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Analysis of empty container management

Antonio Blažina, Renato Ivče, Đani Mohović, Robert Mohović

University of Rijeka, Faculty of Maritime Studies, Studentska ulica 2, 51000 Rijeka, Croatia, e-mail: antonio.blazina@pfri.uniri.hr; renato.ivce@pfri.uniri.hr; dani.mohovic@pfri.uniri.hr; robert.mohovic@pfri.uniri.hr

ABSTRACT

Shipping containers are known as a crucial equipment for global trade. Most of their lifespan containers are spending empty, being in process of repositioning or sitting in a yard. Increasing trade imbalances globally set up empty container logistics as one of the main concerns in container shipping industry. In line with that issue, this paper will analyse the roots of empty container imbalance and port congestion, emphasizing the importance of proper empty container management and challanges which appear along the way.

Results of the research show that there is room for improvement while dealing with management of empty containers which primarily implies a cognition of the imbalance problem and long-term predictions as well as mutual cooperation of all parties involved. Furthermore, new solutions and higher level of digitalization will be required to succesully and efficiently handle today's challanging situations. Reducing empty container transport to a minimum is the key point, where foldable containers and container interchange between carriers can greatly contribute. Efficiency of empty container management must be reflected in increased environmental sustainability throughout the shipping process.

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1 Introduction

Maritime transport represents the backbone of international trade and the global economy, where over 80% of goods by volume is carried by sea [49]. In general, the past decades have marked steady growth in international trade. The economic downturn as a stage of slowdown in economic activity is considered to be a normal part of economic or business cycle. History recorded the steepest fall of world trade in 2008/09 in the „great trade collapse", when the world flows of trade have been 15% below their previous year level [50]. Latest decline of world merchandise trade volume (5.3%) appeared in 2020 due to the COVID-19 pandemic [53].

Containers, known as „drivers of intermodal transportation" are widely used for transportation of various goods at the international level, on various means of transport (ships, trains, trucks, barges). Due to its standardization and efficient handling, containerization transformed shipping industry, simplifying the entire logistic process and increasing economies of scale. In 2020, world container port traffic reached 681.3 million of TEU (twenty-foot equivalent unit), including handling of empty, full and containers in transhipment [30].

Despite of many advantages, containerization faces some challenges. The considerable trade imbalance between some parts of the world leads to shortage of empty containers in export countries and surplus of empty containers in import countries. That fact leads to issues of repositioning and accumulation of empty containers, without generating any income but only a cost where on average containers are spending about 56 percent of their lifespan [42]. 20 percent of container transport at sea belongs to empty container transport, where on land it's rising to 40 percent [1]. Furthermore, container, being full or empty occupies same valuable space on boad or in the yard area and same amount of time for its manipulation. Beside in TEU terms, trade imbalance can be seen in type and size of the containers and seasonal requirements between particular markets. Consequently, shipping lines are spending considerable amount of time and money in empty container management as it is evident a very demanding and complex problem.

Nowadays, shipping is not only to meet the traditional economic criterion, but its performance is challanged by commitment of reducing environmental footprint. According to IMO Greenhouse Gas (GHG) strategy, total annual GHG emissions from international shipping should be reduced by at least 50 percent by 2050 and $C0_2$ emissions by at least 40 percent by 2030, striving to achieve 70 percent by 2050, compared to 2008 [29].

Smart use of the information and communication technologies (ICT) appears to be a driving force for economical and environmental benefits, where world leaders in shipping and logistics are already reaping the fruits of their ICT investments.

Hypothesis of this paper is that imbalance of trade presents the source of structural container problem and the aim of this research is to analyse the roots of empty container imbalance and port congestion, highlighting the importance of proper empty container management and its challanges. Research methods used in this paper consist of statistical method, where data are extracted from shipping statistics; compilation method, based on past studies by other authors in the field of container logistics, increased efficiency and reduced environmental footprint in the shipping industry; description method and method of analysis and synthesis.

The content of the paper is divided into six sections. In the introduction it is explained the importance of the topic, the aim and hypothesis of the paper. To get a deeper understanding of the problem, in the following three sections of the paper it is discussed about global container capacity, trade imbalance and port congestion. Finally, in section 5 authors are giving possible suggestions and solutions for better management of empty containers while section 6 contains a conclusion.

2 Global container fleet

At the beginning of 2022, the vessel container fleet included 5,574 ships with capacity of 24.7 million TEU, giving rise of 4.5% since the start of 2021 [32]. World container fleet development, with number of ships on the market and its total TEU capacity, from 2012-2022 presented on Figure 1.

From 137 new delivered ships in 2020, there was 17 ULCVs (Ultra Large Container Vessel) with individual capacity over 23,000 TEU, confirming trend of container ship growth over the last decades. The avarage size of newly built ships was around 6,200 TEU compared to 5,200 TEU in 2010 [30]. Figure 2 gives a breakdown of the world container fleet: the number of container ships by TEU-size class with respective capacity (situation on 01.01.2021).

Over the last twenty years, the capacity of container vessels has tripled. During the last five years, the container fleet increased on avarage by 4.2% per year in respect of TEU, and only 1.1% regarding number of ships [30]. That fact perfectly shows the concentration of very large ves-

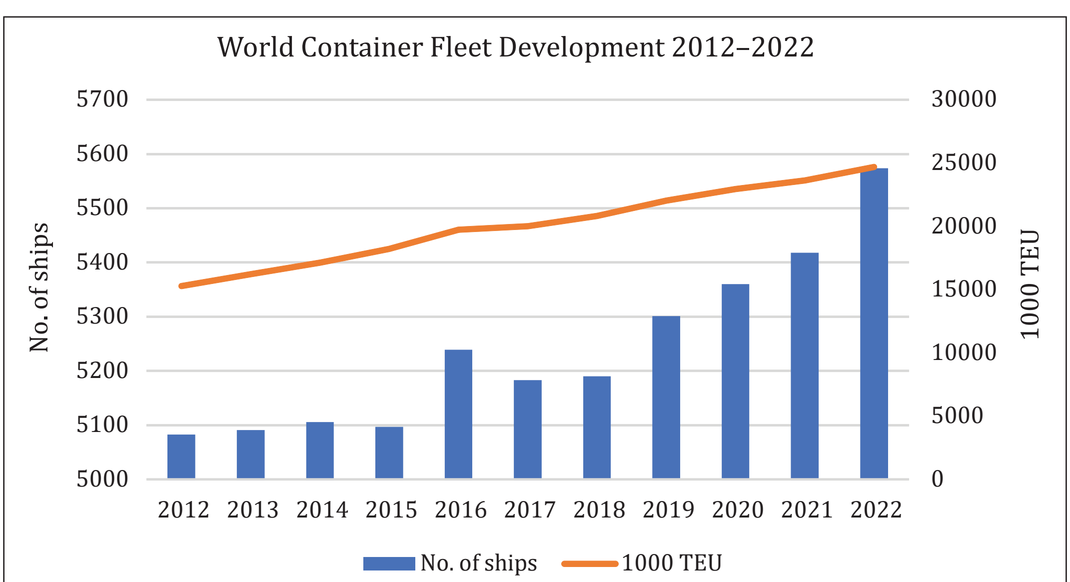

Figure 1 World fully-cellular container fleet development 2012-2022 (based on [30] & [32])

