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THE PORT OF HAMBANTOTA AS A TRANSSHIPMENT PORT: COMPETITIVENESS ASSESSMENT

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ABSTRACT

The Port of Hambantota is strategically located along the East-West main sea route, with an approximate deviation of ten nautical miles. Most current business at the Port of Hambantota relies on automobile roll-on/roll-off, breakbulk, bulk, and project cargo operations. Furthermore, container ship handling operations are expected to commence at the Port of Hambantota. Therefore, this study evaluates the competitiveness of the Port of Hambantota as a container transshipment hub compared to six existing transshipment hub ports: the Port of Jebel Ali and Port of Salalah in Southwest Asia, the Port of Colombo in South Asia, and the Port of Singapore, Port of Tanjung Pelepas, and Port Klang in Southeast Asia. This study considers the mainline-to-feeder transshipment operation. The competitiveness analysis is based on market share using an extended version of the generalised cost approach combined with a discrete choice model. Senior managers attached to the main container line agencies in Sri Lanka evaluated the selection criteria for transshipment hub ports and the performance of the competing hubs. Further scenario analysis was conducted to understand the potential implications for the transshipment business at the Port of Hambantota. The results indicate that the Port of Singapore has the highest potential to become a market leader in transshipment operations despite the presence of the Port of Hambantota. However, the findings also suggest that the Port of Hambantota possesses significant potential for transshipment operations, provided that there are continuous improvements in port performance.

Keywords: *Port of Hambantota, transshipment, generalised cost, South Asia, port development, port competitiveness*

1. INTRODUCTION

The Port of Hambantota is strategically located along the East-West main sea route with an approximate deviation of ten nautical miles. The Southern Province and Hambantota District are the administrative province and district in which the Port of Hambantota is located. Currently, the port is managed as a public-private partnership between one of the leading global port operators, China Merchant Port Holdings, and the Sri Lanka Ports Authority. Most current business at the Port of Hambantota relies on automobile roll-on/roll-off, breakbulk, bulk, and project cargo operations. However, container operations are intended at the Port of Hambantota. This study analyses the potential of the Port of Hambantota to be a container transshipment port by analysing its competitiveness with other regional hub ports.

The remainder of this paper is structured as follows. Section two contains an overview of the related literature. Research gaps are identified after critically evaluating the existing knowledge, and the research objectives are presented. Section three explains the study area and existing methodologies that are feasible to achieve the objectives of this study. The most appropriate method was selected, which was a generalised cost approach with a multinomial logit model to estimate market share. Furthermore, it explains the extended version of the model used in this study. Section four explains the data analysis, simulates the extended version of the model, and presents the results with a scenario analysis. The main findings of the study, including the potential of the Port of Hambantota as a container transshipment port, are discussed. Section five concludes the paper by highlighting the study's limitations and suggesting future research directions.

2. LITERATURE REVIEW

2.1. Transshipment Operation

Transshipment is the movement of containers to an intermediate location before being transported to their destination, which enables shipping companies to retain a minimum number of port calls without limiting their market coverage [1]. The transshipment operation of a port can be categorised into two types based on the characteristics of vessels: the transshipment of containers between mainline to feeder lines and the transshipment of containers between mainlines to mainlines.

There are three major characteristics of a transshipment port: location, infrastructure, and operations. The location is characterised by nautical accessibility, proximity to main shipping routes with minimal deviation from these routes, and proximity to feeder markets. The infrastructure includes deep-draft terminals and adequate yard space to handle the necessary operations. The operational aspect focuses on higher productivity levels, which are crucial for minimising vessel turnaround times [2].

The level of transshipment operation of a port is represented by Transshipment Incidence, which is the ratio between the transshipment container volume of a port and its total container volume. Based on the Transshipment Incidence, ports can be categorised into four types, as shown in Figure 1.

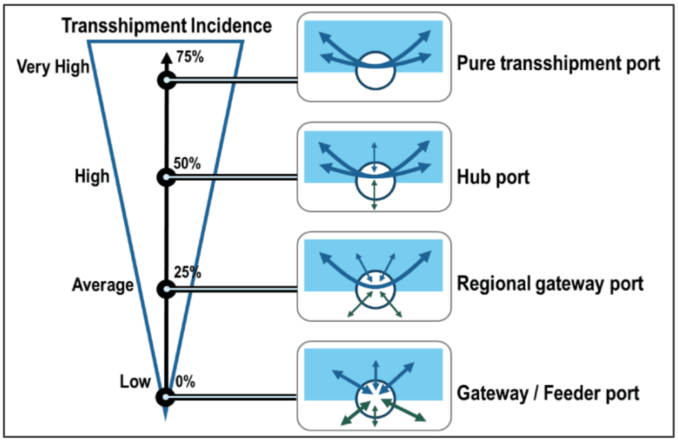

Figure 1: Transshipment incidence [2]

Owing to the competitive nature of the container liner shipping industry, transshipment ports in the same region compete to capture a larger transshipment market share [3]. Therefore, this increases competition among transshipment ports in a region.

2.2. Container Transshipment Port Competitiveness

Competitiveness refers to an organisation's capability to produce and market its output more effectively than both domestic and international rivals. Accordingly, the competitiveness of a container transshipment port refers to the port's capability to offer and market its services to customers more effectively and attractively than domestic and international competing ports. The competitiveness of a container transshipment port can be derived from a specific geographical region or trade route [4], [5], [6]. Moreover, measuring competitiveness is vital for container transshipment ports. The competitiveness of a container transshipment port is one of the best indicators for understanding the latest adjustments in the port industry and responding accordingly. Furthermore, it is vital to understand their current competitive position in the market to develop strategies and policies that will determine their future competitive position [7]. According to the literature, several methods exist to determine container transshipment port competitiveness, which are explained in Section 3.

The level of container transshipment port competitiveness relies on port customers, regions, trade routes, and time. To measure the competitiveness of a container transshipment port, it is essential to understand the key determinants of port competitiveness. These are called factors of port competitiveness, determinants of port competitiveness, or port choice/selection criteria. Port customers influence port choice at different levels and instances [5]. As discussed in the literature, shipping lines, shippers, and freight forwarders are port choice decision-makers. Despite this, it is difficult to determine the real port choice decision-maker because it varies depending on the instance [8]. However, shipping lines primarily make port choice decisions. Therefore, ports should monitor the factors that lead to shipping lines' decision-making [9]. Hence, this study also focuses on the determinants of container port competitiveness from the shipping lines' perspective.

As the literature emphasises, there are many determinants of container transshipment port competitiveness. Studies [3], [4], and [5] recently deep-dived and summarised the determinants used in previous studies.

2.3. Competitiveness of the Port of Hambantota as a Transshipment Port

The Port of Hambantota is strategically located along the world-famous Maritime Silk Route [3], [10], [11], [12]. The Port of Hambantota is situated in the Southern Province of Sri Lanka, approximately ten nautical miles from the East-West main sea route. Currently, Ro/Ro operations, breakbulk, bulk, and project cargo operations are ongoing at the Port of Hambantota, and container operations are intended at the Port of Hambantota.

According to the literature, existing research on measuring the container transshipment port competitiveness of the Port of Hambantota is limited in several ways. First, despite the presence of multiple transshipment ports in the region, previous studies primarily focused on the Port of Colombo when assessing the Port of Hambantota's competitiveness [12], [13]. Additionally, these studies considered only a few feeder ports from the Indian East, South, and West Coasts, neglecting significant markets such as Myanmar, the Maldives, and Pakistan [12], [13]. Moreover, a limited number of determinants were used to evaluate the competitiveness of the Port of Hambantota, highlighting gaps in the comprehensive assessment of its potential [3], [12].

3. METHODOLOGY

This study aims to address the gaps identified in the existing literature by achieving several key objectives. First, it seeks to identify the significant determinants or port selection criteria that influence the competitiveness of Hambantota as a transshipment port. Second, it aims to develop a model that can estimate the expected transshipment market share for the port's intended container operations. Finally, the study simulates the model to analyse various practical scenarios, providing insights into the potential implications for the transshipment business at the Port of Hambantota.

3.1. Study Area

This study focuses on the transshipment competitiveness of the Port of Hambantota, an emerging container transshipment port in South Asia. According to [13] and [14], the South Asian feeder markets can be classified into seven markets, and Table 1 shows the feeder markets and feeder ports in the region.

