CHAPTER 4

Dynamics of Port Costs

The international trade cost of moving goods from ports comprises different elements as given in Figure 4.1. Specific cost dynamics applicable for goods moving through ports is described in the ensuing section. As mentioned earlier international trade happens majorly in volume terms through maritime roots. This study is relevant in the context of understanding of port costs from the viewpoint of two major stakeholders, namely, the carrier and the shipper. Though the shipper has to directly incur port cost under the category of ‘wharfage’ (cargo related charges), all cost borne by the carrier is passed on to the shipper. This contributes to the total landed cost of any good moving through the port. The dynamics of the cost, as revealed from the literature and discussions with the stakeholders, revolves around the port costs incurred by the carrier in the port. This has been analysed in the ensuing sections.

4.1 Ship’s costs at ports

Port costs constitute significant part (almost 25%) of the Ocean Freight rate (De, 2008), which is an important component of the price of a commodity and may be an important barrier to trade and could have an important effect on overall development of a country especially a developing country. Figure 4.1 below gives a pictorial description of total port costs as a part of the export costs of a commodity.

The dynamics of a port system as a part of the logistics chain, arising out of interaction of different variables that describes the system, may be explained as follows.
Figure 4.1: The Ship – Cost at Port

International Trade Cost

- Production Costs
- Distribution Costs

Transportation Costs

Maritime Transport Costs
- Freight Rate
- Insurance
- Transport Operation at Sea

Inland Transport Costs
- Shore Costs
- Storage Costs
- Port Dues and Charges
- Stevedoring Charges

Wharfage Dues
Quay Handling Charges

Ship’s time at Port
Ship’s costs at ports constitute a significant part of the maritime transport costs and thus can have a significant effect on the logistics costs and hence on the final price of a product. The total costs incurred in port are calculated by adding together (1) actual port costs and (2) the cost of ship’s time in port.

Maritime Transport Cost = f(Ship’s cost at port)
Ship’s cost at port = Actual Port Cost + Cost of ship’s time at port

\[ T_c = f(S_c) \]  
\[ S_c = P_c + S_{tc} \]  
\[ P_c = P_d + P_p + P_b \]  
\[ P_b = g(I_f, O_e) \]

Where,

\( T_c \) = Maritime Transport Cost
\( S_c \) = Ship’s cost at port
\( P_c \) = Actual Port Cost
\( S_{tc} \) = Cost of ship’s time at port
\( P_d \) = Port dues
\( P_p \) = Pilotage charges
\( P_b \) = Berth hire charges
\( I_f \) = Infrastructural facilities
\( O_e \) = Operational Efficiency level

Infrastructural facilities \( (I_f) \) constitutes loading, unloading and shore clearing equipment. The stay at berth (that results in berth hire charges) is dependent on number of right equipment and its operational efficiency level \( (O_e) \). Operational efficiency level \( (O_e) \) determines the output per ship per day. Berth hire charges also depends on the parcel load (total cargo carried by the ship) of the ship. As the tonnage increases, stay at berth increases.
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Cost of ship’s time at port ($S_{tc}$) includes opportunity cost ($P_{oc}$) due to non-working time at port. A ship may have to wait due to non-availability of berths or any other resources such as tugs, or may be owing to stoppage of work, delay in clearance of documents or any other managerial issues. In whole the “Cost of ship’s time at port” is function of “Turn Round Time”. The Turn Round Time (TRT) is defined as the time duration from the time ship reports to the reporting point of the port and till she leaves this point.

Port costs are made up of two parts:

(i) A fixed component which is independent of tonnage throughput (includes the capital costs of quays, sheds, cranes etc. and is covered by wharfage dues and port charges).

(ii) A variable component which depends on tonnage throughput (includes labour costs, fuel, maintenance costs etc. and is covered by quay handling charges, port charges and stevedoring charges).

