

Article

A Shared Container Transportation Mode in the Yangtze River

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Abstract: Sharing economy is an emerging concept that has been implemented in several industries and has achieved huge success. Novel solutions, built on the emerging concept of sharing economy, such as Uber, Didi, Mobike, and Cargostream, offer unprecedented opportunities for maritime organizations to reform traditional water transportation. This paper presents an analysis framework of a shared container transportation mode to show the restrictions and benefit of the implementation of the concept of sharing economy in maritime transportation. As a typical inland water area in China, the Yangtze River is selected as the study area. A general shared container transportation framework is designed, including a new waiting mode, business process, and software platform system design. The new business process is developed to overcome the contradiction between the new shared container transportation mode and the traditional shipping process. The potential of the new mode is also discussed. It would contribute to the sustainability of maritime transportation with respect to energy saving.

Keywords: sharing economy; shared container transportation; liner shipping; the Yangtze River

1. Introduction

Recent technological developments—mobile internet, Internet of Things (IoT), autonomous driving, big data, to name a few—have enabled numerous innovations in mobility, transportation, and logistics services. Sharing economy is an emerging concept that has been implemented in several industries and has achieved huge success [1]. Novel solutions, built on the emerging concept of sharing economy, such as Uber, Didi, Mobike, and Cargostream, have attracted a massive quantity of interest recently. Didi has changed the taxi industry and Airbnb has increased the use rate of houses [2]. The successful experience of such cases offers unprecedented opportunities for maritime stakeholders to reform traditional water transportation. The Mobile internet also makes it possible to increase the efficiency of traditional shipping industry. The mode of Didi has already been imported to cruise liners. There is an app named “Xingangwan” in Chinese that is used to book cruises. This app could be regarded as a sharing economy application in passenger transportation. However, there has been no attempt to design a sharing economy app in container cargo transportation. The concept of shared container transport between truck companies has been proposed in previous study [3]. However, the concept is restricted to reduce hinterland container transportation cost, and how the concept would be logically feasible in the business process of container waterborne transportation remains to be solved. To fulfill this research gap, this paper proposes a shared container transportation mode to change the traditional liner shipping industry and designs a new business process to facilitate the shared container transportation idea. It is believed that such a new mode, when implemented properly, can help maritime companies increase their efficiency and productivity.

The total process of international shipping is complicated, involving ports, customs, inspection, and quarantine, to name a few. The business process needs to be re-engineered if the shared container transportation mode is to be recommended in the shipping industry. This would make the re-engineering process easier to propose in the shared container transportation in inland water areas, such as the Yangtze River, because we would not need to consider the inspection of customs in domestic trade. The Yangtze River, which is 6380 km long, is China's longest and the world's busiest inland waterway [4]. It is located in the middle of China, stretching from west to east and linking the Midwest region of mainland China with the Pacific Ocean. Figure 1 shows the relative location of the river in China and the world. More than 2 billion tons of cargoes are transported by the river every year. In 2014, the Chinese government released its Yangtze River economic belt plan, in a bid to develop it into an inland river economic belt with a global economic influence. The economy along the Yangtze River has grown very fast under the national economic plan. For example, Chongqing has become a famous inland city with high economic growth. Unfortunately, maritime accidents have happened frequently along the river and triggered congestion [5]. Owing to traffic congestion and accidents, cargoes sometimes have to wait at the port for a long time. On the other hand, vessels may also wait for cargoes at the port because cargoes are delayed by complicated supervision procedures or for other reasons.

