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Seaports as Nodal Points of Circular Supply Chains: Opportunities and Challenges for Secondary Ports

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Received: 23 March 2020; Accepted: 9 May 2020; Published: 11 May 2020

Abstract: This paper focuses on the development of secondary ports in the circular economy model (as a node of circular supply chains) to implement sustainable seaports in the context of the structural changes taking place in the global economy, trade, and maritime transport. The purpose of this article is to identify the opportunities, challenges, and key actions to be taken by secondary ports in circular supply chains. The research method applied was a single case study. The object of the study was the seaport of Szczecin (Poland). Our study showed that the secondary ports lacking technical conditions to serve large vessels, but with available space to develop their transshipment, storage, industrial, distribution, and logistics activities, may become major participants in circular supply chains. Taking advantage of the opportunities associated with participating secondary ports in the circular supply chain requires facing a number of challenges identified in the current literature, such as return-flow uncertainty, transport and infrastructure, the availability of suitable supply chain partners, coordination and information sharing, product traceability, and cultural issues. Our study partially confirms the significance of these challenges for secondary ports. The significance of these challenges depends on the kind of circular supply chain, i.e., whether the supply chain is a producer or a consumer chain. Our study shows that a very important challenge for both types of chains is the problem of internal resistance to change. This still-unsolved issue involves the persistent linear mindset of the port authority, which is manifested mainly as investor evaluation policy based exclusively on the declared annual transshipment volume, which fails to take actions to provide the available land plots with the infrastructure necessary for the terminals and industrial plants that participate in circular supply chains. Simultaneously, for secondary ports, we proved that it is stevedores (who are flexible and fast in adapting to new market conditions, strongly determined to search for new cargo types to replace those that have vanished, and who adapt the scope of their services) who play a key role in stimulating the development of circular supply chains. As a main managerial implication for the authorities of secondary ports, such authorities should create appropriate policies for investor assessments and the utilisation of available areas within the port premises to encourage the enterprises engaged in circular supply chains to invest in and develop their businesses within the port's premises. It is also necessary to develop appropriate communication between port authorities and their external stakeholders. As a managerial implication for the stevedores in secondary ports, these entities should first develop their service offers to address cargo as part of the circular supply chains (with more comprehensive service offers and added-value services, such as freight forwarding services, stuffing, packing, and mixing of cargo) and develop cooperation with other stakeholders of circular supply chains.

Keywords: circular economy; circular supply chain management; secondary seaports; port authority; stevedores

1. Introduction

While the concept of sustainable and green ports has become the subject of numerous in-depth studies [1–6], the transformation of seaport business models towards a circular economy is a relatively new area of research. The concept of the circular economy is also perceived as a prerequisite for the sustainable growth of a seaport [7]. This approach is observable in the European Union (EU) policy [8–10], in which seaports that function within a circular economy model may constitute a driving force toward sustainable growth.

At the same time, the studies completed so far indicate that, due to the diversity of seaports and port cities, there cannot be a single, universal plan of action for a seaport to undergo a transition towards a circular economy model [11]. Taking into account the classification of seaports that distinguishes between primary, secondary, and tertiary ports [12], current studies on the transformation of ports towards a circular economy focus mainly on the analyses of case studies describing the primary ports in Europe and Asia that hold high competitive positions in the maritime transport market and have significant technological and innovative advantages, i.e., [4,13–16]. Pursuing a circular economy through these ports is mainly done via symbiosis with industry or research and innovation centres focused on a circular economy, while the purpose of those measures is to decrease dependence on fossil fuels, improve energy efficiency, optimise waste management, and increase the engagement of stakeholders in the planning of port development.

To date, no studies address issues related to secondary ports that aspire to implement a circular economy but have lesser technical parameters and operate on a smaller scale (often in a highly competitive environment of primary ports, for whom they fulfill complementary functions) [17]. For any ports of this category, striving for sustainable growth and implementing a circular economy may be a challenge. Secondary ports, to a large extent, are affected by any structural changes in the global economy, trade, and maritime transport, which are stimulated by the increasingly stricter climate policies [4,18–21]. The impacts of those changes on the operations of seaports are manifested by the gradual decrease in traditional bulk cargo groups (e.g., coal and ores) in port transshipment operations. Competitiveness among this category of ports is also limited by the technical parameters that prevent such ports from handling the increasingly larger vessels being put into operation. Consequently, secondary ports are under strong pressure to attract new cargo groups to replace the vanishing ones. A great opportunity for the sustainable development of these ports may be circular supply chains. However, to develop a competitive position with a secondary port as a node in circular supply chains, that port must first face several challenges.

The purpose of this article is to identify the opportunities and challenges, as well as the key actions, for secondary ports approaching circular supply chains. This study applied a single-case-study method for the secondary port in Szczecin (Poland). The results may be used by port enterprises and management bodies of other secondary ports that have similar potential and face similar challenges to help them elaborate their strategies for development as links in circular supply chains.

2. The Literature Review

The underlying assumption of a circular economy model is that waste is used as a resource in other parts of the value chain by shifting the focus to closing material loops through reduction, reuse, and recycling at the system level [22–25]. Therefore, the general purpose of the circular economy model is 'closing the loops' [8]. At the same time, the circular economy model does not focus exclusively on limiting the use of environmental resources as a sink for residuals but instead strives to create self-sufficient production systems in which materials are recycled [26–28].

The circular economy concept stimulates the creation of circular supply chains that make it possible for all products to re-enter the cycle as input materials at the end of their life cycles [29,30]. Nasir et al. [28], by comparing the linear and circular supply chain systems, proved that the circular supply chain makes it possible to reduce greenhouse gas emissions and that transport processes are responsible for more total emissions than the linear chain. At the same time, the enterprises in the study were not convinced that circular supply chains are cost-effective and did not think that obtaining social benefits was a sufficient argument to implement them, especially because the higher levels of circularity attained by the enterprises could be related to higher economic costs due to the increasing prices of resources [31]. The studies completed so far have also shown that the most successful enterprises in implementing reverse supply chains are those able to strictly coordinate their reverse and forward supply chains, thereby creating a closed-loop system and maximising value creation throughout the product life cycle. Nevertheless, reverse supply chains may also be open-loop chains when the materials are recovered by entities other than the original producers and used in the production of other products [32,33].

The related studies underline the key role of seaports in developing a circular economy [16,34–36]. Seaports, as industrial complexes and intermodal nodes with strong interconnections to the hinterland and urban areas, play the role of global centres that handle the flow of resources for which they create added value [37]. Moreover, their impacts reach far beyond the administrative borders of the port. Girard [25] emphasises that the circular economy model in seaports is a manifestation of a synergistic approach that combines economic, logistic, and industrial activities with the cultural heritage of the port and the port city, as well as the creativity of its public, which yields a dynamic, complex, and balanced system. Striving to implement a circular economy model through a port is a circularisation process of the port, which consists of industrial, urban, city-territorial, or regional symbiosis. The transition of the linear structure of major ports like Amsterdam and Antwerp towards circular models is facilitated by the presence of industrial parks, cluster interconnections, and urban centres in the vicinity [35]. In previous studies that consider the experiences of various countries and major ports (especially European, Asian, and North American ports), the circular economy activities comprise three levels: micro, i.e., reusing the waste flows within one company; mezzo, i.e., the industrial symbiosis between two or more companies within the port (the development of eco-industrial parks); and macro, i.e., establishing inter-regional port industry networks focused on exchanging recycled resources [13,23,24,38–40]. Notteboom et al. [16], based on the best practices of leading European ports such as Rotterdam, Antwerp, North Sea Port, and Zeebrugge, emphasize that, under the circular economy business model, the main port activities are the promotion of industrial ecology, the use of renewable energy sources, and the development of seaports as hubs for recycle flows. In this last case, seaports are core nodes (recycling hubs) in the circular supply chains whose recycling flows are delivered, transformed into new products, and re-exported around the world. The experience of primary ports, according to past studies, shows that the port authorities play the key role in stimulating the development of sea–land circular supply chains [4,13,16,41].

At the same time, these studies [4,18,20,21] demonstrate that seaports have to cope with many challenges determined primarily by structural and climatic changes. The circular economy concept may help seaports to increase their competitiveness in an economy with scarce natural resources, thereby facilitating the growth of their innovativeness and decreasing the negative impacts of port operations on the environment and the neighbourhood [42–44]. This particularly concerns the secondary ports threatened with obsolescence and dereliction resulting from, inter alia, the ongoing transformation of the port premises to fulfil urban and tourist functions while abandoning traditional port operations. Secondary ports are also known as minor, assisting, peripheral, feeder, regional, or small and medium-sized ports. In the most general terms, they are classified by their size, capacity, and throughput, which are smaller than those of national major ports [12,45–47], and more broadly by assessing their location, international connectivity, industries, logistics and distribution activities, relative cluster position, hinterland capture area, gross domestic product (of the port city and of the hinterland), and market share [12,48]. In terms of annual handling volumes, secondary ports are considered small and medium seaports —those with an annual handling volume of less than or equal to 10 million tonnes (small ports) and more than 10 million tonnes but up to and including 50 million tonnes (medium ports) [41].

