CONTAINER STACKING APPROACHES

FOR THE MEGA-SHIP ERA

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In the last two decades, multiple emerging trends have guided the shipping industry, but one of the most noticeable trends has been the increase in the size of containerships in response global trade growth and demand for massive capacity to transport containerized goods. Since 1968, the size of containerships has increased by 1,200%. This growth was slow back in the '60s and it took almost 30 years for ship capacity to double. But from 2000 to 2017, the size of ships has almost tripled from 8,000 twenty-foot equivalent units (TEUs) to 21,000 TEUs, creating what we now call mega-ships.

Another emerging trend is digitalization. The whole oceanic transportation chain is moving towards connectedness and, as a result, it is collecting an enormous amount of data. Stakeholders need to take advantage of data to be more adaptable to disruptions, especially in the era of mega-ships. It is essential to create proactive measures to react to sudden changes in container flow (e.g. weather, strikes, congestion, and larger call sizes) with the goal of securing a resilient and sustainable transport network.

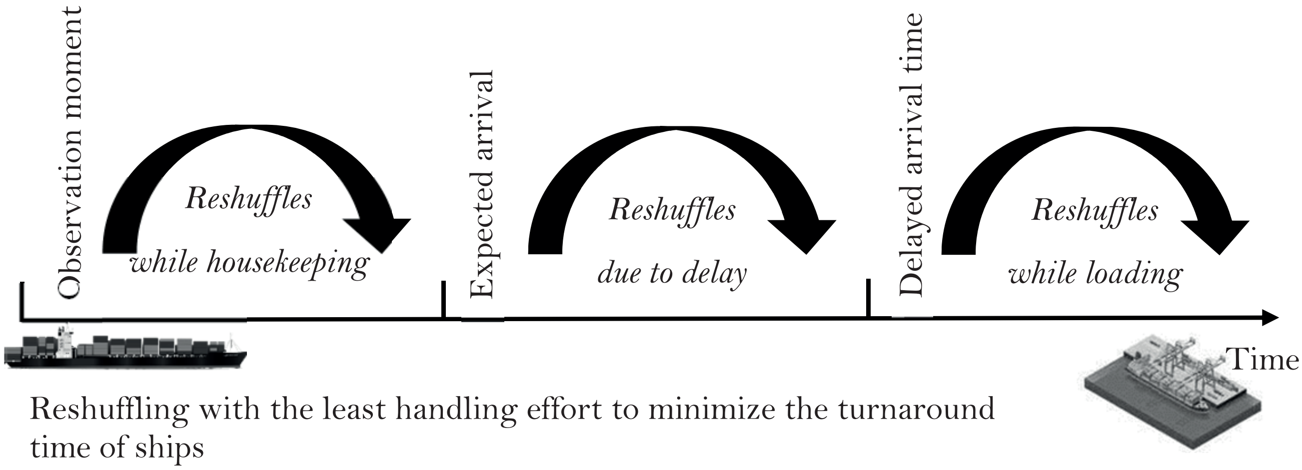
CONTAINER PORTS

Container terminals are important actors in the global maritime supply chain. They are the nodes that connect all modes of transport. All containers throughout their journey from origin to destination need to pass through them at least once. Although mega-ships bring benefits such as economies of scale, they require digging deeper channels, installing larger cranes, and increasing terminal congestion. Furthermore, the available land in major terminals is becoming too scarce to accommodate the increasing number of incoming containers delivered by mega-ships.

To address such challenges, port authorities have considered expanding ports horizontally despite the expense of land reclamation. Port of Rotterdam's new Maasvlakte 2, the Khalifa Port in Abu Dhabi, and Hong Kong's container port are few examples of horizontal expansion. On the other hand, most other growing container ports choose vertical expansion. This involves stacking containers on top of each other in dense blocks using handling equipment like straddle carriers and gantry cranes. Stacking containers in multiple tiers often leads to reshuffling, the removal of a container stacked on top of a desired container.

STACKING VS. RESHUFFLING

In general, ships' stowage plans determine the sequence in which containers must be retrieved from the stacking area. In the stowage plan of a ship, containers are usually sorted into different classes based on their weights and ports of destination. Stacking heavier containers in lower tiers within a ship ensures the ship's stability. Also, containers of nearby destinations need to be in upper tiers. So, to avoid reshuffling, containers need to be stacked



in a reverse sequence. If the containers of multiple ships are stacked together, containers belonging to earlier ships should be stacked on top.

Reducing the number of reshuffles is a top concern for stacking containers as reshuffling does not add value and can increase the turnaround time of ships. Reshuffling happens during the housekeeping, loading operations and when the ship's arrival is delayed. Terminal operators try to limit the number of reshuffles by using a dedicated stacking policy which assigns a portion of the stack to each class of containers categorized based on their weight, ship, destination, and other factors.

