on inland waterways while inland ports depend on cargo flow.

Having efficient port-related transport, including infrastructural access to the hinterland and the availability of transport services, is considered to be crucial in today's competition between ports (Tongzon 2009).

Northwest Europe has a large number of inland ports. They are an important link in the logistics and industrial chains. Undoubtedly, this fact is a significant incentive for the creation of logistics and production complexes.

The European Commission, in its White Paper on transport policy (European Commission, 2011) notes that seaports are logistics centers and require efficient internal communications. The development of inland ports and communication between participants of the supply chain is essential for the situation with the constant increase of the volume of cargo handled through the ports. In addition, the European Commission recognizes that road transport is constantly growing and this is the main cause of pollution and congestion. This fact reveals the need to stimulate "green" modes of transport, such as the rail and inland waterway which have to facilitate a port operation and entire transport system.

This means that the role of the inland port is becoming more significant. Moreover, the inland port is of particular importance in the creation of the supply chain, as it becomes a platform where the interests of industry, seaports, business, society and government intersect.

2.3.2 Port function and typology.

In accordance with Stopford, the main function of the port is to provide an essential interface between land and water.

On the one hand the interaction of inland ports with regional markets is fundamental, since it is these interactions that determine their commercial capabilities, their modal characteristics, the possibility of integration, and the regulatory framework.

The level of port development and integration with seaports depend on geographical location and structure, level of accessibility, management and ownership of hinterland transport systems and internal terminals.

On the other hand, the ports do not necessarily have to be located close to the market with high supply and demand, since they are located in places where industrial capacities are concentrated, activities such as shipbuilding, metallurgy, chemical industry, petroleum industry and transportation services.

The port's cargo portfolio consists of several types of cargoes, however, it should be noted that almost every port has a dominant product, which determines the type of port and affects the port strategy.

Dooms and Haezendonck (2004) proposed a classification for two types of inland ports: the "metropolitan support" (MS) and "industry support" (IS) types. This classification offers three main factors that play an important role in determining the type of port.

This classification consists of three key factors:

- The first factor is the traffic structure. Metropolitan ports are characterized by a strong dominance of construction materials and petroleum products as well as an additional flow of consumer goods. The structure of the port movement of the industrial port indicates a strong dominance of petroleum products, coal, ores, minerals, scrap and metal products, construction minerals intended for industrial activities.
- The second factor is the imbalance of movement between incoming and outgoing flows, also plays a role and, moreover, is considered the most distinguishing factor between these two types. The distribution function affects the share of incoming / outgoing flows of the metropolitan port and imbalances the flow in the direction of increasing the incoming flow. Unlike the metropolitan port, industrial ports have a more balanced structure between the incoming and outgoing traffic; this is due to production processes that unload raw materials and load finished products.
- The third factor is the port area; metropolitan ports occupy less land than industrial ports.

In other words, in order to determine the type of port, it is necessary to determine the dividing load, the balance of incoming / outgoing flows and the area of the port.

2.3.3 Challenges and needs of inland ports.

An inland port is a port that is located on an inland waterway, for instance, a river or canal that is connected to the sea. In addition, the inland port is a part of the network that is connected to the seaport. Its physical location provides the connection of the city with the sea and other inland ports. Inland ports depend on the flow of goods from

the seaports and both complement each other. Some hinterland ports are considered a mixture of both.

The European Federation of Inland Ports (EFIP) believes that a circular economy has significant potential for inland ports. This is due to the fact that they are located near ports, terminals and cities. This means that inland ports access raw materials, which are created during the operation of these business units, despite the fact that they have serious restrictions on the area. In addition, the EFIP expects that the implementation of the circular economy strategy of inland ports creates new transport flows, and, as an important crossing point for the modes of transport, it acts as a logistics hub.

Nevertheless, EFIP noted the main problems for the development of a circular economy for inland ports, such as:

- The lack of space for the installation of prefabricated sewage treatment plants.
- The dependence of the development of a circular economy on the final development of the market and the initiatives of individual companies.
- Reaching critical mass in a circular economy business model for waste in order to gain economic profitability.
- Negative public opinion about waste; waste valorization.
- Long transition process
- Renewal of cooperation between various stakeholders, the increasing role of civil associations.
- Multi-stage process of certain types of waste. Waste must be collected separately to facilitate the process. Consumers must be reasonable.

In addition, EFIP has identified the necessary actions to improve the current situation:

- Supporting the role of inland ports as an intermediate link. In this capacity, the inland ports encourage the development of clusters and create additional value for the port.
- Reducing conflicting regulation. General interpretation of waste disposal criteria and administrative procedures transfer of waste.
- Waste management requires additional permits; it slows down the development of the market.
- Encouraging the company to develop new waste valorization processes through innovative programs.
- Simplifying waste transport by increasing knowledge and information on waste value added.
- EU support in waste valorization innovations
- Standardization and quality schemes for secondary raw materials.
- Stable investment climate.
- Harmonized safety requirements and regulatory framework.
- The maximum period of 3 months for the analysis and decision-making recycling.

Inland waterways and inland ports of unused potential should play a key role in sustainable development of transport in Europe. In order to realize this potential, inland ports face serious challenges.

In spite of this, the development of inland ports and green internal communication is the one of circular initiatives which reduces negative externality of transport and could be one of the main factors of sustainable development of the supply chain.

2.3.4. Circular initiatives in inland port.

Nevertheless, the inland port continues to be a place for formation of circular initiatives. There are many reasons for this process.

On the basis of the vision 2030 of Inland Navigation Europe (INE), it is possible to determine the main directions and prospects for the circularization of inland ports.

Improving infrastructure performance ensures network quality and ensures the use of other modes of transport, which reduces the level of congestion.

Inland ports serve as multimodal nodes leading to sustainable freight transport solutions. Public water transport solves the issue of people's mobility.

Port areas are eco-industrial sites and processing centers that attract an innovative circular economy based on industry, creating a closed loop for the city and industry using water transport. Based on the functional characteristics of the inland port, the port is a place where many different types of waste are collected, a closed-loop strategy can be very successful, because waste is a raw material, as noted before. The closed-loop strategy is also applicable to energy recovery and wastewater and waste disposal. Obviously, this initiative is important for urban mining, because the process of extracting raw materials from waste is a means to reduce the demand for primary raw materials (metal, wood, etc.), energy consumption and negative external factors.

Circular economy sectors - inland ports

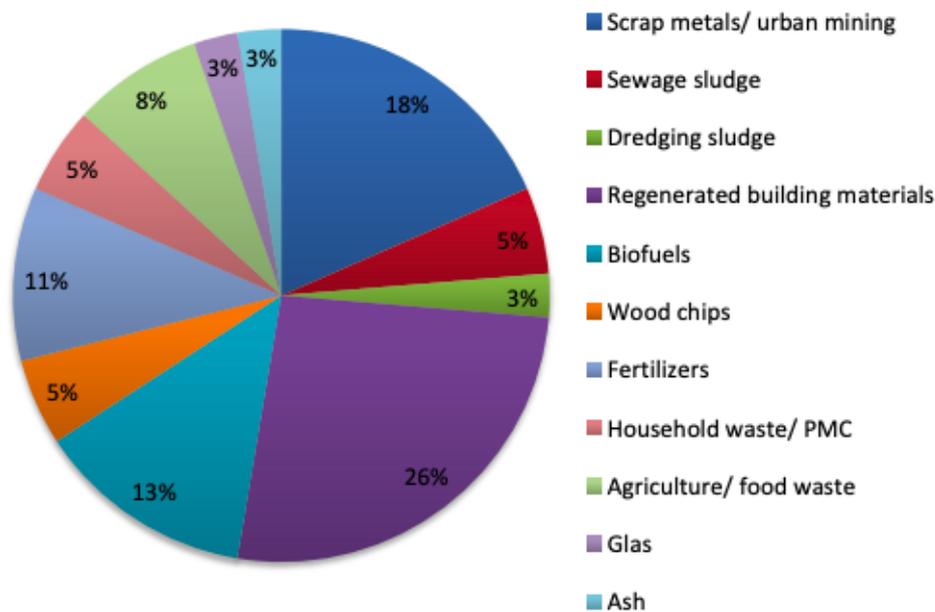


Figure 4. Circular economy sectors – inland ports. Source: Output EFIP-survey on circular economy, 13 inland ports, 2015

Integrated water resources management covers a set of measures to create and preserve infrastructure that meets the requirements for reliable navigation, water supply and protection, habitat and water quality. In other words, the activity of the system is aimed at obtaining maximum benefits for the logistics infrastructure and the city.

In other words, the main activities for the circularization of the economy of the inland port lie in the following areas:

- Minimizing of carbon footprints
- Water management
- Recycling of waste (the part of urban mining)
- Environmental management
- Transport connectivity and accessibility
- Integration with industry, creation of port clusters, smart logistics
- Increasing a social responsibility.

Thus, the inland port plays the role of a business leader in the development of the circularization of the region, which gives impetus to the development of various parts of business and urban life.

2.4 Theoretical frameworks.

As it can be seen, the necessity to give up the principals of linear economy and shift to circular management methods is obvious. More than that, society and business demonstrate their readiness for circularization. The search for solutions for the implementation of circular initiatives is one of the main areas of activity and the basis for the development of innovations. In other words, circularization underlies scientific and technological progress in business and society. Understanding the weaknesses of linear production processes and their limitations lead to appearing of ways to eliminate them and make this process more effective. Strategy of the circular economy of production units is one of these solutions.

It is worth pointing out that the ports are an important element of the global economy, bringing together participants from different parts of the world. Due to the fact that ports are leaders in all trends of the global economy, they are also the first in the development and implementation of initiatives to go circular. Obviously, for a higher level of efficiency, ports must have high availability. One of the facilitators is an Inland port which helps them in this mission, and they are ready to take on the role of intermediary between the port and the final consumer of goods and services.

Thus, inland ports play an important role in the region, since the inland port provides a strong link between the seaport, cities and industry. As mentioned earlier, the port is a leader in all economic trends. In fairness, it should be noted that the inland port can also be called the economic front-runner in the region, in most cases it is a part of the city, which provides the opportunity to create a symbiosis between the city and the transport system. Undoubtedly, this is the basis for the development of green growth. In other words, the middle position between the port, city and industry forces the port to a high level of flexibility and the introduction of new management methods. This may also be due to the development of a circular economy in inland ports. Obviously, the location of the inland port and a wide range of communications in various professional fields are a solid basis for circularization.