The development of secondary ports is hindered mainly by factors such as the insufficient technical parameters preventing the ports from serving large vessels, deficient systems of hinterland transport, a lack of space for development, or an unfavourable regulatory framework. The transformation of secondary ports towards a circular economy thus constitutes an opportunity but also a challenge. Carpenter et al. [13] rightly point out that, for all ports, a key requirement for commercial and economic viability is to retain the business of the ships served by them and to remain accessible to those ships. Simultaneously, De Langen and Sorn-Friese [4] (based on the commodity composition of the United States' foreign trade and in-depth case studies of Dutch ports) indicate that even though the development of the circular economy model stimulates the emergence of circular industries within seaports, it may also contribute to a decrease in transshipment volumes in traditional bulk cargo groups (the outcome of the 'shortening' of supply chains). In our opinion, these effects of the transformation will be experienced most strongly by secondary ports. A greater engagement in the circular supply chains may be an effective solution to secure the future of secondary ports in this competitive and ever-changing environment, thus promoting the sustainable growth of the port and the port city and helping them maintain and develop their basic functions (i.e., ship serving).

However, previous studies rightly highlight the numerous challenges faced by seaports developing their activities in circular supply chains [49,50]. Linder and Williander [49] emphasize that the transition towards circular supply chains may raise challenges related to the uncertainty of the quantity, quality, and timing of product returns that arise, especially in closed-loop supply chains. The importance of return-flow uncertainty in circular supply chain management was also indicated by Bressanelli et al. [50]. The authors, using an in-depth literature review (63 papers) and their own research (the multiple-case-study method), identified 24 challenges to transition towards a circular economy, grouped into the seven categories of economic and financial viability, market and competition, product characteristics, standards and regulation, supply chain management, technology, and users' behaviour. For supply chain management challenges, in addition to return-flow uncertainty, the authors also point to such major challenges as the availability of suitable supply chain partners, higher transportation costs, and problems of coordination and information sharing.

To summarize, the studies completed so far on the transition towards a circular economy in seaports are mainly based on the experiences of major ports that have at their disposal high-quality infra- and superstructures, as well as appropriate regulatory frameworks and know-how. Such ports play the role of major hubs for large general and bulk cargo flows and are less affected by the structural changes taking place in the global economy. In general, these studies show that, in major ports, the process of circularisation pertains mainly to developing industrial symbiosis and implementing solutions that apply renewable energy sources. The studies completed so far have hardly addressed the opportunities and challenges faced by ports as recycling hubs in circular supply chains, particularly secondary ports, which this article focuses on.

3. Materials and Methods

The main steps of the overall research process are presented in Figure 1.

In the first stage, the literature review process was carried out, which highlighted an existing research gap. Then, the research method and main object of the research (a secondary port in Szczecin) were selected. This study applied the single-case-study method [51]. As pointed out in [52], single-case-based research enables direct observations and interactions that provide insights that are not possible from a distance. Following the principles of this method, the following research questions were formulated:

1. What are the main opportunities for secondary ports as nodes in circular supply chains?
2. What kinds of challenges are faced by secondary ports when approaching circular supply chains?
3. How do secondary ports respond to these opportunities and challenges?

The object of the study was the seaport in Szczecin, as a link in sea–land circular supply chains. The seaport in Szczecin is one of the main universal seaports in Poland; it is located on the Baltic Sea and meets the criteria of a secondary port.

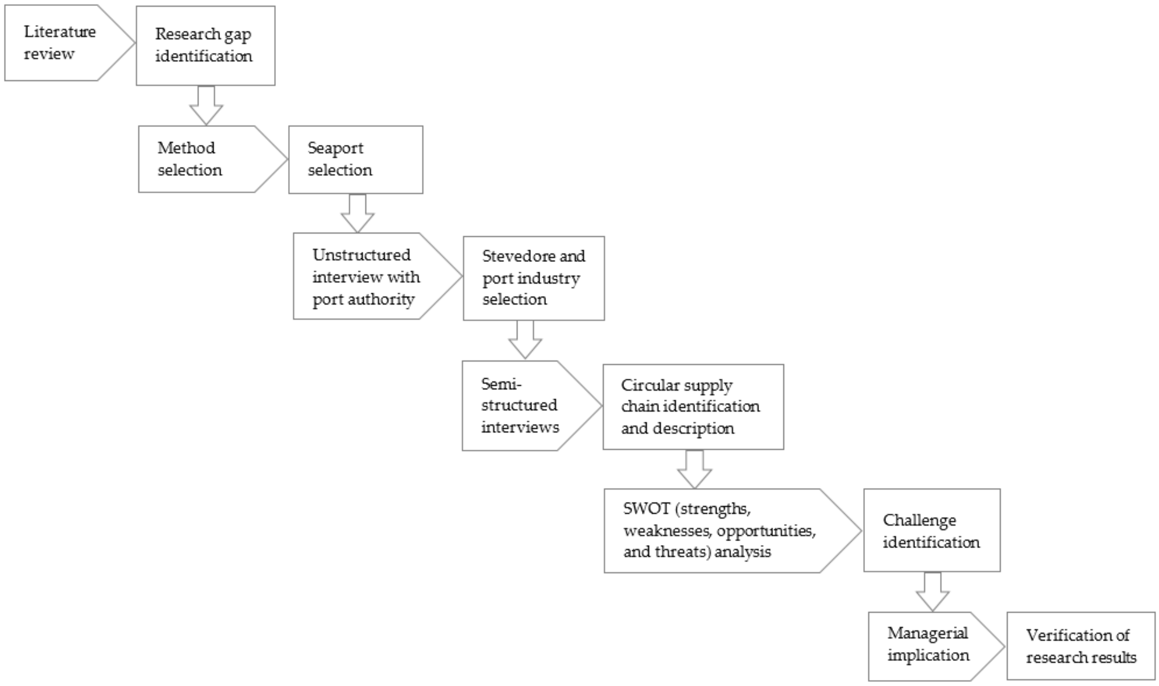


Figure 1. The main steps of the research process.

In recent years, this port has faced a number of challenges connected predominantly with the structural changes in the global economy, in trade and maritime transport, and in the Polish economy (political changes and the development of a free-market economy initiated in the 1990s), which have led to gradual decreases in the transshipment volumes of major bulk cargo, such as coal and ore, accompanied by an increased share of general cargo or cargo classified as 'other bulk cargo' (Figure 2).

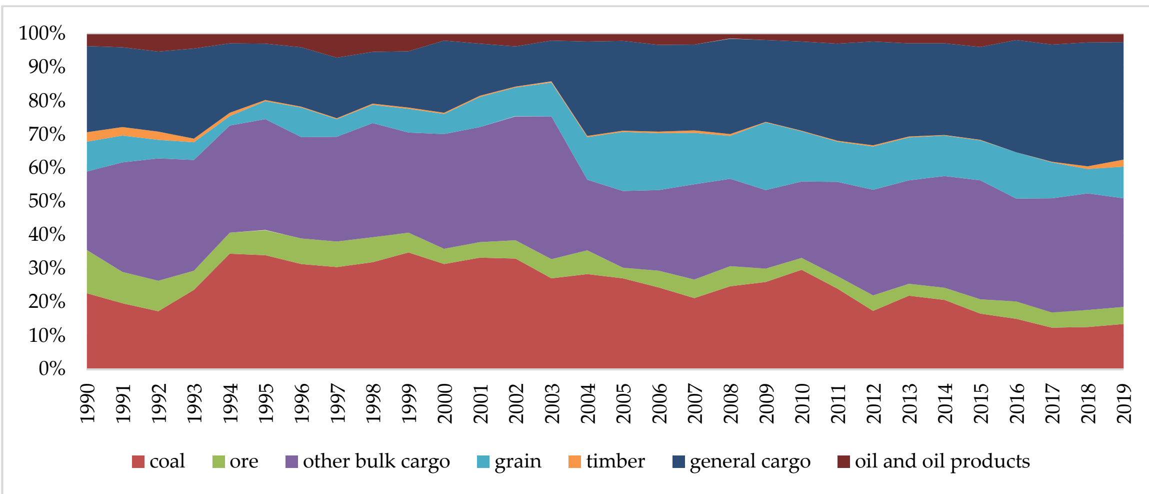


Figure 2. The breakdown of transshipment volumes in the port of Szczecin (1990–2019). Source: Compiled by the authors based on the Szczecin and Świnoujście Seaports Authority.

Handling the cargo flows moved within circular supply chains is a great opportunity for the port in Szczecin due to the lack of a possibility to handle large ships and the lack of interest of the operators of large specialised terminals, the availability of vast areas for investment, the possibility of being served by various hinterland transport modes (including inland shipping), the stevedores' experience in serving various cargo groups (which includes distribution and logistics services), and the location of port industry facilities and waste recycling plants [53].

