Maritime Load Dependent Lead Times - An Analysis

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Abstract. Traditionally, the maritime sector follows a very conservative approach towards sharing information and adopting *information technology* (IT) to streamline logistic activities. Late arrivals of ships create problems especially with the trend to build large ships leading to peak loads of process steps and increased container lead times. Proposed solutions to fight congestion range from extending port capacities to process optimization of parts of the maritime supply chain. The potential that lies in information sharing and integrated planning using IT has received some attention, but mainly on the operational level concerning timely information sharing. Collaborative planning approaches for the maritime supply chain are scarce. The production industry already implemented planning and information concepts. Problems related to the maritime supply chain have great similarities with those encountered in production. Inspired by supply chain planning systems, we analyze the current state of (collaborative) planning in the maritime transport chain with focus on containers. Regarding the problem of congestion, we particularly emphasize on *load dependent lead times* (LDLT) which are well studied in production.

1 Introduction

Timely transportation at least possible costs is one of the main objectives according to which all actors of the maritime supply chain are measured by the customer. In order to fulfill this goal, an efficient information exchange used for planning and scheduling is required. The industrial production sector has been subject to intensive analysis regarding interacting factors influencing lead times. It is recognized and empirically proven that lead times are dependent on the resource utilization and exponentially increase when utilization passes a certain level (see [11] and the references therein). This can also be measured by *work in process* (WIP) building up in front of workstations. When considering the maritime supply chain, we can see the same dependency which becomes evident in ports with high workloads due to uncertain arrival times of containers and congestion effects of subsequent resources.

Recently, a large amount of work has been attributed to information sharing and related supporting systems (see, e.g., [5]). However, information sharing of maritime supply chain partners is reported to be very conservative and limited to data exchange on cargo and related documentation required by country-specific legislation [6]. Additionally, it focuses on the operative and real-time horizon. Aggregate planning and

T. Bektaş et al. (Eds.), ICCL 2017, LNCS 10572, pp. 300–305, 2017.
https://doi.org/10.1007/978-3-319-68496-3_20

scheduling is rare and has only recently been addressed by researchers and practitioners [1, 2].

As the trend of increased ship sizes will continue, new solutions need to be developed that help to plan and coordinate processes and capacities along the maritime supply chain. Special focus should be on capacity utilization smoothing to ensure reliable lead times and robust transport schedules for customers. Costly capacity expansions requiring space are not always feasible due to restrictions of ports in the vicinity of cities as, e.g., in Europe, so that other solutions should be exploited first.

In this paper, we review the literature in maritime logistics regarding congestion and approaches for advanced (lead time) planning. We focus on container transport due to its discrete features and natural analogies to production.

2 Advanced Planning Approaches in the Maritime Supply Chain

Supply chain management (SCM) emerged from logistics and has been a major management issue in the last decades. It has been stimulated by the developments in information and communication technology (see, e.g., [12]. Despite the fact that the shipping industry is quite conservative, their optimization endeavors lead to more and more tight planning and scheduling, so that disturbances have considerably larger impact at heavy system loads (where systems may relate to terminals, access infrastructure to and from the hinterland etc.). Surprisingly, while SCM in maritime transportation and related concepts to enhance supply chain visibility and orientation are becoming an issue (see also [1]), collaborative planning still seems almost nonexistent (see also [3]). This might be due to its history as a sector with complex networks of fragmented, independent trade partners [7] with different business models. Fierce competition as well as a lack of mutual trust in the maritime sector are frequently stated reasons [14]. This situation seems changing at least on the operational time level with IT pilots aiming at improving information provision. For instance, port community systems have been developed in the 1980s, but are subject to continuous improvement (see, e.g., [5]). However, they do not provide planning functionality, but could serve as a data basis for advanced collaborative planning.

In Figure 1, we adapted the planning modules of the *supply chain planning* (SCP) matrix (see [4] and the references therein) to the maritime case further aligning them to the different phases of transport, i.e., pre-, ocean, and on-carriage [15] extending them to more details on departure and arrival port handling phases. This gives an idea of the areas and modules for *maritime collaborative planning systems* (MCPS). The modules in the SCP matrix underlie a hierarchical planning approach and are linked by vertical and horizontal information flows updated in a rolling horizon fashion and require coordination of planning activities [4].

2.1 Congestion Phenomena and Information Sharing

Maritime supply chain partners depend on reliable information about *estimated times of arrival* (ETAs) of containers handled by their direct up- and downstream partners in order to efficiently plan their capacities, processes, and services. Reasons for congestion

