Optimizing Logistics System to Serve Vietnam's Rice Export Strategy

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Abstract

Vietnam is a country with strengths in agricultural production, rich and valuable agricultural products. Vietnam is often described as a giant boom with two big granaries at both ends, the Red River Delta and the Mekong Delta. Besides, the appropriate weather and climate conditions and fertile soil have created an ideal environment for rice production, thereby making rice a strong export item for Vietnam. In order to boost export rice output, the role of the transport and logistics system is very important. If the transport system is equipped and linked together, it will create added value for the components of the system, while reducing transport costs, warehousing costs, distribution, and circulation, ... increase farmers' income, profits for businesses, create great export value for the country. One of the most important tasks to achieve this goal is to optimize Vietnam's rice export system. This issue is always urgent, not only for the executive agency, macro-management of the State but also for organizations, businesses, ... involved in the production and export of rice. This paper focuses on analyzing and assessing the current situation of Vietnam's export rice transport system and forecasting the future in each period. From there, select the basic parameters (or criteria) to build the optimal export rice transport system. The author has built a general and specific model for 02 transshipment scenarios including scenario 1 is Saigon port, scenario 2 is Saigon port and Can Tho port. The core of the paper is a detailed calculation with 05 options for each scenario, based on the selected basic parameters, with the LINGO 13.0 FOR WINDOWS software. From there, identify and select the most optimal plan for Vietnam's export rice transport system in general and the Mekong Delta in particular.

Keywords: transport system, logistics, rice export strategy, Mekong Delta, Vietnam

1. Introduction

Transport is a human-purpose economic activity that aims to change the position of goods and people from one place to another by means of transport. In the field of commercial business, transport plays an important role. In the field of commercial business, transport plays an important role, because trade means that the goods are changed from owner to owner, while transport makes the goods change position (Hanssen, Mathisen, & Jørgensen, 2012). In addition, transport links economies, bridging the gap in geographical space, in order to reduce costs, reduce product costs, promote trade development, create benefits for producers, consumers, and society. Therefore, transport plays a vital role in the economy, promoting economic development (X. Phuong & Pham, 2019).

Freight transport is the movement of goods in space by human force or means of transport in order to fulfill the requirements of purchase - sale, reserve during production - business activities, from a management point of view logistics (Tavasszy & De Jong, 2013). The biggest characteristic of the transport industry is service, ensuring that other material manufacturing industries operate normally. The manufacturing process of the transport industry does not change the physical and chemical properties, but only the location of the employees, to create products (Nguyen, 2020). Transport does not create new products, it only adds to the value of the goods being transported, or satisfies the needs of passengers traveling in space (Lankhuizen, Boonstra, & de Blois, 2020).

Rice is an essential commodity for human life. Rice is not only a purely commercial product but also has political implications (national food security, socio-political stability, job security and livelihoods for farmers in many countries) (Busato & Berruto, 2016). In addition, rice is a separate commodity. In export, the packaging is necessary and not complicated. Rice cargoes are bulk cargoes, when transporting rice cargo by means of transport, carried out in the form of separate packaging (25 kg/bag and 50 kg/bag), or containers containing sacks of rice. Because the goods are packed, easily torn, broken during loading and unloading at the ports, it must be done in accordance with the agreed process of the parties, clearly stating the conditions of loading and unloading, storage conditions. and sign the contract of transportation (Nguyen Thi, 2017). Rice products are easily hygroscopic, easy to cause mold, during

transportation, especially on long-term international maritime routes by ships, the rice must be arranged in accordance with regulations and carefully lined to ensure the ability ventilation of goods, avoid sweating and spraying as required by the contract and the competent authorities. Means of transportation must ensure clean, clean cargo hold, watertight cargo hold (Baiju Radhakrishnan, Totakura Bangar Raju, 2019). Do not line other goods in the same cellar as rice to avoid contamination of the goods. The system of rice export transport plays an important role in the national economy. This system is equipped and linked together in a synchronized manner, which creates added value for the components of the system, reduce freight charges, increase income for farmers, and benefit profits for businesses, creating large export value for the country (Cosslett & Cosslett, 2018; Siddiqui & Parikh, 2018).

The export rice transport system in Vietnam is a stage (or one process) of the export rice supply chain with the set of closely related basic parameters (input factors) which includes volume, market, means, route, system of domestic and international seaports and inland ports, freight charges, ... to transport rice from Vietnam to the import country, ensuring the goal of total transport cost is minimized (output factor) (Wattanutchariya & Kuaites, 2017). Figure 1 shows the main activities of the transportation system for rice export and is interpreted as follows: (1) Rice from the warehouse is transported to the export warehouse through transport system by road, inland waterway, railway, or a combination of these methods (Bonnin & Turner, 2012). (2) Rice from the export warehouse is loaded onto the ship to transfer to the import warehouse, through the above-mentioned transport system, the rice is delivered to the place of purchase according to the contract signed (Chapman & Darby, 2016). Activities and modes of transport are quite complex with many participants, resulting in many intermediary and ineffective activities. These shortcomings have required rice export managers to have effective solutions to optimize the transport or logistics system for rice export. Recent studies suggest that the optimum of the logistics system for rice exports is to develop a rice transport plan so that freight rates are lowest and reflect relationships with other factors such as mean of transportation, routes, loading and unloading port (Azwa, Rosni, Saiful, & Saadon, 2019). In order to propose a plan to export goods by whatever means that is both safe and economical, it is necessary to study the transport system based on region characteristics in country and region experiences around the world in accordance with the means of transport. According to this approach, the actual transport system over the world can be divided into regions as shown in Table 1.