To apply the single-case-study method to the period of January–February 2020, direct in-depth interviews were conducted among the companies operating in the port of Szczecin, such as stevedores and various port industries. An in-depth interview was also conducted with a representative of the Szczecin and Świnoujście Seaports Authority.

The first step of the study was to identify the entities engaged in the operating activities (stevedores) and industrial activities (port industries) in the port of Szczecin, connected (in whole or in part) with circular supply chains (the cargo flows involved waste or by-products in at least one direction). The entities were selected on the basis of our own observations and knowledge obtained by the literature review, studying the enterprises' websites, and information obtained via unstructured in-depth interviews held with a representative of the Szczecin and Świnoujście Seaports Authority. This information, along with statistical data on the volume and breakdown of port transshipments (in terms of cargo type and destination), helped to identify the target stevedore group, while the data on industrial activities (line of business) made it possible to identify the target port industry group.

Finally, out of the total group of 12 stevedoring companies running their operations in the port of Szczecin, 4 entities were selected for further study. Out of the 8 port industry entities, 4 were also selected for further study (3 of which dealt with pyrolysis and 1 with limestone grinding). Due to the temporary suspension of business activity, it was not possible to hold an interview with one of the pyrolysis plants. Consequently, interviews were only conducted with the representatives of 3 entities. The necessary data on the fourth entity's operations were obtained from the Szczecin and Świnoujście Seaports Authority, which made it possible to consider that entity in the research results. (See Table 1).

Table 1. Number and breakdown of the examined entities.

Type of Entity	Stevedores	Port Industries
Total number of entities active in the port in Szczecin	12	8
Number of entities selected to be studied via the in-depth interview method	4	4
Number of entities fully examined via the in-depth interview method	4	3

The second step of the study involved a semi-structured in-depth interview (held by phone and in person) of the 7 entities (4 stevedores and 3 port industries). The interviews were aimed at identifying the circular supply chains that involve the examined entities and operate via the port in Szczecin. The interviews were based on open-ended questions.

In the first part of the interviews with the stevedore representatives, the respondents were asked about their type of handled cargo. The obtained information made it possible to specify the kinds of cargo handled by the entities and to select the cargo types that are part of the flows of the circular supply chains. At this stage, it was necessary to explain to the representatives of said entities the idea of a circular supply chain. The respondents did not know the concept and were not aware that they participated in supply chains defined as circular supply chains. The second part of the interview was aimed at a detailed analysis of the flow and handling of the selected groups of cargo by the examined entities. The surveyed respondents were asked the following questions:

1. What are the directions of the analysed cargo flows (identification of cargo flow routes in the supply chain: place/country of departure)?
2. How is the cargo handled in the sea–land transport chains (identification of subsequent transport modes)?
3. What scope of cargo-related services is provided on the port premises (transshipment, storage, and additional services)?

4. What are the main conditions for serving the analysed cargo groups and developing the relevant services (legal, market, organisational, social, and especially environmental factors)?

In the first part of the interviews with the port industry representatives (analogous to the stevedores), we focused on identifying the resources and products applied in the production operations and their intended use. Further into the interview, the subjects were asked questions analogous to those used for the stevedores (items 1–3) on the directions of the cargo flows, transport services, and the operating conditions for the examined groups of resources / semi-products / finished goods. Additionally, this group of respondents was also asked the following questions:

1. Does the applied production/processing technology have any adverse environmental impacts?
2. How is your cooperation with other entities on the port premises?
3. What are the perspectives for your business operations?

Apart from selecting the entities to be included in the study, the unstructured in-depth interview held with the Szczecin and Świnoujście Seaports Authority was also used to obtain information on the following:

1. Interests of the enterprises engaged in the international trading of waste/by-products, whose business activities are located in Szczecin port, including transshipment and storage services, additional services, and industrial operations.
2. The prerequisites for developing this kind of activity in the port of Szczecin with regard to the available land reserves (port premises management policies) and the cooperation between the port authority, stevedores, and port industries operating on the premises.

The main difficulties encountered during the interviews with all the respondent groups were the groups' lack of knowledge about the circular economy and circular supply chains. Moreover, for some industrial plants, it was not possible to obtain full information due to their business secrets.

The obtained data made it possible to identify and analyse in detail the sea–land circular supply chains running through Szczecin. Flows of the following cargo were analysed: steel products–scrap metal, copper concentrate–sulphuric acid, limestone–gypsum, car tyres–oil, soot, scrap metal, and wood waste–ground wood waste.

In the next stage of research, a qualitative strengths, weaknesses, opportunities, and threats (SWOT) analysis for the secondary port in Szczecin was performed. The main opportunities and challenges of the secondary port as a node in the circular supply chains were identified. Then, the main directions of the necessary remedial actions were determined. The challenges identified in the single case study of the seaport in Szczecin, in connection with the existing opportunities and directions of the postulated actions, were confronted with theoretical knowledge. In the last stage, we verified the obtained results by matching current theory with our empirical observations [52].

4. Results

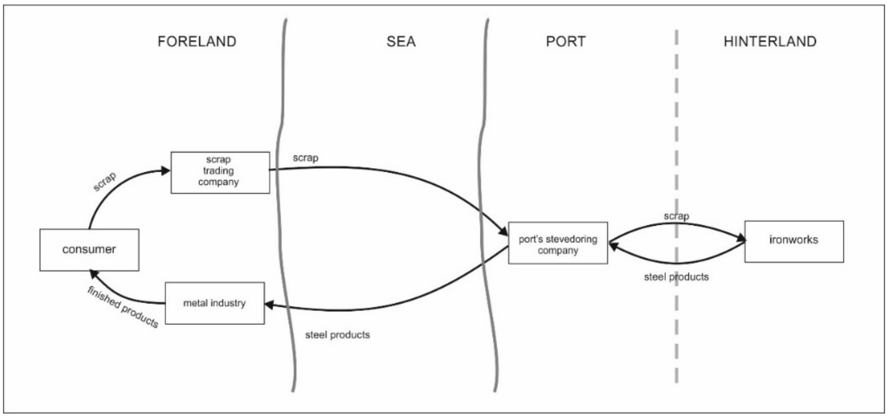
4.1. In-Depth Analysis of the Circular Sea–Land Supply Chain via the Port in Szczecin

To illustrate the opportunities and challenges related to the transformation of seaport business models towards the circular economy as a prerequisite for sustainable seaport development (and considering the gradual decrease in the transshipment volumes of traditional bulk cargo), in-depth analyses of the circular supply chains served via the seaport in Szczecin were performed. This analysis included all supply chains currently passing through the port of Szczecin whose cargo flows involve waste or by-products (in at least one direction). The circular supply chains identified in this way were analysed in terms of their cargo flow routes, subsequent transport modes, cargo-related services, and the main conditions for their presence in the seaport (for legal, market, organizational, social, and especially environmental reasons).

Chain 1. Steel Products–Scrap Metal.

One of the most frequently noted circular supply chains is the transport of steel products (product) and scrap metal (waste/resource). In the port of Szczecin, there are two variations of this chain, which differ by the degree to which the transshipment and industrial enterprises operating in the port engage in processing the cargo being moved within the chain.

In the first variant (1a), the port's role in the chain focuses exclusively on the operations of transshipment and the temporary storage of products (steel products, i.e., wire rods and reinforcement steel) and waste (scrap metal). Scrap metal is transported to the port from the foreland (mainly from Russia) using handy-sized vessels. The port handling operations are performed in the bulk area of the port in Szczecin. The scrap metal is carried on barges to the steelworks located in the port's transit hinterland where steel products are manufactured. On the reverse route, steel products, such as wire rods and reinforcement steel, are shipped to metal engineering and automotive plants in the distant and proximate foreland (ports located mainly in North America, Africa, and Europe). See Figure 3 for detailed cargo flow diagram and cargo flow model.



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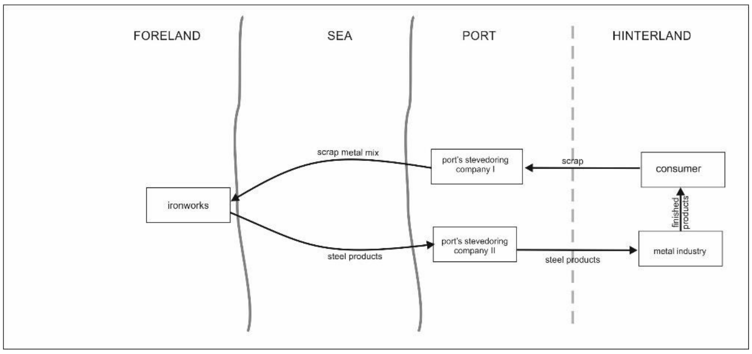
(b)

Figure 3. Example 1a: The supply chain loop for steel products–scrap metal. (**a**): detailed cargo flow diagram; (**b**): cargo flow model. Source: Compiled by the authors.