Table 1: South Asian feeder markets

Feeder Market	Feeder Ports
Myanmar	Port of Yangon
Bangladesh	Port of Chittagong
Indian East Coast	Port of Calcutta, Port of Haldia, Port of Paradip, Port of Visakhapatnam, Port of Kakinada, Port of Krishna Patnam, Port of Kattupalli, Port of Ennore, Port of Chennai
Indian South Coast	Port of Tuticorin, Port of Cochin
Indian West Coast	Port of Mangalore, Port of Goa (Mormagoa), Port of Nhava Sheva, Port of Mumbai, Port of Hazira, Port of Pipavav, Port of Kandla, Port of Mundra
Maldives	Port of Male
Pakistan	Port of Karachi, Port of Qasim

For the above feeder markets, six existing ports compete in three transshipment port clusters, as shown in Table 2 [13], [14].

Table 2: Transshipment port clusters

Transshipment Port Cluster	Existing Transshipment Ports
South Asia	Port of Colombo (LKCMB)
Southeast Asia	Port of Singapore (SGSIN), Port of Tanjung Pelepas (MYTPP), Port Klang (MYWSP)
Southwest Asia	Port of Jebel Ali (AEJEA), Port of Salalah (OMSLL)

Figure 2 illustrates the areas of the study. It includes South Asian feeder markets (shown in red) and competing transshipment port clusters (shown in yellow) with transshipment ports.

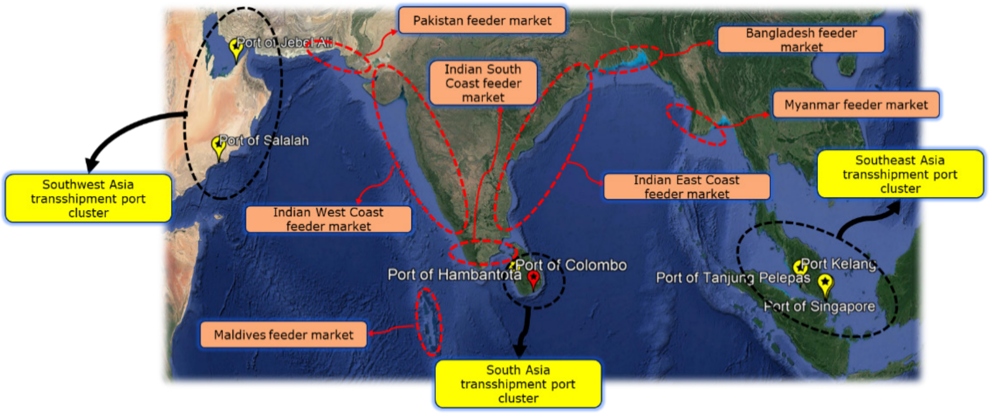

Figure 2: Study area

As section 2.1 highlighted, the Port of Hambantota has already acquired two major characteristics (location and infrastructure) of a transshipment port. A higher productivity level is the only remaining characteristic of the latter. Thus, owing to the possibility of Hambantota becoming a transshipment port in the South Asian region, this study analyses the transshipment port competitiveness of the Port of Hambantota compared to the six existing transshipment ports.

3.2. Existing Methods to Measure Port Competitiveness

As stated in the literature, several methods are available for measuring transshipment port competitiveness. However, the selection of an appropriate method relies on the types of data available (e.g. quantitative/qualitative), the objective of the analysis, and the scope of the study (e.g. the number of ports to consider – one/many and the number of markets) [15]. Therefore, a good understanding of the available methods is vital for achieving the study objectives. Thus, [7] developed a comprehensive and systematic overview of different methods for measuring port competitiveness, which are classified into six categories, as shown in Table 3.

Table 3: Existing methods to measure port competitiveness

Category	Method	Examples
Methods Commonly Employed	Market Share Analysis (MSA)	[16], [17], [18], [19], [20], [21], [22]
	SWOT Analysis	
	Linear Regression	
	Data Envelopment Analysis (DEA)	
Methods Related to Benchmarking Practices	Principal Component Analysis	[23]
	Benchmarking Analysis	

Category	Method	Examples
Methods related to Port Selection Criteria	Discrete Choice Models	[24], [25], [26], [27], [28]
	Factor Analysis	
	Simulation	
Multi-Criteria Decision Methods	Grey Relational Analysis (GRA)	[29], [30], [31], [32]
	Analytic Hierarchy Process (AHP)	
	Promethee Analysis	
	Fuzzy Multi-Criteria Grade Classification Model (FMGC)	
Methods Encompassed in Port Forecasting Models	Logit models	[12]
	Multinomial Logit Models	[14]
Methods Used in Strategic Analysis	Strategic Positioning Analysis (SPA)	[33], [34], [35], [36])
	The Porter's Extended Diamond Framework	

3.3. Selection of Method to Measure the Competitiveness of the Port of Hambantota

According to the literature, market share is a key indicator of transshipment port competitiveness. Furthermore, a high transshipment market share implies stronger competitiveness than that of competitors. As emphasised in Section 2.2, the transshipment port choice is a logical approach to estimating transshipment port competitiveness. Furthermore, generalised cost is one of the best methods for analysing choice behaviours. According to transport economics, the sum of the monetary and non-monetary costs of a particular journey is called the generalised cost of that journey. In this study, generalised cost refers to the sum of the monetary and non-monetary costs of a shipping line for using a transshipment port for their transshipment operations. However, lowering the generalised cost does not imply the cheapest alternative, since the generalised cost deals not only with monetary costs but also with non-monetary costs [37].

Thus, this study uses a multinomial logit model to estimate the transshipment market share of the Port of Hambantota using the generalised cost. Previous studies of [14] and [37] also followed a similar approach to measure transshipment port competitiveness. According to the classification in [7], the selected method belongs to the Methods Encompassed in Port Forecasting Models. Moreover, the selected method can investigate the process behind the decision-making of transshipment port choice, reflect decision-makers for different competing transshipment ports, evaluate attributes of competing transshipment ports which determine their competitiveness, estimate the market shares of competing transshipment ports, conduct scenario analysis, and estimate the impact of policy measures.

3.4. Generalised Cost Approach for Market Share Estimation

The approach used by [14] and [37] can be explained in several steps, as shown in Figure 3.

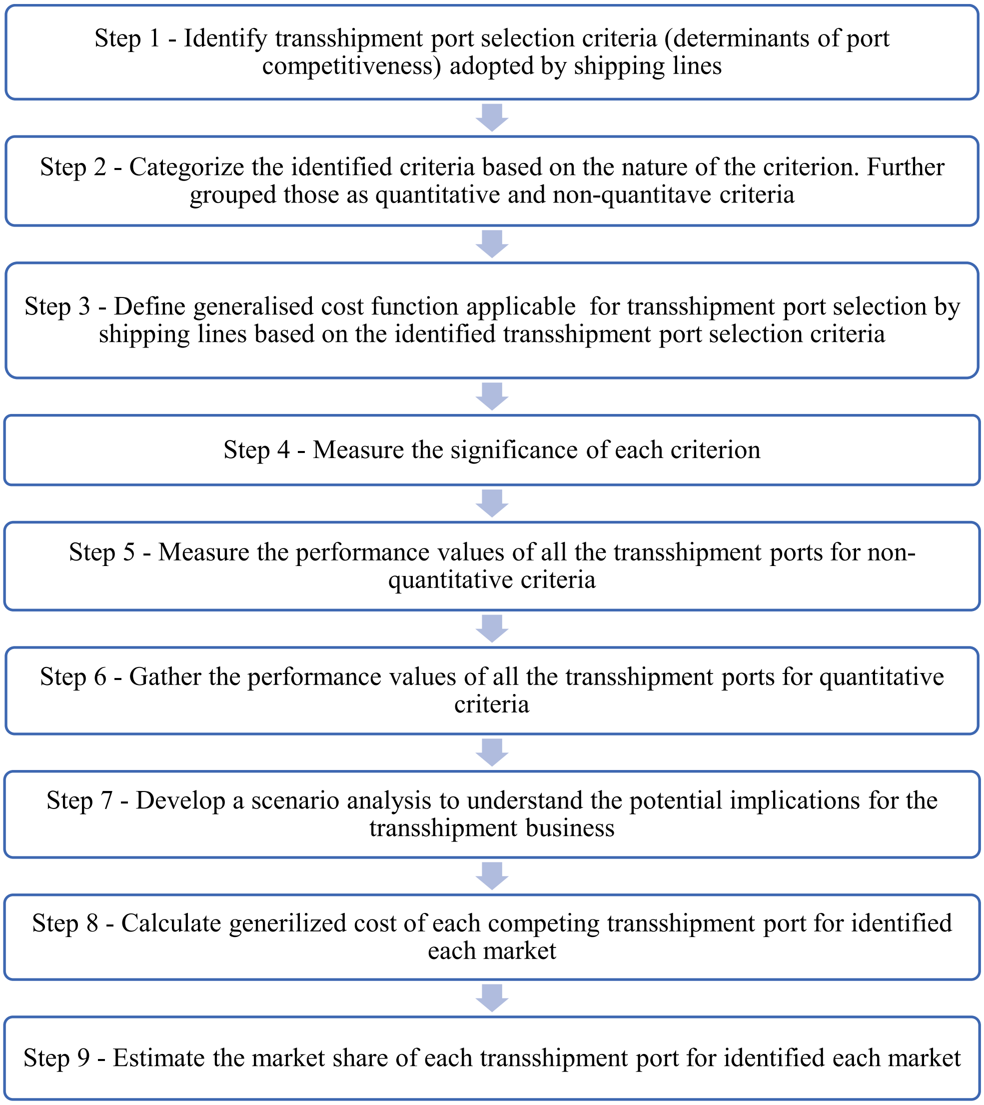

Figure 3: Generalised cost approach for market share estimation

Nevertheless, this study developed an extended version of the above approach to estimate the competitiveness of the Port of Hambantota as a container transshipment port.

