Optimizing maritime routes: A multi-method analysis from Shanghai to Vladivostok

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Abstract. This research analyzes the marine route plan from Shanghai to Vladivostok utilizing Dijkstra's algorithm, Markov chain analysis, game theory, and congestion analysis. Dijkstra determines the route through Busan and Hungnam as the shortest, with a total distance of 2114 kilometers and minimal travel time. The Markov chain analysis supported the designated path by demonstrating greater transition probabilities compared to other routes, so establishing it as the most probable option. Experts in game theory, particularly on the Nash equilibrium, demonstrated that cooperation significantly reduced operating expenses. Further congestion research corroborated that the Shanghai-Busan-Hungnam-Vladivostok route offers a cost advantage, and even with the inclusion of congestion, the route remains less expensive. The study collectively advocates for the consideration of distance, likelihood, collaboration, and congestion while selecting the optimal maritime route, hence enhancing efficiency in maritime logistics.

Keywords: congestion analysis, dijkstra's algorithm, game theory, maritime route optimization, markov chain analysis.

Received: August 18, 2024; accepted: October 17, 2024; available online: February 4, 2025

DOI: 10.17535/crorr.2025.0007

Original scientific paper.

1. Introduction

The symmetry of directions in maritime transportation is seen significant in today's worldwide context, particularly due to the expansion of many shipping options. The continuous expansion of globalization and market liberalization need effective management of these channels to conserve time, reduce costs, and enhance dependability. Numerous variables provide significant challenges to the shipping sector, including fuel pricing, port size discrepancies, environmental impacts, and political instability, among others. Consequently, several characteristics delineate international freight, necessitating enhancements to optimize its advantages for all parties concerned.

Analyzing route options within an intermodal transport network using mathematical models and game theory is the focus of this study. In order to accomplish a marine route mapping without disturbances, we use Dijkstra's algorithm on the issue graph, do Markov chain analysis on the probabilities, and incorporate aspects of the Nash equilibrium and the prisoner's dilemma. The key channel linking the main East Asian economic players is the maritime route

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between Shanghai (China), Busan (South Korea), Hungnam (North Korea), and Vladivostok (Russia), and this route is the focus of the analysis.

In congestion games, players take turns using shared resources, like roadways, which get more congested as more players join the fray. Specifically, we examine how port congestion in cities like Vladivostok and Shanghai affects shipping route costs using congestion game theory. Each shipping business acts as a participant, influencing his or her cost, due to the congestion at these important ports. This method provides theoretical groundwork for evaluating and controlling the effects of congestion on shipping costs.

For graph-based representations of geographical models, such as transportation networks, Dijkstra is employed for path search in order to discover the best possible route. On the other hand, factors impacting shipping time and expense are involved, therefore there are inherent uncertainties in marine logistics. Markov chain is a method for explaining and evaluating uncertainty that depicts state transfers from one port to another along with the associated probability. Thus, the optimal pathways may be analyzed twice using deterministic and stochastic methods.

The incorporation of game theory into the model enhances and conjugates these domains, as game theory addresses strategic decisions in a competitive setting. Shipping corporations, port authorities, and regulators are all important players, yet they may have conflicting interests. The strategic interactions taking place among marine logistics players can be better understood by analyzing the prisoner's dilemma and the Nash equilibrium. In contrast to Nash Equilibrium, which describes a situation in which no one has any reason to seek change that would be better for them than everyone else involved, the prisoner's dilemma explores the possibilities of coordinated and collective cooperation in divided and conflicting scenarios. This synthesis of approaches tackles several important concerns:

1. How can we adjust or reroute marine routes to account for unpredictable time and money?
2. What impact does this optimization method have on strategic relationships among stakeholders?
3. How might game theory enhance cohesion in marine logistics decision-making?

This research contributes to the literature on fleet route planning by integrating Dijkstra's algorithm, the Markov chain model, and congestion game theory. The study aims to provide more specific recommendations for policymakers and various stakeholders, particularly owners and managers of shipping companies, as well as participants in global commerce engaged in the effective control and optimization of maritime supply chain management.