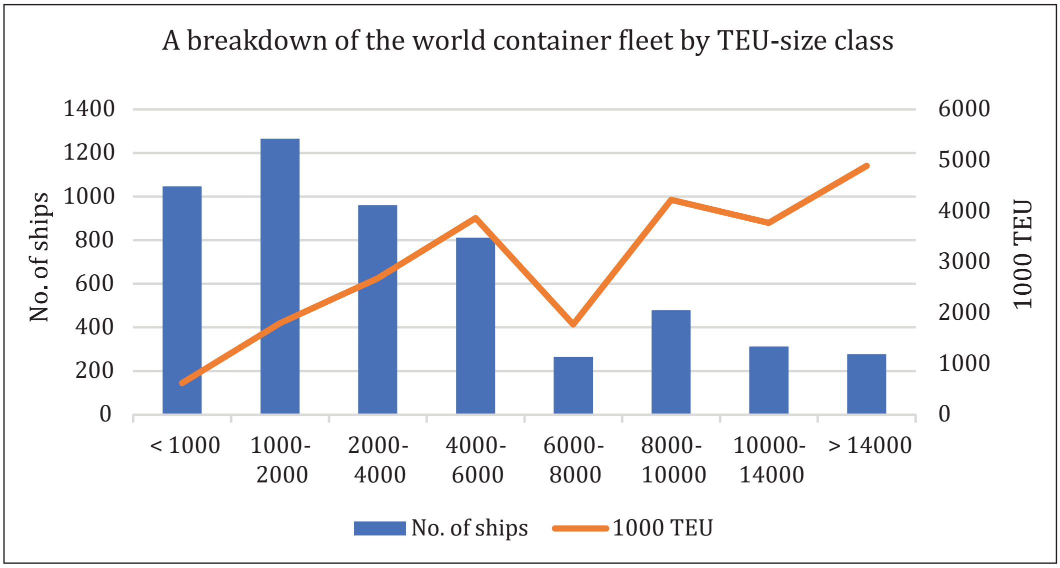

Figure 2 World fully-cellular container fleet by TEU-size class (situation on 01.01.2021, based on [30])

sels, where the size of the newest ships, in terms of length, has not significantly changed so far.

Later research shows that leasing companies owns over 52% of world's container fleet. [28]. Carrier's business strategy will dictate the amount of owned equipment, and it can vary between 50% and 90%. Smaller operators and regional lines rely completely on rented containers. [39] In order to avoid repositioning costs, carriers often lease containers in shortage areas and dismiss them in surplus areas. [26]

Container leasing arrangements fall into three major categories: voyage lease, medium-term lease, long-term lease (5 – 8 years) [34], where the lessee has the option to choose the most suitable contract. Nowadays, there are online platforms available where in a short time frame container user and suppliers meet and negotiate for specific deal [23]. Popularity of leased containers is picking up due to flexibility which is not possible with owned containers in such an extent. The global container leasing market is predicted to grow by over 22 million TEUs in a period from 2020 to 2025, supported by increased popularity of intermodal transportation [41].

Constant increase of the largest container ship capacities has direct influence on port operations, forcing the terminals to develop and improve its infrastructure, deepening and dredging approach channels. Vessel sizes are increasing due to potential economies of scale, giving improved cost-efficiency per ton-NM, keeping in mind expectations of future growth of containerised goods. Larger vessels in port means handling with more container units per call and increasing energy intensity, as more cranes with more moves are assigned [13, 57].

From the environmental point of view, ULCV emissions are higher than the Panamax, but the larger vessel generally giving better efficiency per TEU handled, depending on the assigned number of gantry cranes per vessel. Giving proportional numer of cranes, the ULCV is getting additional improvement efficiency, leading to higher impact on the environment in absolute terms. That impact could be mitigated by deploying more efficient ship to shore cranes that will result in increased number of moves per time unit and finally reducing the total turnaround time of respective vessel [57].

The next operational steps of ship owners and operators is the gradual fleet renewal where newly build ships should enter shipping market with higher fuel efficiency. Nowadays, one part of the orders of newbuildings refers to dual-fuel containerships, mostly LNG-powered (Liquefied Natural Gas), giving an option to operate with both conventional fuel oil and LNG. Shipping fuels of the future will produce lower emissions, possibly zero emissions, but challanging factors are: storage, transport and affordability of the fuel, as well as ability to give enough power to propel ever-increasing ships [52]. The improved vessel designs with reduced hydrodynamic resistances will require less fuel (and cost) to transfer a certain cargo over a given distance.

3 Trade imbalance

Major container trade routes represent Transpacific, Europe-Asia-Europe and Transatlantic trade routes. Transpacific route is the largest shipping zone, where over 31 million TEUs are transported in 2021, while on the same period across the Atlantic there was about 8 million TEUs transported [45]. Figure 3 presents trade imbalance on Transpacific trade route, while on figure 4 it is Asia-Europe case in the period from 2012 to 2019.