Therefore, it should be assumed that one of the most common initiatives in ports of any type is the creation of a logistics complex. However, we expect that the implementation of this initiative in the metropolitan ports is aimed at increasing the level of multimodality of transport, while the initiative in the industrial ports is a deeper industrial penetration and becomes the basis of industrial symbiosis.

Consequently, it should be assumed that the development of circular economy in inland ports depends on many factors, such as cargo portfolio, functionality, network with the seaports, types and many others. Therefore, we assume that the ways of circularization of inland ports can be different to depend on main factors which affect development of its. In other words, the strategy of the circular economy of the inland port, which is located near the city center with a good access to the city markets and whose main function is the transport component of the city will differ from the strategy of circularization of the economy of the inland port which is located in an industrial area and the functionality of which is to provide raw materials and materials for production units.

Hence, the circular initiatives in metropolitan ports will be different from circular initiatives in the industrial ports. Therefore, we propose that:

- metropolitan ports will be more interested in recycling of waste, development of new ways of transport and logistics operation for increasing accessibility of transport. (storage, handling, etc.)
- industrial ports will be more concerned with energy transition, recovery and reuse, the area for testing of circular innovations.
- creating a logistics complex, restoring the environment and activities aimed at reducing greenhouse gas emissions are circular initiatives that will be involved in both types of port.

So, the key target of this study is to test these assumptions, to prove or disprove them. As a result, empirical studies of six internal ports in the Northwestern Europe will help provide information for analysis and draw conclusions that prove or disprove the assumptions made in this chapter.

Chapter 3. Methodology

In order to get the answer to the question of the research, qualitative methodology will be used. As a method, multiple case studies will be used as the best option for achieving results. This method will provide a complete study of why and how the functional features of the inland ports affect their circulation.

In order to implement multiple case studies: firstly, six internal ports must be identified; then, the main data will be set as a base for determining the functionality of these ports, and finally, the strategies of circular economy will be analyzed.

The secondary data will serve as the basis for the analysis and will lead to a complete answer to the research question.

3.1 A multiple case study analysis.

The research method is a multiple case study analysis. This method allows to research into a specific system or systems, using various forms of systematic data collection on how the system functions and analyze it.

According to the definition of Yin, (2009) a case study is an empirical study that explores a modern phenomenon in depth and in the context of real life (Joyner, Rouse, & Glatthorn, 2012). This means that in order to conduct research and obtain data for further comparison, this research method may be applicable. Moreover, this method involves the joint study of several cases simultaneously.

It also should be noted that in this paper the multiple case study is a descriptive and exploratory analysis of the group of ports. This method allows answering the research question.

3.2 Data collection

The data were obtained by studying and analyzing a large amount of data on all the basic indicators of the studied ports, which are contained in various annual reports (sustainable development, annual account statements and other), as well as information available on the information portals of these inland ports, public non-profit organizations and associations. In addition, information that is relevant to the topic of this study is taken from the websites of municipalities of the studied ports. Moreover, statistical data of World and European statistical organizations available strategies and communications for nearby deep-water ports also will be used in this research.

3.3 Data choice

Six inland ports, which are located in the Northwestern Europe, have been selected for this research. They are represented below:

1. The port of Utrecht (Netherlands)
2. The port of Dordrecht (Netherlands)
3. The port of Brussels (Belgium)
4. The port of Liege (Belgium)
5. The port of Switzerland (Basel)
6. The port of Charleroi (Belgium)



Figure 5. Inlands ports and logistics zones around the Rhine and Meuse.
 Source: Notteboom, T. (2006) Port regionalization in Antwerp, in: Notteboom, T., Ports are more than piers, De Lloyd: Antwerp, pp. 307-328.

We chose these inland ports because:

1. Level of access to the main waterways: these ports are located in the Rhine and Meusa basins, which are one of the busiest waterways in Europe.
2. In accordance with the information from Figure 5, it is possible to determine the relationship of the selected inland ports with the main sea ports of the region, such as Rotterdam, Amsterdam, Antwerp. The ports of Utrecht and Dordrecht are selected due to the location of both ports near seaports. This may mean that they are more dependent on seaports, while the ports of Brussels, Charleroi, Liège and the Port of Switzerland are located in the center of the countries and far from seaports. It can be assumed that in ports located near seaports, the influence of circular initiatives of the seaport strongly affects the circularization of the inland port, while inland ports, which have a large connection with the city and the region, are a part of the region's circular strategy. In other words, the ports that are selected for this purpose are very likely to have different circularization strategies.
3. The location of these ports; ports are located on the three main waterways of Europe: the North Sea — the Baltic, the Alpine Rhine and the North Sea — the Mediterranean Sea. The location of these ports; ports are located on the three main waterways of Europe: the North Sea — the Baltic, the Alpine Rhine and the North Sea — the Mediterranean Sea. It should be noted that these are the most used corridors. Moreover, all these ports have a different cargo portfolio and provide a unique business zone for their regions which can underlie the various circular strategies.
4. These inland ports provided a capacity of inland water transport of about 42 million tons per year, which is almost 10% of the total volume of inland water

transport in the EU-28, which, according to Eurostat, in 2018 is 540 million tons in 2018.

5. Type of ports: it should be suggested that they have different functions, and three of them are metropolitan ports, while the others three are industrial ports. The ports of Utrecht, Basel and Brussels are located close to big cities whereas the ports of Liege, Charleroi and Dordrecht are located nearby the manufacturing and industrial areas. This factor may indicate their characteristic differences resulting from differences in their functionality.

3.4 Description of the multiple case study.

The research method is a multiple case study which consists of analysis of six inland ports: Utrecht, Dordrecht, Brussels, Liege, Charleroi, Basel. It means that various annual reports of six inland ports, which contain the main indicators determining the type of port will be analyzed in this research . For the purposes of this study, the following indicators are considered:

- Location of the port;
- Types of cargoes, cargo portfolio;
- Capacity of incoming/outgoing traffic;
- Economy and socio-economy indications (throughput, employment and other);
- Accessibility of the port, class waterway, sufficient draft;
- Type of port authority;
- Size of the port;
- Capacity of the port;
- Connection of the city and the port (port network and urban mining).

The analysis of these indicators will determine the type of each port.

Afterwards, an analysis of the circular initiatives for each selected port from the ports portfolio of this study is carried out. This analysis will include: type of initiatives, relations between the port and other participants in the circular process, the factors impacting on implementation of circular strategy.

Thus, as a result of the multiple case study analyses, summary tables will be presented that determine the type of a port based on the port indexes and the current level circularization of the economy of the inland ports.

The results of the comparison of the obtained data will reveal trends and models that will give a clear understanding of the dependence of the circularization of the economy of the inland port on their type and functional characteristics.

Chapter 4 Multiple case study analysis.

This chapter presents multiple case study analysis that consists of investigating each selected port, namely: Utrecht, Dordrecht (Netherlands), Brussels, Liege, Charleroi (Belgium), Basel (Switzerland).

The main objectives of the case are as follows: firstly, it is necessary to determine the main parameters of the port's business activity, such as throughput, the balance of incoming and outgoing flows, and others. Then analysis of this information is provided to determine the type of ports. After that, the table of circular initiatives is executed and correlated by the type of port. The result of this chapter is summary tables where all the data will be summarized. Finally, the identification of the main dependences of inland ports circularization.



4.1 The port of Utrecht

4.1.1 Basic information about the port of Utrecht.

The inland port of Utrecht is located in the central part of the Netherlands, in close proximity to the 50-kilometer port of Amsterdam. The port of Utrecht has good access to the main waterways, railway and the A2 motorway, the port is ready to accept vessels of class 5a and has sufficient draft over 5 meters with the possibility of calling on the sea vessels.



Figure 6. Aerial photo port of Utrecht Source: Industry association Lage Weide

The port of Utrecht is located on the Amsterdam-Rhine Canal. It is the busiest canal in the world and connects Amsterdam via Utrecht with the German Ruhr Area. Obviously, this location is one of the strategically important advantages of the port, since location near the region with high business activity can be the basis for projects aimed at facilitating communication and relations between these regions. Moreover, the vicinity of Schiphol airport also gives great opportunities for port.

The port Utrecht is the northernmost ice-free inland port which operating 24/7. In addition, the port authority manages city locks and bridges. Call statistics demonstrates that a freight transport account almost 73 percent of calls. The main cargoes handled in the port are bulk, construction (cement, lime, chalk), fertilizers, containers, feed, scrap, waste and others.

It should be noted that the port of Utrecht is a part of the logistics platform, which was created in conjunction with the municipality of Utrecht and the largest companies of the city. This is a public-private partnership, which was created to achieve the ambitious goal of creating an effective logistics center in the region. The business community and the government are jointly focusing on new logistics concepts for road, water, rail and their combinations.

In accordance with Municipality vision, Utrecht the Lage Weide is the largest industrial site in the Utrecht region which offers employment for approximately 18,000 people and has the area about 216 hectares. Lage Weide is one of the oldest industrial sites in the Netherlands and in full development. The annual throughput accounts for 4.4 million tons.

Type of cargo	Handling thousand tons
Glass and cement	82
Gravel and sand	1778
Construction scrap	97
Scrap	539
Silt	283
Waste	202
Metal	9
Feeding	923
Fertilizer	170
Wood, trees	25
Total	4348

Table 1: The throughput port Utrecht Source: Province Utrecht.

Based on the data from Table 1, the diagrams port Utrecht cargo portfolio and Balance incoming/outgoing flows have been created:



Figure 7. Port Utrecht cargo portfolio and Balance incoming/outgoing flows. Source: Table 1.

It should be noted that according to Table 1, freight flows can be divided into three groups. There are construction cargoes, scrap and waste and cargoes for the city. With high degree of probability, the construction goods and cargoes for the city are the incoming flow whereas scrap and waste are outgoing flow. It means that the port Utrecht is a metropolitan port.

4.1.2 The circular economy of the port of Utrecht.

As stated in the Blue Port report (2008-D-R0854/B: TNO 2008), the main driving forces for the development of inland ports and inland water ways in the province of Utrecht are:

- serious problems with accessibility on the roads, generally due to the large flow of suburban traffic;
- discrepancy between the road infrastructure and an increasing traffic flow;
- developed shipping capacities that can be used to realize existing potential, not only in terms of availability, but also in terms of reducing the impact on the environment.