2. Literature review

Logistics and transportation networks have optimization components, rendering their study a complicated domain that incorporates several mathematical disciplines. The integration of Dijkstra's algorithm, Markov chains, and game theory has significantly enhanced the resolution of route selection issues, particularly in congestion games.

2.1. Dijkstra's algorithm in network optimization

Dijkstra's method, introduced by Dijkstra [5], is a foundational algorithm in graph theory that efficiently determines the shortest path between two nodes in a network. This algorithm has been widely employed in several transportation and logistics scenarios, as well as in maritime and intermodal transportation networks. Route optimization has become essential, particularly in selecting appropriate routes, since this aids in minimizing expenses and transit duration. The algorithm's route selection process is particularly crucial in dynamic scenarios, such as fluctuating congestion and time delays, which are prone to frequent changes.

2.2. Markov chains in dynamic routing

Markov chains provide a stochastic method for evaluating systems that progress across time, where the future state of the system relies solely on the current state, independent of its historical context [6, 7]. Route optimization has employed Markov chains to simulate the stochastic performance of transportation systems, enabling dynamic routing based on current conditions. For example, [10] used Markov models to enhance the traffic management of real-time marine navigation, demonstrating that these models can accommodate the stochastic and dynamic attributes of supply chain networks.

2.3. Game theory and congestion games

Game theory applications, such as Nash equilibrium and non-cooperative games, have proved significant in addressing problems related to route selection and network congestion. In [12], the analysis of strategic interactions inside competitively organized systems in non-cooperative games was conducted, establishing a foundational framework. Congestion games are a subset of non-cooperative games, particularly pertinent in transportation networks when several users use the same connection, resulting in interference and a conflict of interest [11, 9]. [1, 13] presents studies on the evolution of cooperation, while [2] authored a 400-page tome on game theory that elucidates the behaviors of various actors inside these networks. [8] further examines the critique of game theory by emphasizing its relevance to the analysis of network congestion and the rational selection of routes. Recent literature has focused on simulating congestion games in transportation networks using game theory. For example, [3] investigated the use of game theory to enhance route selection in logistics management and analyzed the optimization of maritime routes under uncertainty using game theory. These investigations demonstrate that game theory, particularly congestion games, serves as an effective framework for modeling congestion and offers several mechanisms for its management in transportation systems.

2.4. Integrating techniques

Employing Dijkstra's algorithm in conjunction with Markov chains and game theory guarantees the best selection of routes inside transportation networks. These approaches will facilitate the examination of both deterministic and stochastic attributes of network optimization, taking into account constant and changing variables as well as the interactions between leaders and followers. These strategies synergistically enhance one another, yielding more effective and precise solutions to routing challenges, particularly in congested networks where standard optimization techniques struggle to achieve optimal results[4]. The review of literature on Dijkstra's algorithm, Markov chains, and game theory, particularly in the context of congestion games, illustrates the evolution and use of these techniques in addressing modern transportation challenges. As additional participants enter the market and supply chains get increasingly complex, the capacity to maintain and enhance these strategies will be crucial for optimizing routes.

3. Methodology and data analysis

3.1. Sea ports: distances and traveling time

The study concentrates on enhancing marine connections between Shanghai (China) and Vladivostok (Russia) through essential seaports: Busan in the Republic of Korea, Osaka in Japan, and Hungnam in the Republic of Korea. Commence by gathering comprehensive data on the distance of each port along the maritime corridor from Shanghai (China) to Vladivostok (Russia) at a vessel speed of 10 knots, utilizing credible sources such as marine databases, shipping

logs, and geographic information systems (GIS). This data encompasses the subsequent information. Precise distances between each port pair (e.g., Shanghai to Busan, Busan to Osaka, and Osaka to Vladivostok), assuming a vessel speed of 10 knots. Historical and real-time statistics regarding transit durations and frequency of marine routes connecting these ports. Environmental and operational aspects affecting marine transport, including meteorological conditions and seasonal fluctuations. The nodes are assigned as follows:
Node 1 is Shanghai (China), node 2 is Busan (South Korea), node 3 is Osaka (Japan), node 4 is Hungnam (North Korea), and node 5 is Vladivostok (Russia). The distances and travel durations are displayed in Table 1 and may also be seen in Figure 1.