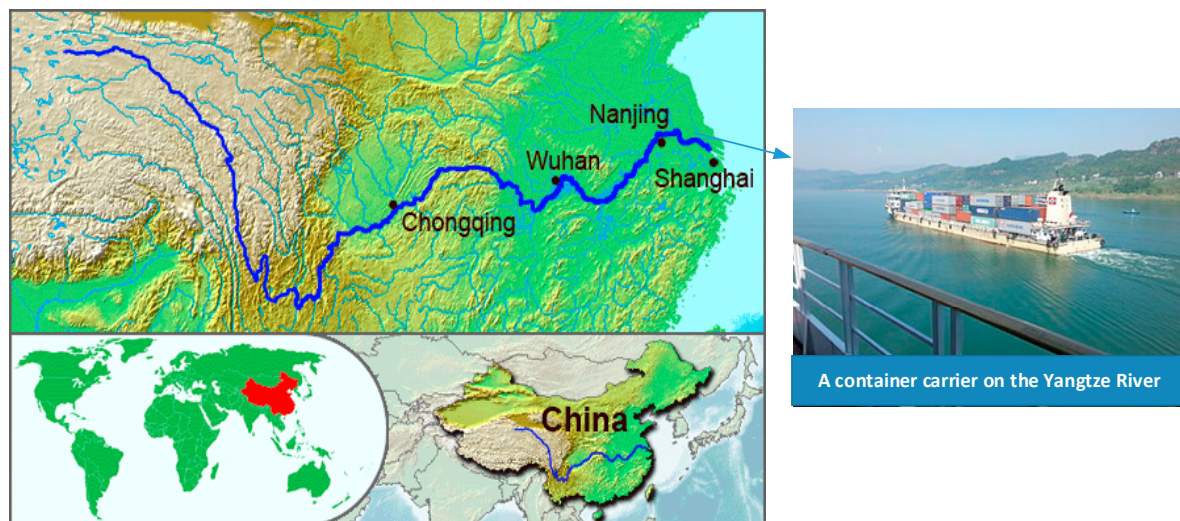


Figure 1. The Yangtze River.

Historically, market cycles have pervaded the shipping industry. According to statistical data from 1741 to 2007, there were 22 shipping cycles, among which the average peak lasted for 3.9 years, while the trough lasted for 6.8 years [6]. It means that the trough time when there is an oversupply of transport services is much longer than the peak time when there is a shortage of transport service. Furthermore, with the fast development of the shipbuilding industry, the peak time will be shorter in the future. Since the financial crisis in 2008, the shipping industry has suffered a long-lasting trough for more than 10 years with an oversupply of vessel fleets. The oversupply of vessel fleets is still a problem for the shipping industry [7]. The oversupply of vessels provides a prerequisite for a shared container transportation mode.

Liner shipping is the main transport mode of manufactured goods in the Yangtze River. It is the service of transporting goods by means of high-capacity, ocean-going ships that transit regular routes on fixed schedules. Nevertheless, the scheduled arrival time of the ships may be out of control. If the ordered vessel is delayed, the cargoes have to wait in the port for several days, even if there are other available vessels. With the traditional mode, demand and supply are matched in advance by shippers and carriers, and these shippers and carriers will try to make their cargoes and ships arrive at the port at more or less the same time, while sometimes this kind of effort seems to be in vain. It is

meaningful to let cargoes and vessels that have both already arrived at the port connect with each other freely. Mobile internet and smart phones provide technological infrastructure for a matching platform. How to design and operate innovative shared container transportation in the Yangtze River is both vital and challenging for all stakeholders: shippers, ports, freight forwarders, carriers, platforms, and policy makers.

The remainder of the paper is organized as follows. Section 2 reviews related literature. A general framework of the proposed shared container transportation mode is developed in Section 3. In Section 4 we discuss the potential of the new mode. Finally, Section 5 summarizes our findings and concludes the paper.

2. Literature Review

The literature is summarized in three aspects: the application of information technology to water transportation; the business process of inland water transportation; and shared maritime transportation.

2.1. The Application of Information Technology to Water Transportation

There are emerging applications of information technology in water transportation, such as information systems, 3S (Sensor, Geographic Information System (GIS), Global Positioning System (GPS)) technology, Automatic Identification System (AIS), Internet of Things (IoT), Internet of Vessels, Unmanned Vessels, big data, intelligent navigation, etc. Information systems, GIS, and GPS are three early traditional technologies. Their applications in water transportation can be seen in previous studies [8,9] and such kinds of technologies are also commonly used in practice. AIS data has become a mainstream data source to help navigation, simulate vessel behavior, and perform risk analysis [10–14]. IoT, Internet of Vessels, Unmanned Vessels, and big data have become technologies of interest in recent years, and will be for the foreseeable future. The popular concept of IoT was also designed and tested in a small inland water area. A dynamic information monitoring system for small-sized fishing vessels on an inland waterway based on IoT to monitor fishing operation was designed by Li et al. (2015). This work integrated wireless sensor networks, remote information transmission networks, and the terminal fishery monitoring center [15]. Lee et al. (2017) used weather archive big data to estimate the real fuel consumption function for speed optimization problems [16]. In order to help maritime companies increase their output and productivity, Wang et al. (2015) proposed a new framework integrating big data analysis and IoT technologies for offshore support vessels based on a hybrid Central Processing Unit (CPU)/Graphics Processing Unit (GPU)/Field-Programmable Gate Array (FPGA) high performance computing platform in Northwestern Norway [17]. This research can help maritime companies increase their output and productivity from a general basis that the application of Database Administrator (DBA) and IoT can increase efficiency. How these technologies will change the business process has not been discussed. Grossardt et al. (2014) partially addressed the incomplete information shortfall to evaluate the desirability of a forward-looking federal policy that supports inland navigation [18].