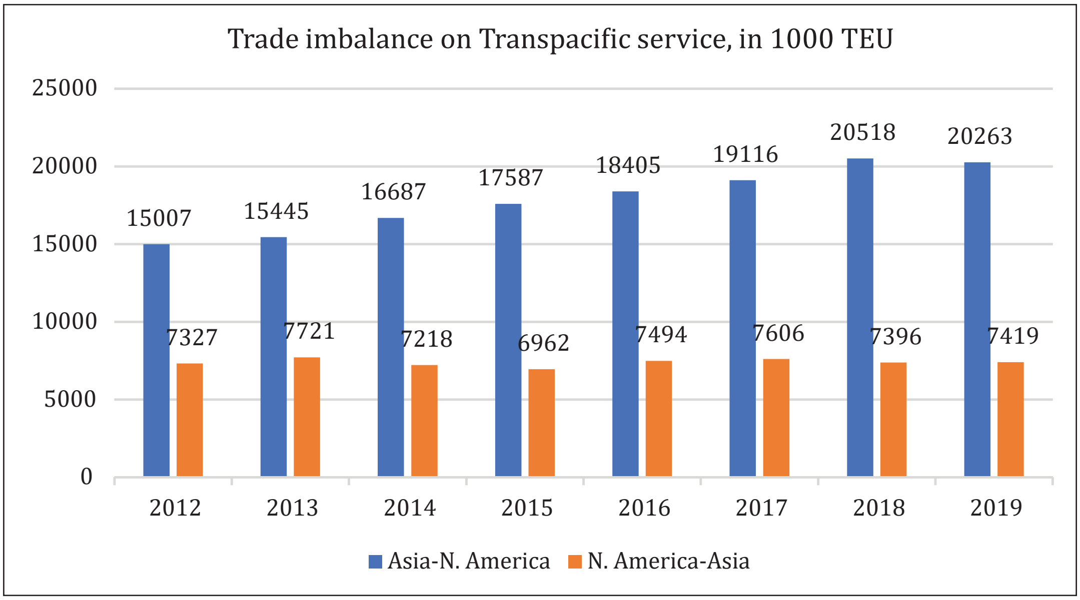

Figure 3 Trade imbalance on Transpacific (based on [16])

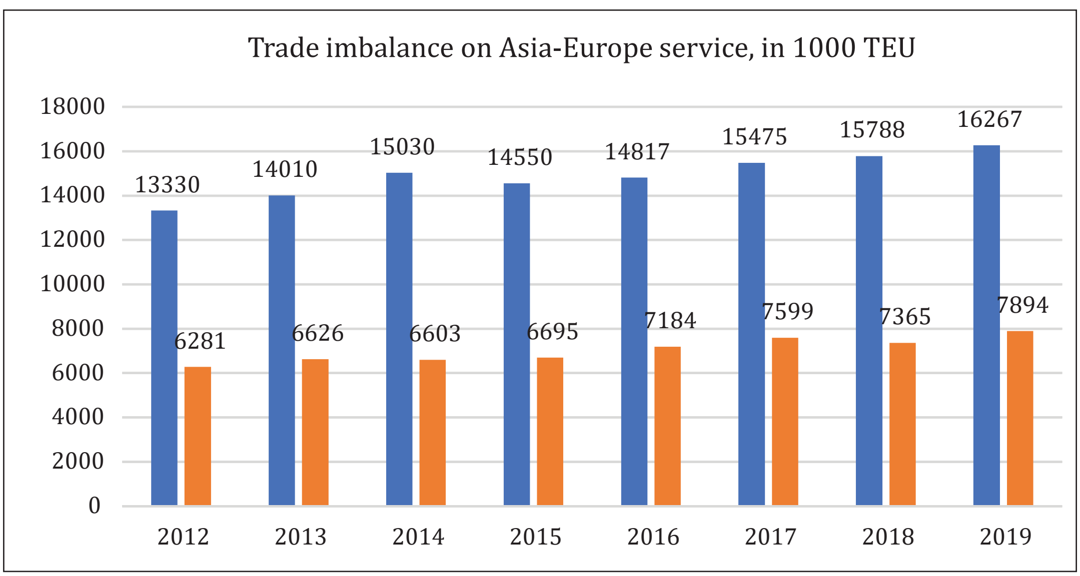

Figure 4 Trade imbalance on Asia-Europe-Asia, (based on [16])

The following figure (Figure 5) shows the throughput of the top twenty world container ports in 2020. The largest container port in the world is Shanghai, with 43.5 million TEU handled in 2020. Singapore is following, with 36.9 million TEU. Ports of Ningbo reached the highest annual growth rates in the listed container ports, with an increase of 9%, in comparison with previous year [31].

On a figure 6 is presented traffic of major world ports, by region (European, Asian, American ports), on a quarterly basis, from 4th quarter of 2019 to 4th quarter of 2021. European ports include: Hamburg, Bremen/Bremenhaven, Antwerp, Rotterdam, Le Havre and Valencia. Asian ports include: Singapore, Shanghai, Hong Kong, Shenzen and Busan. American ports include: Long Beach, Los Angeles, New York/New Jersey and Santos/Brazil [32].

By analysing import and export traffic on most important shipping routes it is concluded that there is no such market where imports and exports are well ballanced, but there is only level of imbalance or the degree to which exports are in level with imports, generating repositioning and pertaining costs [34].

Regional differences could be very significant, where for example American and European ports have a high surplus of empty containers, Asian ports at the same time face severe shortages. In early 2020, during first COVID-19