Paths	Distances (km)	Time(minutes)
$1 \rightarrow 2$	911	3000
$1 \rightarrow 3$	1469	4740
$2 \rightarrow 3$	689	2220
$2 \rightarrow 4$	583	1920
$3 \rightarrow 4$	1187	3840
$3 \rightarrow 5$	1511	4920
$4 \rightarrow 5$	620	2040

Table 1: *Distances in km and time in minutes are calculated.*

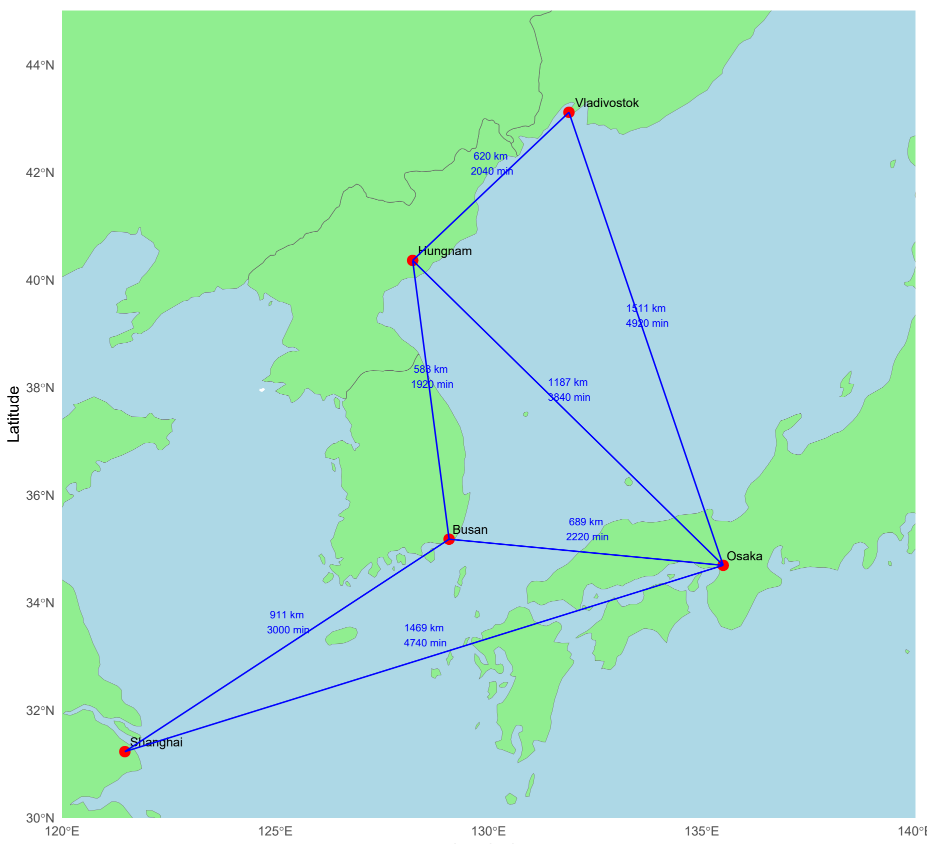

Figure 1: *Map of selected sea ports with their routes.*

4. Dijkstra's algorithm

1. A graph $G = (V, E)$, where V is the set of vertices and E is the set of edges.
2. The direct distance between any two nodes is given and all the distances are non-negative ≥ 0 .
3. In case there is no way of getting from i to j to directly, we set $d_{ij} = \infty$
4. The algorithm proceeds by assigning to all nodes with a label either temporary or permanent.

   Step 0: Node 1 is first designated as permanent and its distance is established at 0, denoted as 0*. Initialize the distances to all other nodes as infinity (∞). Establish a permanent node and include the source node with a priority of zero.

   Step 1: Keep going until either every node has been visited or the shortest path to the target node has been found.