Undoubtedly, it serves as a powerful motivator for the development of the port of Utrecht, which specializes in building sustainable logistics. Thanks to a more efficient organization of logistic processes, a combination of transport modes and the unification of logistic functions, the port of Utrecht promotes sustainable development and unpolluted environment.

That allows to be focused on organizing efficient and innovative logistics activities, which are the foundation of a powerful and sustainable multimodal center.

In this case, as mentioned before, the port of Utrecht is a part of a business park with a wide range of business activities. This means that the participants of the business park have a serious impact on each other, and it serves as motivation for related areas to develop. It is clear that the strategy of sustainable development is aimed at the sustainability of the entire platform. In other words, it is achieved through a synergistic approach among the enterprises.

According to the port of Utrecht, the main measures aimed at circulation are the following:

- the direction of multimodal transport, the development of water and rail transport;
- rebalancing the use of water transport when transporting bulk cargo and waste;
- initiation of incentives for the use of ships with clean engines;

- creation of a multimodal logistics hub for the supply of construction materials and export of construction waste with zero emissions in the port area of Lage Weide. This initiative is dictated by the fact that a high level of construction activity is expected in the center of Utrecht, these measures will help reduce the negative impact of construction;
- cleaning the waterways;
- waste management.

It is clear that as a part of the logistic and industrial park, the port of Utrecht can participate in various sustainable projects, one of which is the restoration and use of green energy. The logistics hub consolidates a critical mass of energy consumers, and this fact provides significant advantages for creating alternative energy sources.

Circularization is a very important process uniting industries and the city and accessible information is the basis for a successful transition from a linear to a circular economy. Therefore, the creation of a circular community in the region is a serious circular initiative due to the fact that various participants can find circular partners there. The interaction platform shows the willingness of each participant to cooperate with each other and also focuses on creating alliances based on a circularization of raw materials.

The good example of the circular community is the Cirkelstad which combines a large numbers of companies in the different cities of the Netherlands, one of them is Utrecht.

According to the Cirkelstad, the main circular goal in Utrecht is circular construction. Obviously, this is a complex goal that combines some tasks, from the use of circular materials and technologies to the analysis of old buildings and the reuse of these materials. In order to achieve this target the municipality involves all kinds of participants who can contribute to the circulation. Utrecht port, through which construction waste is taken, plays a very serious part in this project.

It should be noted that the circularization of Utrecht Port is a part of a circular strategy for more global structures such as the Lage Weide Business Park and the city/region. This fact contributes to the circulation of the port, because global systems have wider horizons for implementing circular initiatives, and the port is only a part of these systems with certain steps to implement a circular strategy.

In accordance with the circular strategy of the Utrecht region, transport and logistics play a decisive role in the implementation of circular initiatives. Moreover, the strategy involves the emergence of circular logistics in the region, because transport and warehouses have a solid foundation there. The main priority of the strategy is the creation of reverse logistics in the city and the coordinated distribution of goods and materials, which will be determined by the redistribution of raw material flows in the entire region.

4.1.3 The port Utrecht summary.

The analysis of the inland port of Utrecht may include the following summary.

This port is a metropolitan inland port that is a part of Lage Weide Business Park. Lage Weide has an active circular position aimed at participating in the circular initiatives of the city and the region. Accordingly, the region's ambitions to achieve sustainable growth and circularization of the economy see the port as the origin of circular logistics.

The creation of reverse logistics and a powerful distribution center is the ultimate goal of the region. An important point is that Utrecht port is already a member of the rebalancing of the flow of materials. In addition, the current Utrecht Port's circular initiatives are aimed at reducing negative emissions, as well as improving road difficulties by changing the balance of vehicles. Consolidation with other logistics units to organize a logistics platform that allows you to concentrate logistics activity and thereby balance material flows.

Based on the analysis, it can be concluded that circularization of the port of Utrecht depends on the city and region. In turn, the region understands the importance of logistics in the process of circularization and stimulates the sustainable development of this industry. This means that the functionality of the Utrecht port affects the choice of direction of the circulation port. However, this is a win-win situation.



4.2 The port of Dordrecht

4.2.1 Basic information about the port Dordrecht.

Dordrecht Inland Seaport has a unique location because the port is located near the port of Rotterdam and inland area. In addition the port of Dordrecht has a high level of access to the main waterways, lies on the A16 motorway, has good rail connections and draft almost 10 meters. Undoubtedly, these conditions give a significant competitive advantages. Therefore, the port Dordrecht is characterized as an inland seaport.

Moreover, location of the port is a strategical advantages because the port of Dordrecht is also connected with the seaports Antwerp and Moerdijk. In addition, the Oude Maas is connected to Baal and the Rhine via Beneden-Merwede, which means that the port is also linked to the German border. It means that the geographical position of the port of Dordrecht is a serious factor which impacts on the strategy of port development, strategy circular economy and others.



Figure 8. Aerial photo port of Dordrecht Source: Port Rotterdam

Dordrecht port is an ice-free port and 24/7 operating. The rail connects the port via the railway station with lines to Rotterdam, Antwerp and Roosendaal. It should be noted the railway line in this part of the Netherlands is one of the busiest lines and, as a consequence the rail transport is limited. The area of the port is 290 hectares. Call statistics illustrates that a freight transport accounts for about 60 percent of calls. The following cargoes are handled in the port: dry and liquid bulk, breakbulk, the storage and transshipment of oil products and chemicals, ores and metal residue, agricultural cargo, semi-manufactured goods (metal), crude minerals and construction materials and others

The port management is carried out by the Rotterdam Port Authority and is responsible for port development. The port of Dordrecht is the result of the interaction of the port of Rotterdam, the city's municipality and the business community, where the main activities focus on the maritime industry, logistics and handling of bulk and liquid bulk cargoes.

Rotterdam Port Authority has identified the following targets for implementation in the port of Dordrecht:

- to increase the competitiveness of the port as a logistics center and a world-class industrial level;
- sustainable energy and digitalization to make the port and supply chain more efficient;
- sustainable manner of development and management which provide fast and secure delivery services.

The port's throughput capacity is constantly growing and amounts to 3.7 million tons per year. Furthermore, the port plays a significant socio-economic role for the city, because the port is one of the important employers in Dordrecht almost 4,000 employees.

Type of cargo	Handling thousand tons
Liquid bulk	676
Construction scrap	2334
Scrap	677
Total	3677

Table 2: The throughput port Dordrecht. Source: ESPO annual report 2017-2018

Based on information from CBS the Netherlands, the statistics for the balance of inbound and outbound flow for liquid and dry bulk show us next indexes:

- dry bulk inbound flow is 88 % whereas outbound 12%;
- liquid bulk inbound flow is 70 % whereas outbound 30%;

On the basis of Table 2 and CBS information the following pie charts have been created.



Figure 9. Port Dordrecht cargo portfolio and balance incoming/outgoing flow. Source: Table 2 and CBS (the Netherlands).

In addition, the port of Dordrecht is a part of an important industrial cluster focused on the maritime industry, and is also part of Westelijke Dordtse Oever (Dutch) including 900 companies. In other words, the port of Dordrecht is a part and facilitator of the region's business.

As noted earlier, the port has a unique location and access to deep-water berths, providing the possibility of transshipment of bulk, break bulk and liquid bulk cargo. Moreover, the location of the chemical clusters of the ports of Rotterdam and Moerdijk in relation to the port of Dordrecht predetermines its importance as a place for transshipment and storage of chemical goods and oil. The proximity of marine clusters, shipyards, processing plants, steel production and processing companies provide all the necessary cargo flows for transshipment of dry goods.

Taking into account this information this port can be classified as an industrial port. The analysis of port cargo portfolio illustrates the dominant position of dry bulk and liquid bulk cargo. They are raw materials needed for the industrial and production complex which is located in the port. In addition, this port is used as a liquid storage facility to facilitate the operation of the sea port. It means that this port is a part of a deep-sea port network, in which it plays key role because the port of Dordrecht is the main hub for storage and transshipment of goods, according to the river-sea scheme.

4.2.2 The strategy of circular economy of the port of Dordrecht.

In accordance with the port Rotterdam Authority visions, they have four key circular paths, and they work together with a wide range of partners:

- innovation and expansion;
- sorting and processing;
- industrial symbiosis;
- capturing and reusing of CO₂.

The port of Rotterdam and the business sector are focused on the development of circularization in the port of Dordrecht, so the main circular initiatives are activated due to the interest of all participants in the process and are used as a point of value added and the use of residual flows.

Major circular initiatives focus on the use of clean energy. Initiatives are related to the production, storage, distribution and refueling of energy. In order to achieve the energy transition, a Clean Energy Center is being created. The foundation for the development of a clean energy cluster has already been laid, an agreement of intent has been signed, and the first LNG bunkering station is operating there.

The Port Authority aims to make the port a dynamic, stable and promising one. The optimal use of available space is the main basis of security and an indisputable advantage of the port. In the near future, the port of Dordrecht plans to optimize the Wilhelminahaven (Dutch) Basin.

It is worth noting that in the context of the transition to circular methods of the economy, this initiative can be considered circular, since this initiative reduces the negative impact of transport on the environment and is aimed at ensuring safety.

The next initiative is creation of a cluster, which gives a serious impetus to the development of a circular economy in the port. This effect enhances the circular strategy through joint projects directed on sustainable development and circularization of partners and strengthening of the joint participation of partners in the circularization of each other.

As already noted, Dordrecht is a place where marine companies are concentrated, being one of the main industries of the city. It means that not only the port of Rotterdam affects the circular economic strategy of the port of Dordrecht, but also other members of the business community. Therefore, the city plays an important role and brings together industrial, manufacturing and logistics companies to create and implement circular initiatives such as reverse logistics, remanufacturing, offshore design and many others. In other words, the city is the collector and the initiator of circular initiatives. As a result, there was a common vision of the circularization of the entire business community located in the city.

