THE IMPACT OF LOGISTICS MONITORING IN THE INBOUND LOGISTICS MODES FOR THE CRUISE SHIPS CONSTRUCTION

M. Monika[1*], J. Merline Vinotha[2]

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Abstract

The maritime tourism business has grown significantly in recent years. The lavishness of cruise business has increased demand for cruise building sector. The construction of cruise liner is a big, complex industry with potential to have a considerable impact on environment. Therefore, making best use of cutting-edge logistics systems to meet needs while generating least amount of waste is now a crucial concern. Managing freight damage is a vital component of an integrated logistics program which has serious consequencesfor shippers like revenue loss and reputation tarnishing. This study investigates the transportation delays and overtime cost in the cruise ship construction due to freight damage. In this study, we incorporated a logistics impact monitor which is versatile, ascendable, intuitive, and suitable for a wide variety of freight and logistics networks. Two typical inbound logistics systems modes were also considered and the optimal ordering strategy also determined. Numerical examples were carried out to illustrate the effectiveness of the logistics impact monitor.

Keywords: Freight Damage, Cruise Ship Construction, Inbound Logistics, Logistics Delays, Logistics Impact Monitor.

PG and Research Department of Mathematics, Holy Cross College (Autonomous), (Affiliated to Bharathidasan University), Tiruchirappalli - 620002, India.

Email: [1*]mmonikaanbu98@gmail.com, [2]merlinevinotha@gmail.com

[*]Corresponding Author: [1]M. Monika
PG and Research Department of Mathematics, Holy Cross College (Autonomous), (Affiliated to Bharathidasan University), Tiruchirappalli - 620002, India.
Email: [1*]mmonikaanbu98@gmail.com

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1. Introduction

The most rapidly expansion of navigate, voyage, and leisure time sector is the cruise industry, which is a very lucrative global business. Additionally, it includes a few entertainment businesses that specialise in cruise entertainment. From the days of transoceanic travel and tropical vacations only available to the wealthiest in society, to the modern multimillion tourism and leisure business that offers a reasonable vacation choice and a level of comfort hard to equal for ordinary citizens, with a number of individuals travelling that seems to grow every year in the world. "The luxurious sector has grown 119 percent since 2012 to a yearly passenger total of almost 721,078 passengers in 2022, from 324,512 in 2012," reports Cruise Industry News. By 2027, it is anticipated that this market segment will have increased to about 1.2 million passengers. As a result, there have been more orders for building cruise ships. One kind of heavy industry that has the potential to seriously harm the environment is the construction of cruise ships. Three key features have been included in cruise ship construction. High modularization comes first. The second factor is that the components are diverse. The third is that there are a lot of parts. Building a cruise ship is a difficult project that requires many different sorts of parts. Therefore, using an efficient inbound logistics system to transport the parts is a key component of cruise ship construction. Utilising inbound logistics (IL), merchandise and other services are brought into a business. Logistics processes of sourcing and purchasing, ordering, transportation, material handling, storing, and warehousing are all aspects of this procedure. Inbound logistics primarily concentrates on supply side of dispense-demand relationship. Since there are numerous purveyors involved in inbound logistics and various components have distinct requirements for logistics, a link error may set off a chain reaction. Freight damage is the most prevalent major issue in logistics. It happens as a consequence of incorrect lashing, packing, and handling the container during loading and unloading. One such catastrophe is freight damage, which not only results in product and financial losses but also may have an impact on other relationships in logistics management. Freight delays are the main impact of the freight damage. It has a significant influence on the entire supply chain, which causes operational expenses to go up, overtime pay to become mandatory, decreased productivity, and most significantly, dissatisfied customers. As a result, model for mass-customized service has proven to be an efficacious way to control costs during the construction of cruise ships, enabling dockyards to more effectively carry out sustainable operations strategies and support the long-term sustainability of the cruise market. Controlling the movement and storage of products, services, people, information, and tools is referred to as logistics. Using logistics tracking, it is possible to keep track of the whereabouts and status of shipments, schedule labor needs, and take appropriate action in case early or delayed delivery is anticipated. Since the manufacturing industry is a dynamic one, it is customarily necessary to alter the circulation of commodities in order to prevent both bottlenecks and overproduction. Logistics tracking monitors the current state of the supply chain, enabling any necessary adjustments. Tracking operations is essential for manufacturing logistics. A shock detector is housed inside a specially constructed vibration detecting device called a logistics impact monitor. The monitoring tool can capture unusual impact and vibration during transit. Glass tube, sticker, and plastic enclosure comprise the logistics monitor. Toner and a specific liquid, primarily water, are placed within the glass tube's interior. The liquid leaks out and mixes with the toner when the items with the logistics monitor are subjected to abnormal stress and vibration because the force breaks the surface tension and viscosity. The combination will then serve as a record for the vibration or shock. The advantages of employing an impact indicator will actually cut the rate of damage of goods by more than 70%. It improves the company's credibility for safeguarding its own goods. It will be possible to identify the actual cause of any goods damage, as well as any involved people. Only a small amount is required to prevent costly damage. It can be cited as solid support for payment. In this study, we have included a logistics impact monitor which is versatile, ascendable, intuitive, and suitable for inbound logistics for the construction of cruise ships.