In the second variant (1b), the flow of products and waste occurs in the opposite direction. Additionally, the variant includes the partial processing of waste, as well as additional operations related to cargo distribution and logistics. (See Figure 4)

Steel products are brought from the ports located in the foreland of the port in Szczecin (i.e., ports in Russia and Finland) to the general cargo and bulk areas in the port of Szczecin, where they are unloaded and stored. The cargo are delivered to consignees in the Szczecin port's hinterland by rail and road transport. On the reverse route, the waste (scrap metal) is brought from customers (mainly from Poland and Germany) by rail and road. In that case, however, port handling is not limited only to transshipment and short-term storage. Scrap metal goes to a dedicated, specialised terminal for processing and transshipment, where scrap metal mixes are prepared to meet the specific needs of specific metalwork. At the terminal, scrap metals are crushed and mixed with some components imported by maritime transport. The sea portion of the reverse chain comprises the transport of scrap metals to various consignees (metalworks) in the foreland of the Szczecin port (i.e., to Finland).



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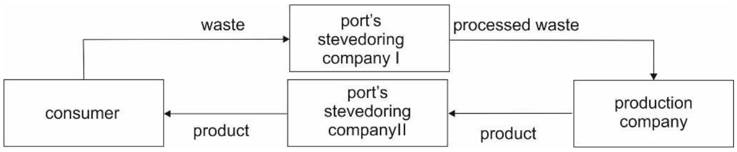

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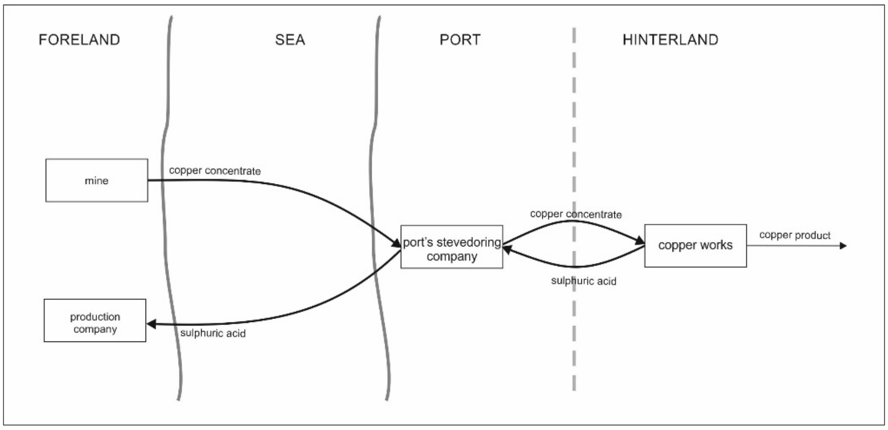
Figure 4. Example 1b: The supply chain loop for steel products–scrap metal. (**a**): detailed cargo flow diagram; (**b**): cargo flow model. Source: Compiled by the authors.

Chain 2. Copper Concentrate–Sulphuric Acid.

The second analysed supply chain encompasses the flow of resources (copper concentrate) and by-products of copper production (sulphuric acid). See Figure 5.



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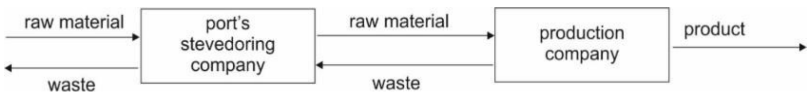

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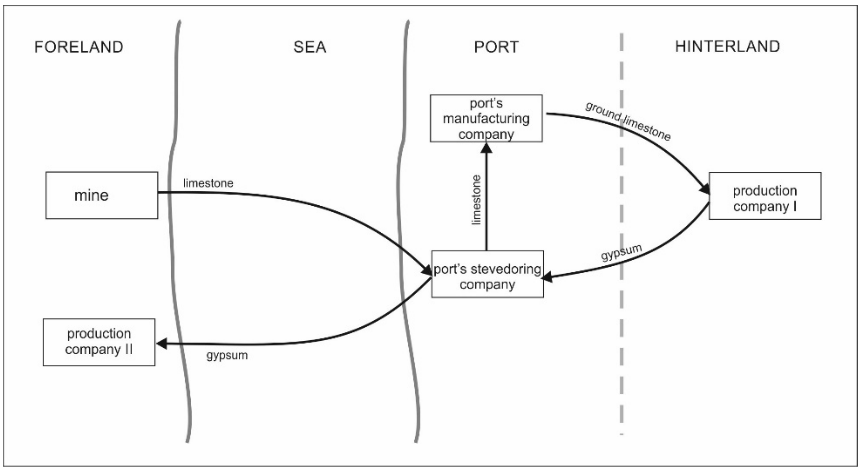
Figure 5. Example 2: The supply chain loop for copper concentrate–sulphuric acid. (**a**): detailed cargo flow diagram; (**b**): cargo flow model. Source: Compiled by the authors.

The resource (copper concentrate) is brought from the distant foreland of the seaport in Szczecin (the ports of South America) and is transshipped in the bulk area of the seaport in Szczecin by a stevedoring company. The recipient is a large copper company in the distant hinterland, and the cargo is delivered by rail (using Talbot self-unloading wagons). On the reverse route, 98% sulphuric acid (post-industrial waste in copper production) is brought by tank wagons to the port in Szczecin. The port handling operations are performed by the same stevedoring company in a specialised terminal for sulphuric acid transshipment. The consignees of the acid located in the foreland are chemical plants (mainly manufacturers of fertilisers) located in Africa, Europe, and South America.

Chain 3. Limestone–Gypsum.

The third analysed supply chain comprises the flow of the resource (limestone) and post-industrial waste (gypsum). See Figure 6.



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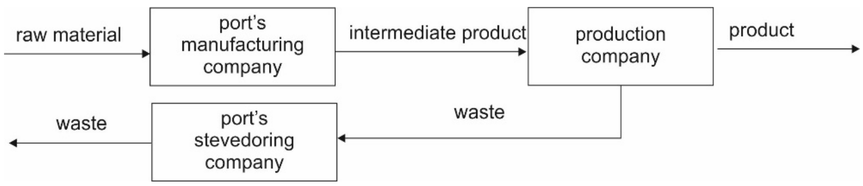

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Figure 6. Example 3: The supply chain loop for limestone–gypsum. (**a**): detailed cargo flow diagram; (**b**): cargo flow model. Source: Compiled by the authors.

The resource (limestone) is supplied from Gotland with small coaster vessels to the port in Szczecin, where it is unloaded in the bulk cargo terminal. Next, the cargo goes to the limestone grinding plant located on the port premises. Following processing, a portion of the cargo is shipped by road transport to the (conventional coal-fuelled) power plant located in the proximate hinterland of the port, where the ground limestone is used to remove sulphur dioxide from flue gases. Synthetic gypsum is the return load. It is brought to the port in Szczecin by road transport, transshipped onto sea vessels, and carried to the ports in Sweden and then to building material manufacturers.

Chain 4. Tyres–Oil, Soot, Scrap Metal.

The fourth analysed supply chain encompasses the haulage of waste, including used vehicle tyres and products resulting from the processing of tyres (pyrolysis). See Figure 7.

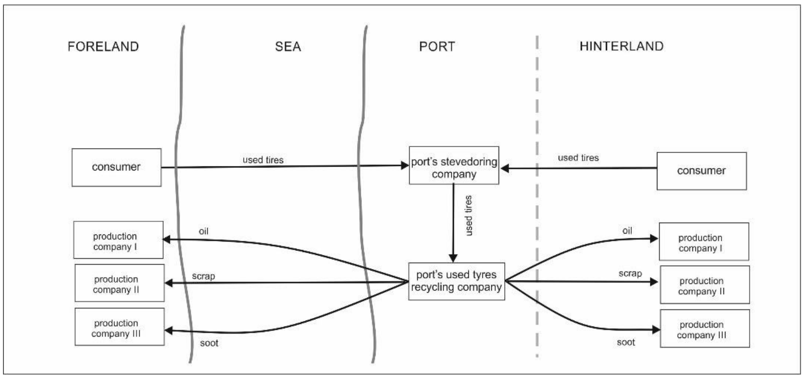

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Figure 7. Example 4: The supply chain loop for tyres–oil, soot, and scrap metal. (**a**): detailed cargo flow diagram; (**b**): cargo flow model. Source: Compiled by the authors.

Used tyres are brought to the port in Szczecin both from the hinterland (by road transport from Poland and Germany) and from the port's foreland (both as bulk and containerised cargo). On the port premises, the used tyres are processed in two processing plants, located, respectively, in the general cargo area and in the industrial part of the port. The resulting products are scrap metal, soot, and oil. Currently, these products are shipped mainly to consignees located in the hinterland. Oil is the most popular among customers, as it is predominantly used as fuel and is one-third cheaper than conventional fuel oil. A potential target group for this oil could also be sea vessel operators. Based on an agreement with one of the companies, a tank for the storage and distribution of this oil by sea was constructed on the port premises.