Based upon this, one of the significant circular initiatives is the creation of circular communities in the region, which can become a platform for the development of new circular methods. Based on the interconnection of different business participants and the search for new opportunities, this is one of the main tasks of this community. Cirkelstad and Circulab are foundation of the circular community for Dordrecht. These platforms bring together different business participants who help generate circular initiatives such as waste reuse, supporting the circularization of the construction industry, an active participant in the development and implementation of circular innovations. This initiative allows making this process transparent and more effective for all participants and to develop together. It should be noted that the level of importance of this initiative is very high, since it unites the efforts of the participants in the process as a whole, opening new horizons for them to develop circularization.

Thus, the platform like these helps the parties to participate in circular processes and increases the effectiveness of cooperation between partners. The circularization becomes a motivator for the association of companies and people who set themselves the goal of making their lives more conscious and environmental, where each business unit is a part of one business environment. This means that in a circular mosaic, everyone can see their contribution.

4.2.3 The port of Dordrecht summary.

The analysis of the inland port of Dordrecht may include the following summary.

This port is an industrial inland port which is a part of the Port of Rotterdam although at the same time retained its specificity and connection with the local business community. Obviously, the main function of this port is the handling of cargoes for industries which are located in the city.

It should be assumed that the circular initiatives such as waste reuse, clean energy use and others are aimed at the connection of the port with business community where the inland port plays one of the most important roles.

The influence of the port of Rotterdam is clear and extends to almost all professional areas of the inland port. However, the connection between the port of Dordrecht and the city is also very close. This factor opens up a high level of opportunities due to the fact that the port is becoming a part of the business community, which expands the possibilities for circularization. This means that these factors influence the development and strategy of the inland port.

So, the circularization of the inland port of Dordrecht depends on:

- the impact of the port of Rotterdam;
- interaction of circular initiatives between the port of Dordrecht and members of the business community;
- the municipal policy and vision of development of the city;
- circular strategy has dependencies that are related to industries.

As a result, this port has all the hallmarks of an industrial inland port with a strong influence from the port of Rotterdam and the city. Given these factors, it can be said that this port can be classified as a seaport, whose circularization strategy depends not only on its functionality, but also on its location and historical ties in the business community.



4.3 The port of Brussels

4.3.1 Basic information about the port of Brussels.

The inland port of Brussels is located in the capital area, and the main function of the port is to serve the city and capital region. Accordance to the vision of the port of Brussels, this is a «landlord port.»



Figure 10. Port Brussels. Source: Port Brussels

Port of Antwerp is the nearest seaport from the port of Brussels at a five-hour voyage from it. Due to the location of the port, Brussels has a high level of access to the main waterways - the Canal Antwerp - Brussels - Charleroi, has access through the roads N 260a, N277, N260 to the motorway E19, has a good rail links and draft 2,5,4 and 5,8 meters. In addition, the port of Brussels operates 15 km of berths along the water canal through the Brussels region. Moreover, the port of Brussels is responsible for the maintenance of canals, locks, quays and lift bridges of the region.

Port of Brussels operates on a 24/7 basis. The area of the port is 107 hectares. The trimodal container terminal operates in the port which uses three types of transports (waterway, rail and auto). Today, the port of Brussels is a port cluster which consists of 400 companies, including the TIR Logistics Center located in the port and created to facilitate storage, transshipment and customs procedures. In general, these are the companies which depend on the use of the waterway. These are urban supply companies, logistics, transport and international trade companies and others. In other words, the port of Brussels is the center of business activity of the city. Twelve thousand people are employed in port-related activities.

It should be noted that the main cargo flows are coming to the city via port. Ports of Brussels cargo portfolio is made up of: foodstuffs, agricultural product, petroleum product, construction materials, containers, bulk cargo and others. According to the port Brussels, the throughput of the port accounts for almost 7 million tons including more than 2 million transit tons.

The Board of Directors manages the Port of Brussels and is determined by the four groups of stakeholders. They are as follows:

- The Brussels-Capital Region, which holds 58,05% of the capital;
- The City of Brussels, which holds 33,40% of the capital;
- The eight municipalities shareholders of the former Canal Company who hold together 4,88% of the capital;
- The Brussels regional company of investment Brinfin, which holds 3,67% of the capital.

It should be noted the main business function of the port of Brussels is to facilitate logistics activities for the Brussels region. In addition, the port positions themselves as a regional logistics expert. This means that port specialists participate in various projects that improve cooperation between companies, create an effective business environment in the logistics community and optimize traffic flows.

Table 3, based on the port of Brussels annual report, represented a cargo portfolio of the port of Brussels in 2017.

Type of cargo	Handling thousand tons
Construction materials	2858
Petroleum products	1149
Others (containers)	375
Agricultural cargo	242
Ore and scarp	120

Foodstuffs	72
Metallurgical products	16
Fertilize	16
Transit	2076
Total	6924

Table 3: The throughput port Brussels. Source: Annual report of port Brussels 2017

In accordance with Table 3 and the annual Port of Brussels report:

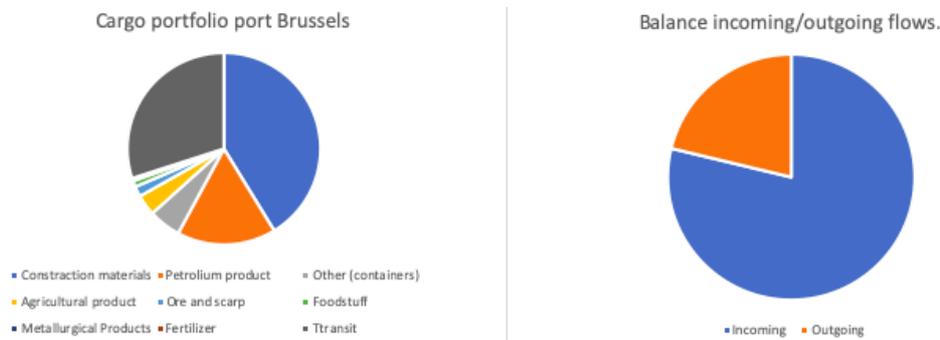


Figure 11. The cargo portfolio and balance incoming/outgoing flows of the port of Brussels. Source: Table 3; Annual report Port of Brussels 2017.

Analysis of the information in Table 3 can be noted that the dominant cargo at this port is the cargo of building materials and petroleum products. Moreover, the incoming flow is three times greater than the outgoing flow, which means that the main task of the port is to provide the market of product which is located in the city with raw materials. This means that this port has all the signs of a metropolitan port.

4.3.2 The circular economy strategy of the port Brussels.

The creation of a regional logistics hub can also be considered as a circular initiative, since cooperation of the logistics company and the port leads to a rebalancing of traffic flows, a decrease in congestion, carbon dioxide emissions and other negative external factors. Moreover, the development of the transport synergy process is aimed at the flexibility of the transport system in the context of its sustainable development.

In addition, the port as a regional logistics center stimulates the creation of a company that becomes a smart urban distributor offering distribution of goods. Such a company allows you to communicate with the port and make the port more accessible to end users. A striking example of a smart logistics company is the Belgian CityDepot. According to CityDepot's vision, they add flexibility for the last of the first transport miles. This means that the port is a business unit that affects the change in the basic logistics principles, and the integration of the port and the logistics company is a circular initiative aimed at reducing and ecological footprint.

It is worth noting that the main goal of integration between the port and the company is an attempt to create a closed loop of goods. For this purpose, it is necessary to organize a consolidated delivery and storage of goods. This could be a major

breakthrough in the unification of all Brussels enterprises with the goal of creating a reverse logistics flow. Which, without a doubt, is the basis for the sustainable development of the port and the city.

Based on this, it can be assumed that the distribution function is the most important function of the supply chain. In order to achieve a high degree of efficiency of port circulation and port-related logistics units, the location of the logistics equipment plays a significant role. One example would be the Building Village, which is located along a canal in the Vernon Basin. As mentioned earlier, the main cargo in the port of Brussels is construction cargo. Therefore, the port has warehouses with various functions from storage facilities to exhibitions of new material, and this is also a circular initiative because it allows the use of water transport as a priority for the transportation of construction materials.

Obviously, the port of Brussels is making every effort and has significant results in achieving the CO2 neutral level. According to the port's management indexes in 2018, they were able to avoid 106 000 tones carbon dioxide emissions and saved 27 million euros in external costs. It should be noted this is the result of significant efforts of the port's management associated with the introduction of innovations and the development of new types of traffic - containers, pallets, land for platforms, glass products and others.

Waterway clearance is a very important circular initiative that exists in the port of Brussels. There are several initiatives: a waste trap and a special clean boat. Both of these initiatives are effective and keep waterways more natural and minimize negative influence of business activity in the port basin.

The important initiative of the port of Brussels is to develop a delivery to the final consumer by water; to achieve this goal, urban water distribution is organized, which is facilitated by the presence of a network of transshipment platforms along the canal. This project consists of a transshipment station and temporary storage facilities that allow to use it as a point for re-parking, grouping and other operations.

The creation of space for river cruises under the patronage and with the help of regional allowances served as the beginning of the integration of the port and the city. The port is the distributor of this strategy. As a result of which, projects have been implemented to improve port infrastructure and the installation of public places. In order to communicate with the port and urban society, the port uses social networks that provide a high level of flexibility and immediate feedback from the urban community.

In addition, the port administration initiated a reduction in the negative impact of the head office building. In order to achieve this goal, the use of sustainable energy sources, hybrid and electric cars was proposed. Moreover, the increasing presence of the port in social networks indicates that the port administration is trying to create an interested community and integrate its circular ideas into the life of the region.

Apparently, a very important step in circularization is the creation of a circular community, which makes it possible to unite companies in the region to achieve the synergistic effect of circular initiatives. In the Brussels region, special platforms were created to stimulate the development of circularization. Based on the methodology that has been proven, IRISPHERE and GreenBizz.Brussel offer individual or group support that allows business participants to identify, evaluate and implement economic business opportunities at the local level. It is also a significant initiative that helps to choose a single direction for the development of circularization in the region.

4.3.3 The port of Brussels summary.

The analysis of the inland port of Brussels may include the next summary.

It is clear that the port of Brussels is a metropolitan port and the core of the logistics activity in the region. The connection between the port and the city is very high. In other words, the port depends on the city as well as the city depends on the port because the port is the basis for the transportation system of the region.

The basis of circular economy strategy of the port of Brussels is:

- rebalancing types of transport to reduce emissions;
- waterway clearance;
- integration with region industry and community;
- creation of a multimodal logistics hub;
- the use of sustainable energy sources.