The remainder of the paper is as follows. Section 2 covers an overview of the pertinent research as well as summaries of the paper's novel ideas and contributions. The model's parameters and annotations are described in section 3.In Section 4, the proposed model is mathematically stated, and the problem's solution process is addressed. The managerial implications of numerical analysis are performed in section 5. Section 6 discussed the conclusion of this article.

Literature Review

The existing research on incoming logistics methods for various cruise ship construction components were scrutinized. Also we have discussed the impact of logistics monitoring in the inbound logistics modes. The preeminent aspects of building a cruise ship is having high-quality supply chain, and inbound logistical support is a vital link in that network. Prior studies on inbound logistics focused mostly on the production of automobiles, steel mills, and fast-moving consumer items, like dairy industry. Boysen et al. characterised the fundamental phases in automotive industry, from first calling order to empty component container return. Thousands of resources and providers, numerous distinct kinds of machinery, and hundreds of logistics people must all be coordinated in order to guarantee that the final assembled lines never run out of supplies [1]. In order to provide a group of interconnected decision making for incoming logistics in the automotive sector, Mincuzzi et al. examined the possibilities of a data integration solution [4]. By revealing the untapped capacities of the unprocessed product handling network of an integrated steel mill, Mukherjee et al. elucidated a technique for designing the incoming logistics volume [5].According to Costa et al.'s analysis, inbound transportation (IL) activities can support organisational resilience [2]. The parts used in cruise ship building are significantly more complicated than those used in auto manufacturing or the fast-moving consumer products industry. Standard parts that are simple to carry to the assembly line make up the majority of the components in auto manufacturing. The output of a manufacturing facility for automobiles may be produced in vast quantities and has a high degree of resemblance. The proportion of standard parts is far lower in dockyards than in auto factories because each cruise ship is custom-built. According to Semini et al., the ship design and building industry, particularly in the cruise ship construction sector, caters to a wide variety of commercial sector with varying stages of necessary customization, requirements, and products and commercial differences. Heinonen, A., developed takt time planning in cruise ship cabin refurbishment [3]. Wang compared the two common incoming logistical methods that utilize JIT production in construction of cruise liners [7]. To assess the technical issues with design and construction of large luxury cruise ships, Zhang presented an approach based on the analytical hierarchy process (AHP). Ordering, receiving, storing, transporting, and managing arriving supplies are all processes in the inbound logistics process for building cruise ships. Freight damage is one of the main causes of supply chain interruption in incoming logistics. It results in increased insurance claim costs, freight costs that must be accelerated, lost revenue from cancelled shipping, and more. According to the National Cargo Security Council (NCSC), “Cargo loss has an annual financial impact of more than $50 billion worldwide”. Wayne TK discussed the determinants of freight damage risk and severity in the case of containership accidents [6]. Wu PJ, developed cargo loss mitigation strategies for logistics risk management [8]. The major consequence of the cargo loss causes freight delays. The delays in offshore platform supply logistics were anticipated by Cepeda FS. Innovative monitoring tools for logistics quality control enables logistics and transportation companies to monitor and reduce impact and drop events. Logistics and transportation organisations can monitor and minimise impact and drop incidents by integrating cost-effective shock sensor devices into a quality control system for logistics. Lowering damage-related expenses also raises customer satisfaction and accountability. Cargo transportation and logistics monitoring are closely related. It has become a necessity for cooperation. Matic T devised a model to detect package damage in the supply network by utilising smart stickers with ultra-low power stress sensing during transportation, storage, and handling. Abraham addressed the future of food packaging through intelligent packing system. In conclusion, the majority of earlier investigations have concentrated on the logistics monitoring in the food supply chain and micro level path of transportation of inventory. It is therefore vital to undertake research on inbound logistics modes that incorporate logistics monitoring in cruise ship design due to the dearth of study in macro sectors.