4.1. Markov chain analysis

1. **States**: Establish the states using our methodology as a foundation. In international transportation, for example, states might stand in for various ports or nodes located in different nations (e.g., Shanghai (China) port to Vladivostok (Russia) port).
2. **Transition probabilities:** These denote the likelihood of state transitions. These might be calculated with assumptions or historical data. One might standardize time and distance to articulate probability if inclusion is desired.

   Distance-based probabilities: A potential approach is to convert distances into probabilities (e.g., inversely proportional to distance) when states are ports or nodes, with transitions dictated by the distance separating them. The total equals 1 for each initial node.
   $p_{ij} = \frac{1}{d_{ij}} / \sum_k \frac{1}{d_{ik}}$, where d_{ij} is the distance from node i to node j.

   Time-based probabilities: If changes depend on trip times, turn them into possibilities (for example, in a way that is opposite to time). That adds up to 1 for each node that starts.
   $p_{ij} = \frac{1}{t_{ij}} / \sum_k \frac{1}{t_{ik}}$, where t_{ij} is the travel time from node i to node j.
3. **Normalization:** Make sure that the sum of the chances of moving from one state to another is one. This shows the Markov property, which says that the future state depends only on the present state and not on the events that happened before.
4. **Transition probability matrix:** A matrix shows the chance of each change between any two states in the system. Put these chances into a transition matrix. Each entry p_{ij} in the matrix represents the chance of going from state i to state j. It should be in the i^{th} row and the j^{th} column.

$$P = \begin{bmatrix} P_{11} & P_{12} & \cdots & P_{1j} & \cdots & P_{1k} \\ P_{21} & P_{22} & \cdots & P_{2j} & \cdots & P_{2k} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ P_{i1} & P_{i2} & \cdots & P_{ij} & \cdots & P_{ik} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ P_{n1} & P_{n2} & \cdots & P_{nj} & \cdots & P_{nk} \end{bmatrix} \tag{1}$$

where the cumulative transition probability from state i to all other states must equal 1.

4.2. Game theory application

4.2.1. Modeling stakeholder interactions

To determine the optimal routes for vessels traveling from Shanghai to Vladivostok, we employ game theory. This elucidates how two competing factions determine their course of action. The groupings under consideration are:
Company A: Ensures that deliveries are consistently made on time while slashing operational expenses.
Company B: Increasing Shipping's market share while maintaining peak efficiency is the company's top priority.

4.2.2. Prisoner's dilemma setup

In the prisoner's dilemma, two stakeholders must negotiate their interactions within a specific context. In decision-making, both sides must select one of two potential tactics.
Optimize route (strategy O): Selecting a strategy that prioritizes route optimization facilitates cost and time savings.
Maintain status quo (strategy M): Entails adhering to established pathways and methodologies.

4.2.3. Constructing the payoff matrix

In the realm of stakeholder decision-making, the reward matrix functions as a navigational tool. It illustrates the consequences of various options, particularly for the distance and duration of maritime travel. This is the methodology employed to construct that map:

1. **Define routes and costs:** Establish the routes to pursue and ascertain their associated costs.

   Route 1: The route begins in Shanghai, proceeds to Busan, traverses to Osaka, and ultimately arrives in Vladivostok. The voyage consists of many segments: first from Shanghai to Busan, including 911 kilometers; secondly from Busan to Osaka, adding 1469 kilometers; and lastly from Osaka to Vladivostok, comprising 689 kilometers, resulting in a cumulative distance of 3069 kilometers. The voyage from Shanghai to Busan requires 3000 minutes, followed by an additional 4740 minutes from Busan to Osaka, and lastly 3840 minutes from Osaka to Vladivostok, culminating in a total duration of 11580 minutes.

   Route 2: The route starts in Shanghai, proceeds to Busan, continues to Hungnam, and concludes in Vladivostok. The voyage starts in Shanghai and proceeds to Busan, encompassing 911 kilometers, followed by a segment from Busan to Hungnam, which adds 583 km, and concludes with the leg from Hungnam to Vladivostok, measuring 620 km, resulting in a cumulative distance of 2114 km. The travel from Shanghai to Busan requires 3000 minutes, followed by an additional 1920 minutes from Busan to Hungnam, and lastly, 2040 minutes from Hungnam to Vladivostok, culminating in a total of 6960 minutes.