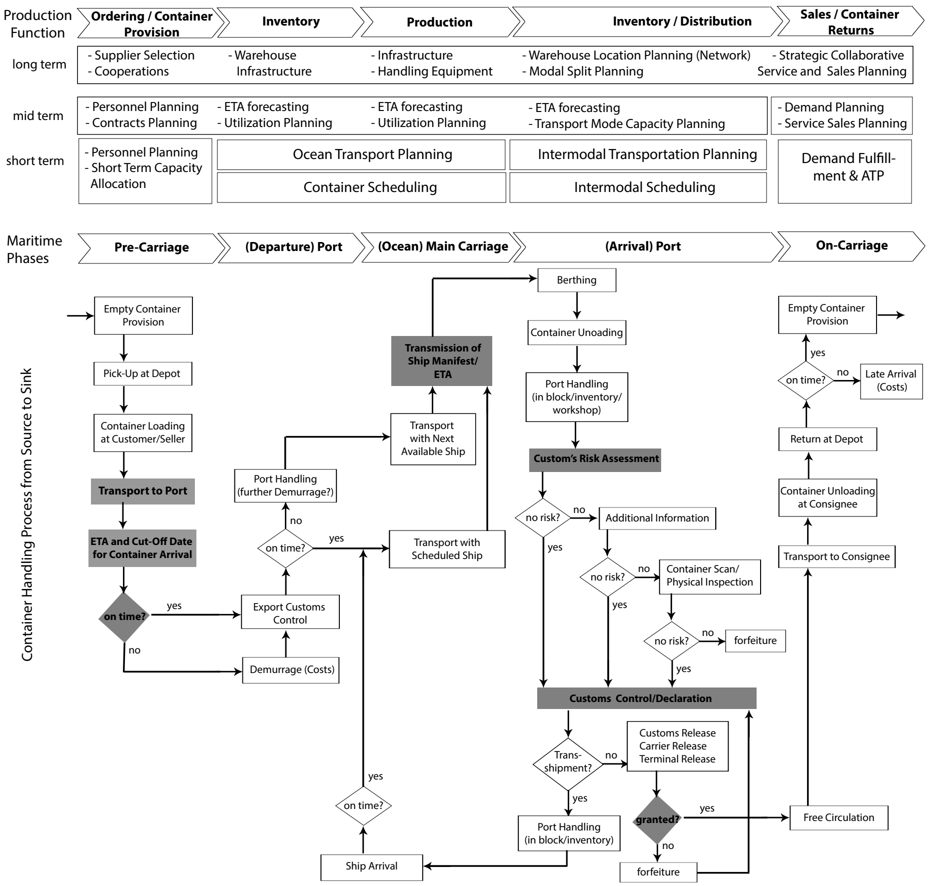

Fig. 1. Analogies in maritime container transport and production planning - process steps and planning functions; own illustration

start with 1) uncertainty of ship and import container ETAs, 2) uncertainty of truck and export container ETAs, and 3) uncertainty of service times of handling equipment and customs.

Innovative IT approaches exist in the form of mobile apps aiming at avoiding congestion on the roads to the port by providing truckers with estimated information on harbor "turn times" (pick-up and delivery) as well as waiting times at the terminal gates (see, e.g., [16]); for more examples see [10]. Apps can also match drivers with empty containers with those needing to pick one up, so that the exchange can be conducted outside the port area.

Especially in the light of increasing ship sizes and related demand peaks, delays of ship arrivals, but also of export containers lead to increases of waiting times. The situation can be improved by short-term provision of sufficient handling equipment and/or long-term capacity extension and related land-side costs [8]. Additionally, the handling of delayed import and transshipment containers becomes more difficult due to export containers congesting the yard and increasing the need for reordering. This decreases port efficiency and increases LDLT as well as costs. Besides, berthing windows for unloading and loading of large vessels extend from 24 to 72 hours not prioritizing unloading [2]. As a result, export containers may loose their hinterland connections or lead to congestion at the port gate due to waiting trucks. Related transport modes depart with unused spaces wasting expensive capacity.

2.2 Collaborative Planning Approaches

There is one reference that directly accounts for MCPS: [1] propose a collaborative SCM system for the maritime logistic chain focusing on three main business processes, i.e., management of 1) orders, 2) demand, and 3) vehicles. These three business processes can be taken into account on a tactical and operational level where demand management contains forecasting and generation of information regarding workloads. Order management is related to coordination, execution, and control of physical and information flows. This is similar to the supply chain processes being one dimension of the SCP matrix (see Figure 1 for the modified version), but differs in the differentiation on orders and demand.

In compliance with other researchers and practitioners, [1] discuss the problem of uncertainty caused by variability on ETAs of supply chain partners as well as related service times also stated in Section 2. The *port river information system project* (PRISE) aims at improving ETA information by providing an IT platform that merges information regarding ship arrivals as well as departures of all partners involved in the dispatching process of ships.[3] Similarly, [2] consider the connection between the arrival of the container and the transport by rail. They reveal that the container-specific ETA is necessary in order to correctly plan a high utilization rate of trains.

The Port of Hamburg recently announced its project “Smart Port Logistics” with several aims, among them optimizing the information flow to manage trade flows in an efficient manner [13]. Related to this, they aim at developing an intelligent IT infrastructure including sensors and (cloud) services.

A major bottleneck of container handling is customs; see Figure 1. Export containers need clearances and release permits to leave the port area [9]. Information on them is given in the ship’s manifest before entering the port, but information is not sufficient for risk assessment at customs. Moreover, multiple manual entering of information in related systems increase processing times. Single Window Systems speed up customs processes by providing correct information on cargo [6]; see also [5] for a framework of a port-centric information management system built as a single window system.

3 Conclusions

Information sharing in supply chains is mandatory for the efficient flow of goods. In case of delays, anticipated information can avoid or reduce LDLT and smooth capacity

[3]Internet source: https://hhla.de/en/2014/03/it-platform-optimises-harbour-processes.html; Last call: 07.07.2016

utilization if collaborative planning is in place. Industrial production has a long tradition in developing and implementing IT systems for information sharing and process planning. The adoption and/or customization of such systems and related planning approaches can be promising to improve the maritime supply chain. LDLT are due to information distortion in planning and control of the supply chain. We review the maritime supply chain for WIP and related congestion in order to highlight bottlenecks and approaches of collaborative planning. Innovative trends exist to improve its overall efficiency on an operational level. Aggregate planning remains a critical issue. Future research will provide an in-depth-discussion on the applicability of SCP solutions.

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