Most of the information technologies are used to increase the safety of water transportation and solve optimization problems under the current business process in the shipping industry. Technology has largely changed tools of navigation, but the business process mode has remained stagnant for decades.

2.2. Business Process of Inland Water Transportation

Research studies about the business process of inland water transportation are relatively rare. Lam and Wong analyzed the business mode of liner shipping companies and categorized it into three business models: cost leadership, service differentiation and innovation, and hybrid [19]. E-commerce is developing very fast in China and it is a cost saving business mode. Big e-commerce giants, such as Alibaba and JD.com, are leading e-commerce in the world. Shipping e-commerce has also been a hot topic in recent years, when shipping suffered a lot from the financial crisis. There exist some shipping

e-commerce platforms providing vessel positions through AIS data, pricing bids, online payments, online insurance, and online acceptance for carriage. Lou et al. (2016) studied the development of e-commerce shipping platforms in China [20]. A few big carriers in China, such as COSCO shipping, have already built their own vertical shipping e-commerce websites, on which customers can book slots. Shipping e-commerce has the potential to change the business mode of shipping, however, there are many obstacles to be overcome. This kind of platform is currently only a supplement to the traditional channel, and is still not a replacement of the traditional channel.

With the development of mobile internet, many apps have emerged on smart phones that can be used to book slots. Because the business process of traditional shipping has not been changed, a lot of mobile applications have remained as a platform to provide information and cannot truly be used to control the real business flow.

2.3. Shared Maritime Transportation

There are already concepts of vessel sharing, truck sharing, and container sharing in maritime transportation. Vessel sharing is a familiar topic in the shipping industry. Qiu et al. (2018) pointed out that liner shipping companies could benefit from vessel sharing in terms of significant profit improvement, and vessel sharing could also benefit the environment by reducing CO₂ emissions dramatically [21]. The vessel sharing here is typically based on the agreement of cooperative carriers, through global strategic alliance [22]. Olsen, Islam, and Ahmed (2013) re-engineered the truck appointment system with a concept of sharing trucks to reduce the number of empty-truck trips around seaport gates by assigning probable export containers to available empty slots of a container truck [23]. Then, in the year 2018, Islam simulated the truck-sharing idea in a seaport with real data and quantified the benefit of the proposed idea, and concluded that the evaluated positive effects of the changes will be useful in persuading port authorities to evaluate truck-sharing initiatives [24].

Kopfer and Sterzik (2012) illustrated the potential of container sharing between cooperative truck companies in the hinterland of seaports [3]. Remarkable savings regarding fixed and variable costs could be obtained from modified data sets, highlighting the advantage of the container sharing idea. Realistic-sized instances were solved by an efficient tabu search heuristic and the results showed that container sharing between trucking companies led to remarkable cost saving [25]. Sterzik (2013) accomplished a comprehensive study on concepts, mechanisms, and algorithms to measure the potential of container sharing in seaport hinterland transportation [26]. It is a valuable idea to reduce hinterland transportation cost through container sharing between carriers. However, there is a shortcoming in previous studies [6,24,25]. The authors find that it could reduce transportation costs by sharing containers of different carriers through simulation, but they have not designed the business process in which the container sharing idea can be realized. It is not practical in the existing business process to assign an empty container owned by one carrier to load cargoes belonging to another carrier without slot sharing agreements. In order to implement the shared container idea, a coordination entity should be involved. This platform entity collects all the containers from different carriers and is responsible for scheduling them in a wide scope.

The motivation for our work comes from shared transportation cases, such as Didi. Didi has increased the efficiency of taxis significantly by decreasing information asymmetry and utilizing the spare resources of household cars. The lesson learned from Didi is that both the supply side (drivers) and demand side (persons who have transportation demand) of Didi are small players. It is easier to build an internet platform to integrate resources in a market with low market concentration rate than in one with a monopoly because it is more difficult to persuade big carriers to use the platform. In the shipping industry, the demand side of the bulk cargo market is made up of big shippers, such as Baowu Steel and Vale of Brazil. These big shippers can easily contact their cooperative carriers or operate their own fleets. Thus, we focus on container transportation at the beginning of the design of the platform. As for research area, market concentration rate in inland water transportation, such as the Yangtze River, is lower than that of ocean transportation. The reasons why we choose internal trade along the

Yangtze River are that in this area, the supply side consists of many small carriers, and the internal trade is free of customs, which will make the design of the system free from the supervision of customs.