2. **Determine payoffs:** (Identify benefits) The advantages of route optimization may be succinctly expressed as follows:

   Operational cost savings: Achieving savings by reducing distances and time.

   Competitive advantage: Enhancing market share and efficiency through optimized routes.

Stakeholder B / Stakeholder A	Optimize route (O)	Maintain current approach (M)
Optimize route (O)	(Cost1, Advantage1)	(Cost2, Advantage2)
Maintain current approach (M)	(Cost3, Advantage3)	(Cost4, Advantage4)

Table 2: *The payoff matrix.*

where

Cost i; $i = 1, 2, 3, 4$ represent costs linked to route choices.
Advantage j; $j = 1, 2, 3, 4$ signify changes, in advantages or market share.

4.2.4. Analyzing equilibrium

A Nash equilibrium is determined to uncover stable strategies in which neither party can enhance their payout by unilaterally altering their policies. This study pertains to the identification of equilibrium points: What are the most probable tactics for each stakeholder? The impact of these tactics on the optimization of weights and dimensions in curricula, together with their competitive positioning.

4.2.5. Strategic implications

1. **If both companies optimize routes:** Compare cost savings of two companies with/without joint optimization of routes.
2. **If both maintain status quo:** Evaluated impact of need to continue depending on established routes.
3. **Mixed strategies:** In cases when one firm optimizes and another stays the same, what changes or responses may be possible.

4.3. Congestion game theory

A congestion model scenario with several participants, including various shipping businesses, that share restricted resources like port facilities. This study focuses on the impact of congestion on the cost structures of each participant and how these costs influence route selection. In the context of transportation routes between ports, each route functions as a participant. The participants may choose their routes, with certain ports perhaps experiencing congestion while others do not. The primary resources for pooling, as perceived by stakeholders, are the port capabilities of Shanghai, Busan, Osaka, Hungnam, and Vladivostok. The utilization of a shared port is marked by congestion, resulting in increased costs. Each participant or shipping business choose their best route from Shanghai to Vladivostok, considering the congestion conditions at the ports. Strategies encompass choosing routes that reduce congestion at ports or alternatively accepting the expenses associated with overloaded ports. The payoff for each participant is contingent upon the cumulative marine cost, the port service costs, and the congestion cost associated with the selected route. The cost function for player i traversing route r is defined as:

$$C_i(r) = c_{\text{maritime}} \times d_r + \text{Port Fees}_r + \text{Congestion Cost}_r \tag{2}$$

where

c_{maritime} = Cost per nautical mile
d_r = Distance of the route (in nautical miles)
Port Fees_r = Handling and other port charges
Congestion Cost_r= Additional cost due to congestion at ports along the route.

The congestion cost of the ports is determined by assessing the average number of users that engage with the respective port. As other players select the same port, the congestion fee increases. This is executed in a way analogous to the preceding example, whereby a function delineates the impacts of congestion, which elevate delays and operational costs inside the system. For instance, if k players utilize port j, the congestion cost Congestion Cost_j may be represented as:

$$\text{Congestion Cost}_j = \alpha \cdot k_j \tag{3}$$

where
α = Congestion factor (a constant representing the increase in cost per additional player)
k_j = Number of players using port j

5. Result and discussion

5.1. Dijkstra's algorithm

Identify the most efficient and quickest maritime route between the ports of Shanghai and Vladivostok, considering distances and transit durations. The most direct route, spanning 2114 km, was determined using Dijkstra's algorithm to go from Shanghai to Vladivostok via Busan and Hungnam. The algorithm's deterministic method efficiently calculated the minimal distances between nodes, providing a key tool for route selection.

1. Shortest path from China to Russia: [Shanghai (China) → Busan (South Korea) → (Hungnam) North Korea → Vladivostok (Russia)] The distances traveled from other communities are 911 km, 583 km and 620 km, collectively 2114 km, with vessel speed, 10 knots. The time traveled from other communities are 3000 minutes, 1920 minutes, 2040 minutes, and collectively 6960 minutes, with vessel speed, 10 knots.