NOTATIONS AND ASSUMPTIONS

Notations

Notations	Description
i	Identifier code
d_i	Demand of the parts i
S_i	Setup production cost i
O_i	Variable production cost i
E_i	Extra production cost i

P_i	Production time of parts i
D_{is}	The distance between purveyor and dockyard
h_{si}	Holding costs of parts i in purveyor
h_{hi}	Holding parts costs i in supply center
h_{wi}	Upholding parts costs i in dockyard warehouse
h_f	Holding cost of Reserve stock in supply center
b	Operational cost of supply center
T_{fsh}	Fixed transportation expenses i to the supply center
T_{vsh}	Varying transportation expenses i to the supply center
T_{fsw}	Fixed transportation expenses i to the dockyard warehouse
T_{vsw}	Varying transportation expenses i to the dockyard warehouse
T_{hw}	Transportation parts costs i from the supply center to the dockyard warehouse
C_{sh}	Transport volume to the supply center
C_{sw}	Transportation volume to the dockyard warehouse
C_{hw}	Transportation volume of parts i from the supply center to the dockyard warehouse
G_{di}	Freight damage rate i
Y_i	Wage labour
Y_o	Overtime pay
R_{sh}	Restock interval of parts i to supply center.
R_{sw}	Restock interval of parts i to dockyard warehouse
R_{hw}	Period between components i replenishments at supply center to dockyard warehouse
γ	Logistics monitor cost of parts i
m	Delay time of parts i
L	Transportation delay i
TC_i	Total inbound logistics cost of parts i

Assumptions

a. The purveyor has sufficient volume to assure the supply of the dockyard. The dockyard warehouse has sufficient space to accommodate the needs.

b. Parts are produced by the purveyor at regular intervals. In the meantime, the volume of manufacturing matches the demand for marine workstations.

c. Parts are delivered by the vendor at regular intervals. In the meantime, the demand for dockyard workstations has been accounted for by the volume of transportation. The purveyor's transportation intervals are exactly the same as the production intervals.

d. When in supply hub mode, the shipyard is close by the supply hub. The transportation interval from the supply center to the dockyard warehouse is quite low because high-energy transportation is employed in order to conserve storage in the dockyard warehouse. Assume that distance travelled between the purveyor and the supply center is N times that of distance travelled between supply center and dockyard warehouse. N is an integer in the ideal design.
e. The travel time between supply center and dockyard warehouse, workstation and the dockyard warehouse, as well as travel time from the purveyor to supply center or the dockyard warehouse, all stay fixed and predetermined under typical circumstances.
f. Transportation delays or damaged cargo are also possible. Workers in the dockyard might need to put in extra hours to keep up with the schedule. Delays are connected to overtime.
g. Reserve stock is kept at the supply center to lessen the impact of delays
h. The cost of storing parts at the dockyard storage and supply center will vary. The supply center's storage expenses are less than those of the dockyard warehouse.
i. The cost of transportation from supply center to dockyard warehouse is constant each time.

Mathematical Formulations and Model Specification

Mode 1: Supply Center: Suppose there is a dockyard that chooses to adopt to use a JIT-logistics method for construction of cruise ships; there will be two practical IL mechanisms for part collection. Model 1 comprises of multiple purveyors, a supply center, a dockyard warehouse, and a workstation. At regular intervals known as R_{sh}, purveyors deliver parts to the supply center. The components are then centralized, kept at the supply center, and then delivered at predetermined intervals R_{hw}, to the dockyard warehouse. The components are then delivered from the dockyard warehouse to the workstation. The various cost associated with this logistics processes are listed below.