Table 1. Area, type and means of transport

Region	Area	Type of transport	Type of vehicle
1	Inter - Regional	Ocean transportation	Vessel
		Aviation transportation	Air plane
2	Short sea	Coastal shipping	Vessel; river-going ships; sea ferry
3	Land	Transport of rivers and canals	River ship; barge; transport boats.
		Trucking	Truck
		Rail transportation	Train

The development of science and technology has strongly promoted the development of the shipping industry. The economic problems of the shipping industry, which need to process a fairly large amount of information, in order to find an optimal plan out of the possible alternatives (Hoang Phuong, Minh Tuan, & Minh Tuan, 2019). If shipping companies, based on their work experience, it will be difficult to get the optimal solution for economic problems. Economic mathematical models are established based on mathematical tools and specialized modeling software (Bazan, Jaber, & Zanoni, 2016). Building an appropriate and strict economic math model can find the optimal solution of the economic problem. The transport problem model is considered as an outstanding economic math model because it is a good tool to optimize the freight transport system. The study of the problem of optimizing the export rice transport system of Vietnam has always attracted interest from organizations, economists and researchers (N. H. Phuong, 2019).

The purpose of the study is to optimize the export rice transportation system in Vietnam. To achieve this goal, the authors perform the following tasks: (1) Study to build a theoretical basis for optimizing the export rice transport system. (2) Analyzing and assessing the current situation of export rice transport system in Vietnam and forecasting turnover and method of transporting exported rice in the future by period. Next, select the basic parameters (or criteria) to build the optimal export rice transport system from the theoretical basis and aggregated data. (3) Research and develop the optimal export rice transport system in accordance with Vietnamese practices. They are setting up a

general model of export rice transport system, also building a specific model for each case of the export rice transport system, and establishing a mathematical model, calculating and selecting the optimal plan for each specific case of the model of the rice export transport system.

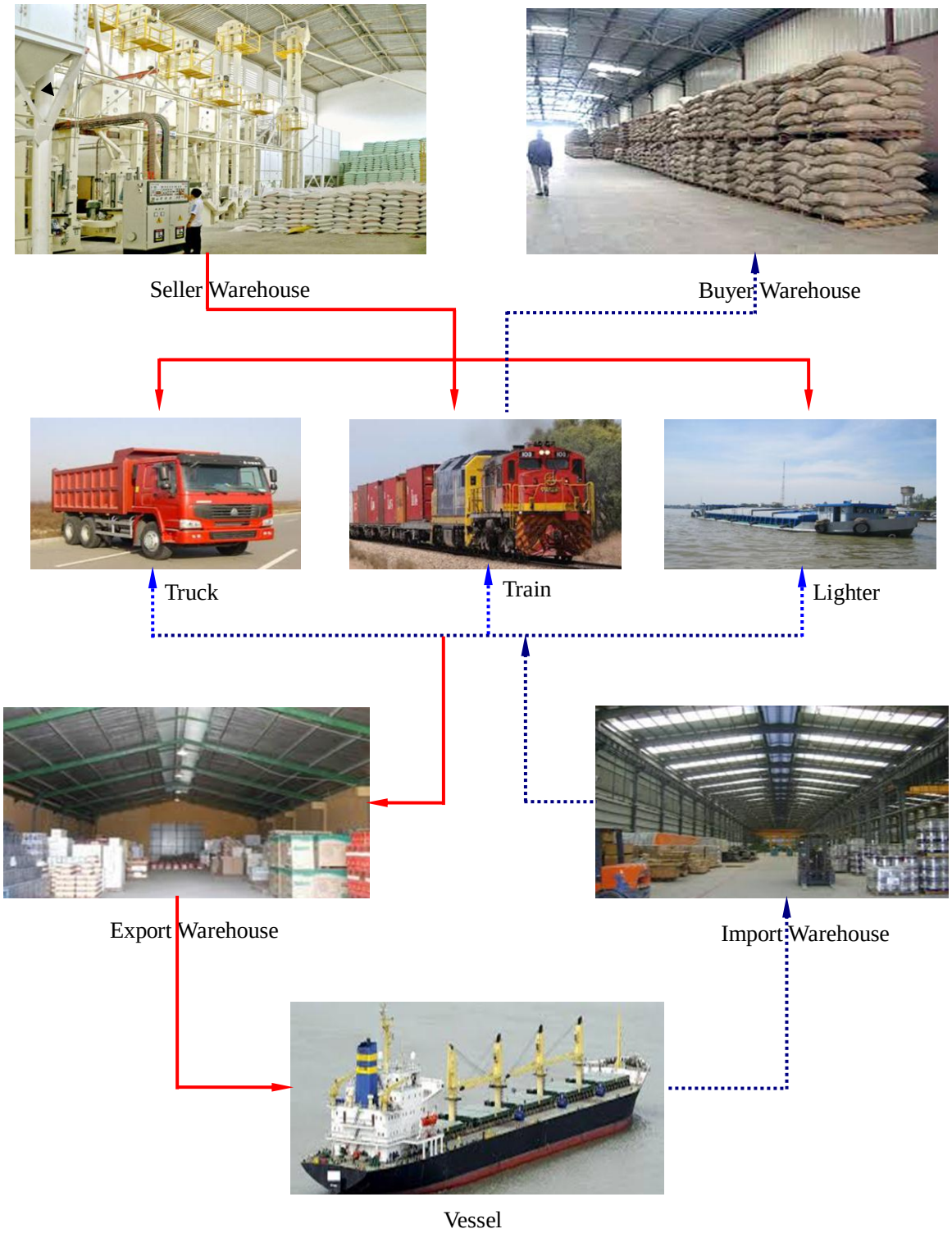

Figure 1. Activities of the rice export transport system

2. Materials and Methodology

In the shipping industry, there is often the optimal type problem, when among the options of using technical means or other reserve resources to find the most optimal plan, these problems often have the objective function. Extreme is the smallest or the greatest. The objective function in shipping is expressed by economic indicators, reflecting the results of activities such as the lowest transportation cost, the largest shipping capacity of the fleet, the large handling equipment. Mathematical planning is a theoretical basis for solving the problem of finding the extreme of the target function. General rationale for transport problems to optimize Vietnam's rice export system includes the theory of optimal transport problems, mathematical models and parameters of rice export problems.