2. Alternative path from China to Russia: [Shanghai (China) → Osaka (Japan) → Vladivostok (Russia)] The distances traveled from other communities are 1469 km, and 1511 km, collectively 2980 km, with vessel speed, 10 knots. The time traveled from other communities are 4740 minutes and 4920, and collectively 9660 minutes, with vessel speed, 10 knots.

5.2. Markov chain analysis

We employed Markov chain analysis to examine transition probabilities between nodes (sea ports) and to determine the most probable path from Shanghai to Vladivostok, incorporating stochastic elements into our route selection process. This is based on the unequivocal findings obtained via Dijkstra's method. We determined the probability of transitioning from one location to another utilising historical data and shipping information. This provided us with a serendipitous perspective on identifying the optimal path. The principal conclusions from the Markov chain research, which presents the distance-based probabilities transition matrix P, are as follows:

$$P = \begin{bmatrix} 0 & 0.617 & 0.383 & 0 & 0 \\ 0 & 0 & 0.470 & 0.530 & 0 \\ 0 & 0 & 0 & 0.890 & 0.110 \\ 0 & 0 & 0 & 0 & 1.00 \end{bmatrix} \tag{4}$$

This matrix displays the likelihood of transitioning from one state to another in a Markov chain. All probabilities in the row total to 1 (or to the input probabilities if some internal states lack complete transition sums), indicating that the probabilities are appropriately normalised. Ultimately, from a practical perspective, it facilitates the computation of transition probabilities in decision-making, route selection, and forecasting the system's future state. The most likely route may be characterised as the path where each transition between states has the highest likelihood of happening, with a vessel speed of 10 knots.
Shanghai (China) → Busan (South Korea) → (Hungnam) North Korea → Vladivostok (Russia)
with probabilities: $p_{12} = 0.617$, $p_{24} = 0.530$, $p_{45} = 1.000$, the total product probabilities = 0.3270, and time-based probabilities transition matrix P:

$$P = \begin{bmatrix} 0 & 0.612 & 0.388 & 0 & 0 \\ 0 & 0 & 0.463 & 0.537 & 0 \\ 0 & 0 & 0 & 0.562 & 0.438 \\ 0 & 0 & 0 & 0 & 1.00 \end{bmatrix} \quad (5)$$

The most likely path is characterised by transitions between states that exhibit the highest chance of occurrence. The most probable path is
Shanghai (China) → Busan (South Korea) → Hungnam (North Korea) → Vladivostok(Russia)
with probabilities: $p_{12} = 0.612$, $p_{24} = 0.537$,$P_{45} = 1.000$, and the total Product probabilities = 0.32

5.3. Game theory analysis

This research aims to establish an academic basis for assessing route optimisation options through the use of prisoner's dilemma game theory, with the strategic actions of two stakeholders (shipping company A and shipping company B) as rationale. The stakeholder's strategies are: (i) Optimize route (O) (implement advanced optimization techniques), and (ii) maintain status quo (M) (continue with existing routing practices).

	Shipping Co. B: Optimize (O)	Shipping Co. B: Maintain (M)
Shipping Co. A: Optimize (O)	(2000, 2000)	(2500, 2200)
Shipping Co. A: Maintain (M)	(2200, 2500)	(2700, 2700)

Table 3: *The payoff matrix.*

Payoffs are expressed in USD, while operating expenses are assessed for each strategic combination. The essence of Nash equilibrium is in the mutual selection of optimization strategies by both parties involved. This yields the minimal operational expenses, with each side receiving 2000 USD. Neither stakeholder has a rationale to choose an alternative approach, since the ideal joint optimization plan provides the most advantageous cost structure, improves market positioning, and facilitates a reduction in total operating expenses.

5.4. Congestion game analysis

This section analyses the congestion game for the two alternative marine routes from Shanghai (China) to Vladivostok (Russia). The research examines the idea of overall costs, encompassing marine transport costs, port handling expenses, and congestion costs.
Route 1: Shanghai (China) → Osaka (Japan) → Vladivostok (Russia).