3. The Framework of the Shared Container Transportation Mode

This section proposes the general framework of the shared container transportation mode, which would make the shared container transportation idea feasible in business logic. Figure 2 illustrates the general analysis framework of the shared container transportation mode, in which the left part shows the import of the sharing economy idea to the shipping industry and the right part illustrates the business flow of the new mode. The framework consists of a new waiting mode, new business process, and software platform system design. The new waiting mode is the target of the new mode designed to reduce the waiting time of cargoes in the port. The new business process is designed to make the new waiting mode reasonable in business logic. The software platform system design is the design of a technological app to realize the new mode in practice.

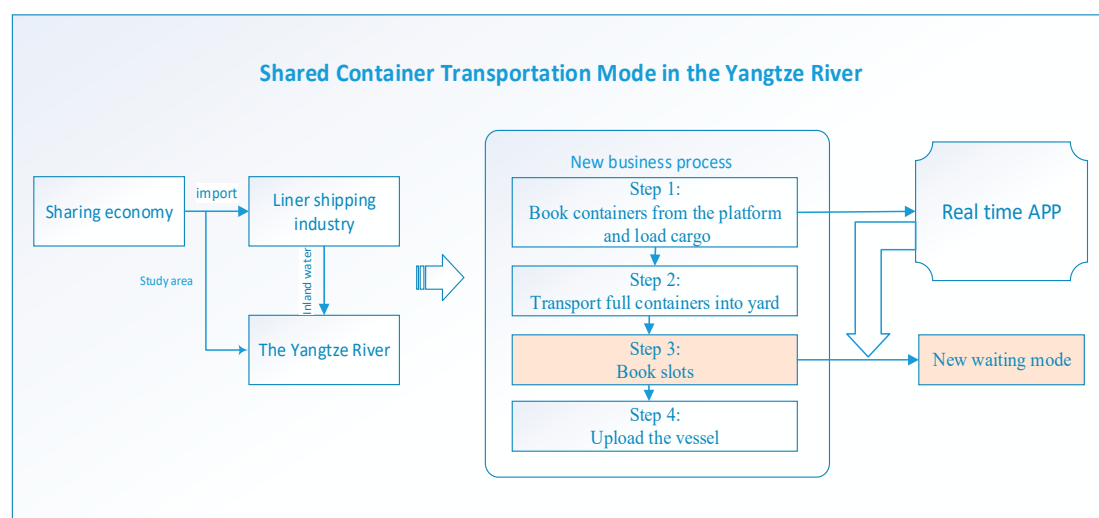


Figure 2. The framework of the shared container transportation mode.

3.1. New Waiting Mode

The waiting mode of cargoes and vessels in the port is illustrated in Figure 3. It is assumed that the origin and destination of cargo1 and cargo2 are the same. In the traditional mode, each cargo in the yard is waiting for its own vessel that is booked by the shippers, as shown in Figure 3a. Cargo1 has to wait for vessel1 and cargo2 for vessel2. In this circumstance, even though there are slots in the vessels that are already in the port, cargoes could not be on board except if their own vessel arrives. Thus, cargo1 could not be loaded on vessel2, even though both of them have arrived at the port. In this scenario, the total waiting time of cargo1 and cargo2 equals to t_1 (the time vessel1 needed to arrive at the port) plus t_2 (the time cargo2 needed to arrive at the port). In order to reduce the waiting time, a new waiting mode is proposed, shown in Figure 3b. In this scenario, cargoes can be loaded on any vessel that is suited for them in time and route. Therefore, cargo1 can be directly loaded on vessel2, and the total waiting time is $|t_2 - t_1|$, which is obviously less than t_1 plus t_2 . This simple computational example shows that the new waiting mode can reduce the waiting time of cargoes compared with the traditional mode.