3.5. Extended Version of Generalised Cost Approach for Market Share Estimation

This section explains the major contributions and significance of this study by introducing an extended version of the generalised cost approach to estimate market share. This approach includes several additional features that are compared with those of the models developed by [14] and [37].

One of the key contributions is the ability to apply the model for a new market entry, which helps assess whether there is potential to acquire an adequate market share over competing transshipment ports. This feature enhances the ability to evaluate market competition effectively.

This study also incorporates 15 new determinants of port competitiveness that are applicable to regions such as South Asia, Southeast Asia, and Southwest Asia. These determinants include proximity to the country's expressway and international airports, the ability to tranship cargo between container and RORO vessels, availability of dedicated facilities for handling DG, OOG, and reefer containers, availability of bunkering services, past records of cargo losses, and availability of investment opportunities for shipping lines. Additionally, the free dwell time for transshipment containers, reputation of terminal operators, availability of terminals operated by different terminal operators, green port initiatives, and future development plans (master plan) of the port are also considered. This study introduces four new categories for the determinants of port competitiveness: Port Facilities, Maritime Connectivity, Commercial & Marketing, and Others. Additionally, it includes four new efficiency indices to calculate transshipment port competitiveness: the Port Facilities Efficiency Index, Maritime Connectivity Efficiency Index, Commercial & Marketing Efficiency Index, and Other Criteria Related Efficiency Index.

Furthermore, the study identifies three new feeder markets—Myanmar, Maldives, and Pakistan—and includes 12 new feeder ports from seven feeder markets, including the Port of Yangon, Port of Paradip, Port of Kakinada, Port of Kattupalli, Port of Ennore, Port of Goa, Port of Mumbai, Port of Hazira, Port of Kandla, Port of Male, Port of Karachi, and Port of Qasim. Additionally, five new competing container transshipment ports—Port of Singapore, Port of Tanjung Pelepas, Port Klang, Port of Jebel Ali, and Port of Salalah are considered.

3.6. Transshipment Port Selection Criteria of Shipping Lines

As explained in Section 2, transshipment port selection criteria (determinants of port competitiveness) are not constant for all contexts (markets, regions, etc.). Therefore, it is vital to understand the selection criteria relevant to the context of this study. Table

4 summarises the transshipment port selection criteria related to this study area, which were derived from previous studies.

Table 4: Transshipment port selection criteria derived from previous studies

Criteria	References
Port Chargers	[5], [8], [9], [12], [14], [32], [38], [39], [40], [41], [42], [43], [44], [45], [46], [47], [48], [49], [50]
Deviation Cost	
Feeder Cost	
Feeder Link Time	
Deviation Time	
Vessel Turnaround Time	
Location Compared to Other Hub Ports	
Location with feeder markets	
Nature of Port Infrastructures	
Nature of Port Superstructures	
Available Yard Capacity	
Availability of Logistics Facilities	
Availability of IT and Advanced Technology	
Container Handling Efficiency	
Availability of a Berth On Arrival	
Efficiency of Navigational Services	
The professionalism of the Employees	
Frequency of Occurring Operational Delays	
Past Records of Cargo Damages	
Ease of Claims Handling	
Flexibility of Port Authority/Customs Policies/Regulations	
Mainline Connectivity of the Port	
Feeder Line Connectivity of the Port	
Availability of Dedicated/Own Terminals by Shipping Line	
Availability of Existing Services to Port from Shipping Line	
Volume of Domestic Cargo (Import/Export)	
Preferences of Shippers and Freight Forwarders to the Port	
Personal Contacts with Port Employers/Employees	
Effectiveness of Port Marketing Strategy	
Ease of Making Payments	

In addition to the above criteria, the following criteria given in Table 5 were identified as more specific to the context of this study through interviews with industry experts.

Table 5: Transshipment port selection criteria derived from interviews with industry experts

Newly Added Criteria	Description
Proximity to the Expressway Network of the Country	The possibility of connecting multiple ports via roads for the transshipment of containers between ports.
Proximity to International Airports of the Country	The possibility of connecting cargo between sea and air transport modes.
Ability to Tranship Cargo from Container Vessels to RORO Vessels and vice versa	The ability to develop new business models by integrating multiple vessel types (RORO and containers).
Availability of Dedicated Facilities to Handle DG Containers	The availability of separate yard blocks, safety precautions, disaster handling measures, etc.
Availability of Dedicated Facilities to Handle OOG Containers	The availability of handling gears, surveyors, etc.
Availability of Dedicated Facilities to Handle Reefer Containers	The availability of reefer stacks, reefer technicians, etc.
Availability of Bunkering Services	The efficiency of bunkering services at transshipment port.
Past Records of Cargo Losses	The incidences of cargo losses at a transshipment port from the shipping line's point of view.
Availability of Existing Services to the Port from Other Alliance Members of the Shipping Line Belongs to	The position of a transshipment port compared to a shipping line's alliance members' services.
Availability of Investment Opportunities for Shipping Lines at the Port Facility	Investing in major ports by shipping lines is a current trend in the container business.
Free Dwell Time Allowed for Transshipment Containers	The number of free storage days provided by a transshipment port is an important factor for shipping lines to minimise transshipment operation costs.
The Reputation of the Terminal Operator	The overall reputation of a container terminal in the maritime industry.

Newly Added Criteria	Description
Availability of Terminals Operated by Different Terminal Operators	The competition among terminals is a plus point for shipping lines to negotiate with each terminal operator.
Availability of Green Port Initiatives	Sustainability is one of the key requirements that most shipping lines are currently looking for.
Future Development Plan of the Port (Master Plan)	The port master plan provides a clear picture of the future development of a port. This is important for shipping lines to develop their future network plans and other plans.

The identified criteria are grouped in Table 6 based on their nature and quantitative or non-quantitative manner.

Table 6: Categories of transshipment port selection criteria

Type	Category	Criterion
Quantitative	Monetary -Port Charges	Container Handling Dues
	Monetary - Journey Cost	Deviation Cost
		Feeder Cost
	Time	Feeder Link Time
		Deviation Time
		Vessel Turnaround Time
Non-quantitative	Location	Location Compared to Other Hub Ports
		Location with Feeder Markets
		Proximity to the Expressway Network of the Country
		Proximity to International Airports of the Country
	Port Facilities	Nature of Port Infrastructures
		Nature of Port Superstructures
		Available Yard Capacity
		Availability of Logistics Facilities
		Ability to Tranship Cargo from Container Vessels to RORO Vessels and vice versa
		Availability of IT and Advanced Technology
		Availability of Dedicated Facilities to Handle DG Containers

Type	Category	Criterion
		Availability of Dedicated Facilities to Handle OOG Containers
		Availability of Dedicated Facilities to Handle Reefer Containers
	Port Operations	Container Handling Efficiency
		Availability of a Berth On Arrival
		Efficiency of Navigational Services
		Availability of Bunkering Services
		Professionalism of the Employees
		Frequency of Occurring Operational Delays
		Past Records of Cargo Damages
		Past Records of Cargo Losses
		Ease of Claims Handling
		Flexibility of Port Authority/Customs Policies/Regulations
	Maritime Connectivity	Mainline Connectivity of the Port
		Feeder Line Connectivity of the Port
	Shipping Line Related	Availability of Dedicated/Own Terminals by Shipping Line
		Availability of Existing Services to Port from Shipping Line
		Availability of Existing Services to the Port from Other Alliance Members of the Shipping Line Belongs to
		Volume of Domestic Cargo (Import/Export)
		Preferences of Shippers and Freight Forwarders to the Port
		Personal Contacts with Port Employers/Employees
		Availability of Investment Opportunities for Shipping Lines at the Port Facility
	Commercial & Marketing	Effectiveness of Port Marketing Strategy
		Free Dwell Time Allowed for Transshipment Containers
		Reputation of the Terminal Operator
		Ease of Making Payments
	Other	Availability of Terminals Operated by Different Terminal Operators
		Availability of Green Port Initiatives
		Future Development Plan of the Port (Master Plan)