2.1 General Basis of Transport Problems

Suppose there are m points of production with a mass of goods an and n points of consumption of a mass of goods being b, then in a unit of time the quantity of supply and demand is equal (Caris, Macharis, & Janssens, 2008)

$$\sum_{i=1}^{m} a_i = \sum_{j=1}^{n} b_j \tag{1}$$

Called $X_{ij} \geq 0$ is the quantity of goods and C_{ij} is the freight per unit of freight from point i to point j.

Requirement of the problem: Find a solution to transport the goods so that the transportation cost is minimal, that is:

$$z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij} X_{ij} \quad \rightarrow \ Min \tag{2}$$

With constraints:

$$\sum_{j=1}^{n} X_{ij} = a_i \,,\ i = 1 \rightarrow m \quad ; \quad \sum_{i=1}^{m} X_{ij} = b_j,\ j = 1 \rightarrow n$$
$$\text{with} \quad X_{ij} \geq 0, i = 1 \rightarrow m;\ j = 1 \rightarrow n \tag{3}$$

This is the common basis of the transport-demand balancing problem, also known as the transceiver balance transport problem.

2.2 Applying Transport Problems to Optimize Vietnam's Export Rice Transport System

2.2.1 1-Stage Transport Problems

Suppose to plan to transport rice from m the place of shipment is: A_1, A_2, ... A_m to n place of receipt is B_1, B_2, ... B_n. The amount of rice to be sent from A_1, A_2, ... A_m, respectively, is a_1, a_2, ... a_m; The corresponding amount of rice received in B_1, B_2, ... B_n is b_1, b_2, ... b_n. Let C_{ij} be the freight for one unit of goods from the place of rice loading i $(i = 1 \rightarrow m)$, to the port of export j $(j = 1 \rightarrow n)$. Planning the transportation of goods from the loading point to the port of export for the lowest total transport costs. Let X_{ij} be the number of goods transported from the place of goods i $(i = 1 \rightarrow m)$, to the port of export j $(j = 1 \rightarrow n)$. Equation (4) is a general mathematical model of the 1-stage transport problem.

$$z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij} X_{ij} \quad \rightarrow \ Min \quad ; \text{ with } \sum_{j=1}^{n} X_{ij} = Q_i \,,\ i = 1 \rightarrow m \text{ and } \sum_{i=1}^{m} X_{ij} = Q_j,\ j = 1 \rightarrow n$$
$$X_{ij} \geq 0, i = 1 \rightarrow m;\ j = 1 \rightarrow n \tag{4}$$

For the transport problem to find a condition to identify whether there is an optimal plan, it is the condition that the sum of the exports is equal to the total of imports, or satisfies Equation (5). Using the optimal search algorithm for the problem of transporting rice exports in Vietnam.

$$\sum_{i=1}^{m} Q_i = \sum_{j=1}^{n} Q_j \tag{5}$$

2.2.2 Multi-Stage Transportation Problem

The model of the multi-stage transportation problem has the form as Equation (6) (Barbarosoğlu & Arda, 2004).

$$z = \sum_{i=1}^{m}\sum_{j=1}^{n} C_{ij} X_{ij} + \sum_{j=1}^{n}\sum_{l=1}^{k} C_{jl} X_{jl} + \sum_{l=1}^{k}\sum_{k=1}^{p} C_{lk} X_{lk} \quad \rightarrow Min \tag{6}$$

With condition is:

$$\sum_{j=1}^{n} X_{ij} = Q_i, i = 1 \rightarrow m \; ; \sum_{l=1}^{k} X_{jl} = Q_j, \; j = 1 \rightarrow n \; ; \sum_{k=1}^{p} X_{lk} = Q_k, l = 1 \rightarrow k \; ; X_{ij} \geq 0, \; \forall i, j, k$$

Therefore, based on the mathematical model in Equation (6) of the multi-stage transport problem, the scope of application in this study is the export rice transport system of Vietnam, implemented in the Me Kong Delta with two stages in transport by inland waterway and sea, specifically: (1) In the first stage, exported rice is transported from inland ports to ports in Saigon and / or Can Tho. (2) In the second stage, exported rice is transported from the gathering port in Saigon and / or Can Tho to the rice importing countries of Vietnam.

With the research terms, for convenience in choosing a port name for building an export rice transport system model, the authors choose the name of Saigon port as the common name for the cluster of ports in Ho Chi Minh city. Export rice transshipment ports can be: Hiep Phuoc, Tan Cang, Ben Nghe, Khanh Hoi, Nha Rong, Nha Be, ... depending on the transport contract, similar to Can Tho port cluster is Cai Cui port or Hoang Dieu port. Moreover, the content of the study does not mention the process of rice production, types of export rice, seasons, rice processing, export prices, raw material areas, rice collection process, ... of enterprises or individual sellers, responding to the modeling of transport problems and conditions, the authors used LINGO 13.0 FOR WINDOWS as a research tool to solve the optimal problem of export rice transport system in Vietnam.

2.3 Basic Parameters Constitute the Export Rice Transport System

The export rice transport system of freight depends on various parameters. Moreover, the parameters in model can change about relationships according to space, time, location, habits and environment, ... However, within the scope of the study is derived from the concept of export rice transport system, combined with the multi-stage problem according to Equation (6). The authors have selected the basic parameters that constitute the export rice transport system in Vietnam, they are the input factors of the system. These parameters include (1) Volume of export rice; (2) Rice importing market; (3) Rice importing country; (4) Methods and means of transport; (5) Routes; (6) Domestic and international seaports and inland ports; (7) Freight for transporting 1 ton of domestic and international rice for export.