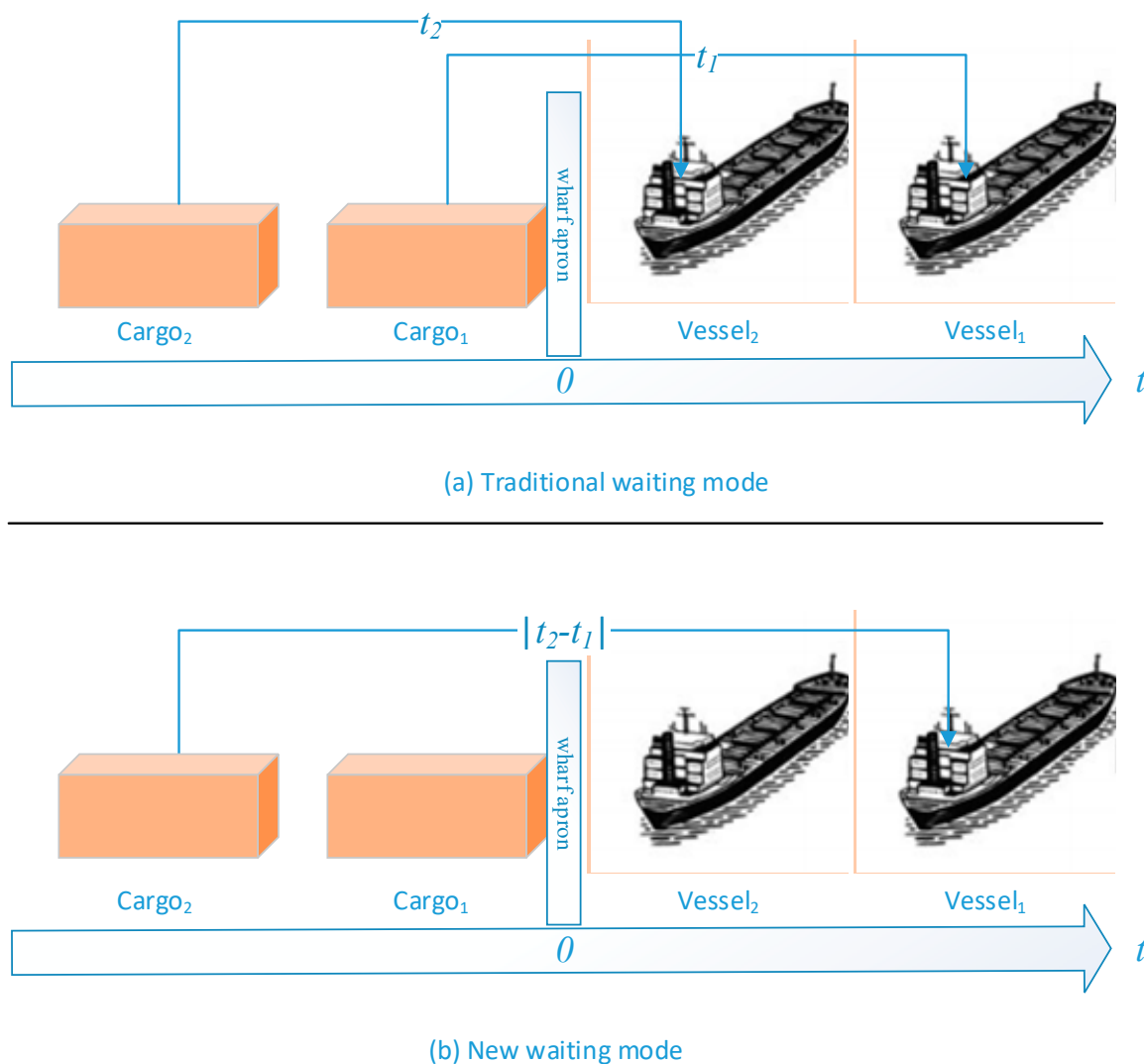


Figure 3. Cargo-vessel waiting mode in the port: (a) traditional waiting mode; (b) new waiting mode.

3.2. The Shared Container Transportation Mode

The stakeholders in the shipping industry are summarized in advance of proposing the new business process. The stakeholders in the traditional mode are described in Table 1.

Table 1. Description of stakeholders in the traditional business process.

Stakeholders	Description
Shipper	the person or company that has cargoes to be transported.
Carrier	the company that provides shipping service and possesses containers.
Freight Forwarder	the person or company that organizes shipments for individuals as agents.
Port	the entity that loads and unloads cargoes, provides storage service
Truck driver	the person who transports empty containers to the shipper (yard) and transports full containers to the yard (receiver).