These initiatives are aimed at facilitating urban life and are driven by connections between industrial companies located in the city. Consequently, the port is a part of the city, which contributes to interconnection in the business community and reduces the negative impact of transport on the environment. In addition, the port is the basis for development innovations, as well as for creating companies with a smart logistic vision that connects the port with end users.

Thus, it should be assumed that the port of Brussels is directly dependent on the functionality of the port and the level of penetration in the city.



4.4 Port of Liege.

4.4.1 Basic information about the port of Liege.

The port of Liege is the largest inland port in Belgium. The location of the port provides significant advantages for the successful operation of the port, since the port is located in the center of the biggest shipping network in the world. The availability level can be estimated as high, since the port has access to three key canals and three sea ports:

- the Albert canal – the port of Antwerp;
- the Juliana canal and the Meuse – the port of Rotterdam;
- East-West corridor – the port of Dunkirk.

In addition, the port of Liege has a good accessibility to the main motorways of the region via the roads N671 and N3 to the E40, E313, E25, the Belgian railway (the port includes two container terminals) and Liege airport.

The Port of Liege Authority is a public organization in Wallonia responsible for managing 33 port areas along the Meuse and Albert Canal in the province of Liege, and the port is responsible for managing, equipping and improving port infrastructure and regulating ship traffic.



Figure 12. Aerial of port Liege. Source: Port of Liege.

The port is 24/7 operating; the area of port consists of 370 hectares. Port facilities are designed for transshipment of various types of cargo, including the storage of liquid, bulk and packaged products and have all the necessary equipment for handling these cargoes (weighbridges, roll-on roll-off dock, cranes, warehouses, hoppers, silos and others). The total area of the berths is 26 kilometers; the draft is 2.8 and 3.4 meters.

The port is one of the key employers in the Liege province because the port's activity creates almost 18 715 jobs, including 7753 directly employed. It means that the port plays a significant economic role in the region and the country. Moreover, the port is the one of important players in the inland port community.

As noted above, there are three modes of transport in the port of Liège: rail, road and water. According to the information of the port of Liège, the main cargo flow is transported by water, which is about 75 percent, while rail and roads account for 7 and 18 percent, respectively. This means that the port of Liege has good opportunities for the development of a logistics platform with a wide range of logistics services. In addition, the proximity to the three borders of France, Germany and the Netherlands, as well as the proximity of the three waterways served as a basis for the creation of a 'Trilogiport' center in the port of Liege. Obviously, the logistics center concentrates companies and activities in one place, which allows to create a logistics product with added value. The symbiosis between logistic activities makes it possible to create unique opportunities for the development of the port and provide a high level of flexibility to achieve successful results. Moreover, this business initiative is to facilitate the logistics of the entire region.

According to the DIPACITY (Development of Inland Ports as sustainable tools for the CITY), the final report and the information of the port of Liege, the annual throughput of port Liege amounts to 21 million tons and accounts for almost 15% of regional GDP.

The main cargo portfolio comprises bulk, chemical products, steel and petroleum products, cereals, general merchandise and containers.

Type of cargo	Handling thousand tons
Non-ferrous mineral products	5985
Refined petroleum products	3308
Coal	1575
Metal	1260
Waste, recycling products	1260
Containers	788
Agricultural products	630
Chemical products	630
Wood	315
Total	15751

Table 4: The throughput port Liege. Source: Annual report of the port of Liege 2018

Based on Table 4 and the annual report of the port of Liege:



Figure 13. Cargo portfolio and balance incoming/outgoing flows of the port of Liege. Source: Table 4; annual report of port of Liege 2018.

Thus, the port of Liege is located on a large territory; the dominant cargo in this port is non-metallic mineral cargo and oil products. In addition, the incoming flow is much larger than the outgoing one. Undoubtedly, this port serves the industrial zone, and the main goal is to provide the raw materials for production sites located in the region. This port has all the features of an industrial port.

4.4.2 The circular economy strategy of the port of Liege.

Walloon is an industrial region of Belgium with well-developed various industries. It is worth noting that initiatives and projects related to eco-innovation and the circular economy are carried out at the regional level. According to the Walloon government, clustering is an important tool for the development of the region's economy.

As it can be seen, two types of clusters for eco-innovation in Walloon are business and competitive clusters. The purpose of creating clusters is the willingness of the various companies for a synergistic effect. It should be noted that the two types of clusters have a difference in business approach: business clusters are aimed at organizing the production system, while competitive clusters can be defined as

companies aimed at a synergistic effect through a partnership approach. This partnership creates these companies around the market.

The organization of partner clusters can be considered as a circular initiative, because as a result, participants in the business community receive benefits:

- improve their economic results;
- develop their competitiveness;
- ensure their visibility;
- improve technology;
- share experience;
- to simplify administration constrains.

In other words, the port is becoming a part of a system that brings together key players to provide an intelligent management approach in the logistics of the Walloon region. Apparently, it should be assumed that partnerships aimed at facilitating the development of logistics determine the direction of development of the industry, including circular one.

The port Liege is a participant of regional clusters such as Logistics in Wallonia. The essential goal of this cluster is to organize the innovation environmental and business community in the logistics industry of the region.

It should be noted that the Walloon region has other direction in eco-innovation, circularization and creation of clusters. It is obvious that almost all these activities, such as ecological construction, energy consumption reduction, renewable effective energy, climate impact in service and industry sectors, recycling end-of-life products and many others are aimed at the industrial sector.

The port of Liege, which is a part of the region's economic system, is trying to meet the high circular standards defined in the Walloon region.

First of all, the port of Liege is the basis for the creation of a logistics hub, which consists of a port, the "Trilogiport" logistics platform and two container terminals - the Northern container terminal (Monsin port) and the Southern container terminal (Renori port). It is clear that the creation of a logistics hub is a circular initiative due to the fact that the multimodal complex plays a significant role in the distribution by the city, since the main function of the hub is to distribute freight flows by mode of transport and create a unique logistics product. Apart from this, the usage of a multimodal transport scheme is the basis for reduction of carbon dioxide emissions. In accordance with the information provided by the port of Liege, the use of water transport for transportation of 15 million tons allows to avoid the use of 800 000 vehicles. It reduces greenhouse gases and the likelihood of congestions on the regional roads.

Afterwards, it should be noted that one of the circular initiatives is to promote economic viability and transport waste by water. This initiative is aimed at collecting waste in the port, which is one of the features of the port, and transporting it by water. Working together with processing companies such as Intradel, Sametal, Recyliege and others creates an industrial symbiosis between companies and the port and facilitates a number of garbage management production processes. In other words, the port is the place of origin of garbage; the appearance of such companies in the port makes it a place for garbage collection and sorting. As a result, this also affects the change in the balance of the transport modes portfolio and production symbiosis with recycle companies.

According to the report, over the past years, the port's cargo portfolio has changed due to macroeconomic recession and steel crisis. This fact served as an incentive for the reconstruction of the port and the regrouping of cargo flows from traditional

segments into containers and renewable energy sources. Biomass is becoming increasingly important and, as a result, it proves to be an essential element of the port's renewable energy system. The main reason for switching from coal to biomass was the reconstruction of a power plant on the Meuse River, as a result of which it went fully circular. This is a very important circular initiative of the port of Liege and the province of Liege.

4.4.3 The port of Liege summary.

The analysis of the inland port of Liege may include the next summary.

The analysis indicates that the port of Liege is an industrial port. The functionality of the port is providing the logistics and transport service for industrial clusters.

The main circular initiatives of the port of Liege are directed on:

- changing of balance in modes of transport to reduce emissions and congestions in the region;
- using of water transport for transporting waste and production symbiosis with recycle companies;
- creating a multimodal logistics hub with the minimum level of emission;
- using renewable energy and bio-ethanol;
- creation of the single space between the port and the region.

Certainly, the circular economy strategy depends on the functionality of the port, and the circular initiatives related to renewable energy and the development of multimodal transport confirm this. However, port circularization also depends on the regional and city circularization strategies. A confirmation of this can be considered the development of such initiatives as rebalancing modes of transport, creating a single space between the port and the city.

The connection between the port and the region can be rated as high, which allows to integrate the port and the region with the possibility of creating an interactive zone for the port community, which with the help of timely feedback affects the results of the port.

Thus, port functionality affects port circularization methods, but this is not the only dependence that affects the development and implementation of circular initiatives.



4.5 Rhine port of Switzerland (Basel)

4.5.1 Basic information about the port of Switzerland.

In 2008, as a result of merging of the ports of Basel-Land and the Rhine Maritime Authority of Basel-Stadt, the organization the Rhine port of Switzerland (SRH) appeared. The area of the port is 160 hectares. This company consists of three sections: Basel-Kleinhünningen, Birsfelden and Muttenz Auafen. The main functions of the port are handling of goods and passengers, management of water equipment, pilotage, towage and others.



Figure 15. Rhine Port of Switzerland. Source: Rhine Port of Switzerland.

SRH is located in the Rotterdam-Basel-Genova corridor and forms the national transport hub. According to the information of the canton Basel-Stadt, the ports of the Rhine are the most important freight hub for railways, which has more than 100 km of railways along the strategic transport axes of Benelux - France / Germany - Switzerland - Italy.

The basis for this is a developed infrastructure that can provide a high level of logistics. This means that the infrastructure allows to handle various types of cargo and includes storage facilities for bulk and liquid cargo, silos, railways, a container terminal and others. It is clear that a wide range of objects gives a high degree of flexibility and attractiveness for customers. Moreover, most port projects are created after a thorough analysis of customer needs.

An important feature of the Rhine port of Switzerland is the constant pursuit of development. In current time, there are several projects in the port aimed at expanding and improving its functionality.

In addition to the above, the port offers a high level of integrated logistics solutions for transportation of all the goods listed above, as well as services for the storage and processing of goods.

The port has good access to the main roads of the region; these are 2,3 and 5 motorways. In addition, a well-developed and extensive railway network is one of the competitive advantages of the port and the Rhine as a waterway. These factors have become an important basis for the development of the trimodal container terminal. According to the annual report of the Rhine port of Switzerland for 2018, the capacity of the trimodal container terminal is 120,000 TEU.