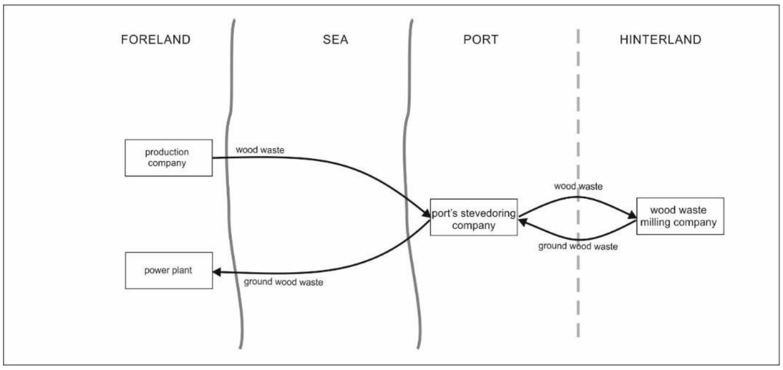
The other product, soot, is also transported by road (with silo trucks) to customers in the domestic market. In the future, soot could also be shipped in a containerised form to overseas consignees. Soot is a resource used in the automotive industry for the production of rubber products such as car mats and new tyres (if sufficient quality can be assured). The third type of product resulting from the pyrolysis of tyres, scrap metal, is used in the metal industry.

Chain 5. Wood waste–ground wood waste.

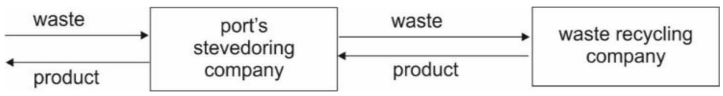
The fifth analysed supply chain covers the flow and processing of wood waste as a resource for the power engineering sector. See Figure 8.

Polluted wood waste is delivered to the seaport in Szczecin from Swedish ports. The port handling services are performed in the bulk cargo terminal of the port in Szczecin by a stevedoring company. Then, the cargo is carried by inland shipping to a wood-waste processing plant in the proximate hinterland (cross-border transport to Germany). On the reverse route, ground wood waste is carried to the bulk cargo terminal in the port of Szczecin This cargo, which is lightweight and takes up significant space, is difficult to tranship. Therefore, it requires a wider range of services apart from transshipment (e.g., compacting it on the ship). Next, the cargo is carried by sea to Swedish ports, from where it is delivered to power stations as biomass.

There are many factors important for creating the abovementioned circular supply chains via the seaport in Szczecin. For example, for the 'steel products–scrap metal' chains (1a, 1b), the most significant factor was waiving the obligation for companies to have permits for the cross-border transport of scrap metal in 2013. Obtaining these permits took much time and effort. Issuing a permit was dependent on indicating a concrete entity with which the company was to cooperate in serving the supply chain, as well as the cooperation time and estimated cargo (scrap metal) volume to be brought into the country. Apart from the proximate location in relation to the German market, an important factor was also the navigable inland waterway connecting Szczecin with the German inland waterway system (chain 1 and chain 5), the vast unoccupied areas within the port premises (suitable for the location of distribution terminals and industrial plants) (chain 1b, chain 2, chain 3), and the stevedore's guarantee of high-quality transshipment, distribution, and logistics services for the cargo in question (all the chains covered by the study). The study also showed that the durability of the identified sea–land circular supply chains via the secondary port of Szczecin is affected mainly by the rising domestic demand and changes in the destinations of waste deliveries and products as the objects of the transport flows. These factors cause a periodic and partial shifting of cargo flows from sea–land supply chains to land supply chains (chain 2, chain 3).



(a)



(b)

Figure 8. Example 5: The supply chain loop for wood waste. (**a**): detailed cargo flow diagram; (**b**): cargo flow model. Source: Compiled by the authors.

Moreover, the analysed examples indicated that the developing local cooperation between the entities participating in the circular supply chain (i.e., between stevedores and industrial plants and between stevedores and specialised distribution terminals) did not rule out further cooperation between the entities operating in the port with the circular supply chain links in the distant hinterland or more remote foreland. The decisive factor is the value of the cargo (waste) itself. For cargo of a low unit value (e.g., saw dust, gypsum, and scrap metal), the shippers strive to minimise the transport costs (proximate locations in the hinterland and in the foreland). In turn, for cargo with higher unit values (e.g., acid), the costs of transport are less important and are not a constraint when searching for partners, even in the more distant foreland of the port.

The analysed sea–land circular supply chains contribute to the diversification of the transshipment volume breakdown of the seaport in Szczecin (Figure 9).

An increasingly more significant share in the breakdown is held by cargo from the 'Other bulk cargo' group, which contains the above described by-products or waste. The share of this cargo category, excluding periodic decreases, has presented a rising trend since 2004, while the volumes of traditional cargo groups, such as the coal and ore transported in linear supply chains, have been falling.

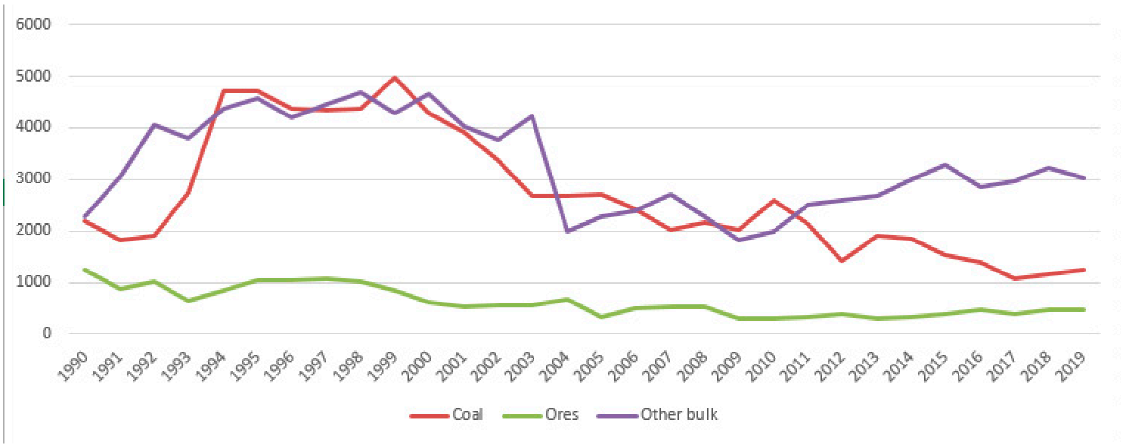


Figure 9. Changes in the port transshipment volumes in the analysed sea–land circular chains ('Other bulk cargo') compared to the transshipment of coal and ore in the seaport in Szczecin for 1990–2019 in k tonnes. Source: Compiled by the authors based on the Szczecin and Świnoujście Seaports Authority.

4.2. SWOT Analysis for the Port in Szczecin Approaching Circular Supply Chains

Taking advantage of the opportunities associated with the greater participation of the seaport in circular supply chains, as one of the ways to achieve sustainable development, requires tackling a number of challenges. To identify these challenges, a qualitative SWOT analysis for the port in Szczecin as a node in the circular supply chain was performed (Table 2).

Table 2. SWOT analysis for the secondary port in Szczecin as a nodal point in a circular supply chain.

Strengths	**Weaknesses**
1. Location of the port far from residential areas 2. Land reserves within the port premises 3. Varied and flexible offer of added-value services 4. Proven cooperation model: producer–stevedoring company–port authority 5. Labour market–universal staff availability 6. Access to road, rail, and inland waterway hinterland transport infrastructures	1. No circular supply chains among the priorities of the port authority's strategy 2. Complicated ownership structure for the port premises 3. No infrastructure in undeveloped port areas 4. Existing evaluation criteria for investors interested in investing in the port 5. Emissions performance of some industrial technologies
Opportunities	**Threats**
1. Sustainability policy implementation: a. planned development of the inland waterway infrastructure b. policy of promoting alternative sources of energy c. changes in waste management policy d. the development of low-emission processing technologies 2. Dredging the entrance fairway to the port and to the quays	1. Increased consumer demand in the port's hinterland 2. Increasing sensitivity of the local environment to adverse environmental impacts of the port 3. Regulations on the cross-border movement of hazardous waste 4. No cross-border arrangements for the development plans for the Oder waterway infrastructure

Source: Compiled by the authors.

Although circular supply chains do not generate large transshipment volumes, they generate considerable quantities of added-value services like the stuffing, packing, or mixing of cargo. A significant opportunity for developing these chains in the port of Szczecin, as well as in other seaports, lies in the activities connected to sustainability policy implementation, including the promotion of alternative sources of energy or changes in waste management that make it possible for industrial plants to obtain profits because they collected the waste.

Unfortunately, even though waste utilisation provides clear benefits in terms of environmental protection, some waste processing technologies generate considerable pollutant emissions. A clear advantage of the port in Szczecin is its location in an area excluded from residential functions. However, this does not limit the social pressure to mitigate the negative impacts of business activity on the local environment. A challenge and opportunity for the future growth of circular supply chains involving environmentally harmful processing is to apply new processing technologies. This is exemplified by the emission-free tyre pyrolysis technology developed in cooperation with academics and applied in practice (chain 4).