In the new waiting mode described in Section 3.1, cargoes are transported into ports without booking slots. The left part of Figure 4 shows the traditional four steps of inland water transportation: booking a slot, fetching an empty container from the yard and loading cargoes into the container, then transporting the full container into the yard and waiting for the vessel, and finally loading the container into the previously booked vessel. The new waiting mode is contradictory with the traditional business

process. The biggest challenge of this new waiting mode is the management of containers. In order to make the new waiting mode feasible, the traditional business process needs to be re-engineered. In order to solve the contradiction, we can change the ownership of the containers or persuade the carriers to rent containers to the shippers, regardless of whether they book their slots or not. Therefore, all the containers need to be owned or rented by a third party company and can be shared by all the shippers and carriers, similar to the sharing economy of taxis. The third party would be the software company who provides the software platform. The shippers should pay money to the platform once they use the containers, and at the same time they will pay less to the carriers in the new mode than in the traditional case. In the first stage, the platform company may buy or rent the containers from the main carriers in the Yangtze River. Besides solving the business process contradiction, taking the platform as the owner of the containers can, on the other hand, achieve the most possible street turns, i.e., available empty containers are moved directly between customer locations without frequenting a container depot as an intermediate return and reduce transportation costs through scheduling the containers in a wide scope with the concept of shared containers, which has been verified in a previous study [26]. If there is unbalanced traffic flow from upstream to downstream in the Yangtze River, the platform needs to transport empty containers from places where there is less transportation demand to places where there is more transportation demand.

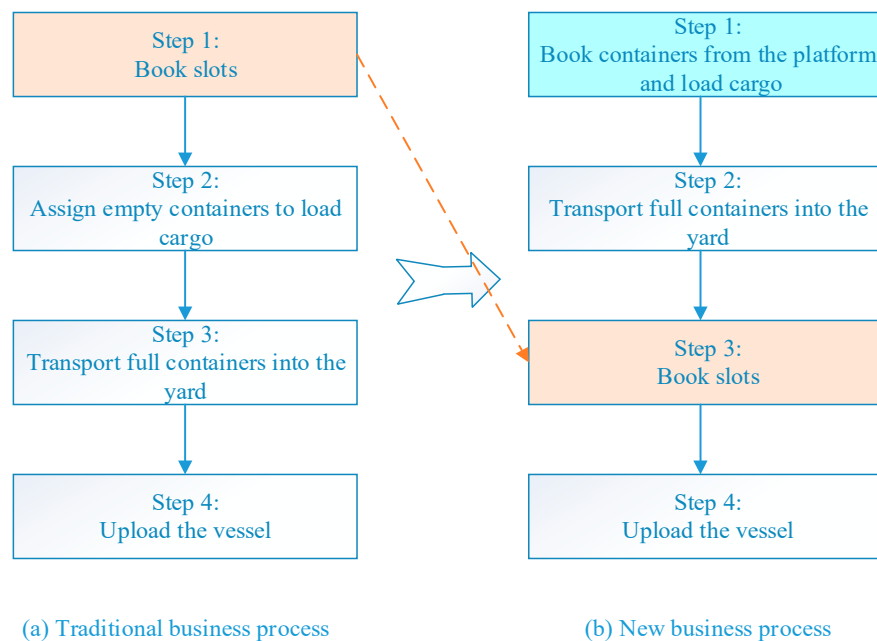


Figure 4. Business process flow of internal trade in the Yangtze River: (a) Traditional business process; (b) new business process.

The new process is illustrated in Figure 4b. The biggest change is that the shippers book containers from the platform at first and “Book slots” becomes the third step. After all the containers are managed by the platform, the shipper would at first rent containers from the platform, and load their products into the containers, and then send them to the yard, and finally select suitable carriers. It is feasible in business logic for the new waiting mode to be implemented.

In this new process, the roles of the stakeholders are also changed. The descriptions of different stakeholders are shown in Table 2. The platform operator is a new stakeholder who is responsible for the operation of the platform, which is the key aspect of the new mode. The shippers and carriers or their freight forwarders will apply an app to match each other. This mode is not designed to replace the freight forwarder. Shippers can also assign a freight forwarder to use the app to fulfill the transport demand. The role of the port remains the same except that the port will receive a lot of orders from the platform, such as sending containers to the truck driver. Previously, the truck drivers were scheduled

by a particular carrier. In the new mode, the drivers are scheduled by the platform in a wide scope. The last step, “upload cargoes to the vessel”, is the same in both modes.

Table 2. Description of stakeholders in the new business process.