On the other hand, relationship of parameters is closely and dialectical, which means that there is mutual support. As such, the good handling of input parameters to achieve system operation efficiency is appropriate to the user perspective and practical conditions. Specifically, the relationship of these parameters is as follows: (i) To establish an export rice transport system, an important and prerequisite factor is to have the volume of exported rice, which depends on many factors, such as crop, weather, soil, cultivated area, rice varieties. Within the scope of the study, the direct influence of these factors is not considered, authors carry out comprehensive research, statistics and detailed evaluation of the export volume of rice in different stages in a region. Moreover, to ensure a stable and sustainable rice export system depends on many objective and subjective factors. In particular, in the trend of integration and many countries have exported rice and rice imports. Therefore, one of the fundamental factors is the choice of market and country where import rice in Vietnam. (ii) Rice production and export in Vietnam, mainly in the Mekong Delta, with natural features of the region, mainly intermittent systems of rivers and canals. Therefore, the inland waterway transport system is very developed, especially transport routes. On this basis, on the one hand, dragging the means of transport in general and the export of rice in particular, mainly barges, river ships, and river-phase seagoing vessels, in order to suit transport routes. On the other hand, it is the planning of the domestic port system of

the region, ensuring the inheritance and conformity with reality, promoting efficiency during the exploitation process.

The analysis, evaluation, and selection of parameters including modes of transport, transport routes, port systems are important and imperative to set up optimal export rice transport systems. The freight of 1 ton of rice exported domestically and internationally is very high aggregate and competitiveness parameter. Because freight is constantly changing, a variable quantity, and depend on many factors, especially sensitive to the fluctuations of the world trade market. Therefore, it is relatively difficult to predict freight rates, including exported rice, with certain errors. Based on these input parameters, the research team built a mathematical model to calculate the optimal plan for Vietnam's export rice transport system, ensuring the goal of total transport costs is the smallest, which is the output parameter of the system. Finally, authors determine and select the basic parameters, to build the export rice transport system in Vietnam by 2025 and the period of 2025-2035, ensuring the most optimal. The authors performed detailed analysis, evaluation and selection of 7 basic parameters, summarized as follows: (1) *Selection of forecasting parameters of Vietnam's export rice volume*: Average of 7.5 million tons/year by 2025, 8.5 million tons/year by 2025 and 9.5 by 2035 million tons/year. (2) *Selection of rice export market parameters*: By 2025 and the period of 2025-2035, rice export markets of mainly Asia and Africa. The total volume of rice exported to these two continents could reach over 90%. (3) *Selection of rice importing countries*: For the Philippines and Indonesia, it is forecasted to increase by an average of 3 million tons/year by 2025; 4 million tons/year by 2030 and by 2035, increase by 5 million tons/year. For Nigeria (or Ivory Coast close to Nigeria), an average increase of 1 million tons/year by 2025; 1.2 million tons/year in 2030 and by 2035 increase 1.5 million tons/year. Thus, the total volume of Vietnam's rice exports to three selected countries is the Philippines, Indonesia, and Nigeria, an average of 4 million tons/year by 2025, an average of 5.2 million tons/year by 2030 and reach 6.5 million tons/year by 2035. (4) *Select parameters of waterway route, with the following three routes*: Route 1: Saigon - Kien Luong (via Sa Dec - Lap Vo Canal) accounting for 60.87%; Route 2: Saigon - Ca Mau (via Xa No canal) accounting for 29.42%; Route 3: Saigon - Kien Luong (via Thap Muoi canal) accounts for 9.71% of the rice volume for export transport of the Mekong Delta. (5) *Selection of parameters for exporting rice transport means*: For means of transport by inland waterway, using barges with a tonnage of 500 tons - 1,000 tons, river ships with a tonnage of 1,000 tons - 3,000 ton; For international sea transport means, using ships with a tonnage of 5,000 tons - 20,000 tons (the Philippines and Indonesia market shall select a fleet of ships of between 5,000 tons and 10,000 tons or from 10,000 tons to 20,000 tons.; Nigeria market selected fleets with a tonnage of 10,000 tons - 20,000 tons). (6) *Selection of parameters of loading and unloading port for export rice*: For the case where the port of loading is Saigon, select the five main ports of Can Tho, My Thoi, Vinh Long, My Tho, and Sa Dec. For cases where the port of loading goods is at the same time two ports of Saigon and Can Tho (when Quan Chanh Bo canal is put into operation, the canal is completed in 2020 when the large ships of 10,000 - 20,000 tons can directly via this channel to Can Tho port) choose 5 main ports: My Thoi, Vinh Long, My Tho, Sa Dec, and Ham Luong. (7) *Currently, the selection of freight parameters for Vietnam's export rice exports* is described in detail in Table 2.

Table 2. Freight of 1 ton of rice between domestic and foreign ports (USD / ton)

Port	My Thoi	Vinh Long	My Tho	Sa Dec	Ham Luong	Sai Gon	Can Tho
Jakarta	23,55	23,75	22,15	22,60	23,80	24,50	24,10
Manila	24,75	25,75	24,05	24,80	24,85	26,15	26,00
Lagos	40,65	38,95	38,45	38,85	39,60	41,95	41,85
Sai Gon	11,75	11,85	11,55	11,82	11,90	-	11,70
Can Tho	11,05	11,60	12,50	11,12	13,20	11,70	-

3. Experimental Set Up

Calling rice export ports in Vietnam is EX1, EX2, ... EXm. Calling for Vietnam's rice imports ports is IM1, IM2, ... IMn. Saigon port (and / or Can Tho Port) is the last port to consolidate rice cargo (transshipment port) for export by the sea called TP_1. While: n, m, l are positive integers. The general model of export rice transport system in Vietnam is shown in Figure 2. From the general model of Figure 2, authors continue to build a model of export rice transport system in Vietnam into two seniors with *Scenario 1: The port of consolidation (transshipment) of Vietnam's export rice is Saigon; Scenario 2: The port of consolidation (transshipment) of Vietnam's export rice is Saigon and Can Tho.*