From the perspectives of various stakeholders of circular supply chains (e.g., industrial plants and distribution terminals), an important advantage of the examined port is the availability of land reserves on its premises. However, for the port in Szczecin, this land is undeveloped and lacks any hydrotechnical or land infrastructure (e.g., quays, electric power networks, a water supply, or sewage pipework). The priorities listed in the current strategy of the Szczecin and Świnoujście Seaports Authority do not include any provisions related to supporting circular supply chains through this port. Moreover, it seems that the measures generally applied by ports to evaluate investors (total turnover) disqualify any investors who are unable to declare large transshipment volumes (i.e., several hundred thousand tonnes per year). The transshipment of the cargo served in circular supply chains is much smaller (most often tens of thousands of tonnes per year), which, as per the current investor evaluation criteria, makes such ports unattractive to the port authority. A possible challenge and guideline to be followed by port authorities would be an enlargement of the investor evaluation criteria, e.g., including the environmental benefits of the planned activities (disposal / waste processing).

Another barrier to the development of circular supply chains in the analysed port is that some land plots to be used for business purposes belong to entities other than the port authority. This Authority has a pre-emptive right to purchase land plots. However, in recent years, the Authority has rarely availed itself of this right. Having all the land plots located on the port premises would provide a better possibility for the port authority to administer the land resources and would make it possible to establish new entities operating within circular supply chains.

An undoubted advantage of the examined port becoming a participant of circular supply chains is the varied and flexible services provided by stevedores, such as flexible transshipment and storage services, as well as additional services (e.g., freight forwarding) and added-value services provided in relation to the cargo in circular supply chains (e.g., chain 5, where stevedores provide typical handling operations, such as compacting the wood waste on the ship), as well as a wide range of services offered to industrial plants and specialised distribution terminals participating in such chains. This flexibility would not be possible without highly qualified staff, which is an advantage held not only by the analysed port. In secondary ports equipped with multitask terminals, qualified staff perform various works (e.g., on-site transport, stacking, stowage, and other handling operations). The said service offers are related to the trilateral cooperation model developed in the port: producer–stevedoring company–port authority. The process by which stevedores adapt to serving cargo as part of a circular supply chain is a permanent process that results from both the diversity of cargo and the added-value services accompanying the cargo flows, as well as the legal requirements connected with handling hazardous cargo in cross-border transport.

The strength of the studied port is its access to three modes of transport, including inland shipping, which is suitable for carrying low-value waste. An opportunity for the further growth of circular supply chains via this port is the national programme for developing the inland waterway infrastructure, which has been adopted and commenced, through which the Oder Waterway is set to be upgraded to achieve international waterway parameters. A threat for this programme implementation is the lack of coordination of activities in the cross-border area.

Opportunities for the development of circular supply chains should be identified with the development project implemented within the current EU programming period, which consists of dredging the entrance fairway and the quay area up to 12.5 m (to serve fully loaded 40,000 DWT vessels instead of the present 20,000 DWT). The new parameters of the port infrastructure will contribute to improved competitiveness of the land–sea chains via Szczecin relative to the land chains (resulting from the growing demand for some types of cargo to be part of circular chains in the port's hinterland). Vessels with a two-times higher carrying capacity will make it possible to reduce the transport costs, which will enable the fulfilment of contracts with partners located in the port's more remote foreland. Some threats for circular supply chains may be connected to the following interdependence: serving larger ships requires the storage of larger consignments in the port, which requires more storage space. Consequently, there may be more pressure on using the last available areas provided with the infrastructure for purposes other than handling the cargo that is part of the circular supply chain. Therefore, it is important to coordinate any development projects aimed at improving the parameters of the existing port infrastructure with any development projects aimed at providing infrastructures in undeveloped parts of the port premises. Many secondary ports implement measures to serve larger vessels. Given that the port authorities' strategies do not aid circular supply chains, many new investors operating in circular supply chains may go unnoticed.

To generalize the obtained research results based on the SWOT analysis for the port in Szczecin, the identified challenges for secondary seaports connected with the development of circular supply chains were confronted with the current literature.

5. Discussion

The current literature has thoroughly investigated the challenges of circular supply chains. Great cognitive value can be found, for example, in the research results of Bressanelli et al. (2019) [50], which include a broad overview of the academic literature supplemented by empirical studies, thereby offering a source of current knowledge about the major challenges connected to the development of circular supply chains. However, these studies do not refer directly to land–sea chains. The challenges to circular supply chain development identified in the literature, compared to the research results for the secondary port in Szczecin, are presented in Table 3. Our study primarily showed that the relevance of particular challenges depends on the kind of circular supply chain. Based on the completed analyses of the circular supply chains running via the port in Szczecin, we identified the following two kinds of chains:

1. Consumer chains, which include the individual consumers from whom the waste originates (chains 1a, 1b, and 4)
2. Producer chains, which include post-industrial waste or the by-products of industrial plants (chains 2, 3, and 5)

Table 3. Challenges of secondary ports when approaching circular supply: Current theory versus empirical observation.

No./type of circular supply chain Challenges:	1a	1b	2	3	4	5
	Consumer	Consumer	Producer	Producer	Consumer	Producer
Return-flow uncertainty	✓	✓	o	o	✓	–
Transportation and infrastructure	✓	✓	–	–	✓	–
Availability of suitable supply chain partners	–	–	–	–	–	o
Coordination and information sharing	✓	✓	o	o	✓	o
Product traceability	✓	✓	–	–	–	–
Cultural issues	✓ for port authorities – for stevedores					

Legend: ✓ - applied; **o** - partly applied; **–** - not applied. Source: Compiled by the authors based on [50].

In the literature, the most frequently indicated challenge to circular supply chain development is return-flow uncertainty. However, the study conducted in the port of Szczecin only partially confirmed the importance of this challenge to secondary ports. This challenge is relevant predominantly to the circular supply chains whose waste comes from individual consumers. This is exemplified by the analysed chains 1a, 1b (scrap metal), and 4 (tyres), even though, for these chains, the implemented waste management policy (mandatory waste collection by municipality services) ensures the possibility of recycling more waste, so the stabilisation of such chains may be expected.

For the chains whose waste is derived directly from the production process (chains 2, 3, and 5), the risk resulting from flow uncertainty is generally no different than that of linear chains. Both the nature of the contracts (the contracting parties are often large industrial plants) and the minimum volumes agreed upon with the port terminals guarantee the continuity of flows in the circular supply chains. Some degree of uncertainty results only from the fluctuations in the regional and national demand for cargo to be a part of the circular supply chains (chain 2 and chain 3).

According to the literature, circular supply chains generate a greater demand for transport compared to linear chains. Our study only partially confirmed the legitimacy of this claim. For chains based on production waste (chains 2, 3, 5), the engagement of transport processes in circular supply chains is similar to that for two separate linear chains (resources for production and products), whereas an increase in transport takes place for chains engaging individual customers who generate waste. This situation is observed for chains 1a, 1b (closed-loop chains), and 4 (partially closed-loop).

Another significant factor indicated in the literature is the availability of suitable supply chain partners. However, this study conducted in the port in Szczecin did not confirm the problems connected with sourcing partners to serve circular supply chains. Considering the problems faced by secondary ports (a decrease in transshipment volumes, e.g., coal and ores), stevedoring companies having at their disposal multitask terminals and qualified staff who are eager to serve circular supply chains. However, the challenges may be significant when serving chains that involve hazardous cargo (e.g., chain 5) that requires appropriate administrative permits, or when the production plant in the seaport applies a pollution-intensive technology (one of the plants in chain 4), but even these obstacles are overcome by the ports (through the development of alternative technologies).

Another significant challenge is the problem of coordination and information sharing. The significance of this challenge was confirmed by the majority of cases we analysed. This problem is distinctly visible for consumer chains (1a, 1b, and 4), as waste dispersion among small suppliers generates problems with the information flow. However, for producer chains (2, 3, and 5), in which all the links within the chain are unambiguously identified and between which cooperation takes place on a long-term contract basis, this factor has limited impact. It is manifested if there was no prior and precise information on the planned transshipments in a given year from a producer participating in the circular supply chain.

Our study also confirmed the significance of yet another challenge identified in the literature: product traceability. This is a significant challenge for consumer chains, whose waste is not standardised (e.g., the scrap metal in chains 1a and 1b). For chains whose waste is precisely specified (which is a requirement for any waste generated in production plants) or when waste comes from individual consumers but with standardised parameters (chain 4), product traceability does not seem to be a considerable challenge.

However, our study confirmed the considerable challenge of internal resistance to change (cultural issues). This challenge impacts all the circular supply chains in a similar manner. In the operational areas (stevedores) of secondary ports, there is already a strong conviction that it is necessary to adapt to handling the cargo involved in circular supply chains. However, this is not the case for port authorities, who show a more linear mindset. As a consequence, their fundamental instruments (i.e., the port's development strategy) do not provide any offers for circular supply chains. The investor evaluation policy is thus based on the transshipment volume only, and no actions are taken to provide available land plots with the infrastructure necessary for the terminals and industrial plants that participate in circular supply chains.

