Adriatic Ports of the Future: Trieste and Koper Towards Circularity

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Abstract. The present study aims to investigate the effects of applying circular and industrial symbiosis models within the maritime sector, with a focus on logistics and transport. The intention is to focus on location decisions and the reduction of emissions. The rationale underpinning this study is to integrate strategies that facilitate the reutilisation of waste as a secondary raw material. The paper will analyse and examine how such circular practices can promote the sustainability of port infrastructures. The present study investigates and compares circular economy and industrial symbiosis initiatives integrated in the activities of port systems. The investigation will concentrate on two ports, Trieste and Koper, given their geographic proximity, in order to identify the actions and decisions taken by the ports with regard to the relationship between territorial location, territorial development and the various collaborations between actors. It is anticipated that the implementation of circular initiatives will result in a reduction of emissions, an enhancement of the competitive advantages held by the two analysed ports, and the promotion of activities and strategies that are aimed at efficient traffic management in accordance with European sustainability standards.

Keywords: Maritime transport · Port of Koper · Port of Trieste

1 Introduction

The advent of the circular economy (CE) can be attributed to the necessity of transitioning from linear economic models to more circular and sustainable ones in an era of globalisation. The objective of this phenomenon is to reduce and minimise the creation of waste, as well as to achieve a more conscious and efficient use of available resources. The Ellen Macarthur Foundation is a prominent proponent of the circular economy, a concept which emphasises the necessity of transitioning towards more sustainable economic practices. As posited by this foundation, the concept of the circular economy has been subjected to rigorous analysis, resulting in the observation and study of its application across various sectors and disciplines. This analysis has highlighted the potential of the circular economy to be integrated with new digital technologies. As demonstrated in the relevant literature, reuse and recycling practices have been shown to play a crucial role in waste management, with a concomitant decrease in negative externalities generated by human activities [1, 2].

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Furthermore, it has emerged how the circular economy and industrial symbiosis (IS) can generate advantages and benefits, both economically and socially, in the creation of new jobs and social equity. Recent studies have also focused on the transport and logistics sector, highlighting how waste reduction and efficient use of resources are important in creating sustainable ecosystems, leading to a reduction in environmental footprint [3, 4].

As a result, it is possible to state that the circular economy and industrial symbiosis are now important in the development of long-term sustainable strategies.

In this context, the present paper aims to investigate the influence and impact that circular economy and industrial symbiosis strategies can have in the maritime transport sector. The rationale behind the selection of this sector is twofold. Firstly, ports are of pivotal significance in the realm of international trade, serving as pivotal nodes for the convergence of transport networks. Even more, they represent pivotal points of confluence for these networks, thus underscoring their role as critical infrastructure. Secondly, in recent years, environmental sustainability has become a concept of significant interest to ports, which have sought to adopt various circular economy and industrial symbiosis strategies in order to mitigate the negative externalities generated by their activities and achieve efficiency in the use of resources [1–4].

The present work considers two ports: The two locations under discussion are Trieste, located in Italy, and Koper, in Slovenia. The selection and investigation of these two areas of interest is represented by their geographical proximity. The objective of this study is to compare the various strategies that have been implemented for the purpose of achieving circular practices in order to facilitate a sustainable transition.

The paper is organized as follows: Sect. 2 Metodology; Sect. 3 Data; Sect. 3.1 Port of Trieste; Sect. 3.2 Port of Koper; Sect. 4 Discussion; Sect. 5 Conclusion.

2 Methodology

The present study employs a qualitative approach to identifying strategies implemented in the port sphere with reference to the circular economy and industrial symbiosis. To develop this analysis, a thorough review of existing literature in the port sphere has been carried out. This includes institutional documents and environmental reports issued by the ports themselves. The review also includes official documents and releases as well as web sources. The objective of this study is to identify and analyse the waste management, reusable material recovery and treatment, water and energy resources management, and collaborative efforts implemented by the Port of Trieste and the Port of Koper.

3 Data

The circular economy represents an economic model that moves from a linear to a circular model by adopting strategies that are aimed at minimising waste and making efficient use of available resources. For this reason, this model includes the recycling and reuse of materials and waste, and the use of renewable energy sources. Alongside the circular economy, industrial symbiosis is also an integral part of it, through collaboration and exchanges between companies, where waste for one company can become a resource

for another, leading to the creation of an interconnected and sustainable ecosystem. These concepts can also be applied in the port sphere, as they are crucial nodes for the development of a given territory and territorial economic development. In fact, CE and IS allow the reduction of impacts on the environment and constitute competitive advantages for the optimisation of processes and activities carried out within port areas, as well as the reduction of operating costs.