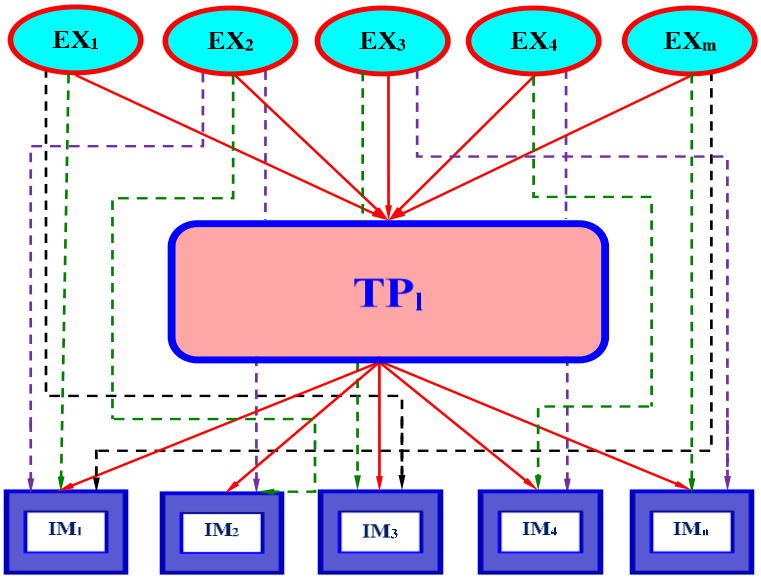

Figure 2. The general model of export rice transport system in Vietnam

3.1 Scenario 1

Rice exported from the Mekong Delta provinces via selected transshipment ports in this area, focusing on the main port of consolidation is Sai Gon. It is then transported to selected Vietnamese rice importing countries. Specifically, rice exported from Vietnam to import countries (Philippines, Indonesia, and Nigeria) not be directly transported from Can Tho, My Thoi, My Tho, Vinh Long and Sa Dec ports in Vietnam. Because of the characteristics of the area's natural conditions, the channel of the channel is often deposited by silt, sand, ... causing shallow phenomenon (especially Dinh an estuary on the Hau Giang river route to Can Tho port). Therefore, ships of about 10,000 tons or larger are not able to travel on transport routes to enter these ports. Figure 3 describes in detail the model of Vietnam's export rice transport system by scenario 1.

Figure 3. Model of Vietnam's export rice transport system with Saigon transshipment port

3.2 Scenario 2

Scenario 2 establishes Vietnam's export rice transport system from 2025 onwards. Because, by the beginning of 2020, the Quan Chanh Bo canal system was completed. Therefore, large tonnage ships from 10,000 tons fully loaded to 20,000 tons reduced load, convenient to enter and exit Hau Giang river route to Can Tho port, without going through the Dinh a regular channel of sedimentation. Figure 4 describes in detail the model of Vietnam's export rice transport system by scenario 2. In this scenario, Vietnam's export rice goods, through inland ports, were selected, namely: My Thoi, My Tho, Vinh Long, Sa Dec, and Ham Luong, and two transshipment ports are Sai Gon and Can Tho. After that, it is stuffed the ship at Can Tho port and Saigon port, to transport by sea to the rice importing country of Vietnam.

Figure 4. Model of Vietnam's export rice transport system with Saigon and Can Tho transshipment port

3.3 Setting up an Optimal Generalized Mathematical Model for Export Rice Transport System in Vietnam

Based on the mathematical model in Equation (6) of the multi-stage transportation problem, it is possible to formulate and set up a general mathematical model of export rice transport system in Vietnam with the two stages. The coefficients, parameters and conditions of the mathematical model are set as follows: *(i)* There are m rice export ports of Vietnam, these ports are designated as EX_1, EX_2, ..., EX_i ..., EX_m with the volume of exported rice at EX_i port is Q_i (ton); *(ii)* There are n foreign rice import ports and their symbols are IM_1, IM_2, ..., IMj, ..., IM_n, with the volume of imported rice at IM_j port is Q_j (ton). *(iii)* There is a port for gathering (transshipment) of exported rice for transshipment from Vietnam to foreign countries, symbolized as TP_1, TP_2, ..., TP_k, ..., TP_l. *(iv)* The cost of transporting 1 ton of rice from the EX_i port to the TP_i port is C_{ik}. *(v)* The cost of transporting 1 ton of rice from the TP_i port to IM_j is C_{kj}. *(vi)* Calling for export EX_iTP_k is the amount of rice (tons) to be transported from the EX_i rice export port to the TP_k rice transshipment port. *(vii)* Calling TP_kIM_j the amount of rice (tons) to be transported from the TP_k rice transshipment port to the IM_j rice import port. The objective of the problem is to find the values of X_{ik} and X_{kj} so as to minimize transport costs. This problem model has a general form in Equation (7), (8) and (9).

$$z = \sum_{i=1}^{m}\sum_{k=1}^{l} C_{ik}.EX_i TP_k + \sum_{k=1}^{l}\sum_{j=1}^{n} C_{kj}.TP_k IM_j \rightarrow Min \qquad (7)$$

$$\sum_{k=1}^{l} EX_i TP_k = Q_i, i = 1 \to m; \sum_{k=1}^{l} TP_k IM_j = Q_j, j = 1 \to n; \quad (8)$$

$$\sum_{j=1}^{n} TP_k IM_j - \sum_{i=1}^{m} EX_i TP_k = 0, k = 1 \to l; \quad (9)$$

$$EX_i TP_k, TP_k IM_j \geq 0, \text{ with } i, j, k$$

The general mathematical model in Equation (7), the objective function z is the total transport cost of the rice transport system exported from Vietnamese ports to abroad import ports, ensuring that is the smallest. With the general mathematical model (7), authors set up a specific mathematical model, to apply to each of the two scenarios mentioned above. From there, calculate, analyze and select the plan that satisfies the condition that the objective function z is the smallest. Based on the mathematical model (7) built, combining theoretical basis, with selected basic parameters and specific models of the two cases, with support of LINGGO 13.0 FOR WINDOWS program software (Kittilertpaisan & Pathumnakul, 2015), to calculate, analyze and select the rice export transport system of Vietnam is the most optimal, ensuring that the objective function z is the smallest.