Stakeholders	Description
Platform operator	The entity who is responsible for the design of the software platform and the marketing and operation of the platform that is used to organize the shippers and carriers. It is also the operator of shared containers. The vessels can belong to different ship owners.
Shipper	The person or company that has cargoes to be transported and uses the shipper app of the software package.
Carrier	The company that provides the shipping service and uses the carrier app.
Freight Forwarder	The person or company that organizes shipments for individuals.
Port	The entity who loads and unloads cargoes, provides storage service, and receives orders from the software platform.
Truck driver	The person who transports empty containers to the shipper (yard) and transports full containers to the yard (receiver) in a wide scope.

3.3. Software Platform System Design

The software platform consists of three layers: user, service, and backstage, as shown in Figure 5. The main users are the shipper and the carrier or their freight forwarder, and the truck driver. Three different apps are designed for shippers, truck drivers, and carriers, respectively. The users can only see their own app that will be installed on their smart phones. The services include Linux Virtual Server (LVS), push server, order grabbing, payment, and interface with Management Information System in ports. Backstage consists of MongoDB, DBproxy, and Master Structured Query Language (SQL) and Slave SQL. Backstage is dedicated to storing structural and non-structural data and to supporting the service layer, with the ability to handle big data by DBproxy.

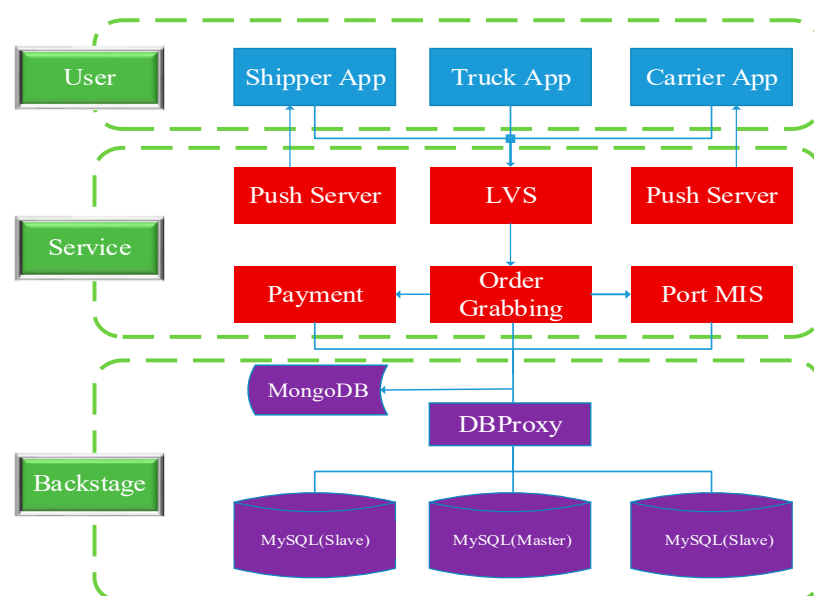


Figure 5. System framework design of the shared container transportation mode.

3.3.1. Real-time Order App Based on Smart Phone and Electronic Navigational Chart

Traditionally, the shipper books slots in more than ten days in advance and transports the cargoes to the port waiting for the vessel it has booked. In this scenario, it wastes much time if the booked ship

is delayed or has an accident. Even though there are other available ships in the berth, the cargoes cannot be transported by the available ships because they have not been assigned to these ships.

With the development of mobile internet and the sharing economy, it is becoming convenient for the shippers to book according to real time vessel position after the cargoes have already entered the port yard. A real time order app based on smart phones and electronic charts should be designed to help the shippers find the proper vessels. Most of the apps, such as Didi and Uber, integrate maps into their app to help the drivers and individuals find each other. In maritime transportation, electronic navigational charts can help to increase the matching of shippers and carriers. When the vessel confirms the ordering information, it can send information to the port control center and the port facilities will deliver proper containers to the vessel. The vessels set out according to the scheduled time or the indicator of loading percentage.

3.3.2. Services

LVS is short for Linux Virtual Server, which is used for building highly-scaled and highly-available network services, such as web, email, media, and Voice over Internet Protocol services, and integrating scaled network services into large-scale reliable e-commerce or e-government applications. In our platform, there would be millions of visits from different shipping stakeholders. Furthermore, the shipping industry is a capital intensive industry. Once the network is not reliable, it may cause huge losses. Thus, LVS is applied to provide reliable service for this highly-scaled platform.

A push server, which is also called push technology, is a style of Internet-based communication where the request for a given transaction is initiated by the publisher or central server. It is contrasted with pull coding, where the request for the transmission of information is initiated by the receiver or client. Here, push technology can be used to push cargo information to the carrier app for the carriers to grab orders, and on the other hand push carrier information to the shipper through the shipper app. As for truck transportation, different truck drivers can register the truck app and find container transportation demand released by the platform.