3.7. Formulation of the Extended Generalised Cost Equation

3.7.1. Generalised Cost Calculation

Equation 1 represents the generalised cost function of a particular transshipment port based on the choice of shipping line. All the criteria listed in Table 6 were incorporated into this equation.

$$\text{Generilsed Cost}_{(h)} = \text{Port Charges}_{(h)} + \text{Journey Cost}_{(h)} + \text{Time Cost}_{(h)} - \text{VNQC}_{(h)} \quad \forall h \tag{1}$$

According to Equation 1, the generalised cost is calculated using the port charges, journey cost, time cost, and value of non-quantitative criteria (VNQC) associated with transshipment port *h*. As Table 6 shows, both port charges and journey cost-associated criteria are included under the monetary category, and time cost-associated criteria are included under the time category. Furthermore, these three components were grouped under quantitative criteria because the performances of competing transshipment ports were gathered as quantitative data. VNQC is also considered a monetary value in Equation 1 because it is based on monetisation. However, the VNQC was derived based on the performances of competing ports, which were provided by shipping lines. Moreover, VNQC denotes the satisfaction/utility of shipping lines towards ports measured in monetary terms. Therefore, the VNQC is given as a negative cost component in the generalised cost function because a higher satisfaction/utility reduces the generalised cost of shipping lines. The following subsections explain each cost component of the generalised cost function and market share estimation.

3.7.2. Port Charges (PC)

As [51] stated, port charges are a critical component of shipping lines' transshipment port choice. Stevedoring and storage dues are the major cost components that are incurred during transshipment operations. Both components are considered per TEU under port charges. However, due to the competitive nature of the container transshipment market, it is hard to obtain the exact port charges. Although ports publish their tariffs, they provide several discounts, incentives, rebates, and promotions to customers [52]. Therefore, the exact port charge of a shipping line may differ from the published tariffs. Despite this limitation, this study obtained port charges via recently published port tariffs.

3.7.3. Journey Cost Calculation

As classified in Table 6, the deviation and feeder link costs are components of the journey cost. Considering the limitation of estimating vessel cost per nautical mile with actual data, this study also follows the Unit Distance Cost (UDC) approach ([12], [14]). UDC refers to the journey cost for one unit distance (in this study, it is the cost per nautical mile). UDC is calculated for both the deviation cost and feeder link cost separately, as shown in Equation 2. The total journey of a particular transshipment port is calculated using Equation 3, which incorporates the UDC.

$$UDC_{(j,h)} = \frac{\left(\frac{\text{Average PC}}{AvSS_{(PC)}}\right) * AvSS_{(j)}}{\frac{\left(\sum_{h=1}^{h=7} D_{(j,h)}\right)}{7}} \quad \forall j, \forall h \quad \text{------------------------------------} \quad (2)$$

$$\text{Journey Cost}_{(h)} = \left[m * D_{(\text{deviation cost},h)} * UDC_{(\text{deviation cost},h)}\right] + \left[k * D_{(\text{feeder link cost},h)} * UDC_{(\text{feeder link cost},h)}\right] \quad \forall h \quad \text{--------------------------} \quad (3)$$

Where;

UDC $_{(j, h)}$	**Unit Distance Cost of jth Criterion for Transshipment Port h**
j	Criteria related to journey cost, j = {deviation cost, feeder link cost}
h	Competitive transshipment ports; h = {LKHBA, LKCMB, MYWSP, MYTPP, SGSIN, OMSLL, AEJEA}
$D_{(j,h)}$	Nautical mile distance of j^{th} criterion for transshipment port h • e.g., D $_{(\text{deviation distance, LKHBA})}$ → quantitative deviation distance from main sea route to the Port of Hambantota
Average $PC_{(h)}$	Average of monetary port charges (USD) of all seven transshipment ports considered in the study
$AvSS_{(PC)}$	Average Significance Score of port charges
$AvSS_{(j)}$	Average Significance Score of j^{th} criterion
Journey $Cost_{(h)}$	Total journey cost incurred with transshipment port h
m	Dummy variable • m=1 for mainline to feeder line transshipment operation
k	Dummy variable • k=1 for mainline to feeder line transshipment operation

3.7.4. Time Cost Calculation

As shown in Table 6, deviation time, vessel turnaround time, and feeder link time are the components of time cost. Considering the limitation of estimating the actual cost per hour, this study also follows the Value of Time (VOT) approach ([12], [14]). VOT refers to the time cost for a unit of time (in this study, it is the cost per hour). VOT is calculated separately for each time-related criterion, as shown in Equation 4. Then, the total time of a particular transshipment port is calculated using Equation 5 by incorporating the VOT.

$$\mathrm{VOT}_{(t,h)} = \frac{\left(\frac{\text{Average PC}}{\mathrm{AvSS}_{(PC)}}\right) * \mathrm{AvSS}_{(t)}}{\frac{\left(\sum_{h=1}^{h=7} T_{(t,h)}\right)}{7}} \quad \forall t, \forall h \quad \text{-----------------------------------} (4)$$

$$\text{Time Cost}_{(h)} = m * \left[\left(T_{(\text{deviation time},h)} * \mathrm{VOT}_{(\text{deviation time},h)}\right) + \left(T_{(\text{vessel turnaround time},h)} * \mathrm{VOT}_{(\text{vessel turnaround time},h)}\right)\right] + k * \left[T_{(\text{feeder link time},h)} * \mathrm{VOT}_{(\text{feeder Link time},h)}\right] \quad \forall h \quad \text{-----------------------} (5)$$

Where;

$\mathrm{VOT}_{(t,h)}$	**Vale of Time of t^{th} Criterion for Transshipment Port h**
t	Criteria related to time cost, t = {deviation time, vessel turnaround time, and feeder link time}
h	Competitive transshipment ports; h = {LKHBA, LKCMB, MYWSP, MYTPP, SGSIN, OMSLL, AEJEA}
$T_{(t,h)}$	Quantitative time value of t^{th} criterion for transshipment port h • e.g., $T_{(\text{deviation time}, \text{LKHBA})}$ → quantitative time value from main sea route to Port of Hambantota
Average $PC_{(h)}$	Average of monetary port charges (USD) of all seven transshipment ports considered in the study
$\mathrm{AvSS}_{(PC)}$	Average Significance Score of port charges
$\mathrm{AvSS}_{(t)}$	Average Significance Score of t^{th} criterion
Time $\mathrm{Cost}_{(h)}$	Total time cost incurred with transshipment port h
m	Dummy variable • m=1 for mainline to feeder line transshipment operation
k	Dummy variable • k=1 for mainline to feeder line transshipment operation

3.7.5. Value of Non-Quantitative Criteria (VNQC) Calculation

As discussed previously, the selection of transshipment ports by shipping lines is based on quantitative and non-quantitative criteria. Thus, this section explains the impact of the VNQC on the generalised cost function. As explained previously, VNQC implies the monetary value of the utility/satisfaction of shipping lines regarding a transshipment port because of its high-performance level. In simple terms, a higher VNQC implies a higher performance of a transshipment port, which leads to minimisation of the total generalised cost of the shipping line.

As the first step in calculating the VNQC, it is necessary to formulate efficiency indices for individual categories, as expressed by Equations 6 – 12.