4. Results and Discussion

4.1 Scenario 1

4.1.1 Options for Rice Export Transport System in Vietnam until 2035 With One Transshipment Port (Sai Gon Port)

Freight transport of 1 ton of rice between domestic and international ports, with the symbols, as follows: EX_i (i = 1 ÷ 5) are rice export ports of Vietnam (ports of Can Tho, My Thoi, My Tho, Vinh Long, and Sa Dec); TP_k (k = 1) is a transshipment port where rice is gathered for export to foreign countries (Sai Gon); IM_j (j = 1 ÷ 3) are rice import ports (Manila - Philippines, Jakarta - Indonesia and Lagos - Nigeria). The transport cost of 1 ton of rice between inland ports and international ports as described in Table 3. To elaborate details of Vietnam's export rice transport system plans for cases from 1 to 2035. Specifically, 5 options in Table 4.

Table 3. Transport cost for 1 ton of rice between domestic and international ports of scenario 1

(Unit: USD/ton)

Ports	**EX_1**	**EX_2**	**EX_3**	**EX_4**	**EX_5**	**TP_1**
TP_1	11,75	11,85	12,50	11,82	13,20	-
IM_1	23,55	23,75	22,15	22,60	23,80	24,50
IM_2	24,75	25,75	24,05	24,80	24,85	26,15
IM_3	40,65	38,95	38,45	38,85	39,60	41,95

Table 4. Options of rice import and export in Vietnam for scenario 1

Export ports	**Export volume** *(Million tons)*	**Import ports**														
		Manila (*Philippines*)					Jakarta (*Indonesia*)					Lagos (*Nigeria*)				
		A	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Can Tho – Sai Gon	2,0															
My Thoi – Sai Gon	1,5															
My Thoi – Sai Gon	1,0															
Vinh Long – Sai Gon	1,0	3.0	2.0	2.5	2.5	2.5	2.0	3.0	2.5	1.5	2.0	1.5	1.5	2.5	2.5	2.0
Sa Dec – Sai Gon	1,0															
Total	6,5															

For the data and input parameters in Tables 3 and 4, the authors used LINGGO 13.0 FOR WINDOWS software to calculate the distribution of transport rice volume and the total cost of transporting exported rice under 5 options A,

B, C, D and E respectively. The calculation results are shown in Table 5.

Table 5. Results of volume distribution and total export transport cost of rice in scenario 1

From port to port	Distribution of transport rice volume (*thousand ton*)					Total transport cost of export rice volume (*thousand USD*)				
	A	B	C	D	E	A	B	C	D	E
Can Tho – Sai Gon	2.000	2.000	2.000	2.000	2.000	267.62	269.27	268.35	284.15	276.25
My Thoi – Sai Gon	1.500	1.500	1.500	1.500	1.500					
My Thoi – Sai Gon	1.000	1.000	1.000	1.000	1.000					
Vinh Long – Sai Gon	1.000	1.000	1.000	1.000	1.000					
Sa Dec – Sai Gon	1.000	1.000	1.000	1.000	1.000					
Sai Gon - Manila	3.000	2.000	2.500	2.500	2.500					
Sai Gon - Jakarta	2.000	3.000	2.500	1.500	2.000					
Sai Gon - Lagos	1.500	1.500	1.500	2.500	2.000					

4.1.2 Analyze the Total Transport Cost and Model of Export Rice Transport System Until 2033 by Options

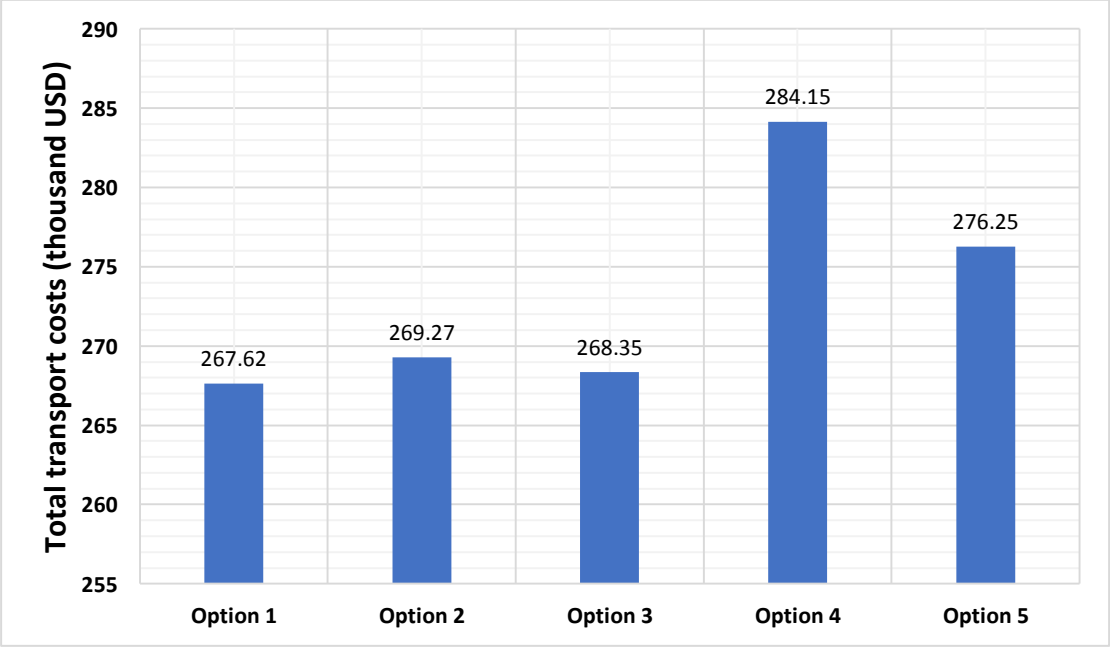

Figure 5. The graph depicts the relationship between the total transport costs of the 5 options in scenario 1