Route 1	Distance (km)	Distance (nautical miles)	Maritime cost (€)	Port handling (€)
Shanghai to Osaka	1,469 km	794 miles	1,588	400
Osaka to Vladivostok	1,511 km	816 miles	1,632	550

Cost component of route 1	Amount (€)
Total maritime cost	3,220
Total Port handling cost	950
Total cost without congestion	**4,170**
Congestion cost (10%)	417
Total cost with congestion	**4,587**

Table 4: *Distance, time, and cost calculations for Shanghai-Osaka-Vladivostok route.*

Route 2: Shanghai (China) → Busan (South Korea) → Hungnam (North Korea) → Vladivostok (Russia).

Route 2	Distance (nautical miles)	Maritime cost (€)	Port handling (€)
Shanghai to Busan	491 miles	982	450
Busan to Hungnam	315 miles	630	350
Hungnam to Vladivostok	335 miles	670	550

Cost component of route 2	Amount (€)
Total base maritime cost	2,282
Total Port handling cost	1,350
Total cost without congestion	**3,632**
Congestion Cost (10%)	363.20
Total cost with congestion	**3,995.20**

Table 5:*Distance, time, and cost calculations for Shanghai-Busan-Hungnam-Vladivostok route.*

A congestion game aims to assess the overall expenses associated with two distinct marine routes from Shanghai (China) to Vladivostok (Russia). The total expense of marine transport is thus determined by maritime transport costs, port management costs, and congestion costs.
Route 1: Shanghai (China) → Osaka (Japan) → Vladivostok (Russia).

The distances between the stops on the Shanghai-Osaka-Vladivostok route are 1,469 km, while those on the Osaka-Vladivostok-Shanghai route are 1,511 km.The total marine cost amounts to €3220, with the port handling cost being €950. The aggregate expense excluding congestion is €4,170. With the inclusion of a 10% congestion cost of €417, the total cost with congestion increases to €4,587.
Route 2: Shanghai (China) → Busan (South Korea) → Hungnam (North Korea) → Vladivostok (Russia).

The distances for the Shanghai-Osaka-Vladivostok route are 1,469 km, while the Osaka-Vladivostok-Shanghai route measures 1,511 km.The total marine cost amounts to €3220, while the port handling fee is €950. The aggregate expense excluding congestion amounts to €4,170. With the inclusion of a 10% congestion fee of €417, the total cost with congestion increases to €4,587.

This research indicates that Route 2, which has more port handling stops, is less expensive than Route 1, including both direct expenses and congestion considerations. The effectiveness study findings encompass the relative efficiency of marine routes between Shanghai and Vladivostok, utilizing Dijkstra's algorithm, Markov chain analysis, game theory, and congestion game analysis. These findings align with Dijkstra's shortest path between Busan and Hungnam, as well as the Markov chain exhibiting a high transition probability for this particular route. From a game theory viewpoint, it may be noted that cooperation in optimizing work routes can lead to a significant reduction in operating expenses; the Nash equilibrium demonstrates that all parties benefit. Analysis of congestion games reveals that, despite the greater number of ports serviced along the Shanghai-Busan-Hungnam-Vladivostok route compared to the Shanghai-Osaka-Vladivostok route, its congestion costs are relatively lower. This focus highlights the need of utilizing distance, likelihood, cooperative approach, and congestion variables as criteria for route selection.

6. Conclusion

The examination of marine routes from Shanghai to Vladivostok, using Dijkstra's algorithm, Markov chain analysis, game theory, and congestion game analysis, indicates a preference for the Shanghai-Busan-Hungnam-Vladivostok route. This route provides the shortest distance, higher transition probabilities, and reduced overall cost when accounting for congestion. Strategies from cooperative game theory are employed to enhance efforts in maintaining cost efficiency and presenting evidence that demonstrates effective optimization as a means of reducing costs. Consequently, the designated route of Shanghai-Busan-Hungnam-Vladivostok is crucial for players seeking to achieve operational and economic improvements in marine logistics.

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