$$\mathrm{LEI}_{(h)} = \frac{\left[\sum_{i=1}^{i=n} \mathrm{AvAS}_{\left(\mathrm{location}_{(i)},h\right)} * \mathrm{AvSS}_{\left(\mathrm{location}_{(i)}\right)}\right]}{n} \quad \forall h \text{ ------------------------ } (6)$$

$$\mathrm{PFEI}_{(h)} = \frac{\left[\sum_{i=1}^{i=n} \mathrm{AvAS}_{\left(\mathrm{port}_{\mathrm{facilities}_{(i)}},h\right)} * \mathrm{AvSS}_{\left(\mathrm{port}_{\mathrm{facilities}_{(i)}}\right)}\right]}{n} \quad \forall h \text{ ------------- } (7)$$

$$\mathrm{POEI}_{(h)} = \frac{\left[\sum_{i=1}^{i=n} \mathrm{AvAS}_{\left(\mathrm{port}_{\mathrm{operation}_{(i)}},h\right)} * \mathrm{AvSS}_{\left(\mathrm{port}_{\mathrm{foperation}_{(i)}}\right)}\right]}{n} \quad \forall h \text{ ----------- } (8)$$

$$\mathrm{MCEI}_{(h)} = \frac{\left[\sum_{i=1}^{i=n} \mathrm{AvAS}_{\left(\mathrm{maritime}_{\mathrm{connectivity}_{(i)}},h\right)} * \mathrm{AvSS}_{\left(\mathrm{maritime}_{\mathrm{connectivity}_{(i)}}\right)}\right]}{n} \quad \forall h \text{ --------- } (9)$$

$$\mathrm{LREI}_{(h)} = \frac{\left[\sum_{i=1}^{i=n} \mathrm{AvAS}_{\left(\mathrm{liner}_{\mathrm{related}_{(i)}},h\right)} * \mathrm{AvSS}_{\left(\mathrm{liner}_{\mathrm{related}_{(i)}}\right)}\right]}{n} \quad \forall h \text{ ------------- } (10)$$

$$\mathrm{CMEI}_{(h)} = \frac{\left[\sum_{i=1}^{i=n} \mathrm{AvAS}_{\left(\mathrm{commercial}_{\mathrm{marketing}_{(i)}},h\right)} * \mathrm{AvSS}_{\left(\mathrm{commercial}_{\mathrm{marketing}_{(i)}}\right)}\right]}{n} \quad \forall h \text{ -------- } (11)$$

$$\mathrm{OEI}_{(h)} = \frac{\left[\sum_{i=1}^{i=n} \mathrm{AvAS}_{\left(\mathrm{other}_{(i)},h\right)} * \mathrm{AvSS}_{\left(\mathrm{other}_{(i)}\right)}\right]}{n} \quad \forall h \text{ --------------------------- } (12)$$

Where;

i	**Any Criteria Related to Non-Quantitative Seven Categories**
$LEI_{(h)}$	Location Efficiency Index of transshipment port h
$PFEI_{(h)}$	Port Facilities Efficiency Index of transshipment port h
$POEI_{(h)}$	Port Operation Efficiency Index of transshipment port h
$MCEI_{(h)}$	Maritime Connectivity Efficiency Index of transshipment port h

i	Any Criteria Related to Non-Quantitative Seven Categories
$LREI_{(h)}$	Shipping Liner Related Efficiency Index of transshipment port h
$CMEI_{(h)}$	Commercial & Marketing Efficiency Index of transshipment port h
$OEI_{(h)}$	Other Criteria related Efficiency Index of transshipment port h
n	Total number of criteria in each category
$AvAS_{(i,p)}$	Average Appreciation Score of transshipment port (average performance of a transshipment port concerning a specific criterion based on shipping lines perspective) h for criteria i.

Once the efficiency indices are calculated using Equations 6 -12, Equation 13 is used to monetise them. Monetisation is conducted with the average port charge of transshipment ports to calculate the final $VNQC_{(h)}$ of a particular transshipment port following the same approach used by [12] and [14].

$$\mathrm{VNQC_{(h)}} = \left[\mathrm{Average\ PC_{(h)}} * \frac{\mathrm{LEI_{(h)}}}{\mathrm{AvSS_{(PC)}}}\right] + \left[\mathrm{Average\ PC_{(h)}} * \frac{\mathrm{PFEI_{(h)}}}{\mathrm{AvSS_{(PC)}}}\right] + \left[\mathrm{Average\ PC_{(h)}} * \frac{\mathrm{POEI_{(h)}}}{\mathrm{AvSS_{(PC)}}}\right] + \left[\mathrm{Average\ PC_{(h)}} * \frac{\mathrm{MCEI_{(h)}}}{\mathrm{AvSS_{(PC)}}}\right] + \left[\mathrm{Average\ PC_{(h)}} * \frac{\mathrm{LREI_{(h)}}}{\mathrm{AvSS_{(PC)}}}\right] + \left[\mathrm{Average\ PC_{(h)}} * \frac{\mathrm{CMEI_{(h)}}}{\mathrm{AvSS_{(PC)}}}\right] + \left[\mathrm{Average\ PC_{(h)}} * \frac{\mathrm{OEI_{(h)}}}{\mathrm{AvSS_{(PC)}}}\right] \quad \forall h \text{ --- } (13)$$

3.7.6. Market Share Estimation

Once the cost of every component in the generalised cost equation is determined, Equation 1 estimates the overall generalised cost. Then, Equation 14 is used to convert the generalised cost values into utilities, as the attractiveness of transshipment ports is reflected by utilities ([12], [14]). Then, the transshipment market shares of ports are estimated with a multinomial logit model as expressed in Equation 15.

$$\mathrm{Utility_{(h)}} = \frac{1}{\frac{\mathrm{Generalised\ Cost_{(h)}}}{\mathrm{Generalised\ Cost_{(Least)}}}} \quad \forall h \text{ ------------------------------------- } (14)$$

$$\mathrm{EMS_{(h)}} = \frac{e^{\mathrm{Utility_{(h)}}}}{\sum_{h=1}^{h=7} e^{\mathrm{Utility_{(h)}}}} \quad \forall h \text{ -- } (15)$$

Where;

$Utility_{(h)}$	**Utility of transshipment port h**
Generalised $Cost_{(Least)}$	Generalised cost of the best-performing transshipment port among the seven transshipment ports
$EMS_{(h)}$	Estimated market share of transshipment port h

Accordingly, to calculate the generalised cost, it is required to measure AvSS and AvAS values. Thus, it is required to derive the significance score for each criterion and the appreciation score (performance of transshipment ports) of each transshipment port for each criterion. Thus, the same questionnaire survey approach used by [14] and [37] was used to gather data through snowball sampling. The survey respondents were senior-level industry experts (container liner agents of Sri Lanka who represent top shipping lines) who were knowledgeable and expert in the South Asian region. Twelve responses were obtained. The questionnaire consisted of two sections. Section one is to gather the significance scores of each transshipment port selection criterion. The respondents were asked to indicate the significance of each criterion when selecting a transshipment port by a shipping line using significance scores (5 - Very Significant, 4 - Significant, 3 - Some Significance, 2 - Little Significance, 1 - Nearly No Significance, 0 - No Significance at All). Section two gathers the appreciation scores of each selection criterion to compare the six existing transshipment ports. In this section, the respondents were asked to indicate the performance of ports under each criterion based on their experience using an appreciation score (+3, Very Positive; +2, Positive; +1, Somewhat Positive; 0, Neutral; -1, Somewhat Negative; -2, Negative; and-3, Very Negative).

4. ANALYSIS, RESULTS AND DISCUSSION

4.1. Scenario Analysis Framework

This section explains the development of scenarios for estimating the market shares of competing transshipment ports to discuss significant implications.

Assuming future scenarios is one of the key challenging tasks of this study because the Port of Hambantota is not currently operating as a container transshipment port. Thus, based on the literature review, interviews with industry experts, and survey results, four scenarios were developed. As [12] discussed, port charges, time efficiency, and port efficiency are the key driving parameters that led to the development of the Port of Hambantota. Thus, those parameters which are not dependent on the geographical features (parameters which depend on geographical features, such as deviation distance, feeder link distance, deviation time, feeder link time, etc.) are used as inputs in deciding scenarios to estimate the market share of the Port of Hambantota, as summarised in Table 7.

Table 7: Parameters setting for the scenario analysis

Scenarios	Inputs			
	Stevedoring Dues (USD)	**Storage Dues (Free Dwell Days)**	**Vessel Turnaround Time (Hours)**	**VNQC**
1	93 (same as HIPG tariff)	14 (same as HIPG tariff)	Maximum turnaround time among competing ports (24.72) * 1.5	Minimum AvAS value among competing ports * 0.5
2	93 (same as HIPG tariff)	14 (same as HIPG tariff)	Maximum turnaround time among competing ports (24.72)	Minimum AvAS value among competing ports
3	93 (same as HIPG tariff)	28	Maximum turnaround time among competing ports (24.72)	Minimum AvAS value among competing ports
4	93 (same as HIPG tariff)	28	Maximum turnaround time among competing ports (24.72)	Same as LKCMB AvAS values

The following assumptions were considered while calculating the generalised costs under each scenario: stevedoring and storage dues were included as inputs under the port charge category; vessel turnaround time was considered as an input under the time efficiency category; and VNQC was considered as an input under the port efficiency category. Stevedoring and storage dues were calculated based on the latest published port tariffs, and calculations were performed by considering the cost per TEU. External factors such as political stability and the economic conditions of countries where competing ports are located were not considered in this study. Additionally, LKHBA's AvAS values for the location category were assumed to be equal to those of LKCMB due to their proximity. All six competing transshipment ports were considered for all scenarios, and each identified transshipment port was assumed to have the potential to function as a transshipment port catering to the identified feeder ports.