Analyze the results obtained in Table 5, Figure 5 and combine with equation (7) to show that: Comparing the total transport costs for the 5 options of the first scenario that highlighted the optimal plan is option 1 with the smallest total transport costs, with the result: $z = z_{min} = 267.62$ (thousand USD). Moreover, Sai Gon port is an export rice transshipment port in Vietnam, at that time the optimal export rice transport system is described in detail in Figure 6, with the optimal rice export volume allocated along the transport route.

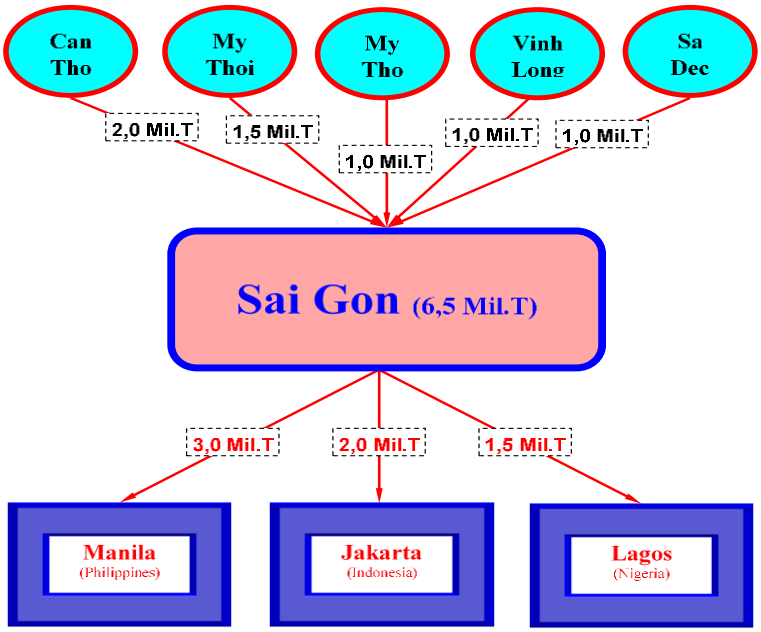

Figure 6. Model of the optimal export rice transport system via Saigon port

4.2 Scenario 2

4.2.1 Options for Rice Export Transport System in Vietnam Until 2035 With 2 Transshipment Ports (Sai Gon Port and Can Tho Port)

Freight transport of 1 ton of rice between domestic and international ports, with the symbols, as follows: EX_i (i = 1 ÷ 5) are rice export ports of Vietnam (ports of My Thoi, My Tho, Vinh Long, Sa Dec, and Ham Luong); TP_k (k = 2) are transshipment ports where rice is gathered for export to foreign countries (Saigon and Can Tho ports); IM_j (j = 1 ÷ 3) are rice import ports (Manila port - Philippines, Jakarta port- Indonesia and Lagos port - Nigeria). The transport cost for 1 ton of rice between inland ports and international ports is described in Table 6. The five options for export rice transport in Vietnam, which are elaborated specifically for the routes with two transshipment ports by 2035, are shown in Table 7.

Table 6. Transport cost for 1 ton of rice between domestic and international ports of scenario 2

Unit: USD/ton

Ports	**XK_1**	**XK_2**	**XK_3**	**XK_4**	**XK_5**	**CT_1**	**CT_2**
CT_1	11,75	11,85	11,55	11,82	11,90	-	-
CT_2	11,15	11,60	12,50	11,12	13,20	-	-
NK_1	23,55	23,75	22,15	22,60	23,80	24,50	24,10
NK_2	24,75	25,75	24,05	24,80	24,85	26,15	26,00
NK_3	40,65	38,95	38,45	38,85	39,60	41,95	41,85

Table 7. 5 options for export rice transport system in Vietnam with scenario 2

Export ports	**Export volume** *(Million tons)*	**Import ports**														
		Manila (*Philippines*)					Jakarta (*Indonesia*)					Lagos (*Nigeria*)				
		A	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
My Thoi – Sai Gon My Thoi – Can Tho	2.0	**3.0**	**2.0**	**2.5**	**2.5**	**2.5**	**2.0**	**3.0**	**2.5**	**1.5**	**2.0**	**1.5**	**1.5**	**1.5**	**2.5**	**2.0**
My Tho – Sai Gon My Tho – Can Tho	1.0															

Vinh Long – Sai Gon Vinh Long – Can Tho	1.0
Sa Dec – Sai Gon Sa Dec – Can Tho	1.5
Ham Luong – Sai Gon Ham Luong – Can Tho	1.0
Total	6.5

Table 8. Results of distribution of volume and total transport costs of exported rice in scenario 2

From port to port	**Distribution of rice transport volume** (*thousand ton*)					**Total transport cost of export rice volume** (*thousand USD*)				
	A	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
My Thoi – Can Tho	2.000	2.000	2.000	2.000	2.000	**261.65**	**263.43**	**262.48**	**278.68**	**270.85**
My Tho - Can Tho	1.000	1.000	1.000	1.000	1.000					
Sa Dec - Sai Gon	1.500	1.500	1.500	1.500	1.500					
Vinh Long - Can Tho	1.000	1.000	1.000	1.000	1.000					
Ham Luong – Sai Gon	1.000	1.000	1.000	1.000	1.000					
Sai Gon - Jakarta	1.000	1.000	1.000	2.500	500					
Sai Gon - Lagos	1.500	1.500	1.500	2.500	2.000					
Can Tho - Manila	3.000	2.000	2.500	1.500	2.500					
Can Tho - Jakarta	1.000	2.000	1.500	2.000	1.500					

4.2.2 Analyze the Total Transport Cost and the Model of Export rice Transport System to 2035 by Options

The calculation results in Table 8 and the optimal plan graph in Figure 7 have shown the relationship between the total transport cost (z) and the alternatives in scenario 2. The smallest total transport cost value found in Option 1 with z_{min} = 261.65 (thousand USD) has shown that the distribution of routes and the amount of rice exported under Option 1 is optimal. Saigon Port and Can Tho Port are transshipment ports for rice exports, while the optimal rice export transport system is described in detail in Figure 8, together with the optimal amount of exported rice distributed along the route.