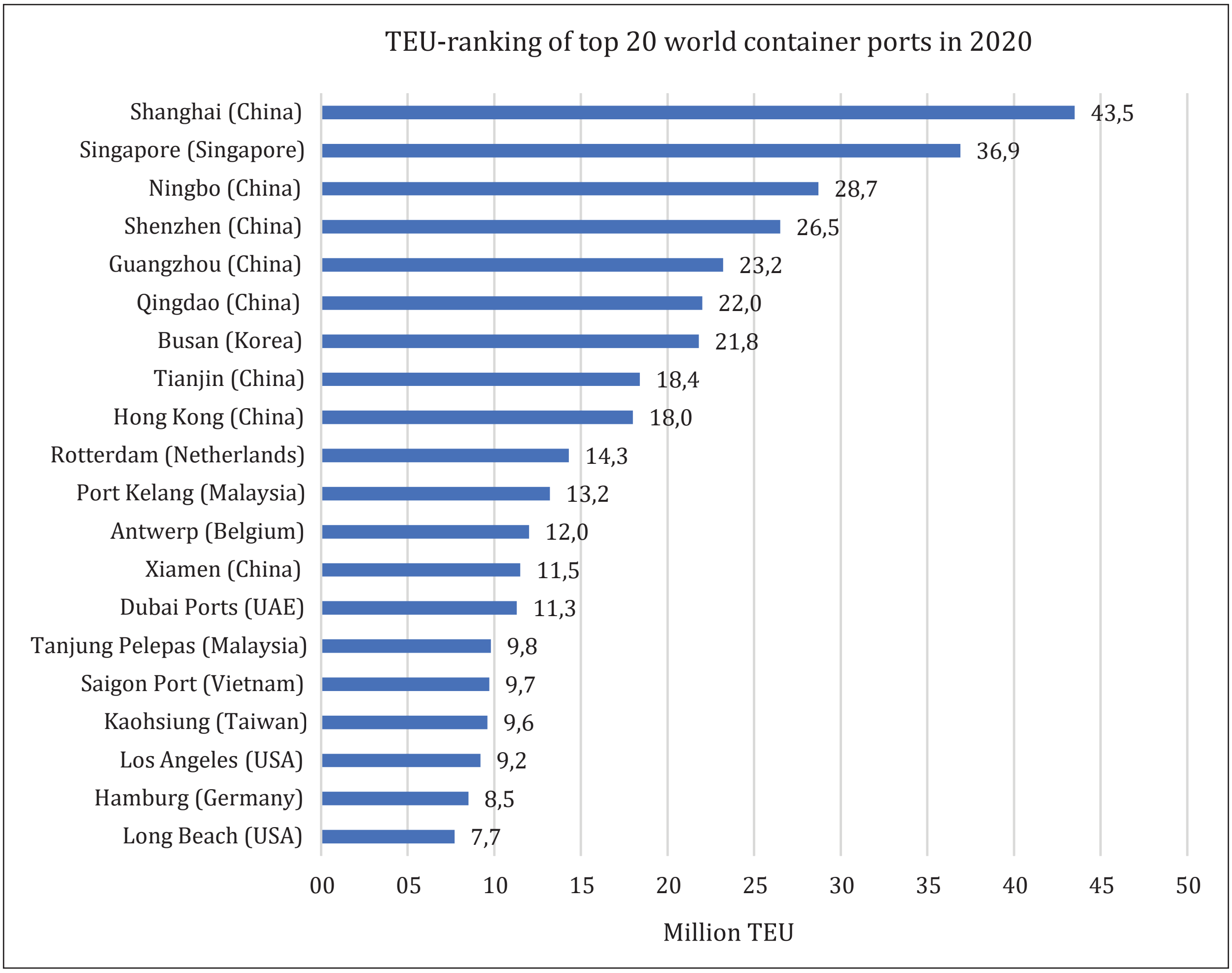

Figure 5 Throughput of the top 20 world container ports, 2020 (based on [31])

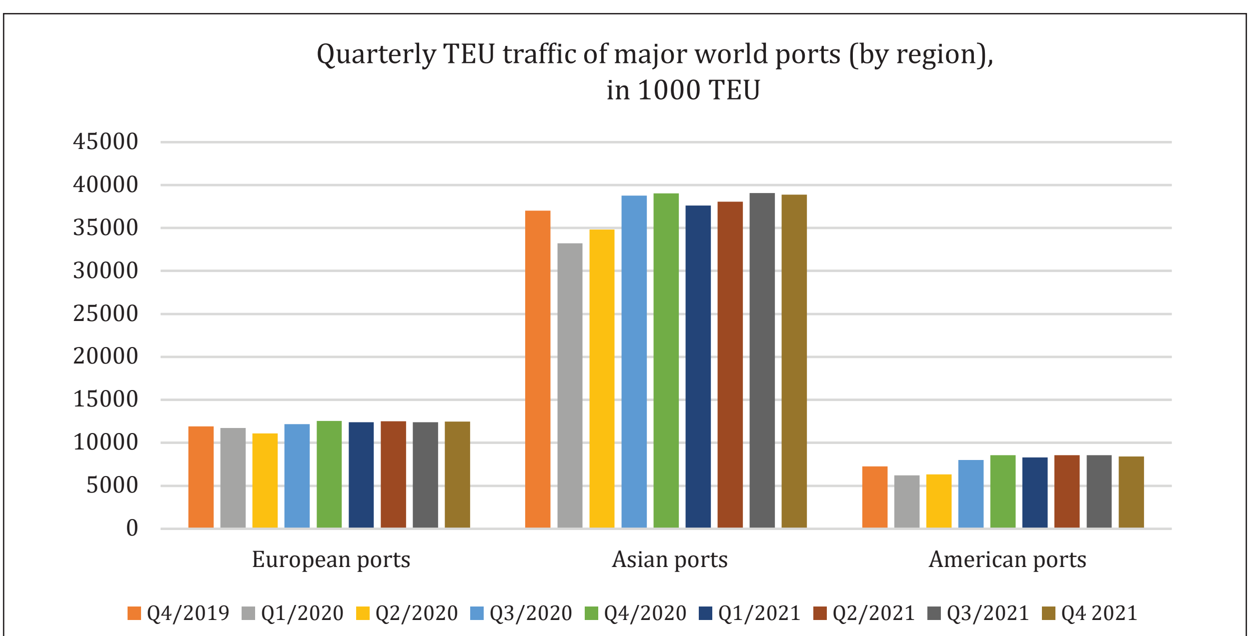

Figure 6 Traffic of major world ports, by region, quarterly (based on [32])

lockdowns, transportation restrictions hit the world trade of goods drastically, specially the exports from Europe and US, falling by 25% [24]. On the other side, exports from China surpassed the imports, giving unexpected shift in the trade direction, where empty containers got accumulated in the West during high demand in the East.

When the global trade slowed down at the beginning phase of pandemic, many operators decided to send part of their fleet for refurbishment. Some voyages were disturbed due to COVID-19 cases on board. A changed flow of goods appeared in the market due to unpredictable pandemic development and changes in people's buying behaviour, affecting regular global trades. Reduced number of operative ships and available containers on the market in the adequate locations during recovery phase had an enormous effect on freight rates, within a short time period. Empty containers were stranded in ports with low demand for exporting goods resulting in concentration of containers in undesirable locations. When alike unexpected increase in demand happens, it results in container equipment challanges that are difficult to manage [36].

Consumer demand in the USA, as in the rest of the world, increased due to e-commerce during COVID-19 lockdowns and afterwards relaxation of restrictions, leading to outstanding quantities of imported containerised cargo in the Port of Los Angeles, as an example. In the first quarter of 2021, the total full imported containers reach a record-breaking 1.34 million TEU, giving 48% rise from 2020 and 25% from 2019. At the same time, containerised export cargo from Los Angeles has been declining. The natural outcome was escalation of already existing trade imbalance, and the number of empty containers in the port exceeded the volume of cargo for export. Therefore, process of global repositioning of empty containers continued [30].