Order grabbing is an important design in the app to guarantee free competition of trucks drivers and carriers. The first round order grabbing is where the shippers release container demand on the app and the truck drivers compete to grab the orders. The second round order grabbing occurs after the shippers or their freight forwarders the release transportation demand on the platform and different carriers compete to grab orders. Once the matching of the cargo and vessel is accomplished, the software platform will send the matching information to the port, which will schedule the production plan and load the cargoes onto the ship according to the matching information.

The specific process implemented on the platform can be summarized as follows. The shipper distributes empty container demand on the platform through the shipper app. The truck driver grabs orders to send empty containers to the shippers and transport them to the port. After the containers are transported into the yard, the shipper distributes transportation demand on the platform through the shipper app. The carrier distributes transportation supply on the platform through the carrier app. The push server can suggest carriers to the shipper and vice versa, according to the time competence and capacity of the vessel through big data analysis. The carriers can grab orders distributed by shippers, and the shippers can also select from the suggested carriers via the platform. After the transaction is completed, the platform sends the information to the port, which can schedule the operation of the cargoes in the port and load the cargoes onto the ship.

3.3.3. Backstage

MongoDB is a free and open-source cross-platform document-oriented database program. Classified as a Not Only SQL (NoSQL) database program, MongoDB uses JavaScript Object Notation (JSON)-like documents with schemata. MongoDB is employed to solve spatial search problems. DBproxy is imported to solve the separation of reading and writing operations of MySQL DB. Master

SQL and Slave SQL are a typical high-end configuration that includes a powerful master database that handles data writing operations and is replicated to multiple slaves that handle all read operations.

4. Potential of Shared Container Transportation Mode

The designed shared container transportation mode has great potential to reduce waiting time in the port and decrease the transportation cost in the hinterland, as containers are scheduled in a big scope. Figure 2 gives an example of a common situation, in which the waiting time is reduced by the new waiting mode. As for the transport cost in the hinterland, the potential of the shared container has already been tested in previous studies [25]. In addition, the empty container re-positioning cost between different ports along the Yangtze River in the new mode could also be less than that in the traditional mode because of economies of scale and complementation.

Even though we can believe that the new mode can reduce cost theoretically, there is still a long way to go in practice. For the platform, as described in the previous chapter, a real-time ordering app needs to be developed, a group of people need to be hired to operate the platform, and the market must be developed. In the short run, the company developing the platform may need to invest millions of dollars. In the long run, economically, the platform may decrease the information asymmetry and reduce transaction costs. Furthermore, in the new mode, the platform, as the operator of containers, can earn money from renting containers. Technologically, it is not difficult to build a real-time integrating app to coordinate the cargoes and vessels. Such a kind of system has been used very efficiently in taxi industry and other industries. The challenge is how to persuade all the stakeholders to use the platform. From the whole industry's viewpoint, the mode has the potential to increase efficiency and the government has the motivation to support such a mode.

5. Conclusions

This paper proposes a shared container transportation mode in the Yangtze River. The framework of the new mode is designed, including a new waiting mode, a new business process, and a new platform software system design. Theoretically, it is a feasible mode and can increase the efficiency of liner shipping in Yangtze River in the long run. Advantages of the new mode are twofold: Reduce the waiting time of containers in the port (in the new mode, cargoes no longer need to wait for a particular vessel), and coordinate containers in a more wide scope. Traditionally, each liner shipping company manages their own containers. In the new mode, containers are scheduled by the app company in a wider scope, which can increase the efficiency of container shipping. The new mode would contribute to the sustainability of maritime transportation through energy saving.

The contributions of this study are twofold. Firstly, we propose a shared container transportation idea in the Yangtze River. Secondly, the framework of the mode is designed, including a new waiting mode, a new business process, and a new software platform system design to make the shared container transportation idea logically feasible in a business process based on mobile internet technology. The proposed mode has potential to reduce container or vessel waiting times in the port and increase the utility rate of containers by scheduling them in a wider scope.

Further opportunities exist in the following two aspects. Computational tests will be needed to verify the mode designed. Theoretically, the new mode can reduce waiting time and increase the utility rate of containers. The difference between the new mode and the traditional one remains to be tested by a simulation method based on real data. The price of containers rented should be discussed quantitatively. Because the cost of buying and managing containers has been transferred to the software platform company, the price of the carriers should also be reset.

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