The port is the foundation for the existence of a multimodal complex, which joins more than 1,000 companies and creates 16 000 jobs including 3,000 jobs of direct workers in the port. The annual throughput capacity of the port complex is more than 5 million tons and more 100 000 TEU. According to the SRH, this is almost 10 percent of all Swiss imports. In other words, the Rhine port of Switzerland has a significant impact on the logistics industry and the entire economy of the country.

The information presented in Table 5 indicates that the dominant cargo in the port is construction materials, crude oil and petroleum products. In addition, the balance between the incoming and outgoing flows shows that the incoming flow is almost 4 times larger than the outgoing one. It should also be noted that the port area is not very large and occupies 160 ha. Having analyzed this information, we can conclude that this is a metropolitan port.

Based on the annual report 2018, the cargo portfolio of Rhine Port of Switzerland is as follows:

Type of cargo	Handling thousand tons
Crude oil, petroleum product	1786
Minerals, building materials	987
Foodstuffs and animal food, agricultural products	705
Chemical products, fertilizers	376
Iron, steel, and ores and scrap metal	329
Others	282
Cars, machines	235
Total	4700

Table 5. Throughput of Rhine port of Switzerland. Source: Annual report of Rhine port of Switzerland 2018.

According to the annual report of Rhine port of Switzerland and Table 5, the diagram of cargo portfolio and balance incoming and outgoing flows has been made:

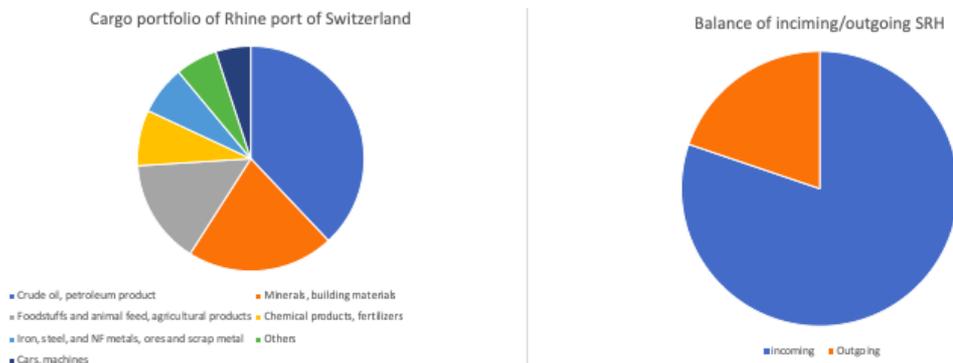


Figure 15. Cargo portfolio and balance incoming and outgoing flows SRH. Source: Annual report of Rhine port of Switzerland 2018 and Table 5.

4.5.2 The circular economy strategy of the port of Switzerland.

The canton of Basel - Stadt is one of the leaders in the circularization of the economy in Switzerland. Key initiatives are aimed at reducing greenhouse gas (GHG) emissions and saving energy. In order to achieve these goals, the Basel authorities passed a law with the main goal of reducing carbon dioxide emissions. Moreover, in a period of serious decline in the cost of energy resources, the Basel authorities kept energy price high due to the introduction of a tax rise. This price stimulates consumers to save energy, and the funds raised as a result of increased taxation are the foundation for the development and implementation of new circular management approaches.

The port of Switzerland supports all circular initiatives of Basel Authority, since the port and city are integrated with each other. This means that the region and the city are developing together, and they have the same vision of improving the environment and the development of the region; This is the basis for creating a port community. For example, all that is needed for living is all that is needed for walking, relaxing and playing sports with mandatory landscaping of these areas.

Moreover, Basel is a densely populated city on the borders of France, Germany and Switzerland, which faces growing transport problems that go beyond the borders of one state. The local authority realizes that transport is a factor affecting the stability of the region and enhancing its competitiveness. Therefore, a number of regional circular projects, such as the regional agglomeration program and "Future 2030", include activities which provide the efficient use of transport infrastructure and are aimed at strengthening and developing the transport system. In this regard, the role of the port in the region is increasing, in addition, it should be a circular port that meets regional circular ambitions.

An important tool for urban and regional development is societies that define issues for the development of the region in order to improve the quality of life in the long term. IBA Basel is one of such societies that pushes and accelerates the transition from the level of strategy to the practical level, facilitating the involvement of public and private decision-makers, and strengthening common models of investment, sponsorship and financing. The increasing importance of such a society in Basel is associated with the development of the port in triangular cooperation which can be considered as the initiatives that increase competitiveness of the port.

In addition, the 3Land project is aimed at developing urban space along the Rhine, which is based on the adjustment of port infrastructure aimed at developing port and logistics infrastructure. This means that as a result of this project, a sustainable transport hub will appear. Moreover, this project allows increasing the concentration of transport devices, and it opens up new opportunities for the city, as land for construction and logistics companies are freed up to increase their efficiency.

In other words, the circular design of the port allows making a hub with the optimal placement of logistics activities, which reduces the negative impact of transport on the city and bring the industry together. It can be seen that the trends in concentration logistically at the regional level are as follows:

- The transshipment of goods between different modes of transport has a high priority in the Basel region.
- The Basel region is the gateway for transporting goods to and from Switzerland.
- Logistics is a growing industry with high-level potentials.

The result of this may be industrial symbiosis with a high level of penetration into almost all urban circular projects. In other words, the transport system becomes a mechanism for ensuring interconnection in the region, the region's added value, competitiveness and circularization.

As earlier noted, the creation of multimodality in transport is a circular initiation due to the fact that this process involves a shift in the balance of use of transport modes. In addition, it encourages the use of cleaner modes of transport. It means that the circular vision of port is an exact match with regional view.

According to the information of Canton Basel-Stadt, Basel uses 100 percent of renewable energy. The port also follows this strategy since the port is a part of the city. This is a significant contribution to sustainability of the port.

Then, a very important initiation is called “Clean Rhine”, which involves using a special boat that collects oil stains and petroleum waste from the water surface of the Rhine and the same formations on ships, including the oil-water mixture produced in the engine room. A boat can also be used to save oil. It stands to reason; the use of these special devices ensures the purity of water and makes a significant contribution to the preservation of the environment. Moreover, the port is a very serious participant of waste management of the region and clearance of water.

4.5.3 The port of Switzerland summary.

The analysis of the inland port of Switzerland may include the next summary.

The analysis shows that the port of Switzerland is a metropolitan port. The methods of circularization have a direct dependence on the type of the port since the main functions of the port services are to provide the city industries with production units of the city such as a container terminal, construction, agricultural products and so on.

Totally, the main circular visions of Rhine port of Switzerland are aimed at:

- Increasing of the level of multimodality of the region;
- Using renewable energy;
- Waste management;
- Cleaning of water;
- Concentration of logistics in the one place;
- Cleaning of ships and recovery of oil waste.

Port circular initiatives intersect with regional circular vision and strategy. The port plays an important role in many circular initiatives in the region that are related to the various activities of the canton. Moreover, the unique geographical position of the port provides a number of opportunities for the development of circularization through international collaboration and the exchange of experience in the framework of triangular cooperation.



4.6 The port of Charleroi

4.6.1 Basic information about the port of Charleroi.

Charleroi's inland port is located in the center of Europe and is connected to major European routes which provide quick connection with all important economic participants in the region and country. According to the port's authority, the main goal of the port is to provide intra-modal transport for the optimal use of all port sides.



Figure 16. Port of Charleroi: Source: Port of Charleroi.

The port of Charleroi has good experience in using and operating three modes of transport; they are the railway, automobile and waterway. It is possible due to a high level of accessibility of the port. The port has access to two waterways:

- the Charleroi – Brussel canal;
- the Sambre river.

These canals define two areas which are managed by the port:

- Along the Charleroi – Brussel canal – from the mouth at Marchienne to Luttre;
- Along the Sambre – Landelies to Farciennes.

As noted above, the port of Charleroi operates various port units. It should be mentioned that these objects have a different functional base, which is aimed at the development of certain tasks. For instance, the dry port is designed to ensure uninterrupted and seamless connection of various modes of transport and support a high level of multimodality of the port. In addition, this unit allows using all the necessary tools in terms of symbiosis of transport with a high level of efficiency and low costs.

It is possible due to the fact that the port has a good transport access to E,19, E420 and E42, the main regional motorways, which provide excellent communication to key customers. Also, the port has a railway connection with Belgian railway through 3 rail-connected sides and a trimodal container terminal. According to the port of Charleroi, the main mode of transport is road transport, whose share is 42 percent. Water and rail transport make up 27 and 31 percent, respectively. This means that each mode of transport has a more or less equal share. Generally speaking, this port has a good opportunity to improve this situation and develop more ecological modes of transport.

The Autonomous Port of Charleroi is a public organization uniting the city, the Igretec Association and the province of Hainaut. A key function of the port is the promotion of water transport in the region, which is the basis for the regional economy. Moreover,

the port's activity creates almost 2700 jobs, including 1700 directly employed. The port consists of 29 ports and has a total of 500 hectares, which also include rental areas, future projects, public areas and others. It should be noted that the port has 8 kilometers of quays.

In accordance with the information of port Charleroi, the annual throughput is more than 5 million tons including 10 000 containers and the 3,8 million transit tons. The care of cargo portfolio is minerals, construction materials, metallurgical products, agricultural products, solid fuel, oil production, fertilizes, and others.

Type of cargo	Handling thousand tons
Agricultural product	19
Solid fuels	9
Ore and waste for metallurgy	107
Metallurgical products	239
Minerals, construction materials	722
Fertilisers	93
Miscellaneous	116
Transit	3841
Total	5146

Table 6: Throughput of port Charleroi. Source: Annual report of port Charleroi 2018.



Figure 17. Cargo portfolio and balance incoming/outgoing flows of the port of Charleroi. Source: Table 6; annual report of the port Charleroi 2018.

Thus, the port of Charleroi lies on extensive territory, the dominant cargoes in the port are minerals, construction materials and metallurgical products. Moreover, the incoming and the outgoing flows are almost equal to each other. Apparently, this port serves the wide industrial zone, and the key target is to provide the raw materials for the production sites located in the region. The port Charleroi has all the features of an industrial port.

4.6.2 The circular economy strategy of the port Charleroi.

The vision of the port administration offers three main functions of the port:

- The production function is aimed at creating a zone with the best conditions for receiving raw materials and sending finished products.