Due to this trading imbalances, containers need to be transported back to Asia empty, increasing freight rates to a remarkable level. Alternative would be ordering new shipping containers in export prevailing countries, but it pulls behind a very high manufacturing costs and the inability to produce such a large number of containers due to increased demand. China is the largest container production country in the world, with over 85% of the world's total container production [2]. If the costs of manufacturing new containers are lower than repositioning prices, containers start to accumulate in one area. It might be cheaper to sell containers in surplus areas if a buyer is found, and buy new units in Asia. But, when manufacturing costs are higher, empty container repositioning builds up.

Trading imbalance can appear due to specific customer demand, where size and type of available containers don't match with customer's need. There might be necessary different container type (e.g. high cube container, open-top container or reefer container), or condition of the container (e.g. food-grade, cargo worthy) [36].

The Container Availability Index (CAx) is an index (or tool) to monitor the import and export moves of full containers around major ports. Its value of 0.5 means that same amount of containers leave and enter a port in the same week. Values higher than 0.5 means that more containers enter, and values less than 0.5 means more containers leave a particular port. The CAx does not include empty repositioning of containers. When CAx is in a range between 0.45 and 0.55 it represents balanced demand for export and import containers [9]. As an example, figure below shows the container availability index for Shanghai and Los Angeles for 40' high cube containers during the first 32 weeks of 2018. Shanghai (CNSHA) presents low availability of empty containers, while in Los Angeles (USLAX) is the opposite case.

The Figure 8 shows container availability index for 20' containers in port of Hamburg from beginning of 2020 to 16th week of 2022.

Successful forecasting of the container availability index, especially in a volatile situations, would result in optimal repositioning of empty containers, economical and environmental benefits. It includes reliable forecasting of significant events, port congestion, war, strikes, changes in

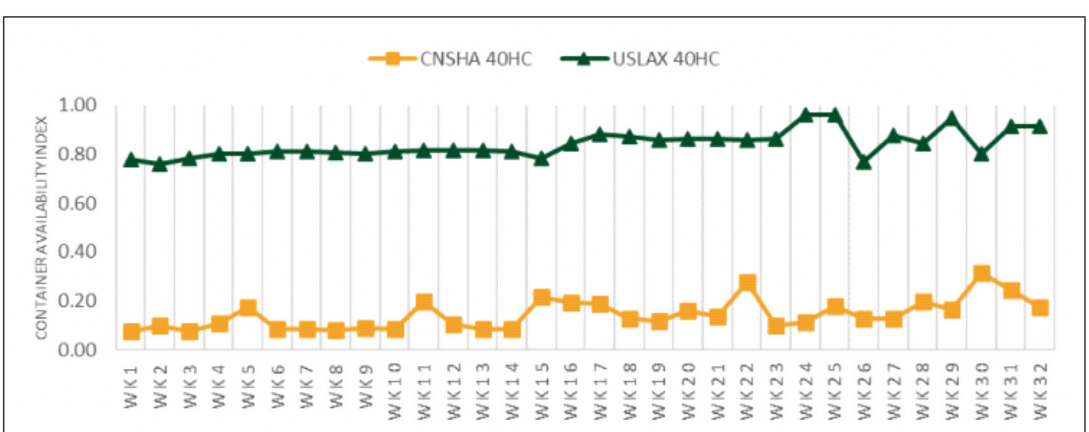

Figure 7 Container availability index for Shanghai and Los Angeles, 2018 [9]

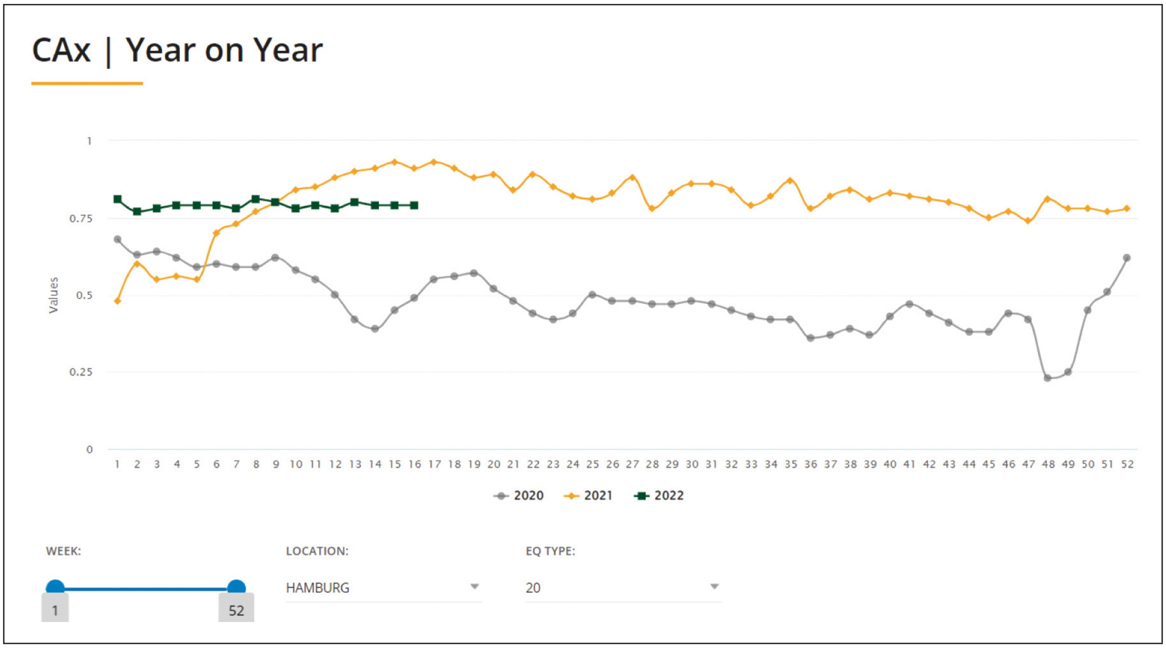

Figure 8 Container availability index for Hamburg [9]

seasonal and trade demands, or the weather, what is not an easy task.

Blank sailing or void sailing happens when a shipping line or operator decides to skip a specific port, region or entire voyage on the scheduled route. During COVID-19 pandemic, number of blank sailings increased drastically.

Liner shipping companies have a fixed number of days to complete the schedule of one liner service, and come back to the base port, making final destination the key port where the vessel should be on time. Sometimes, keeping up with the schedule is not possible, due to various reasons such as port congestion or weather conditions. Thus, to avoid delays to the base port, the shipping line has to mark particular port as a blank sailing. The containers which supposed to be loaded at the cancelled port have to wait next vessel with the same destination or adequate port of call where cargo delivery will be re-organized to the final recipient. Similarly applies for containers intended for unloading in skipped port.