Thus, Ship’s cost at port ($S_c$) can be defined as sum total of one-time cost payable to the port per voyage ($P_{ot}$) and the variable component ($P_{vt}$) that is proportional to ship’s time at port (TRT). $P_{ot}$ includes Port dues ($P_d$) and Pilotage charges ($P_p$). Hence we redefine equation (5.2) as:

$$S_c = P_{ot} + P_{vt}$$ 

Where,

$$P_{vt} = P_b + P_{oc}$$

As the tonnage handled at a berth increases, the fixed component, when expressed as a cost per tonne, decreases. The variable component, when expressed as a cost per tonne, will probably remain fairly stable until the berth comes under pressure to achieve high tonnage throughputs, at which point the variable cost per tonne will tend to rise owing to use of more costly methods of cargo handling. These costs are realized by the ports through various port charges and dues. This will in turn reduce the TRT.

Thus, we can conclude that the “Turn Round Time” is a function of parcel load, infrastructural facilities, and Operational efficiency level.

Average charges calculated on the basis of shipping rates provided by the Maersk Sealand for (De, 2008) for import of a container vessel in India reveals that almost 25% of the total freight charges are collected by the terminal or port operators (of which around 13% at
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destination i.e at Indian ports) for various port related activities. Thus, an increase in the efficiency level of the ports may have a significant effect on the logistics costs. Besides, an increase in the efficiency level of the ports may also increase the overall efficiency level of the supply chain.

The port costs are realised by the port authorities through various charges covered under shore costs and berth costs. The shore cost consists of wharfage, quay handling and storage charges. The wharfage is the charge usually assessed against all cargo passing or conveyed over, onto, or under wharves, or between vessels (i.e., to or from barge or lighter or into water) when berthed at a wharf or when moored in a ship adjacent to the wharf. Wharfage is solely the charge for the use of the wharf and does not include charges for any other services. Quay handling charges are the charges for taking cargo from storage to the quay and from the quay to the storage area for export cargo and import cargo respectively. It also covers the charges for handling the cargo over to and from inland transport in case of direct cargo.

Berth costs consist of Port dues and charges and stevedoring charges. Port Dues are imposed for general use of port facilities and does not relate to any specific services received on a port call. Port Dues are also charged for Conservancy Services like dredging, construction and maintenance of breakwaters, jetties etc. and based on projected volume/weight of cargo carried (by ship) or the registered tonnage - Gross registered tonnage (GT) or Net registered tonnage (NT).

We conclude that TRT has a bearing on the ship’s cost at port, besides other factors such as size of vessel. The time – cost relationship can be expressed as:

\[ C_{\text{time}} = g(\text{TRT}) \]  \hspace{1cm} \text{......(4.7)}

\[ \text{TRT} = k(Q, C_T, \text{IF}, \text{EL}) \] \hspace{2cm} \text{......(4.8)}

Where

\( C_{\text{time}} \) = Cost of ship’s time at port

\( \text{TRT} \) = Turn Round Time

\( Q \) = Traffic Volume

\( C_T \) = Nature of cargo: Container Cargo

\( \text{IF} \) = Infrastructural Facilities,

\( \text{EL} \) = Operational Efficiency level

Ship’s time in port is made up of two parts:

(a) The time the ship spends waiting for a berth to become vacant;
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(b) The time the ship spends at the berth.

As traffic increases, the time ships waiting to obtain a berth increases. At high berth occupancies, this increase in ship waiting time may be quite dramatic. The time ship spends at the Berth depends on the nature of cargo, infrastructural facilities at the port and operational efficiency of the port. The summation of actual port cost and the cost of ship’s time in port results in the total costs incurred by ships in port.

The minimum total cost depends on the size of the various cost elements. It is dependent on the relative capital costs of ships and of berths. Thus in respect of break bulk general cargo ships higher berth occupancies are economically justified than in the respect of more sophisticated vessels container ships, tankers, liquefied natural gas carriers.

Average charges calculated on the basis of shipping rates provided by the Maersk Sealand for the year 2006 for import of a container vessel in India reveals that almost 25% of the total freight charges are collected by the terminal or port operators (of which around 13% at destination i.e at Indian ports) for various port related activities. Thus, an increase in the efficiency level of the ports may have a significant effect on the logistics costs. Besides, an increase in the efficiency level of the ports may also increase the overall efficiency level of the supply chain.