6. Conclusions

This paper focused on issues connected with the development of secondary ports as nodes in the circular supply chains of the circular economy model, which is the basis for implementing the sustainable seaports in the context of the structural changes taking place in the global economy, trade, and maritime transport.

Firstly, our study confirmed that the most important threat to the development of secondary ports is a decrease in the transshipment volume in the traditional bulk cargo group. This is shown by the changes in the breakdown of transshipments in the port of Szczecin (Figure 9). Secondary ports that do not have technical conditions to serve large vessels, but have available space to develop their transshipment, storage, industrial, distribution, and logistics activities (and are trimodal (i.e., have access to road, rail, and inland waterway hinterland transport infrastructures)), may become major participants in circular supply chains. Focusing port development on serving circular supply chains can help secondary ports retain the business of ships. The completed analysis of the case studies additionally indicates that, regardless of the significance of geographical proximity (highlighted in the literature) for the development of industrial symbiosis and eco-industrial parks in seaports, circular supply chains may also operate on a global level. This concerns cargo with higher unit values (e.g., chain 2), where transport costs are not a constraint in searching for partners, even in the port's remote foreland.

Secondly, taking advantage of the opportunities associated with the secondary ports in the circular supply chain requires facing several challenges. Our study partially confirmed the significance of the challenges to circular supply chain management identified in the literature, such as return-flow uncertainty, transport and infrastructure, the availability of suitable supply chain partners, coordination and information sharing, product traceability, and cultural issues. The significance of these challenges depends on the type of circular supply chain, i.e., whether it is a producer or a consumer chain. The in-depth analysis of the sea–land circular supply chains presented in this article proves that most of the challenges indicated in the literature pertain to consumer chains, particularly return-flow uncertainty, higher transport costs, and product traceability, as well as the problem of coordination and information sharing. Producer chains, in turn, tend to be more durable because they are contract-based. The issues related to the availability of suitable supply chain partners were not a substantial problem for the stevedores and port industries, apart from the handling of hazardous goods.

However, our study showed that a very important challenge for both types of chains is internal resistance to change (a cultural issue). This was relevant for all the analysed examples of circular supply chains. The example of the port in Szczecin indicates that stevedores systematically adapt to the changing market conditions and understand the potential of circular supply chains. They are urged to search for new cargo flows to replace their vanishing traditional bulk cargo. This stimulates them to cooperate with the port industry and expand their range of services. Some of the sea–land circular supply chains analysed in this article require a broader range of time-consuming additional logistics services provided by port enterprises in addition to the basic transshipment services. The cargo types flowing in the circular supply chains are characterised by considerable diversity, while their annual volumes are relatively low (50–300 thousand tonnes). Consequently, they are not attractive to stevedores operating in large primary ports, who are interested in serving larger cargo flows under long-term contracts. However, an unresolved issue is the persisting linear mindset of the secondary port authority, which is manifested mainly in the investor evaluation policy based exclusively on the declared annual transshipment volume and fails to provide the available land plots with the infrastructure necessary for terminals and industrial plants that participate in the circular supply chains. At the same time, the analysed examples of the secondary port in Szczecin indicate that sea–land circular supply chains may contribute to developing—within the port premises—specialised terminals that serve several port functions through one entity (the terminal operator).

The studies completed so far indicate the overarching role of port authorities in the development of circular supply chains. However, according to our study, for secondary ports, stevedores (who are flexible and fast in adapting to new market conditions, strongly determined to search for new cargo types to replace those that have vanished, and adapt the scope of their services) play the key role in stimulating the development of circular supply chains. Nevertheless, from a long-term perspective, the conditioning factor for the further growth of the circular supply chains in secondary ports will be appropriate policy developed by port authorities (a circular mindset).

As the main managerial implication for the authorities of secondary ports, such authorities should support the development of sea–land circular supply chains and thus the port's pursuit of increased sustainability, especially via an appropriate policy for investor assessment (taking into account, besides quantitative criteria like total turnover, qualitative criteria, such as the value of cargo services or the amount of waste used in the process) and the utilisation of any available areas within the port premises (synchronising the process of port infrastructure development and the process of providing utilities to undeveloped port areas) to encourage enterprises engaged in circular supply chains to invest in and develop their business within the port's premises. It is also necessary to develop appropriate communication between port authorities and their external stakeholders, including the local environment (seaport city residents), to transfer information on replacing pollution-intensive production technologies with low-emission or zero-emission ones, the cross-border environment for providing information on cross-border transport infrastructure for the development of circular supply chains, and the competitiveness of secondary ports (also including major participants of the sea–land circular supply chains located in the seaport hinterland with regard to information on the impact of the upgraded port infrastructure to ensure the competitiveness of sea–land circular supply chains relative to land chains).

As a managerial implication for stevedores operating in secondary ports, these entities should first develop their service offers to address cargo as part of the circular supply chains (i.e., more comprehensive service offers and added-value services, such as freight forwarding services and the stuffing, packing, and mixing of cargo) and to meet the requirements of hazardous waste handling, which is one of the main types of cargo moved in circular supply chains; they should also develop cooperation with the other stakeholders of circular supply chains (dedicated distribution terminals and industrial plants).

As a suggestion for future research, it is necessary to further study the transformation of secondary ports towards a circular economy, including both in-depth studies of single cases and multiple case studies on other secondary ports that cope with similar problems as the port in Szczecin. In particular, we recommend developing studies on the impact of circularising secondary ports on the revitalisation of port areas to handle the circular supply chain. It is also worth developing studies that address the issues related to sea–land circular supply chain development, taking into account the specific nature of producer and consumer chains.

Author Contributions: Conceptualization, M.M.; data curation, M.P.; formal analysis, M.M.; investigation, I.K., M.M., and M.P.; methodology, I.K. and M.M.; resources, M.M.; writing—original draft, M.M., M.P., and I.K.; review and editing, M.M., M.P., and I.K. All authors have read and agreed to the published version of the manuscript.

Funding: The project is financed within the framework of the program of the Minister of Science and Higher Education under the name "Regional Excellence Initiative" in the years 2019–2022; project number 001/RID/2018/19. The amount of financing: PLN 10,684,000.00.

Acknowledgments: We would like to thank all the reviewers and the journal editors for their insightful comments and suggestions towards improving our manuscript.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Lam, J.S.L.; Notteboom, T. The Greening of Ports: A Comparison of Port Management Tools Used by Leading Ports in Asia and Europe. *Transp. Rev.* **2014**, *34*, 169–189. [CrossRef]
2. Davarzani, H.; Fahimnia, B.; Bell, M.; Sarkis, J. Greening ports and maritime logistics: A review. *Transp. Res. Part D Transp. Environ.* **2016**, *48*, 473–487. [CrossRef]
3. Di Vaio, A.; Varriale, L. Management Innovation for Environmental Sustainability in Seaports: Managerial Accounting Instruments and Training for Competitive Green Ports beyond the Regulations. *Sustainability* **2018**, *10*, 783. [CrossRef]
4. de Langen, P.; Sornn-Friese, H. Ports and the Circular Economy. In *Green Ports*; Bergqvist, R., Monios, J., Eds.; Elsevier: Amsterdam, The Netherlands, 2019; pp. 85–108.
5. Dooms, M. Stakeholder Management for Port Sustainability. In *Green Ports*; Bergqvist, R., Monios, J., Eds.; Elsevier: Amsterdam, The Netherlands, 2019; pp. 63–84.
6. Oniszczuk-Jastrząbek, A.; Czermański, E.; Cirella, G.T. Sustainable Supply Chain of Enterprises: Value Analysis. *Sustainability* **2020**, *12*, 419. [CrossRef]
7. Geissdoerfer, M.; Savaget, P.; Bocken, N.M.P.; Hultink, E.J. The Circular Economy—A new sustainability paradigm? *J. Clean. Prod.* **2017**, *143*, 757–768. [CrossRef]
8. *COM(2014) 398 Towards a Circular Economy: A Zero Waste Programme for Europe*; European Commission: Brussels, Belgium, 2014.
9. *Closing the Loop—An EU Action Plan for the Circular Economy COM/2015/0614 Final*; European Environment Agency: København, Denmark, 2015.
10. *COM(2019) 190 Report from the Commission to the European Parliament, The Council, The European Economic and Social Committee and the Committee of the Regions on the implementation of the Circular Economy Action Plan*; European Commission: Brussels, Belgium, 2019.
11. Ezzat, A.M. Sustainable development of seaport cities through circular economy: A comparative study with implications to Suez Canal corridor project. *Eur. J. Sustain. Dev.* **2016**, *5*, 509. [CrossRef]
12. Rahman, N.S.F.A.; Ismail, A.; Othman, M.K.; Roslin, R.A.M.; Lun, Y.V. Decision making technique for analysing performance of Malaysian secondary ports. *Int. J. Shipp. Transp. Logist.* **2018**, *10*, 468–496. [CrossRef]
13. Carpenter, A.; Lozano, R.; Sammalisto, K.; Astner, L. Securing a port's future through Circular Economy: Experiences from the Port of Gävle in contributing to sustainability. *Mar. Pollut. Bull.* **2018**, *128*, 539–547. [CrossRef]
14. Karimpour, R.; Ballini, F.; Ölcer, A.I. Circular economy approach to facilitate the transition of the port cities into self-sustainable energy ports—A case study in Copenhagen-Malmö Port (CMP). *WMU J. Marit. Aff.* **2019**, *18*, 225–247. [CrossRef]
15. Karimpour, R.; Ballini, F.; Ölcer, A.I. Port-City Redevelopment and the Circular Economy Agenda in Europe. In *European Port Cities in Transition*; Carpenter, A., Lozano, R., Eds.; Springer: Cham, Switzerland, 2020; pp. 53–71.
16. Notteboom, T.; van der Lugt, L.; van Saase, N.; Sel, S.; Neyens, K. The Role of Seaports in Green Supply Chain Management: Initiatives, Attitudes, and Perspectives in Rotterdam, Antwerp, North Sea Port, and Zeebrugge. *Sustainability* **2020**, *12*, 1688. [CrossRef]
17. Monios, J. Cascading feeder vessels and the rationalisation of small container ports. *J. Transp. Geogr.* **2017**, *59*, 88–99. [CrossRef]
18. Notteboom, T.E.; Winkelmans, W. Structural changes in logistics: How will port authorities face the challenge? *Marit. Policy Manag.* **2001**, *28*, 71–89. [CrossRef]
19. Pallis, A.A.; de Langen, P.W. Seaports and the structural implications of the economic crisis. *Res. Transp. Econ.* **2010**, *27*, 10–18. [CrossRef]
20. Oniszczuk-Jastrząbek, A.; Czermański, E.; Dębicka, O.; Czuba, T. Globalization process in the maritime transport-causes, symptoms and effects. *Annales Universitatis Apulensis Series Oeconomica.* **2019**, *21*, 65–74. [CrossRef]
21. Lees, R.M. The impacts of a world in transformation on the prospects for maritime transport. In *Maritime Transport and the Climate Change Challenge*; Routledge: Abingdon, UK, 2012; pp. 60–69. [CrossRef]
22. Feng, L. *An Introduction to the Circular Economy*; People's Press: Beijing, China, 2004.