Reasons behind „blank sailing" are usually: port congestion, low demand for container space on a ship, mechanical problems of the ship, bad weather, war and port strikes, intention to increase freight rates etc. Blank sailings are very common just after major holiday seasons, e.g. Chinese New Year or Golden Week in Japan. If a cargo in question is perishable (food stuff, dairy products, flowers, etc.) the effect of the blank sailing is obvious [10].

4 Port congestion

Port congestion is very common situation and challange by many container terminals globally, occuring due to various reasons: lack of cargo handling equipment and its failures, delays due to bad weather, war and strikes, productivity level of the port, restricted port access, hinterland connections, lacking yard space, overbooking of the terminal, pandemics (e.g. COVID-19) etc. [44].

Continuous growth of seaborne trade leads to bigger vessels and rising economies of scale, having the side effect of pushing container terminals to handle increasing volumes of container units. To achieve this demand, terminals are using more labour and more handling equipment. Adding more gantry cranes is most often used solution for quicker cargo operations, but this is limited due to previously said fact that size of the vessel is not so much increased in terms of length but in its width and height. With improved technology, gantry cranes become able to lift two containers at the same time, increasing number of moves per hour. If productivity level of the terminal is not sufficient to clear the offloaded containers, it will soon reach its capacity and consequently the ship will stay longer in port and other ships will keep coming at anchor to wait for the berth.

As recently seen, congestion can easily occur due to pandemics (e.g. COVID-19). To avoid the spread of infection, first step of the affected port is to reduce the labour force, meaning less available people for the same quantity of containers to handle. In some situations, level of productivity of such ports drops more than 60-70 percent. At the beginning of pandemic (early 2020) there was decrease on imported goods due to the closure of many Chinese ports. On the countrary, end of the year brought high demand in consumer goods leading to shortage of empty containers and sharp increase in freight rates as a consequence. That situation was even further deteriorated in

March 2021, when M/V Ever Given grounded at Suez Canal blocking the passage for 6 days, creating major delays and disruptions in global maritime supply chains [43].

Empty containers in port in some cases could be the reason for port congestion. Due to imbalanced overseas trade high surplus of empty containers in the yard are occupying valuable space and if at the same time a lot of full import containers are coming in the port without enough cargo for export, problem appears. Because of that, inland container depots are used for temporary storage of empty containers.

Large storage spaces (yards) are required for the containers which are staying at the port area for few days. That area should be positioned at close vicinity of the berth to shorten time for the transport of containers and ship's stay in port. The transportation method between the quay and the yard varies from port to port, depending on resources available, port size and throughput handled. Movements inside the yard, for containers which are to be transported to the hinderland, are mostly done by stacking cranes. Losses of energy are noticed due to inefficient transportation or relocation of containers [46, 57].

Nowadays, port congestion in modern and busiest container terminals is greatly reduced by using advanced information technology and various solutions for container handling and storing. One example of innovative technology using High Bay Storage (HBS) system is „Boxbay", where each container is placed in an individual rack, instead of supporting standard global practice, i.e stacking containers on top of each other [3].

„Boxbay" system automatically stores containers in a rack up to eleven tiers high, delivering over three times the capacity of standard conventional yard with increased performance. It enables direct access to any container at any given time without moving containers above, thus avoiding any unproductive move. As it is fully automated and electrically driven system, it reduces cost for personnel and maintenance. Furthermore, the system doesn't need any lighting for its operation, noise levels are minimized and solar panels on the roof are eliminating CO_2 impact. Testing of Boxbay system is performed by DP World at Jebel Ali port in Dubai, achieving 19.3 moves per hour at each waterside transfer table to the straddle carrier and 31.8 moves per hour at each landside truck crane [15].

The Port of Long Beach built its Container Terminal (LBCT), becoming one of the most tehnologically advanced and environmentally sustainable cargo facilities in the world. The terminal possess electric and zero-emissions equipment, where all berthed vessels will shut down diesel engines and plug into shore power connections, process known as cold ironing [12].

There is room for further emission reductions in yard and it would be achieved by replacing machinery and truck fleet running on diesel fuel with electric or hybrid cargo handling equipment. Truck emissions can be reduced by optimizing truck arrival pattern [5]. Efficiency of horizontal moves will be increased by deploying AGVs (Automated Guided Vehicles), at the same time minimizing lighting requirement at the yard during night-time operations [57].

5 Empty container management improvement options

5.1 Foldable containers

One of the issues of repositioning empty containers is required space for its transport and storage, where standard empty containers are occupying same space as full containers. At a same time, storage and repositioning of empty containers around the globe involves very high costs. Great efforts are being made in attempts to increase efficiency and reduce those "futile" costs. One of the ideas was usage of foldable containers in the container market, as a possible mitigating solution. After becoming empty, the foldable container will be folded to increase storage space in depots and shipping space during repositioning, leading to reduced storage costs and transport costs per unit. Foldable containers can also reduce the canal fees, determined by the height of the containers stacked on the deck. Furthermore, introducing foldable containers would contribute to reduction of road traffic volume, port congestion and finally carbon emissions [37, 56]. Only few foldable container concepts achieved pilot/testing phase and market introduction.

The SIO (Six-in-One) container is fully dismountable 20' dry container that can be folded, stacked six high and interlocked to the dimensions of standard container. The most significant characteristic of the SIO was the absence of the hinges, except standard door hinge, avoiding well-known problems of bending and corrosion. To fold that type of container, a forklift with a three-person team is required, where it is possible to handle six containers per hour. SIO containers didn't reach the market in strong echo due to its purchase price and costs of folding and unfolding. Additionaly, susceptibility to damage and theft of container parts made this system vulnerable.

Fallpac container is 20' container, where its roof is dismountable and remaining elements foldable. Four folded boxes can be stacked inside a fifth assembled unit for empty transport. The container could be folded within 10 minutes by two people and a forklift. Only reported issues was its high tare weight (4,000 kg), specially in case of handling and transporting a large number of containers. [8]

A Japanese company Boxtics has designed a 3-in-1 foldable container which can be easily folded/unfolded [4], while Zbox containers, manufactured by Spanish company Navlandis alows to transport five folded containers in the space of one standard container, with CSC (International Convention for Safe Containers) and ISO (International Standards Organization) certification [11].