4.2 Port’s Operational Efficiency and Ship’s Cost Dynamics

A change in the operational efficiency of a port results in a change in the cargo handling rate, idle time at port, waiting time of ships, time for ship’s stay at berth, time for cargo receipt and delivery. An increase in the operational efficiency increases the cargo handling rate, reduces total operational time and thus results in a faster delivery of cargo at both ends of operation (ship and shore). This reduces the time for ship’s stay at port or average turn round time. As ship’s cost at port is a function of ship’s time at port as explained above, this in turn reduces ship’s total cost at port. A decrease in the ship’s total cost reduces the maritime transport cost along the logistics chain. As a result, the port’s competitiveness compare to other neighbouring ports increases and the port is likely to experience increase in number of ship calls and traffic. The ships immediately cannot perceive the decrease or increase in its total costs. Some time may be needed by them to assess the situation. This perception delays by
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the carriers for proper assessment of effect of any increase or decrease of the average turn round time may play as a compensatory feedback loop, and may send a wrong signal to the port management if not interpreted correctly.

4.2.1 Elements of Maritime Logistics:

Maritime logistics have two components:
  i. Port and related operation
     Loading – unloading operation, quay transfer operation, storage operation (within port) and receipt and delivery operation
  ii. Shipping operation
     Transport operation at sea

Time component Distribution of Maritime logistics:
  i. At port : vessel load/ productivity $T_1$
  ii. At sea : Distance/Average speed per vessel load $T_2$

Total time $T = T_1 + T_2$

Variable component: Productivity
$T_1/T$ is impact of port on overall time and cost which will decrease with increase in productivity in port operation. $T_2/T$ is impact of ship operation on overall time and cost which will decrease with increase in productivity in ship operation.

Cost component
  i. At port ($T_{cp}$) depends on $T_1/T$
  ii. At sea ($T_{ship}$) depends on $T_2/T$

Theoretical model:
Minimize $T_1/T$ or Minimize $T_1$
Minimize $T_{cp}/T_{cost}$ or Minimize $T_{cp}$

From equation (5.7) we conclude that minimization of TRT leads to minimization of cost. This leads to the proposition: Maximize efficiency for minimising maritime cost

Let Efficiency at port be defined as $E = y^0/y^*$
Whereas, \( y^0 \) is the actual output of ports and \( y^* \) is the maximum possible output that can be produced.

\[ 0 \leq E \leq 1 \]

Measure of port output

i. **Total Turn Round Time of ships:** It is total time spent by the ship in the port – from arrival at anchorage to departure (sailing).

Higher the efficiency of ports, lower the turn round time (TRT) of ship with a given parcel load.

Proposition now stands as “Minimise TRT, a single index measure of port efficiency”.

### 4.3 Chapter Summary

- Ship’s costs at ports constitute a significant part of the maritime transport costs and thus can have significant influence on the logistics costs and hence on the final price of a product.
- The total costs incurred in port are calculated by adding (1) actual port costs and (2) the cost of ship’s time in port.
- Actual port cost is a function of infrastructural facilities and operational efficiency level at the port. It has two components: i) A fixed component which is independent of tonnage throughput (includes the capital costs of quays, sheds, cranes etc. and is covered by wharfage dues and port charges), and ii) A variable component which depends on tonnage throughput (includes labour costs, fuel, maintenance costs etc. and is covered by quay handling charges, port charges and stevedoring charges).
- Ship’s time in port is made up of two parts: (a) The time the ship spends at the berth; (b) The time the ship spends waiting for a berth to become vacant.
- Cost of ship’s time at port is a function of average turn round time which depends on traffic volume, nature of cargo, infrastructural facilities, operational efficiency level, and capacity of the port.

Maritime logistics have two components: (i) Port and related operation comprising of loading – unloading operation, quay transfer operation, storage operation (within
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port) and receipt and delivery operation; and (ii) Shipping operation i.e., Transport operation at sea.

With increase in the productivity of the port operation the time and cost component of the Port related operation decrease.

By maximising efficiency level at port the port operation related cost can be minimised which in turn may decrease the total logistics costs at the desired level. Higher efficiency of ports lowers the turn round time of ship with a given parcel load.

The evaluation of ports efficiency using TRT as key performance indicator has been carried out in Chapter 5. The relationship of TRT with the key dimensions has been described in Chapter 5.