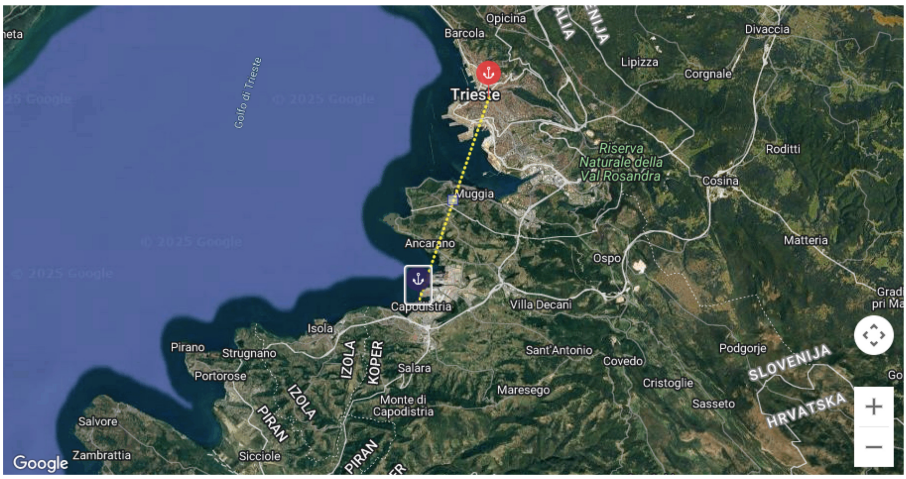

Fig. 1. Distance between the port of Trieste and the port of Koper [5]

The distance between the two ports is approximately 22 km by land and 6 nautical miles by sea. So, due to their proximity, the port of Trieste and the port of Koper were chosen for the analysis by the authors.

3.1 The Port of Koper Through Circular Economy and Industrial Symbiosis

The port of Koper, is a commercial port located in Slovenia, in the northern part of the Adriatic Sea and mainly connects the markets of the Mediterranean Sea with Central and South-Eastern Europe and the Far East. It is the main port of call in the North Adriatic for container traffic and vehicle handling, handling approximately 2/3 of the total national maritime traffic (Fig. 1). It is part of the North Adriatic Ports Association (NAPA) together with the port of Venice, Trieste and Rijeka and is connected to the main road and rail infrastructure. The port is managed by the company Luka Koper, whose capital is 100% owned by Slovenia (Fig. 2).

In relation to circular operations, the Port of Koper is implementing a proactive approach towards a sustainable transition through the Solar Power for Reducing Emissions (SOPOREM) project. This project involves the construction of a large solar power plant with a total capacity of 3.3 MW.

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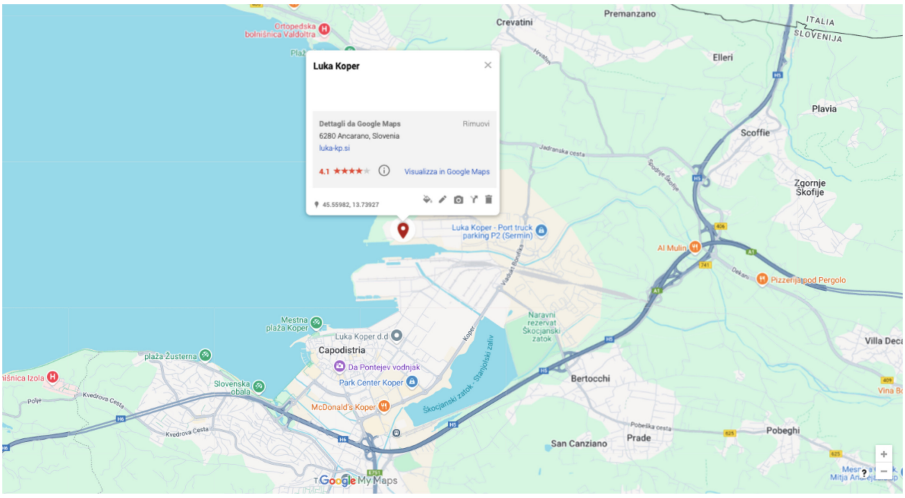

Fig. 2. The Port of Koper

is designed to reduce CO_2 emissions into the atmosphere by 1,500 tonnes per year, thereby contributing to the achievement of sustainability objectives. In addition, the port has made substantial investments in recent years in the electrification of port operations, notably through the replacement of diesel cranes with electric cranes and the utilisation of low-emission vehicles for internal activities [6, 7]. These measures are intended to enhance the energy efficiency and reduce the ecological impact of the port's operations, thereby aligning with the sustainability objectives outlined in the 2030 Agenda at both the national and European levels.