Although this methodology can measure market share, there are a few limitations to consider. Ports typically offer several tariffs for their customers, including rebates, incentives, promotions, and discounts that are not visible to the public. This analysis was conducted based on values obtained from recently published port tariffs, meaning that the estimated market shares may differ from the actual market shares. Additionally, owing to the complexity of the study, only the generalised cost related to the transshipment segment was considered, rather than the entire journey. Considering these input values, assumptions, and limitations, the following sections explain the estimated market share of competing transshipment ports for the identified feeder markets.

4.2. Estimated Market Share of Competing Transshipment Ports

4.2.1. Results of Scenario 1

In Scenario 1, the initial behaviour of the Port of Hambantota after commencing its container operations is analysed.

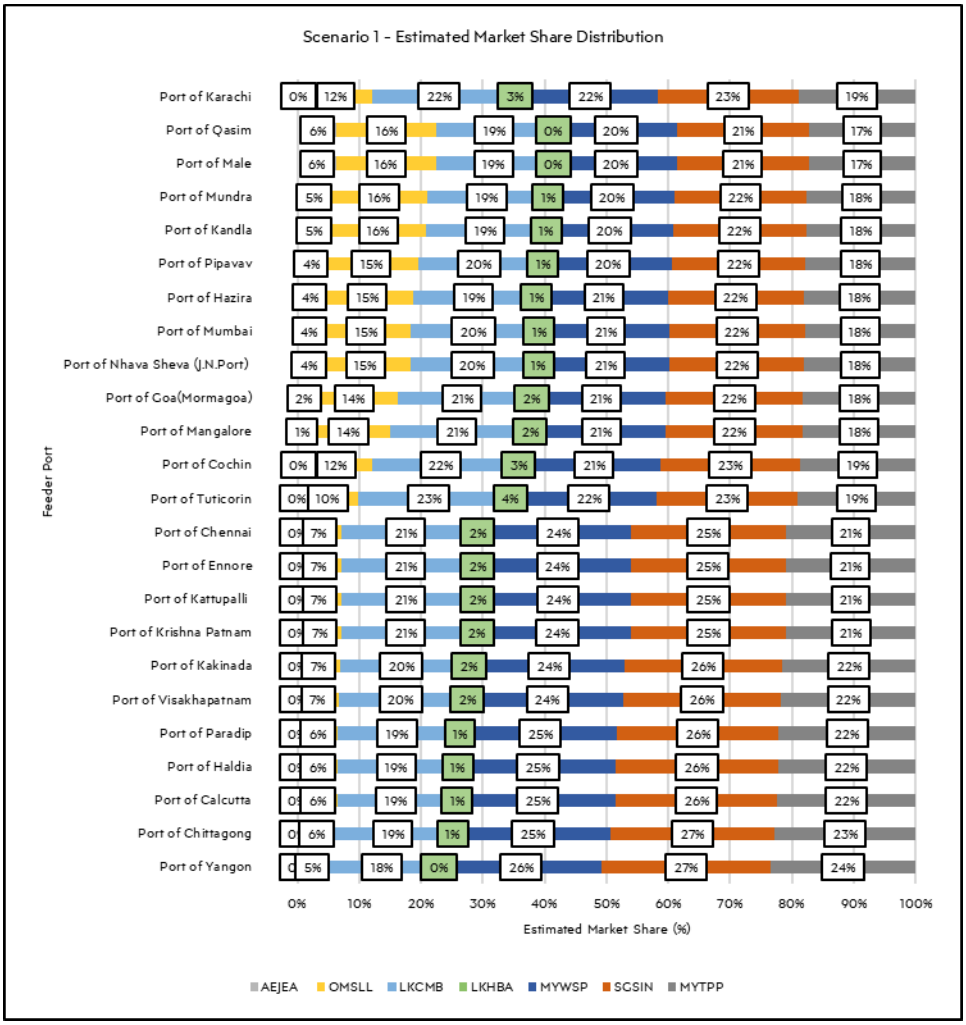

Figure 4: Scenario 1 - estimated market share distribution

As a new transshipment port in the region, its time and port efficiency may be lower than that of other competing transshipment ports. Therefore, to represent this behaviour, the authors assumed that the Port of Hambantota had 150% of the maximum turnaround time among competing ports and 50% of the minimum AvAS value among competing ports. However, as a new entrant to the transshipment market, the authors assumed that the port charges were the same as HIPG's recently published tariff in this scenario. Figure 4 illustrates the estimated market share distribution among competing transshipment ports for each feeder market under Scenario 1.

According to Figure 4, SGSIN has the highest market share for most feeder ports, and AEJEA has the lowest market share for most feeder ports in Scenario 1. The maximum market share that LKHBA will be able to gain is 4%, and it is for the Port of Tuticorin. Furthermore, for some ports, such as Port Qasim, Port of Male, and Port of Yangon, LKHBA will not be able to gain at least a 1% market share over its competitors. This implies that, as a new market entry, LKHBA must develop its performance as soon as possible to compete with well-established regional competitors because its low-performance indices in Scenario 1 generate significantly lower market share for LKHBA than other competing ports, despite its reasonably low port charges.

4.2.2. Results of Scenario 2

In Scenario 2, the authors expect a slight improvement compared to Scenario 1 in terms of time efficiency and port efficiency in the LKHBA. However, the port charges were assumed to be the same as those in Scenario 1. Figure 5 illustrates the estimated market share distribution among the competing transshipment ports for each feeder port under Scenario 2.

According to Figure 5, SGSIN has the highest market share for most feeder ports, and AEJEA has the lowest market share for most feeder ports in Scenario 2. With the assumed development of LKHBA, the maximum market share that LKHBA can gain under Scenario 2 improves to 17% for the Port of Tuticorin. Furthermore, the minimum market share that LKHBA will be able to gain under Scenario 2 also improves to 13% for Port Qasim, Port of Male, and Port of Yangon. Thus, by comparing the estimated market shares of LKHBA in Scenarios 1 and 2, a significant improvement in the port competitiveness of LKHBA can be observed owing to its development in time efficiency and other port efficiencies. Owing to the higher competitiveness of LKHBA, the estimated market shares of other competing ports are reduced almost equally compared to Scenario 1.

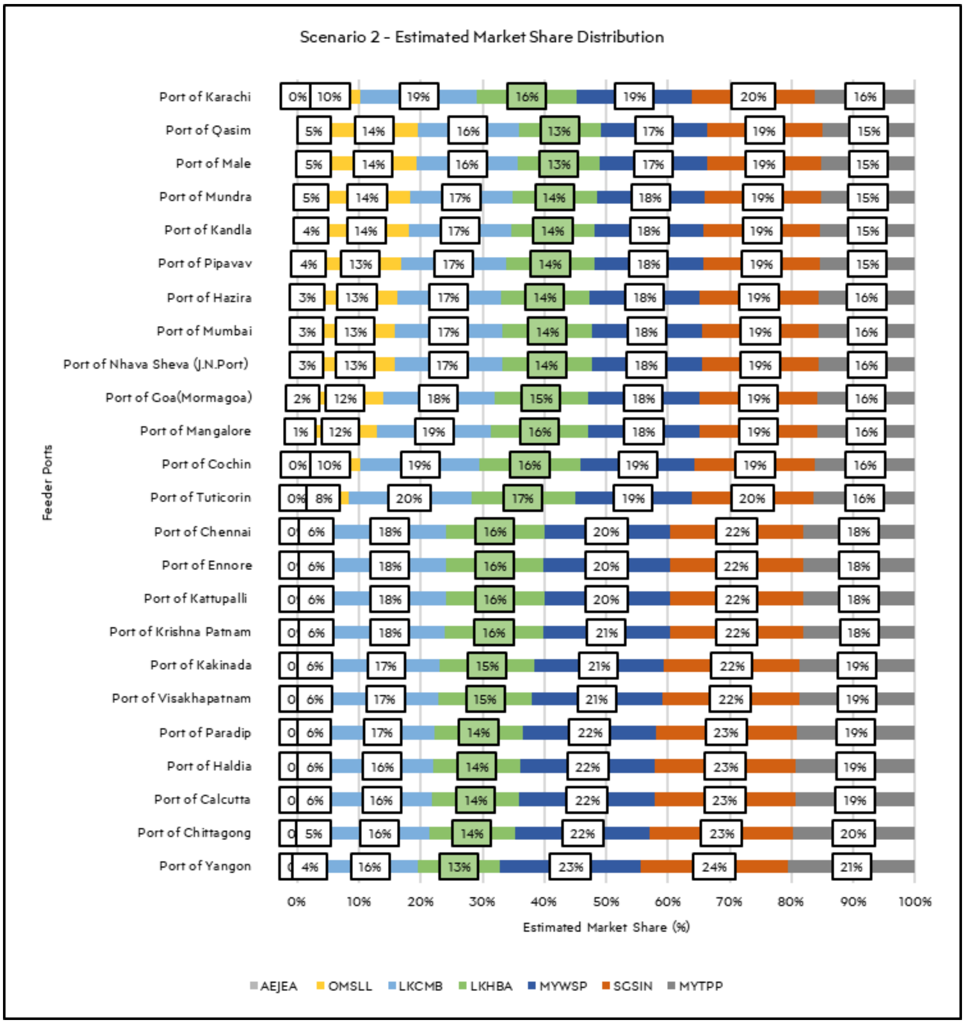

Figure 5: Scenario 2 - estimated market share distribution

4.2.3. Results of Scenario 3

In scenario 3, the authors expect the same time efficiency and port efficiency in LKHBA as in scenario 2. Furthermore, the stevedoring dues are the same as in Scenario 2. However, the free dwell time for transshipment containers doubled because of the high significance of the free dwell time criterion. Figure 6 illustrates the estimated market share distribution among competing transshipment ports for each feeder port under Scenario 3.