The cost of manufacturing per unit time for parts i is represented by C_1, which is made up of both fixed and variable costs. The quantity of manufacturing $R_{sh}d_i$ determines the variable cost O_i.
A parameter is O_0.

$$C_1 = \frac{S_i + O_i}{R_{sh}} \qquad \text{..... (1)}$$

$$O_i = O_0 \times R_{sh}d_i \qquad \text{..... (2)}$$

The cost of transportation per unit of time for parts i is represented by C_2 . In (3), the first expression denotes transportation expenditure from provider to supply center per unit of time, which contains both fixed and variable expenses. The second expression symbolizes transportation expenditure per unit of time when parts i get transferred from supply center to dockyard warehouse. The distance between the purveyor and the supply center D_{is} determines the variable cost T_{vsh}. The parameter is T_0.

$$C_2 = \frac{T_{fsh} + T_{vsh}}{R_{sh}} \times \left[\frac{d_i R_{sh}}{C_{sh}}\right] + \frac{T_{hw}}{R_{hw}} \times \left[\frac{R_{hw}}{C_{hw}}\right] \qquad \text{..... (3)}$$

$$T_{vsh} = T_0 \times D_{is} \qquad \text{..... (4)}$$

The storage cost for part i is represented by C_3. The first term in (5) denotes the price per unit of time for storing parts i in the vendor's warehouse. The second term is the price per unit of time for storing parts i in supply center. The third expression denotes price per unit of time for storing parts i in the dockyard warehouse.

$$C_3 = \frac{1}{2}h_{si}p_i d_i^2 R_{sh} + \frac{1}{2}h_{hi}d_i(R_{sh} - R_{hw}) + \frac{1}{2}h_{wi}d_i R_{hw} \qquad \text{..... (5)}$$

The freight damage cost for part i is represented by C_4. Another reason for delays is damaged cargo. To prevent this, there is reserve stock.

$$C_4 = E_i \times G_{di} \times d_i \qquad \text{..... (6)}$$

C_5 denotes the supply center's operational costs and reserve stock maintenance expenses.

$$C_5 = h_f + b \qquad \text{..... (7)}$$

The expense of investing in adding a logistics impact monitor is represented by C_6. It is calculated by multiplying the demand of dockyard workstation for parts i per unit time by the cost of the shock detector

$$C_6 = \gamma d_i \quad \text{……(8)}$$

The overall inbound logistics expense for the purveyor center mode in the cruise ship construction implemented with a logistics impact monitor

$$minTC_i = \frac{S_i}{NR_{hw}} + O_i \times d_i + \frac{T_{fsh} + T_{vsh}}{NR_{hw}} + \frac{T_{hw}}{R_{hw}} + \frac{1}{2}Nh_{si}p_i d_i^2 R_{hw} + \frac{1}{2}R_{hw}d_i \times [(N-1)h_{hi} + h_{wi}] + \frac{1}{3}(E_i \times G_{di} \times d_i) + \frac{1}{4}(h_f + b) + \gamma d_i \quad \text{….. (9)}$$

$R_{sh} = NR_{hw}N \geq 1$, N is an integral ….. (10)

where ordering strategy is given by

$$\frac{dTC_i}{dR_{hw}} = -\frac{S_i + NT_{hw} + T_{fsh} + T_{vsh}}{NR_{hw}^2} + \frac{1}{2}Nh_{si}p_i d_i^2 + \frac{1}{2}d_i \times [(N-1)h_{hi} + h_{wi}] = 0 \quad \text{…..(11)}$$

$$R_{hw} = \sqrt{\frac{2 \times (S_i + NT_{hw} + T_{fsh} + T_{vsh})}{N^2 h_{si} p_i d_i^2 + Nd_i \times [(N-1)h_{hi} + h_{wi}]}} \quad \text{……..(12)}$$

Direct Sending

Mode 2 comprises of one purveyor, a warehouse from a dockyard, and a workstation. At predetermined intervals known as R_{sw}, parts are delivered directly from the purveyor to the dockyard warehouse where they are then distributed to the workstation. The following is a list of the various costs related to this logistical procedure.