As is evident in the published annual report, there has been a notable emphasis on sustainable policies. Consequently, the port has been identified as one of the most active in the Adriatic region in terms of sustainability.

Indeed, a range of strategies have been implemented for the purpose of measuring and monitoring various environmental indicators. These indicators include, but are not limited to, the following [6, 7]:

- air quality,
- energy consumption,
- water management,
- waste management,
- greenhouse gas emissions,
- and noise pollution.

With reference to waste management, activities aimed at separate waste collection have been implemented, reaching 60% of recycled products, thanks to the monitoring of waste, the port is able to optimise waste disposal and implement strategies of circular economy and industrial symbiosis. Furthermore, the Luka koper association has committed to contributing annually, by donating funds in excess of 700,000 euro to

the Municipality of Koper, for the implementation of measures aimed at mitigating the negative externalities generated by the port's activities [6, 7].

The summary picture shows a growing focus on sustainability but also a strong consideration of the relationship with residents, seeking to build a bond of trust.

These initiatives highlight the strong propensity of the port of Koper to invest in green technologies, strategies and sustainable policies oriented towards the medium-long term. This leads to assert that Port Luka Koper is an example for the development of circular practices and environmental protection in the Balkan-Adriatic region.

3.2 The Port of Koper Through Circular Economy and Industrial Symbiosis

The port of Trieste is located in the gulf of Trieste and is the leading port in terms of cargo traffic in Italy, with a total of 62 million tonnes of cargo per year, of which 75% is related to preoil products (2017 figure), making it the leading oil port in the Mediterranean. The port of Trieste is divided into five free zones, of which three are destined for commercial activities [8]:

- The Old Free Port
- The New Free Port
- The timber terminal,
- The Mineral Oils Free Port (from which the oil pipeline originates)
- Zaule Canal, utilised for industrial activities.

The port of Trieste is distinguished by its deep water, which facilitates efficient nautical accessibility. Additionally, it boasts well-developed rail and road connections, further enhancing its logistical capabilities. This infrastructure is part of the main TEN-T network, where the port is identified as a core node between the European Baltic-Adriatic and Mediterranean corridors. Likewise the port of Koper, also the port of Trieste is a constituent of the NAPA. The port of Trieste is overseen by the Trieste Port Authority (L.84/94); in conjunction with the ports of Nogaro and Monfalcone, it constitutes the Eastern Adriatic Sea System Authority (Decree implementing L.124/2015). Further information can be found at [9] (Fig. 3):

In terms of environmental sustainability, the Port of Trieste is engaged in the enhancement and advocacy of practices within the framework of the circular economy. Specifically, the National Recovery and Resilience Plan (NRRP) has allocated funding for the primary sustainable measure, the cold ironing project.

This initiative involves the electrification of docks, with the objective of reducing emissions and noise pollution. The cold ironing project enables moored ships to disconnect from their engines and connect to the port's electricity grid. Moreover, projects encompass the initiation of the electrification of the quays belonging to Pier V and Pier VII, with the objective of supplying energy to cargo ships during their period of stay in port [10].

In addition to the aforementioned measures, the Port of Trieste has committed itself to the implementation of systems aimed at environmental monitoring. The objective of these systems is to obtain measurements of air quality and the management of waste generated by port activities. Furthermore, the integration of circular economy strategies into the daily operations of the port is a key commitment, often in collaboration with