According to Figure 6, SGSIN has the highest market share for most feeder ports, and AEJEA has the lowest market share for most feeder ports in Scenario 3. Furthermore, developing LKHBA will result in further improvements, with a maximum market share gain of up to 18% for the Port of Tuticorin. Moreover, the minimum market share that LKHBA will be able to gain under Scenario 3 also improves to 14% for Port Qasim, Port of Male, and Port of Yangon.

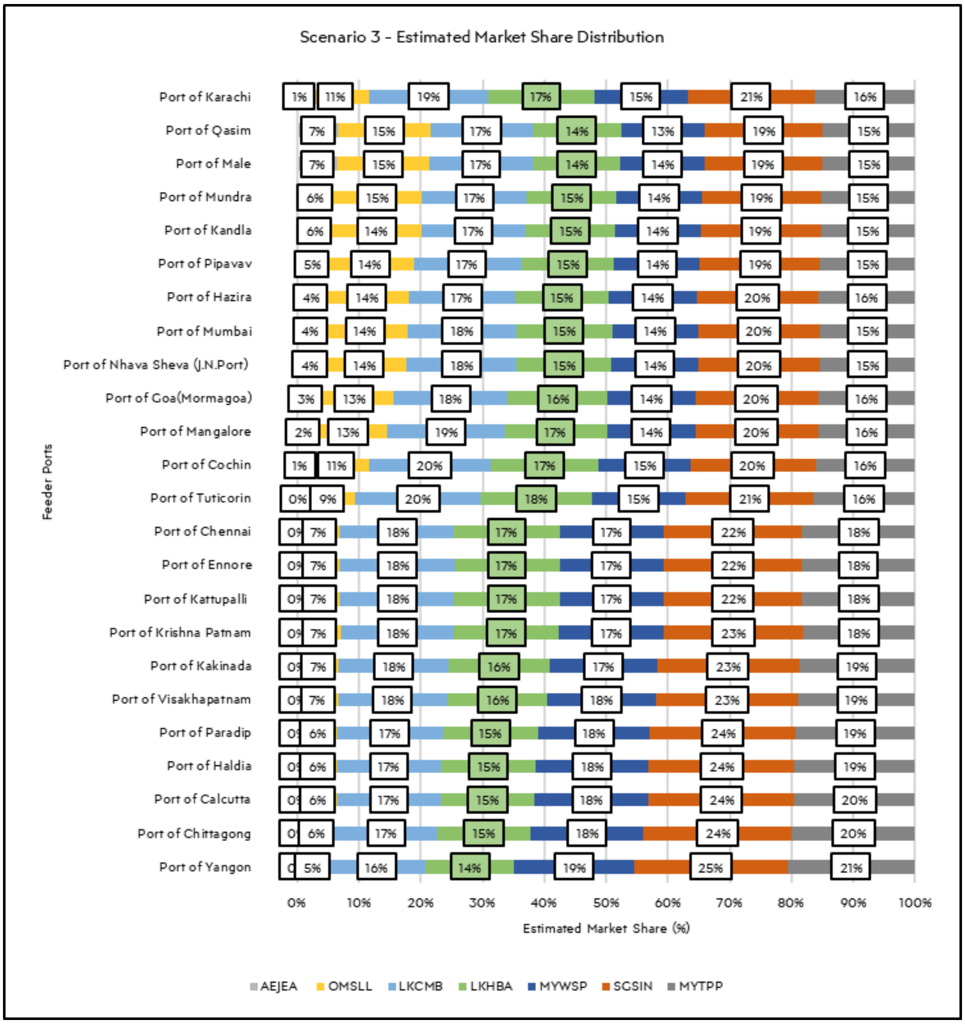

Figure 6: Scenario 3 - estimated market share distribution

4.2.4. Results of Scenario 4

In Scenario 4, the authors expect the same time efficiency in LKHBA as in Scenario 3. Furthermore, the free dwell time was kept the same as in Scenario 3. However, the port efficiency was considered the same as that of the LKCMB. The objective is to benchmark the port efficiency of LKHBA against that of its local competitor and measure its competitiveness. Figure 7 illustrates the estimated market share distribution among competing transshipment ports for each feeder market under Scenario 4.

According to Figure 7, the highest VNQC is for SGSIN, and the lowest VNQC is for OMSLL in Scenario 4. LKHBA will receive a 20% market share for the Port of Tuticorin under the highest development scenario assumed in this study. Furthermore, the minimum market share that LKHBA will be able to gain under Scenario 4 also improves to 17% for Port Qasim, Port of Male, and Port of Yangon. Accordingly, a significant improvement in LKHBA's competitiveness can be observed with the development effort given in Scenario 4 compared to Scenario 1, which represents the initial situation.

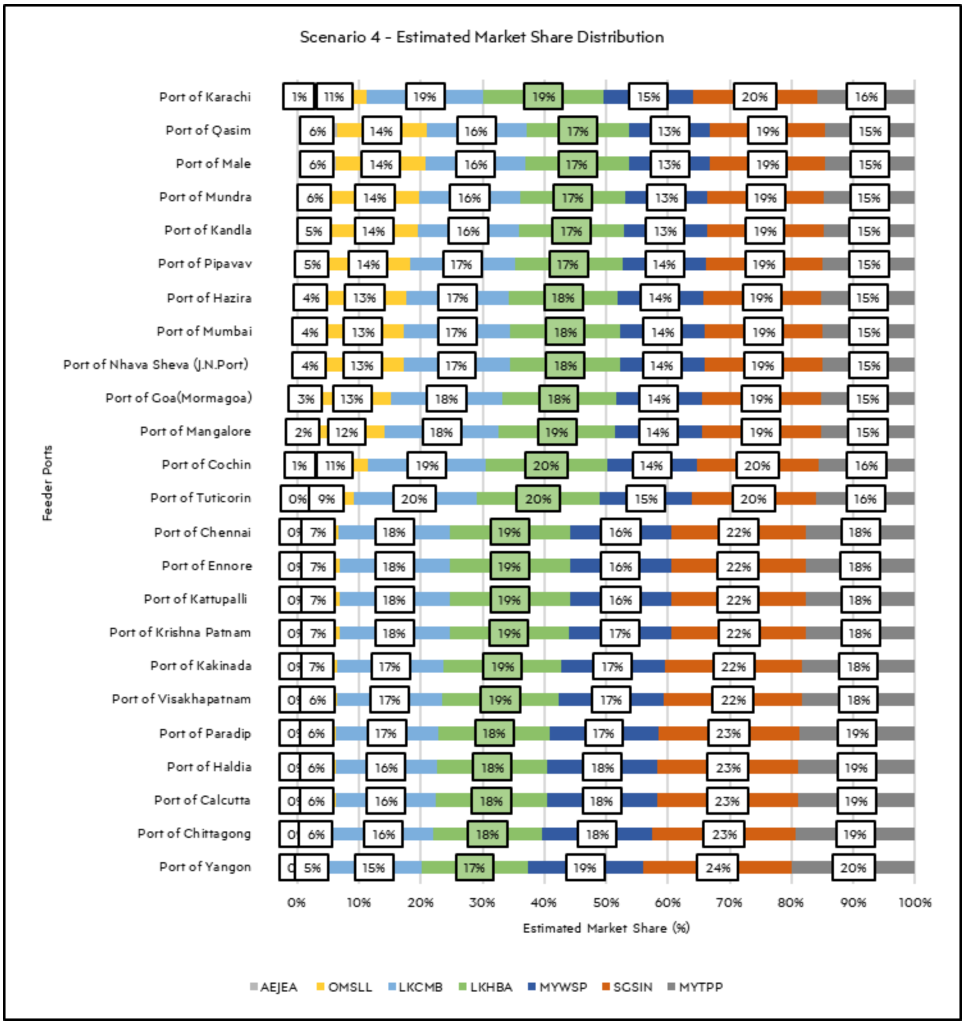

Figure 7: Scenario 4 - estimated market share distribution

4.2.5. Summary of LKHBA Market Shares from All Scenarios

This section summarises the estimated market shares of LKHBA in all four scenarios, as illustrated in Figure 8. Accordingly, LKHBA receives high market shares from the

Tuticorin and Cochin ports in all scenarios. Scenarios 2, 3, and 4 derive significantly higher market shares for LKHBA than Scenario 1, highlighting the significance of enhancing time and other port efficiencies at LKHBA. These results also emphasise that shipping lines consider a range of non-monetary port selection criteria as significant in transshipment port selection rather than focusing only on port handling charges, because Scenario 1, with relatively lower port charges only, could not attract a higher market share for the LKHBA. Although future scenarios highlight the competitiveness of the LKHBA in the South Asian region, this will be realised only if the expected development occurs at the LKHBA.