4FOLD represents a foldable 40' container, fully CSC and ISO certified, manufactured by company Holland Container Innovations (HCI), that requires only a quarter of the capacity in folded state, and operates like a standard container in unfolded state. Four foulded containers could be attached to each other using twistlocks and then handled like one standard container. On figure 9 is presented the way 4FOLD containers are being folded. Specifications of HCI foldable (when unfolded) and standard container, shown in the Table 1, gives almost the same values.

If the number of foldable containers in the network is small, economies of scale cannot be reached, giving higher fixed costs of the facilities than the reduced costs in transport process. In other words, no economic benefits of foldable containers could be achieved if installed facilities and folding/unfolding process is used by only a few companies. However, environmental benefits are evident, in terms of lower greenhouse emissions, reducing the number of required trucks by 75%. Time consuming factors should be considered closely. From one side, folding and unfolding of containers take extra time before its final delivery, while on the other side number of folded containers (depending on the system observed) bundled together are reducing the handling time [37, 56].

Figure 9 The folding process of the 4FOLD container [1]

Table 1 Specifications of standard and foldable containers

Description	Standard container	Foldable container
Cubic capacity	67.7 m^3	72.9 m^3
Maximum payload	26,760 kg	26,600 kg
Gross weight	30,480 kg	32,500 kg
External length	12.192 m	12.192 m
External width	2.438 m	2.438 m
External height	2.591 m	2.896 m
Internal length	12.032 m	12.012 m
Internal width	2.352 m	2.324 m
Internal height	2.392 m	2.615 m
Door opening width	2.340 m	2.172 m
Door opening height	2.280 m	2.508 m
Bundle (4in1) height	-	2.896 m

Source: Based on data from [51]

Foldable containers are not widely used on global container market due to additional costs which appear. The building cost of the foldable container is double than standard container [25]. Also, folding and unfolding procedure requires additional labour cost for the empty container repositioning. Terminal operators and hauliers might be threatened if this type of containers break into the market [35]. Terminals, on the sea side and inland depots, would potentially face decrease of revenues due to reduced number of empty moves and lower throughput figures at the end of the year. Thus, there will be necessary additional measures and shared agreements between various parties operating in the container shipping value chain to support strong development of foldable containers [25].

5.2 Container interchange between carriers

Poor container management strategies implies that container volume is usually more than double of ship capacity [20]. Therefore, strategies that increase the utilization of existing containers would be of great interest for the sustainability of the industry.

In the 1980s, Hapag-Lloyd carried out a study where it was concluded that utilization of ship capacity on the North Atlantic would rise by 17% if services were coordinated, leading to cost savings of over 20%. Consequently, Hapag-Lloyd and ACL (Atlantic Container Line) made an agreement to rationalize their shipping services on the routes between North America and Europe. As a result, shipping lines managed to remove four vessels with the same level of service, while sharing equipment and port facilities [17].

There are three basic ideas which motivate most alliances, mergers and other forms of concentration in shipping: reducing unit costs by improving productivity and scale economies; achieving greater market domination and increase earnings; and reducing risk exposure [18].

There is main difference between the slot exchange and container interchange. Space/Slot Exchange Agreement is mostly incorporated into Vessel Sharing Agreement, where carriers agree to perform joint liner service in such a way that each of them participates with a certain number of ships. Each carrier has the right to use capacity i.e. „slots" on each individual ship in the joint service in proportion to the capacity (slots) it contributes to the joint service [33].

The principle of exchanging the ships slots is successfully for already two decades, and if similar approach is extended to physical containers, it would help in efficiency of empty container repositioning. Basically, interchange between those carriers that have surplus and those who have shortages at specific location is the simplest way to balance container inventories. For two parties higher level of trust most often lead to better interactions affecting their supply chain partnerships [54].

Container interchange become a widely accepted idea as an effective mechanism of container management, where one interchange reduces repositioning of two empty containers. Although many service agreements actually contain provisions for interchange containers in addition to slot exchange, it has failed in its implementation in reality.

The study conducted in Sri Lanka during 2016 by Edirisinghe showed that the imbalance might be reduced by implementation of container interchange between carriers. In 2014 port of Colombo exported 515,875 TEUs (laden and empty containers), where 289,474 TEUs refer to empty containers. In the same period, there was 48,629 TEUs of imported empty containers. [19]

The following table shows two scenarios for port of Colombo, for 2014 – the imbalance of containers with and without container interchange between carriers.

Table 2 Imbalance of containers – w/out and with interchange between carriers, port of Colombo

Container size and type	Imbalance without container interchange	Imbalance when container interchange applies
20' General Purpose	158,221	156,285
40' General Purpose	10,486	794
40' High Cube	44,586	27,842
45' High Cube	2,155	101
20' & 40' Reefer	5,975	4,791
TOTAL	**221,423**	189,813

Source: Based on data from [19]

Results show that applying container interchange between carriers could have reduce imbalance in Sri Lanka for 2014 by 31,610 containers (14.3%) of various sizes and types. By doing so, freight rates and more important, environmental pollution could be reduced.

The barriers affecting cooperative approach by container carriers could be: confidentiality, legal issues and insurance, ethnic issues, company policy / business philosophy, or competition (by indirect support to new entrants) [27].

5.3 Transition towards automation

Automation is a concept which may start with simple digitalisation of the port paperwork and extend to a fully automated operating terminal with a minimum human intervention. Achieving higher automation results in reduced labour costs, and consequently possible tense relation with the trade union [27].

The first decision must be to fully understand the main trends in external trade and shipping, and to create a strong business model. Only after that digital solutions could be used as a tool to support and improve the business. The human element will be crucial to the success of digitalization, involving employees with expertise outside the shipping industry. The technology companies will then strengthen their understanding of maritime business by working closely with ship owners, operators, shippers and charterers to come up with most useful solutions for all involved [38].

The main barriers for investing in digitalization are: merging new technology with existing equipment, insufficient skills of the employees, doubts about which system to choose, security concerns and payback time. Sustainability should not be focused only on greenhouse gases and introduction of alternative fuels, but also on education at every level of the shipping industry and its associates [6]. While large share of the shipping industry is not prepared for this transformation, world leaders in shipping and logistics already recognized digital and innovation strategies as a potential shipping's game changer.

As an example, Maersk and IBM (International Business Machines) enhanced digitalisation in the maritime transport sector by introducing TradeLens in 2018, an interconnected ecosystem of supply chain partners i.e. cargo owners, ocean and inland carriers, logistics providers, ports and terminals, freight forwarders, custom authorities, etc. The system is handling more than 700 million events and 6 million documents per year, speeding up decision-making and reducing administrative work [47]. Information from various shipping companies could be available on a common platform with a shared and single view, where only the customers and its partners are allowed to access the data. The system provides more effective operation on a global scale, enhancing customer satisfaction and lowering operational costs.