- The commercial function is aimed at expanding the port's influence on remote regions; the basis of this function is multimodal types of delivery of goods and raw materials.
- The regional function is to promote the transport component of the region, as well as the sustainable development of the port and the introduction of circular initiatives, which are an incentive for joining efforts between the industrial complex, the region and the port.

This means that the strong link between the port, industry and the city defines a joint effort to implement circular principles in the region, and the port becomes the flagship in this process.

Modern business trends show that the economic situation in the region is constantly changing. This means that the level of industrialization in the region has declined markedly. Contemporary business trends show that the economic situation in the region is constantly changing. This means that the level of industrialization in the region has declined markedly. The current situation offers new management methods, such as multimodality. Moreover, the port has an available space which can be used as potential for future activities of port. This means that the port, guided by a strategic vision, must take into account circular initiatives and principles for the development of modality. The development of multimodality is obvious and has a number of advantages such as:

- Fuel economy;
- Reduced environmental impact
- Reduced risk of accidents;
- Road unloading.

In addition, the use of water transport is a solution to the problem of energy saving. Moreover, water transport has a high level of safety in comparison with cars and rail.

It is pointed out that the creation of a multimodal hub, in the case of the port of Charleroi which is a dry port, it is not just a commercial activity, it is an important step for creating a sustainable business unit. In addition, this strategy is not only commercially viable, but it is also an initiative aimed at reducing the negative impact of transport by strengthening the position of transport with the least negative impact. Therefore, this initiative should be considered circular because by changing the balance of transport by type, it is possible to improve the environmental impact and reduce the level of traffic congestion.

It is also worth noting that the port makes significant efforts to preserve the biological diversity that exists in large numbers in the port. This implies that natural places are maintained to ensure the presence of natural parks in the port, which in turn reduces the negative impact of transport on the environment.

However, the essential circular initiative of the port of Charleroi is the creation of public limited company SEDISOL S.A. that allows to ensure using inland and maritime waterways. The company was established together with Ecoterres S.A. and Wallonia's environmental service company SPAQuF S.A.. The core activity of the company is the innovative processing of dredging deposits. The center offers various combinations of cleaning and dehydration technologies and is a leader in the field of dredging in Europe with unique technical and technological potential, which is created due to the support of various companies and regional authorities. This center is unique not only because of its location and potential, but rather it is unique due to

understanding the need to change the existing situation and to apply skills and technologies for changing it.

For instance, one stage of the dredging process that stabilizes heavy metals uses the NOVOSOL process. This process was developed by the chemical leader Solvay. The policy of the company Solvay is to provide environmental technologies for solving such problems and to act as an environmental partner. In other words, the goal of this initiative is not only to clean the remains of dredging, but also to create new standards for cooperation.

4.6.3 The port of Charleroi summary.

The analysis of circular economy of Charleroi's inland port may include the following summary.

The analysis shows that the port of Charleroi is an industrial port, although changes are taking place in the cargo portfolio, which may indicate that the economic situation in the region is changing, which entails a change in the economic priorities of the port. This means that the port is changing along with the industrial park and the city. A similar thing can be said about the circular strategy of the port of Charleroi, which is based on the requirements of industry and the city. The main circular initiatives in the port of Charleroi are:

- Creation of a multimodal hub with a minimum level of emissions;
- Increasing the modality of the position in the port;
- Preservation of natural parks in the port;
- Dredging deposits and water treatment;
- Energy conservation;
- Collaboration with environmental partners.

This means that the port of Charleroi has a partial dependence on the type of port. It should be noted that the port has a great dependence on the city and the region, initiatives such as energy conservation or conservation of the natural park emphasize this. It should also be noted that interaction with processing and environmental companies is accompanied by the development of a strategy for the conscious choice of a counterparty. Moreover, interaction with circular companies contributes to the appearance of a circular approach in the ports since the latter takes on some of the functions of these companies.



4.7 Summary of multiple case study.

A multiple case study summary is all the information discussed earlier in the case study, which is presented as summary of the main characteristics that are necessary to achieve the goal of this study. In addition, based on the data obtained during the study, a portfolio of circular initiatives is presented, as well as a list of the main dependencies of the cyclical initiatives of inland ports.

The first summary table provides information that illustrates the following indexes: area, availability, type of authority, and location. It should be noted, this information helps identify very important metrics to further determine port functionality.

As mentioned earlier, the port area is one of the factors that indicates its type. Therefore, first of all, the port area was determined. Then, the accessibility level and location of the port are indicators that affect professional opportunities, affordable markets and its competitiveness. Moreover, these factors influence the development

of ports as new, such as the main ones, potential cooperation with other business participants and integration with the city. These indicators also have a major impact on strategic management and are the basis for creating port strategies that include circular economy strategies.

Port	Area	Accessability		Authority	Location
		rail and road	canal		
Utrecht	216	A2 motorway, Dutch railway via container terminal	Amsterdam-Rhine Canal	Public-Private partnership	The loading - unloading docks are located on the industrial Lage Weide park.
Dordrecht	290	A16, A15 motorways, Dutch railway via container terminal	Oude Maas, Beneden-Merwede	Under control of Rotterdam Port Authority	The port is located between three sea ports and has high level of accessibility.
Brussels	107	road N260a, N277, N260 motorway E19, Belgium railway via trimodal container terminal	Antwerp-Brussels-Charleroi canal	Organization of public interest with a legal personality	The port is located in capital area.
Liege	370	road N671, N3 motorway E25, E40, E313, Belgium railway via 2 container terminal	the Albert canal; the Juliana canal and the Meuse; East-West corridor	Public organization	The port is located in the center of Europe and has a high level of access to water due to its location in the center of the shipping region in the world.
Basel	160	2,3,5 motorways, Swiss railway through trimodal container terminal	Rhine river	Public organization	The port is located in the center of Europe and has a high level of access to water due to its location. In addition, accessibility is a significant factor in this post, because the port is located near the borders with France and Germany.
Charleroi	500	motorway E42, E420, E19, Belgium railway via trimodal container terminal	Sambre river; Brussels-Charleroi canal.	Public organization	Charleroi's inland port is located in the center of Europe and is connected to major European routes which provides quick connection with all important economic participants in the region and country.

Table 7: Summary table: Area, accessibility and location of ports. Source: the summarize data of the chapter 4.

Based on this table, we can identify three ports (Dordrecht, Liege and Charleroi) that have a large area in terms of the other three (Utrecht, Brussels and Basel). The difference between areas of these groups is obvious. This means that with a high degree of probability the first three ports belong to one type of port and have the same functionality, while the second three belong to another type of port.

In addition, all ports have good transport accessibility due to the fact that in all ports there are three modes of transport (rail, road and water) as well as and each port has a unique location that determines its market niche.

The following table shows the cargo portfolio of each port, main cargoes and port capacity. As noted earlier, these dates are the basis for determining the type of port formed in this table, which confirms the conclusions made during the consideration of the previous table.

Port	Capacity ktons	Incoming	Outgoing	Dominant cargo	Type of port
Utrecht	4400	Construction cargo, cargoes for city	Construction scrap and waste	Construction cargo	Metropolitan
Dordrecht	3700	Dry bulk, liquid bulk, general cargo	General cargo, liquid bulk, dry bulk	Liquid bulk	Industrial
Brussels	7000	Construction cargo, containers, petroleum products, foodstuffs	Ore and scrap, containers, metallurgical products	Construction products	Metropolitan
Liege	21000	Non-ferrous mineral products, refined petroleum products, containers agricultural cargo, coal, wood	Containers, metal, waste, recycling product, chemical product	Non-ferrous mineral products, refined petroleum products	Industrial
Basel	4700	Agricultural products, foodstuffs, petroleum products, ores, iron, steel, construction materials, fertilizers, chemical products	Agricultural products, Foodstuffs, Petroleum products, Ores, Iron, Steel, building materials, Fertilizers, Chemical products	Crude oil, petroleum products, construction materials and minerals	Metropolitan
Charleroi	6000	Minerals, construction materials, ore and waste for metallurgical	Metallurgical products, fertilize, miscellaneous	Construction materials, minerals, metallurgical materials	Industrial

Table 8: Summary table: Throughput and dominant cargo of ports, type of port. Source: the summarize data of the chapter 4.

The multiple case study identified the type of port and its functionality. In order to achieve this goal, the methodology described in the chapter 3 “Methodology” was used. The base for determining the functionality and type of port used information about the port area, dominant cargoes and the balance of incoming and outgoing flows.

Thus, the ports of Utrecht, Brussels and Basel are the metropolitan ports whereas the ports of Dordrecht, Liege and Charleroi are the industrial ports.

The next table is a summary table which indicates the core of the circular initiatives in the study ports. This table provides the information about port, its functionality and main circular directions in these ports that have a large impact of development of port.

Port	Type of port	Circular initiatives
Utrecht	Metropolitan	<ul style="list-style-type: none"> the development of water and rail transport; using of water transport when transporting bulk cargo and waste; using of ships with clean engines; multimodal logistics hub with minimum level of emission; cleaning the waterways; waste management.
Dordrecht	Industrial	<ul style="list-style-type: none"> the development of water and rail transport; creation of a clean energy hub; using a clean energy; multimodal logistics hub with minimum level of emission; industrial symbiosis; renovation and optimization production facilities.
Brussels	Metropolitan	<ul style="list-style-type: none"> rebalancing type of transport to reduce of emissions; waterway clearance; integration with region industry and community; creation of multimodal logistics hub; the use of sustainable energy sources.
Liege	Industrial	<ul style="list-style-type: none"> change of balance in modes of transport to reduce of emissions; using of water transport when transporting bulk waste; multimodal logistics hub with minimum level of emission; using renewable energy; creation the single space between port and region.
Basel	Metropolitan	<ul style="list-style-type: none"> Increasing of level multimodality of region; Using renewable energy; Waste management; Cleaning of water; Cleaning of ships and recovery of oil waste.
Charleroi	Industrial	<ul style="list-style-type: none"> Creation of multimodal hub with minimum level of emission; Preserve a natural parks on the port land; Dredging deposits and cleaning of water. Collaboration with environmental partners. Energy conservation Increasing the modality of the position in the port.

Table 9: The summary table of case study: core of circular initiations if the research ports. Source: the part of 4 (case study) this paper.