23. Yuan, Z.; Bi, J.; Moriguichi, Y. The Circular Economy: A New Development Strategy in China. *J. Ind. Ecol.* **2008**, *10*, 4–8. [CrossRef]
24. Yong, R. The circular economy in China. *J. Mater. Cycles Waste Manag.* **2007**, *9*, 121–129. [CrossRef]
25. Fusco Girard, L. Toward a Smart Sustainable Development of Port Cities/Areas: The Role of the "Historic Urban Landscape" Approach. *Sustainability* **2013**, *5*, 4329–4348. [CrossRef]
26. McDonough, W.; Braungart, M. *Cradle to Cradle: Remaking the Way We Make Things*; North Point Press: New York, NY, USA, 2010.
27. Francas, D.; Minner, S. Manufacturing network configuration in supply chains with product recovery. *Omega* **2009**, *37*, 757–769. [CrossRef]
28. Nasir, M.H.A.; Genovese, A.; Acquaye, A.A.; Koh, S.C.L.; Yamoah, F. Comparing linear and circular supply chains: A case study from the construction industry. *Int. J. Prod. Econ.* **2017**, *183*, 443–457. [CrossRef]
29. Guide, V.D.R.; Van Wassenhove, L.N. The evolution of closed-loop supply chain research. *Oper. Res.* **2009**, *57*, 10–18. [CrossRef]
30. Jayant, A.; Gupta, P.; Garg, S.K. Perspectives in Reverse Supply Chain Management(R-SCM): A State of the Art Literature Review. *Jordan J. Mech. Ind. Eng.* **2012**, *6*.
31. Ellen MacArthur Foundation, McKinsey Center for Business and Environment. *Growth within: A Corcular Economy Vision for a Competitive Europe*; Ellen MacArthur Foundation: Isle of Wight, UK, 2015.
32. Guide, J.V.; Van Wassenhove, L.N. The reverse supply chain. *Harv. Bus. Rev.* **2002**, *80*, 25–26.
33. Genovese, A.; Acquaye, A.A.; Figueroa, A.; Koh, S.C.L. Sustainable supply chain management and the transition towards a circular economy: Evidence and some applications. *Omega* **2017**, *66*, 344–357. [CrossRef]
34. Cerceau, J.; Mat, N.; Junqua, G.; Liming, L.; Laforest, V.; Gonzalez, C.; Lin, L. Implementing industrial ecology in port cities: International overview of case studies and cross-case analysis. *J. Clean. Prod.* **2014**, *74*, 1–16. [CrossRef]
35. Kuipers, B. Ports as catalysts for change towards a circular economy Illustrations from the ports of Amsterdam and Antwerp. In Proceedings of the ESPO Conference, Athens, Greece, 21–22 May 2015.
36. Kyllönen, M. Can the EU's circular economy apply to ports. Parliament Magazine Politics Policy People. Available online: https://www.theparliamentmagazine.eu/articles/opinion/can-eus-circular-economy-apply-ports (accessed on 7 February 2020).
37. Haezendonck, E.; Coeck, C.; Verbeke, A. The Competitive Position of Seaports: Introduction of the Value Added Concept. *Int. J. Marit. Econ.* **2000**, *2*, 107–118. [CrossRef]
38. Zhang, L.; Yuan, Z.; Bi, J.; Zhang, B.; Liu, B. Eco-industrial parks: National pilot practices in China. *J. Clean. Prod.* **2010**, *18*, 504–509. [CrossRef]
39. Liu, C.; Côté, R. A Framework for Integrating Ecosystem Services into China's Circular Economy: The Case of Eco-Industrial Parks. *Sustainability* **2017**, *9*, 1510. [CrossRef]
40. Masi, D.; Day, S.; Godsell, J. Supply Chain Configurations in the Circular Economy: A Systematic Literature Review. *Sustainability* **2017**, *9*, 1602. [CrossRef]
41. Verhoeven, P. *European Port Governance Report of an Enquiry into the Current Governance of European Seaports*; European Sea Ports Organisation: Brussels, Belgium, 2010.
42. Hollen, R.M.A.; Van Den Bosch, F.A.J.; Volberda, H.W. Strategic levers of port authorities for industrial ecosystem development. *Marit. Econ. Logist.* **2015**, *17*, 79–96. [CrossRef]
43. Merk, O. *OECD Regional Development Working Papers 2013/13 The Competitiveness of Global Port-Cities: Synthesis Report*; OECD: Paris, France, 2013.
44. Van Dooren, N.; Braam, G. The Netherlands as a Circular Hotspot. 2015. Available online: http://green-alliance.org.uk/resources/6 (accessed on 7 February 2020).
45. Khalid, N.; Ang, M.; Cory, E.; Hasan, A. *Assessing the Issues, Challenges and Prospects of Selected Secondary Ports in Peninsular Malaysia*; Centre for Maritime Economics and Industries: Kuala Lumpur, Malaysia, 2011.
46. Margarino, S. *A Cluster Initiative: Secondary Ports as Hubs for Smart Growth and Sustainable Connectivity*; European Regional Development Fund (ERDF): Lille, France, 2014.
47. Ding, Z.Y.; Jo, G.S.; Wang, Y.; Yeo, G.T. The Relative Efficiency of Container Terminals in Small and Medium-Sized Ports in China. *Asian J. Shipp. Logist.* **2015**, *31*, 231–251. [CrossRef]
48. Feng, L.; Notteboom, T. Peripheral challenge by Small and Medium Sized Ports (SMPs) in Multi-Port Gateway Regions: The case study of northeast of China. *Pol. Marit. Res.* **2013**, *20*, 55–66. [CrossRef]

49. Linder, M.; Williander, M. Circular Business Model Innovation: Inherent Uncertainties. *Bus. Strategy Environ.* **2017**, *26*, 182–196. [CrossRef]
50. Bressanelli, G.; Perona, M.; Saccani, N. Challenges in supply chain redesign for the Circular Economy: A literature review and a multiple case study. *Int. J. Prod. Res.* **2019**, *57*, 7395–7422. [CrossRef]
51. Yin, R.K. *Case Study Research. Design and Methods*, 3rd ed.; SAGE Publications, Inc.: Thousand Oaks, CA, USA, 2003; ISBN 01796437.
52. Andersen, P.H.; Dubois, A.; Lind, F. Process validation: Coping with three dilemmas in process-based single-case research. *J. Bus. Ind. Mark.* **2018**, *33*, 539–549. [CrossRef]
53. Mańkowska, M.; Pluciński, M. A Strategy Towards Diversification of Operations. The Case Study of the Stevedoring Enterprise. *Eur. J. Serv. Manag.* **2018**, 257–268. [CrossRef]