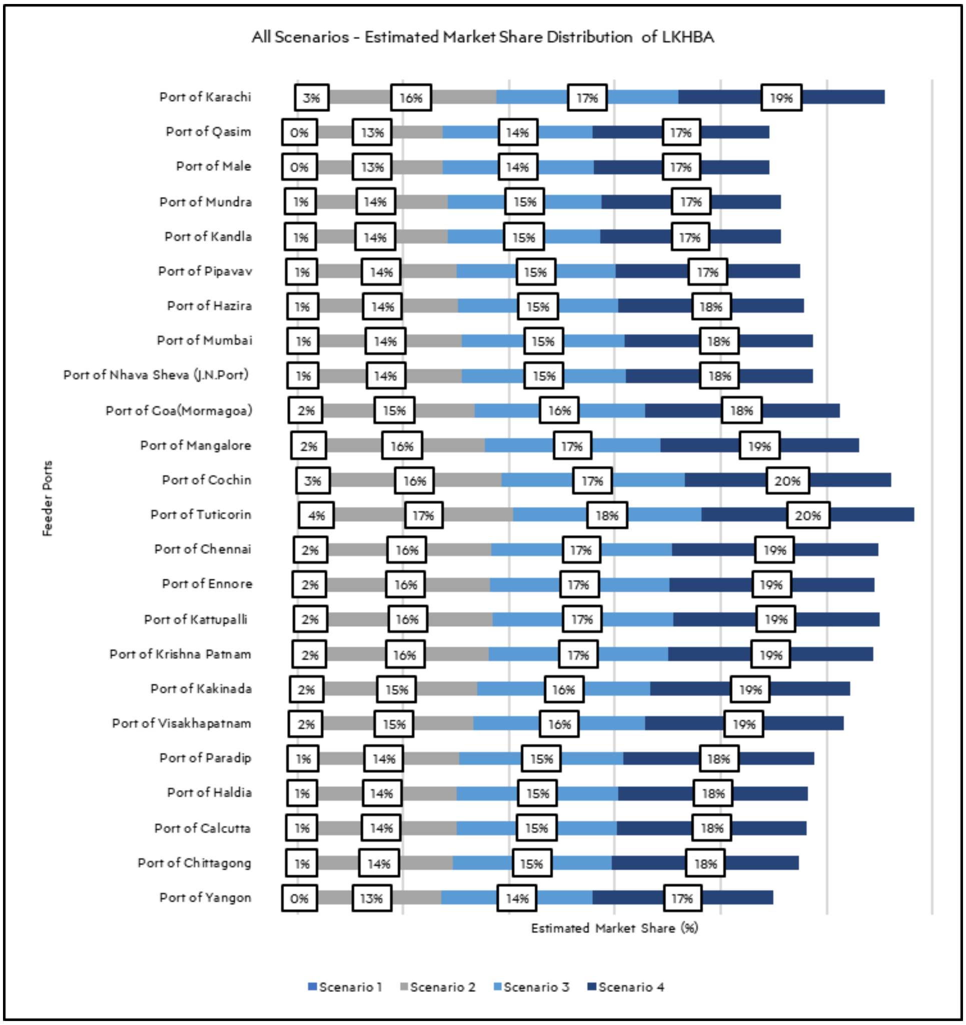

Figure 8: All scenarios - estimated market share distribution of LKHBA

Considering the numerical values of the estimated market shares for each feeder port, Table 8 presents the order of potential feeder ports (highest to lowest) for transshipment operations at LKHBA. Hence, the highest potential is for the Port of

Tuticorin, and the lowest is that of the Port of Qasim. Accordingly, LKHBA has significant potential for container transshipment operations along the South Coast India.

Table 87: Order of potential feeder ports (highest to lowest) for transshipment operation at LKHBA

	Feeder Market	Feeder Port
1	South Coast India	Port of Tuticorin
2	South Coast India	Port of Cochin
3	East Coast India	Port of Kattupalli
4	East Coast India	Port of Chennai
5	Pakistan	Port of Karachi
6	East Coast India	Port of Ennore
7	East Coast India	Port of Krishna Patnam
8	East Coast India	Port of Kakinada
9	West Coast India	Port of Mangalore
10	East Coast India	Port of Visakhapatnam
11	West Coast India	Port of Goa (Mormagoa)
12	East Coast India	Port of Paradip
13	East Coast India	Port of Haldia
14	East Coast India	Port of Calcutta
15	West Coast India	Port of Nhava Sheva (J.N.Port)
16	West Coast India	Port of Mumbai
17	Bangladesh	Port of Chittagong
18	West Coast India	Port of Hazira
19	West Coast India	Port of Pipavav
20	Myanmar	Port of Yangon
21	West Coast India	Port of Mundra
22	West Coast India	Port of Kandla
23	Maldives	Port of Male
24	Pakistan	Port of Qasim

Although the feeder market in East Coast India has moderate potential for LKHBA's transshipment operation, West Coast India and Maldives have lower potential as feeder markets for LKHBA. However, LKHBA's competitiveness as a transshipment port for the Pakistan feeder market depends on the respective feeder port because LKHBA receives a high market share from the Port of Karachi and the least share from the Port of Qasim.

5. CONCLUSION

This study analysed the competitiveness of the Port of Hambantota as a container transshipment port by estimating its transshipment market share in related feeder markets. Although the Port of Hambantota is currently not operating as a container transshipment port, its competitiveness was estimated based on the market share derived through an extended version of a generalised cost approach with a multinomial logit model. To estimate the market share of the Port of Hambantota, this study considered six competing container transshipment ports in Southwest Asia (Port of Jebel Ali, Port of Salalah), South Asia (Port of Colombo), and Southeast Asia (Port of Singapore, Port of Tanjung Pelepas, Port Klang) regions. This study introduces 15 new determinants of container transshipment port competitiveness. A scenario analysis was performed in this study to understand the potential implications of the transshipment business at the Port of Hambantota.

When summarising the main findings, the initial situation with lower port efficiencies at the Port of Hambantota could not derive a significant market share in transshipment operations from any feeder ports. However, the study demonstrated that the Port of Hambantota has significant potential for container transshipment operations with continuous port performance improvements. The highest competitiveness of the Port of Hambantota was observed from the feeder market in South Coast India, which includes the Ports of Tuticorin and Cochin as feeder ports. The Port of Hambantota demonstrated lower competitiveness in serving feeder ports such as the Ports of Qasim and Male. In all scenarios, the Port of Singapore demonstrated the highest competitiveness in serving most feeder ports. These results emphasise the significance of enhancing the performance of the Port of Hambantota, especially in terms of non-quantitative performance criteria, to develop it as a container transshipment port.

However, this study had some limitations. Generally, ports offer multiple tariffs for their customers, including rebates, incentives, promotions, and discounts, which are not visible to the public. However, this analysis was conducted based on values obtained from recently published port tariffs. Therefore, the estimated market shares may differ from the actual market shares. Furthermore, owing to the complexity, the study only considers the generalised cost related to the transshipment segment instead of the entire journey. Additionally, validation of the results was impractical because of the lack of market share data availability.

Despite these limitations, several future research directions can be suggested. The analysis can be further conducted by considering the development of the six competing transshipment ports, the development of new ports in the region (for example, the Port of Vizhinjam), and the development of other existing ports in the region. In this study, the Port of Colombo is considered a competing port for the Port of Hambantota. However, it would be beneficial to conduct further research considering coopetition instead of competition between these two ports to measure the overall benefit to Sri Lanka. Additionally, developing an approach to validate the results obtained using this method would be advantageous. The model's accuracy can also be further improved over time by including new determinants and excluding non-significant determinants of port competitiveness based on market dynamics.

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