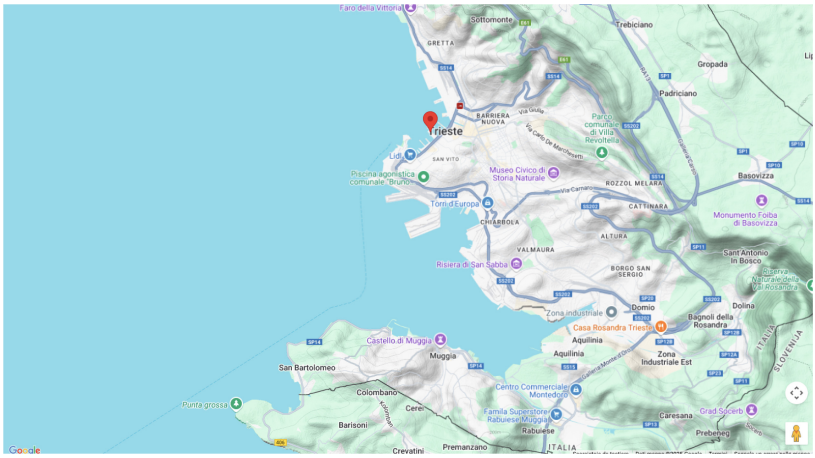

Fig. 3. The Port of Trieste [8]

the industries present in the area. Moreover, in collaboration with ARPA FVG, the environmental impact of maritime traffic will be monitored, encompassing not only emissions but also the risks of hydrocarbon spills and underwater noise [11].

In consideration of the circular economy, the Port of Trieste has initiated collaborative endeavours with companies that possess specialized knowledge in this domain. In collaboration with the Crismani Group, a partnership has been established with the objective of enhancing the recycling and material recovery activities of waste materials from port activities [12]. This initiative is designed to contribute to the active implementation of circular practices and industrial symbiosis within the port's area of responsibility.

4 Discussion

In this brief overview, it is evident that the approaches of the two ports considered are distinct. Despite this, they appear complementary in that, on the one hand, the port of Trieste focuses more on infrastructural energy transition and on building an industrial ecosystem that is able to support circular practices and industrial symbiosis strategies. The proximity to the industrial zone and the funding obtained from the PNRR-national recovery and resilience plan-supports the sustainable transition of the port itself. On the other hand, the Port of Koper is focusing more toward renewable energy production, through solar and internal electrification facilities, along with sustainable governance, allows for the development and implementation of solutions that are sustainable and allow for the measurement of achieved goals.

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So, the two appear complementary in that, on the one hand, the port of Trieste focuses more on infrastructural energy transition and on building an industrial ecosystem that is able to support circular practices and industrial symbiosis strategies. The Trieste port's sustainable transition is supported by two factors: its proximity to the industrial zone and the funding obtained from the PNRR (National Recovery and Resilience Plan). Conversely, the Port of Koper has adopted a strategy that prioritizes renewable energy production through solar and internal electrification facilities, complemented by sustainable governance. This approach enables the development and implementation of sustainable solutions and facilitates the measurement of achieved goals.

Despite this, both ports, are not exempt from facing specific challenges in order to best deal with the current transition. In fact, the port of Trieste needs to improve and strengthen collaboration, synergies, and integration with industrial logistics system actors to implement industrial symbiosis strategies while the port of Koper, thanks to its involvement in several European projects in the circular economy, could increase cross-border.

5 Conclusion

The analysis highlighted the differences between the two ports analyzed, highlighting how the two ports, which are geographically close, can develop and adopt distinctly different circular economy and industrial symbiosis practices, akin to the same field.

Trieste implements a systemic approach that is aimed at the organization and integration of infrastructure, industry and logistics. The reduction of emissions can be carried out by the port thanks to the projects developed in the field of cold ironing and industrial symbiosis initiatives, with the aim of waste minimization. Trieste also, due to its proximity to the industrial zone can promote industrial symbiosis strategies.

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Koper, on the other hand, seems to focus more on energy self-production and electrification of inland operating assets, for example by investing large sums in photovoltaic systems, highlighting how it focuses more on energy efficiency and giving more weight.

We can state that both ports are trying to implement good practices of circular economy, despite the differences between the two realities, where more collaboration between the two ports, would bring benefits and advantages as well as stronger cross-border cooperation.

Furthermore, given the proximity of the two ports, they could implement circular strategies to enhance their competitiveness and foster international cooperation and cohesion between ports.

Therefore, the need to implement shared strategies in the Upper Adriatic Area emerges, in order to share synergies, knowledge, strategies and technologies that could turn into a reference model for other ports in Europe.

The cases considered represent different but virtuous examples, although still improvable, of the environmental transition taking place in the Mediterranean port area, overcoming barriers to achieve not only environmental but also economic and social transition.

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