The cost of manufacturing per unit time for part i is represented by C_1, which is made up of both fixed and variable costs. The quantity of manufacturing $R_{sw}d_i$ determines the variable cost O_i. A parameter is O_0.

$$C_1 = \frac{S_i + O_i}{R_{sw}} \quad \text{….. (13)}$$

$$O_i = O_0 \times R_{sw}d_i \quad \text{….. (14)}$$

The expense of transportation per unit of time for part i is denoted by C_2 . The transportation expense from the vendor to the dockyard warehouse per unit of time, which is comprised up of fixed cost and variable cost, is expressed by formula (15). Distance D_{is} is between the purveyor and dockyard storehouse is what determines the variable cost T_{vsw}. Parameter T_0 is used.

$$C_2 = \frac{T_{fsw} + T_{vsw}}{R_{sw}} \times \left[\frac{d_i R_{sw}}{C_{sw}}\right] \quad \text{………… (15)}$$

$$T_{vsw} = T_0 \times D_{is} \quad \text{….. (16)}$$

The storage expense for part i is represented by C_3. The first term in (17) denotes the price per unit of time for storing parts i in the purveyor warehouse. The second expression is the cost of storing parts i in the dockyard warehouse for one unit of time.

$$C_3 = \frac{1}{2}h_{si}p_i d_i^2 R_{sw} + \frac{1}{2}h_{wi}d_i R_{sw} \quad \text{….. (17)}$$

The freight damage cost for part i is represented by C_4. The first expression denotes the extra expense of producing parts i per unit of time.

$$C_4 = E_i \times G_{di} \times d_i \quad \text{….. (18)}$$

The transportation delay cost for part i is represented by C_5. The shipping and freight damage are to blame for the delay L. In the event when assembling the pieces is a crucial step, the first expression represents the delay cost owing to freight damages. Since assembling the pieces i is a crucial step and dockyard workers must wait for parts i, the formula $L \times Y_i$ shows labor waste. The cost of overtime is given by the formula $kL \times Y_0$. Workers in the dockyard are required to put in extra hours in order to catch up with the schedule. Delays are connected to overtime. A parameter is k.

If assembling the parts is not a crucial step, the second expression stands for delay cost.

If assembling the pieces i is a key step in the construction, M_1 = 1,M_2 = 0, else M_1 = 0,M_2 = 1.

$C_5 = (L \times Y_i + kL \times Y_0)M_1 + (kL \times Y_0)M_2$ ………(19)

C_6 represents the investment cost for incorporating logistics impact monitor. It is obtained by multiplying the demand of dockyard workstation for parts i per unit time by the cost of the shock detector

$C_6 = \gamma d_i$ ……(20)

The total inbound logistics cost for direct sending mode in the cruise ship construction incorporated with a logistics impact monitor

$$minTC_i = \frac{S_i}{R_{sw}} + O_i \times d_i + \frac{T_{fsw} + T_{vsw}}{R_{sw}} + \frac{1}{2}h_{si}p_i d_i^2 R_{sw} + \frac{1}{2}h_{wi}R_{sw}d_i$$

$$+\frac{1}{3}(E_i \times G_{di} \times d_i) + \frac{1}{4}[(k(p_i + mD_{is}) \times Y_0)M_2(L \times Y_i + kL \times Y_0)M_1 + (kL \times Y_0)M_2] + \gamma d_i \quad \text{..... (21)}$$

Where ordering strategy is given by

$\frac{dTC_i}{dR_{sw}} = -\frac{S_i + T_{fsw} + T_{vsw}}{R_{sw}^2} + \frac{1}{2}h_{si}p_i d_i^2 + \frac{1}{2}d_i h_{wi} = 0$ .... (22)

$R_{sw} = \sqrt{\frac{2S_i + T_{fsw} + T_{vsw}}{h_{si}p_i d_i^2 + d_i h_{wi}}}$ .... (23)

Numerical Examples

As an illustration, two typical parts namely ship parts and prefabricated cabins in two inbound logistics modes incorporated with a logistics impact monitor are discussed. The numerical values of each parameter are given in A1–A4.