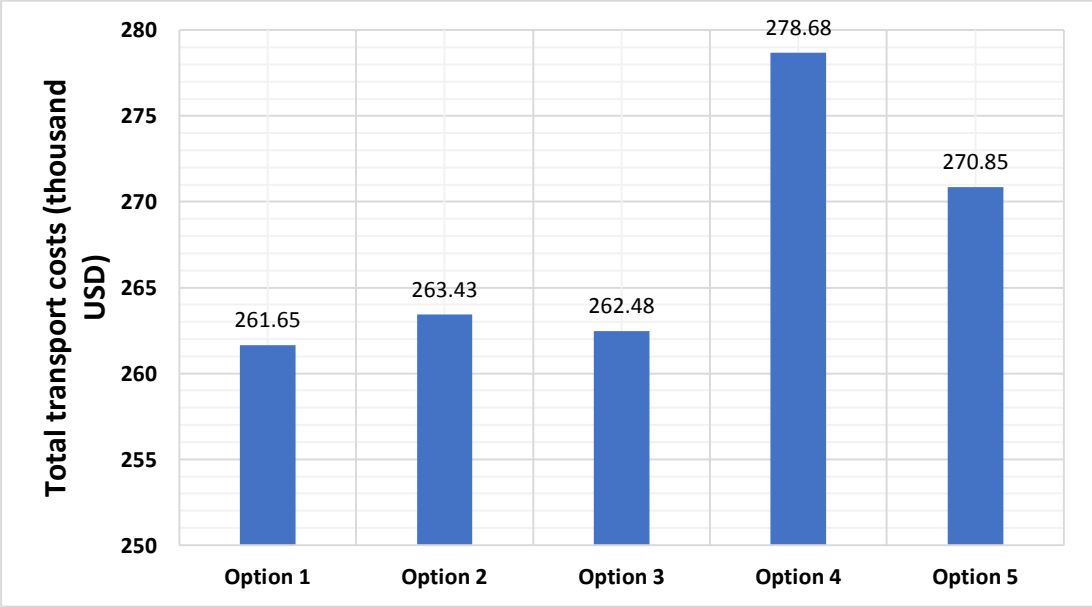

Figure 7. The graph depicts the relationship between the total transport costs of the 5 options in scenario 2

Figure 8. Model of optimal export rice transport system through Saigon and Can Tho ports

In this scenario, rice exports through selected inland ports, such as My Thoi, My Tho, Vinh Long, Sa Dec and Ham Luong (This is a very potential port, a port in the port development strategy until 2020 with a vision to 2030) to two transshipment ports inluding Saigon port and Can Tho port. After that, the rice is unloaded on vessels with large tonnage of 10,000-20,000 tons, to transport by sea to the rice import country (Philippines, Indonesia and Nigeria).

Thus, this study has systematized the theoretical basis of the transport system, optimizing the export rice transport system. Moreover, the concept of "Vietnam's export rice transport system" has been developed to ensure logic, science and practice. Analyze and evaluate in detail the current situation of export rice transport system in the Mekong Delta. From there, select and analyze the dialectical relationship of 7 basic parameters, to build the optimal export rice transport system of Vietnam. Seven basic parameters include: Exported rice volume; Rice export market; Rice import country; Inland waterway route for transporting export rice; Means of transporting exported rice; Port of loading and unloading rice for export; Freight for export rice. Furthermore, a mathematical model has been built, specific calculation of 2 scenarios (each scenarior is calculated according to 5 options). Since then, identifying and successfully selecting the optimal plan for each scenario of the model of the rice export transport system, this is also an important new point, practical and topical. Scenario 1: $z = z_{min} = 267,62$ (thousand USD); Scenario 2: $z = z_{min} = 261,65$ (thousand USD).

5. Conclusion

This study has built a scientific and logical basis for Vietnam's export rice transport system. From systematizing the basic concepts related to the transportation system, optimizing the freight system and exported rice, to building a separate concept of Vietnam's export rice transport system, formulating the optimal problem of Vietnam's export rice transport system. On the other hand, analyzing and evaluating a number of experiences in rice export and rice export transport systems of the two typical countries that export the world's largest rice are Thailand and India. With 95.17% of Vietnam's export rice volume from the Mekong Delta. From the rich and specific data, the authors focused on analyzing and assessing the status of Vietnam's rice export transport system, conducted within the study area of the Mekong Delta.

The optimal process begins with the successful construction of a general model of Vietnam's export rice transport system. The next process is to build a specific model, with Vietnam's export rice transport system in 2 scenarios and on the basis of 7 selected basic parameters. The transformation of the transshipment port model in the export rice transport system has shed some light on the role of logistics system planning in Vietnam's supply and value chain strategy.

The overall model of Vietnam's export rice transport system can be considered as part of Vietnam's rice export chain process. Depending on characteristics, conditions, business purposes, facilities, ... of organizations, units, businesses, ... when applying this model, especially when it is deployed into specific model cases, it is necessary to be flexible,

study specifically, ensure satisfaction and meet practical requirements of the unit. On this basis, organizations, units, individuals, ... need to calculate and select to offer the most optimal export rice transport system for the unit.

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