The following table analyzes the difference between the approaches depending on the functionality of the ports. This table consists of seven main circular areas that have been highlighted in the literature review. Circular initiatives defined at each port were assigned to each area. Based on these data, the differences in port circularization approaches were determined depending on their type.

#	Description	Metropolitan inland port			Industrial inland port		
		Utrecht	Brussels	Basel	Dordrecht	Liege	Charleroi
1	Minimizing of Carbon Dioxide	+	+	+	+	+	--
	Development of water transport	+	+	+	+	+	--
	Rebalancing of transport portfolio	+	+	+	+	+	--
	Conclusion	This initiative is important for both types of inland ports. However, in this case reducing CO2 emissions is a more important principle for metropolitan ports, as actions are aimed at reducing vehicles and road congestions.					
2	Water management	Cleaning the waterways	+	+	+	--	--
		Renovation and optimization of water facilities	--	--	--	+	--
		Cleaning of ships and recovery of oil waste	+	--	+	--	--
		Dredging deposits	--	--	--	--	--
	Conclusion	This initiative is more relevant for metropolitan ports than for industrial ones. Nevertheless, clearing the waterway is the main initiative that is used in the metropolitan ports, while industrial ports implement initiatives aimed at developing industry in the port. A prime example is the SIMIDOL factory in the port of Charleroi.					
3	Waste management	Transportation of waste by water	+	--	--	--	+
		Recycling of waste	+	+	+	--	--
	Conclusion	Actually, The waste management is more relevant circular initiative in the metropolitan ports. The functionality of the port determines the development of this CI, because metropolitan ports have a strong connection with markets of the city which, in this case, is a factor development of this initiative.					
4	Environment management	Using renewable and clean energy	--	+	+	+	+
		Energy conservation	--	--	--	--	+
		Renovation and optimization of production facilities	--	--	--	+	--
	Conclusion	Management based on the use of renewable and clean energy sources is more inherent in industrial ports since this port is connected with manufacturing enterprises and is part of the industry in the region. Moreover, the large territory of the industrial port allows you to place new production and transition of the energy.					
5	Integration with industry	Creation of logistics hub	+	+	+	+	+
		Industrial symbiosis	--	--	--	+	--
	Conclusion	This initiative is a very important trend for both types of ports. This provides great opportunities for creating smart logistics with a high level of communication between the participants in the process. In addition, this allows creating a unique logistics product and minimize logistics costs and greenhouse gas emissions.					
6	Transport accessibility and connectivity	Increasing level of multimodality	+	+	+	--	--
		Creation of single space between city and port	--	--	--	--	+
	Conclusion	Transport accessibility is a more necessary initiative in the circulation of city ports, as it plays a decisive role in providing the city with construction materials, gasoline, food products.					
7	Increasing of social responsibility	Creation of circular community	+	+	+	+	+
		Integration of community	--	+	+	+	+
		Preserve a natural park on port land	--	--	--	--	+
		Collaboration of environment partners	--	--	--	--	+
	Conclusion	Social responsibility is developing in both types of ports. The creation and integration with the community is aimed at the targeted development of the circularization of the region. The creation of a single communication space has a significant impact on the development of society and business and determines the development vector based on collective vision, taking into account the needs of the entire region.					

Table 10. The analysis of circular economy strategies. Source: Table 9.

Through this analysis, we can create a portfolio of circular initiatives (CI) for each type of port. Portfolio CI allows identifying the main sequences and trends of circularization of each type of port.

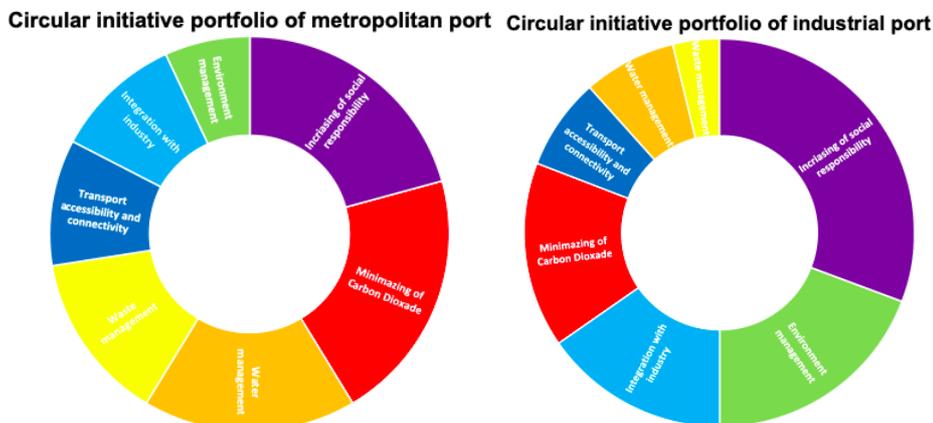


Figure 18. The Circular Initiatives portfolio for metropolitan and industrial ports. Source: table 10 and chapter 4.

The CI portfolio diagrams demonstrate that ports of various types have different set of circular initiatives. This is partly the effect of port functionality.

This study confirmed the assumption that:

- Some circular initiatives related to both types of ports, such as integration with industry, minimizing carbon dioxide emissions, increasing social responsibility;
- For industrial inland ports, initiatives aimed at the conservation and use of clean energy are of greater importance;
- Circular initiatives in metropolitan ports are more focused on recycling of waste and increasing transport accessibility.

Moreover, based on information obtained during multiple case study, the following sequences and trends can be identified:

- the circularization of metropolitan ports depends on the functionality of the ports since ports of this type have a pronounced dependence on the city and are a part of the city;
- the obvious dependency of circularization on urban strategy: the port becomes the foundation for many urban circular projects, the port is the place where the city, industry and logistics meet; basis for industrial symbioses which is a foundation for sustainable urban and regional symbioses.
- the dependence of the circular economy strategy of an industrial inland port on its functionality is not clear, although some areas of circularization are very closely related to the industrial interests of the port; however, the dependence on the regional vision for the development of circular initiatives in the port is also clear. The explanation of this fact may be the importance of industrial development in the regional framework.
- the dependence of the circularization of inland port on the nearby seaport and development of business community.
- the creation of multimodal nodes and further integration with industries is a widespread phenomenon in inland ports.

It is worth noting that inland ports are the starting point for a new economic model of the city, which aims to reduce waste, energy consumption, negative emissions and so on. Moreover, this is the place where almost all city systems meet, it provides a good environment for modeling circular experiments. This is indicated by the fact of creating multimodal complexes in the port. This means that the port is not just a connection point between land and water, it is also a place for modeling various approaches to the implementation of circular methods and sustainable development of the region.

Also, a very important point on the path of circularization is the fact of the emergence of the social aspect of the economy, which supports this model of the economy and becomes the basis for the development of the synergy of the port with other areas of business. Moreover, it can be noted that for the implementation of the circular approach, the social responsibility of an individual and business is of great importance. In other words, a circular economy increases the importance of social capital, makes a person responsible and involved, which, in turn, stimulates the circularization of the economy. This means that the creation of a smart economic system with anonymized participants is impossible. A person should take their place in this model, making a conscious personal contribution to its development.

Obviously, hinterland ports have a high level of adaptation to new trends in the development of the city, their sustainable development and circularization depend on their type and functionality in the general context. As mentioned earlier, the port is a place to introduce new practices and innovations. However, the need for such a practice is dictated by the regional vision of sustainable development. In other words, the interaction of ports and cities is the foundation for mutual development and underlies the change of the urban metabolism. Moreover, port-industrial symbiosis is the groundwork for the formation of more global synergetic units, for example, urban or regional symbiosis, which will contribute to the sustainability and circularization of business and the region.

Thus, the circularization of the inland port is more dependent on the level of consciousness of the individual and society, the relationship with the region, than on its type and functionality.

Chapter 5. Conclusion.

In conclusion, we can say that those dependencies that were determined as a result of the multiple case study suggest that the transition to circular management methods requires a change in the balance between resources and goods flows, processes and relationship between numerous participants of the process, which contain a large number of human and non-human resources with different time frames and far-reaching consequences for the ecology, economy and many other spheres of human life.

In order to achieve a circular system, it is necessary to create new opportunities for interaction between participants in the business process and try to use other resources. As a result, synergy is created between them, which serves as a catalyst for the integration of processes and flows in the circular system. In other words, the change of metabolism of economy is a crucial point in the circularization of economy in any business unit. It is obvious that the modern enterprises are faced with many challenges such as: global competition, environmental problems, energy dependence and others.

In order to solve these problems circularization of the economy and increasing the level of cooperation between participants in the processes are used. It is clear that circularization helps ports achieve their sustainable development, which is able to respond to external changes. The implementation of metabolic changes in port areas makes the port more open for circular undertakings in it at different levels: economic, social and environmental and other. As it is pointed out, the interaction between companies to create value is the basis for industrial and logistic symbiosis that ensures the development of circular processes for the reuse of materials, energy, waste recycling and other.

An extremely important aspect is the interaction of the port with the city or region, since regional vision can influence the port's circularization strategies and introduce main directions in them. This suggests that the city and the port are strategically important partners in achieving the circularization of the region. As it is known, the hinterland ports of North-Western Europe are located in historical cities, and one of the goals of the circular economy strategy is to preserve the historical heritage of these cities. This means that eco-industrial symbiosis is the basis of urban and regional symbioses.

It should be assumed that the strategies of a circular economy depend on many factors, the type and functionality of the port is one of them with a partial influence on the circularization of the port. However, as this study shows, port circularization is largely driven by the region's circularization strategy. Moreover, the economy is similar to a mirror that reflects the current moment in time and varies depending on circumstances, trends, tendencies and so one that arise in a certain place at a certain point of time. Thus, the region is a platform that combines a large number of activities where the role of water transport is obvious.

However, the economy is not just indices, charts, indicators, and much more. First of all, this is the science of our society, where people are the bridge between business units. Since all human activity is connected with nature, and its resources are limited, human consciousness is of great importance in promoting circulation and sustainable development of business and industries.

The current situation shows that the circulation of the economy is obvious, and the basis for changing the economic model is a conscious person, it is that who will create a new approach to the economy. What kind of economy will it be? What place will be allotted to man in this economy? Can a person awake its own consumer behavior and open values as the basis for a new economic approach? All these questions arise in the process of studying the circular transition and open new horizons for the study of these interactions in ports.

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