A1. Ship plate parameter setting in Mode 1.

d_i=125 quantity; $S_i = 10$ thousand RMB/batch; O_i=3 thousand RMB/quantity; $E_i = 3.1$ thousand RMB/quantity;P_i =0.05month; D_{is} =200 km; h_{si}=1 RMB/month*quantity thousand; h_{hi} =0.5 RMB/month*quantity thousand; h_{wi} = 1 RMB/month*quantity; h_f=30 thousand RMB/month ; $\gamma =$ 1.68; b =15 thousand RMB/month; N =5; $T_{fsh} = 5$ thousand RMB/batch; $T_0 = 0.1$ thousand RMB/km; T_{hw} =0.2thousand RMB/batch; C_{sh} =10000quantity; C_{hw} =1000 quantity; G_{di} =0.03

A2. Ship plate parameter settings in Mode 2.

d_i=125 quantity; $S_i = 10$ thousand RMB/batch; O_i=3 thousand RMB/quantity; $E_i = 3.1$ thousand RMB/quantity;P_i =0.05month; D_{is} =200 km; h_{si}=1 RMB/month*quantity thousand; h_{hi} =0.5 RMB/month*quantity thousand; h_{wi} = 1 RMB/month*quantity;$T_{fsw} = 5$ thousand RMB/batch; $\gamma =$ 1.68; C_{sw} =1000quantity; G_{di}=0.01; Y_i =100 thousand RMB/month; Y_0=110 thousand RMB/month; $L = 0.2$ month; m=0.005; k= 0.4; M_1=0; M_2=1

A3. Prefabricated cabins' Mode 1 parameter settings.

d_i=30 quantity; $S_i = 25$ thousand RMB/batch; O_i=40 thousand RMB/quantity; $E_i = 50$ thousand RMB/quantity;P_i =0.2month; D_{is} =1500 km; h_{si}=3 RMB/month*quantity thousand; h_{hi} =1.5 RMB/month*quantity thousand; h_{wi} = 3 RMB/month*quantity; h_f=80 thousand RMB/month ; $\gamma =$ 1.68; b =20 thousand RMB/month; N =5; $T_{fsh} = 50$ thousand RMB/batch; $T_0 = 0.1$ thousand RMB/km; T_{hw} =1thousand RMB/batch; C_{sh} =10000quantity; C_{hw} =1000 quantity; G_{di} =0.05

A4. Prefabricated cabins' Mode 2 parameter settings.

d_i=30 quantity; $S_i = 25$ thousand RMB/batch; O_i=40 thousand RMB/quantity; $E_i = 50$ thousand RMB/quantity;P_i =0.2month; D_{is} =1500 km; h_{si}=3 RMB/month*quantity thousand; h_{hi} =1.5 RMB/month*quantity thousand; h_{wi} = 3 RMB/month*quantity;$T_{fsw} = 50$ thousand RMB/batch; $\gamma =$ 1.68; C_{sw} =1000quantity; G_{di}=0.001; Y_i =80 thousand RMB/month; Y_0=88 thousand RMB/month; $L = 0.1$ month; m=0.005; k= 0.4; M_1=1; M_2=0

The numerical problem was taken from [7]. The numerical problem was solved using the algorithm that was proposed. The obtained solution was compared to [7]. The effectiveness of the logistics monitoring is shown in the table below

Table 1. Comparison of the total costs of two common parts in modes 1 and 2.

Parts	**Supply center T_{ci}**		**Direct sendingT_{ci}**		**Optimal IL mode incorporated with logistics monitoring**
	Proposed method	Existing Method	Proposed method	Existing Method	
Ship plate	664.66	679.8	668.166	685.7	Supply center
Prefabricated cabins	1073.4644	1192.4	1044.3	1047.6	Direct sending

2. Conclusion

This paper analyzed two different modes of inbound logistics incorporated with a logistics impact monitor in cruise ship construction. Most often, in logistics incorrect lashing, stuffing, and handling of the container during loading and unloading result in freight damage. Additional relationships within the logistics service will be impacted by it. Significant freight damage has a negative impact on productivity, increases operating expenses, and, most importantly, consumer satisfaction. So in this paper, we have incorporated a logistics impact monitor in the inbound logistics for the construction of cruise ship. Numerical examples were carried out to show the effectiveness of logistics monitoring. There are several restrictions on this article, and future extensions may be conceivable. For example, it assumed the cargo is damaged. This work can be extended by considering the cargo parts are screened and reworked. Additionally the impacts of collaborative transportation will be considered in the future.

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