TradeLens eBL is the first truly end-to-end digital electronic bill of lading that provides simplified and secured process from the issuance and transfer to surrender of original bills of lading to all the parties involved. Thus, the risks of using paper original BLs are eliminated, as documents are immediately available to all parties [40].

Same year CMA-CGM Group created ZEBOX, the international incubator and accelerator of innovative startups, as a part of its digital and innovation strategy, with a goal to make digitalization one of the pillars of its development. The mission is to connect startups and large companies to help them innovate together [55]. This innovation accelerated already launched initiatives by the Group: *Nyshex*, the first digital marketplace for ocean freight contracts, *e-dray*, a collaborative platform enabling drayers to limit port congestion, etc. [7].

Tracking of the goods in container is high priority of all shipping lines. Smart shipping containers are providing high level of transparency, satisfaction of the customers, but also possible optimization of the supply chain enabling shipping companies to make better decisions. Most of smart containers are connected with IoT (Internet of Things) and smart sensors technology which can be better monitored and tracked in the shipping process, significantly improving shipping management on the global scale.

Smart sensors in containers provides various useful informations: temperature, pressure, humidity and movement of container, responding immediately on any change by informing or triggering the alarm to the central monitoring facility. Most shipping companies are prone toward using smart containers to reduce losses due to damaged/ spoilt goods or loss of cargo and to increase its security [48]. As an example, CMA-CGM in co-operation with Traxens is using Smart dry container to monitor the conditions and status of cargo in a process of transport. Still, mostly for small shippers, lack of awareness for modern shipping technology and high capital investment are restrictive factors for this equipment upgrade.

Smart use of ICT can lead to direct environmental benefits. According to DNV-GL (Det Norske Veritas-Germanischer Lloyd), CO_2 reduction from shipping requires a combination of actions: alternative fuels, reduction measures in logistics and technical and operational measures. Each year, 5% of DNV's revenue is invested in research, development and innovation. Their research focuses on digital assurance and the assurance of purely digital and cyber-physical assets, to be able to achieve the UN Sustainable Development goals [14].

The information and communication technologies should assist in the procedure of reducing harmful emissions, aiming for smart operations, shared information and for an integrated logistics chain, where the operations are safe and economical. Good and affordable communications solutions will make new operational models that can enhance the productivity and competitiveness due to lower cost and improved client service. Advanced decision support systems and data analysis will result in optimization and protection of commercial and technical operations through higher level of prevention and control of undesirable events [22].

Sustainability could be acchieved by efficient planning and smarter operation of the fleet, development of new technologies and changeover to alternative forms of energy. Smart decision-making assumes integration of people, information technology, work processes and organizations.

Empty container transport, by sea or land, should be minimized. Concept of integrated planning i.e. integrating logistic systems between parties involved in the transport should be developed. The key is to have the whole picture of all related operational activities to make better decisions. Therefore, it is inevitable to have interaction of all parties involved to attain desired results [22].

To realize energy savings, changes in business models may be required. For example, if ship's speed needs to be optimized, higher level of cooperation between ship operators, ports and charterers is neccesary to adjust arrival and departure times in/from the port. This would lead to more efficient port operations, reducing time on the anchor and idle berth, and finally, lower impact on the environment. New logistic solutions and transport patterns may be necessary to achieve reduced emissions. This would include modern and cost-effective cargo handling technology, possibly autonomous.

The sufficient connectivity between shore side and the ship for accessing data from the cloud and other data storage system will be among the main challanges. Shipping autonomy will undoubtedly increase in the following years, with more advanced algorithms and more integrated sensors. Some of the essential techologies are including artificial intelligence and big data analytics for decision support [22].

6 Conclusion

Empty container management is a complex system directed towards achieving the best logistic solutions with minimum costs and ideally, with the least possible impact on the environment. As various parties are involved in the whole supply chain process, smooth operation and desired results are attainable only by mutual interaction and cooperation.

Trade imbalance, leading to shortage of empty containers in export oriented countries and surplus of empty containers in import countries, is presenting the root cause of global empty container repositioning which cannot be entirely avoided. However, enhanced forecasts of the container availability index (CAx) would significantly improve repositioning issues and economical and environmental benefits. Since world trade depends on a variety of factors, many of which are unpredictable or difficult to predict (e.g. world pandemic, war), accurate predictions are presenting quite a demanding task.

Rising economies of scale are leading to increased capacity of newly build container ships refering to higher width and height values, while in terms of length no major changes occured. This has direct effect on port operations and occasionally congestions, pushing terminals to improve its handling and storage capacity due to increasing volumes of container units. Furthermore, due to increased draft, approach channels should be deepened and dredged. New technologies and digitalization will be required to succesully and efficiently handle such situation. A live examples of serious port congestion were noticed due to COVID-19 pandemics presenting challange for many container terminals worldwide. Additionaly, high surplus of empty containers in yard and port due to imbalanced trade are giving extra load on the valuable space.

Additional space for empty container transport and storage can be „created" by introducing foldable containers into container shipping supply chain. Various manufacturers developed several designs with different amount of space occupied with their containers in folded state (e.g. 3in1, 4in1, 5in1), making its handling and storage more practical and economical. Although there are known downsides of this concept and it is not widely used on global container market, it has very high potential in today's uncertain environment, with evident environmental benefits. As foldable containers does not reduce the number of containers required to reposition, the concept of cooperation between carriers may directly influence on the number of units that need repositioning. Leading shipping lines in their contracts already have provisions to interchange containers, but it is not yet practiced in reality, despite its obvious benefits.

By using advanced information technology and new solutions for container handling and storing, port congestion could be greatly reduced. With example of „Boxbay", a smart, environmentally friendly innovative techology using High Bay Storage (HBS) System, port performance is significantly improved. Digital and innovation strategies are also recognized by many successful companies in shipping and logistics, where with adequate business model improvements are visible on multiple levels. Improvement of the supply chain and consequently enhanced container management is achieved by using „smart containers" and smart sensor technology.

Container shortage is deep-rooted in the shipping industry and management of empty containers is presenting a huge structural problem to the industry. Commitment of reducing environmental footprint will force the industry for accelerated development and transition to ICT, digitalization and finally automation, even if not fully justified from the pure economic point of view, as it is a path to a greener and more efficient future.

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