In light of the growth in international freight transportation, terminal operators are forcibly shifting toward a shared stacking policy in which containers of different classes are stacked together in multiple tiers. Under the shared policy and with a proper stacking method, the number of reshuffles while housekeeping and loading can be managed to a large extent, but the situation quickly deteriorates if any ship is delayed. Given the large call sizes of mega-containerships at terminals, there is an immediate need for new and robust stacking methods that account for ship delay.

ANALYSIS OF DELAYS

It is the challenge of low probability, high impact risks; although some may even claim that it is not low but high probability. Based on the analysis done by CargoSmart on the arrivals of 587 vessels by 25 different carriers at the United States and South American ports, 32.9 percent were delayed more than 12 hours, and 16 percent were delayed over 24 hours. Mega-ships experienced even greater delays. The results in Europe are the same if not worse .

A ship delay can have a huge impact on container handling operations in a container terminal. Many containers may need to be repositioned in order to access containers of other ships or free up space for stacking other containers.

Our research investigates how to manage the risk and time lost in container stacking operations by estimating the expected number of reshuffles (ER) when a ship is delayed. Container terminals collect data on a daily basis. Computers record all ship arrival times, container movements, container handling equipment movements, gate arrivals, and all the other departures, arrivals and movements. Such databases can be used in order to forecast and mitigate disruption. Inspired by the credit risk models common in the banking system, the ER is estimated using probability of delay (PD), probability of delay of a ship, reshuffles given delay (RGD), magnitude of likely number of reshuffles, and call size at delay (CSD).

HISTORICAL DATA

Each variable can be determined based on the historical data collected by terminal operators on ship arrival times and the number of container stacking handlings performed to service each ship. In other words, estimating each variable requires data mining huge container terminal databases. In some instances, external databases may also be necessary to get a holistic picture.

For example, estimating PD requires defining and collecting data on variables such as ship size, shipping line, ship age, fuel type, flag of convenience, etc. Similar models can be built for the other two variables using a terminal's internal and external data.

One difficulty is that the data may be unavailable or the terminal may not be willing to provide the required data due to fear it will be used by the competition. Furthermore, the variables estimated based on the data of a specific terminal cannot be generalized to other terminals. To deal with these challenges, in our research, simulation has been used to create all potential scenarios that can happen in a container terminal.

STACKING POLICY

Our analysis confirms that choosing a proper stacking policy is an important decision. The stacking policy can range anywhere between a pure dedicated policy, where containers of a specific class are stacked on top of each other in each pile, to a complete shared policy, where each pile is shared by container all classes. In this spectrum, there is a trade-off between accessibility of containers (i.e., the number of reshuffles) and utilization (i.e., more land and space is required); the more dedicated the stacks are, the lower the number reshuffles and the lower the utilization, whereas the more shared, the higher the number of reshuffles and the higher the utilization. Our analyses show that the larger the probability of delay, the larger the expected number of reshuffle. Based on this finding, container terminals need to dedicatedly stack containers from shipping lines that have many delays to minimize the risk of reshuffling. The same holds for a terminal where delays are longer.

MEGASHIPS IMPACT RESHUFFLING

Additionally, increasing the size of ships calling a terminal, from 10,000±2,000 TEUs to 15,000±2,000 TEUs, increases the expected number of reshuffles. So, it is again suggested that containers of larger ships be stacked dedicatedly. A similar conclusion can be made for an increase in the call size of ships from an average 20% to 30% of their maximum size. The final point relates to the number of ships handled in a terminal. As long as the container terminals deal with ships that have fewer delays, the number of ships does not negatively impact the container handling operations.

ABOUT THE AUTHOR

Amir Gharehgozli is an Industrial Engineer who has got his PhD in Logistics and Operations Management from Rotterdam School of Management. His research interests are Facility Logistics Management, Distribution Logistics Management, Supply Chain Management, and Maritime Logistics; in particular, studying recent innovations in these areas. His research findings have been published and presented in highly scientific journals and conferences. He has had the opportunity to put theory into practice by working in different projects in close collaboration with Port Authorities and Supply Chain and Logistics companies. He is currently an assistant professor in Texas A&M University.

ABOUT THE ORGANISATION

Texas A&M University at Galveston is a special-purpose institution of higher education for undergraduate and graduate instruction in marine and maritime studies in science, engineering and business and for research and public service related to the general field of marine resources. The institution is under the management and control of the Board of Regents of The Texas A&M University System, with degrees offered under the name and authority of Texas A&M University at College Station.

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