CHAPTER 7

Summary of Findings, Conclusion and Scope of Further Work

7.1 Summary of Findings

This research had two major contributions. One, it proposed an analytical framework for decision making in ports and second, it analysed the performance of major container handling ports in India. The research benchmarked the efficient ports and identified the causes of low efficiency of the in-efficient major container handling ports of India

I. Analytical Framework

This research proposed an analytical framework to integrate the dimensions and the variables affecting port performance. The framework concluded with a causal model for policy experimentation of the decision makers. The proposed analytical framework included the following steps.

Step 1
Identification of the port performance indicators

The research work started with the objective of identifying the dimensions and the variables under each dimension that impact port efficiency.

The various port performance indicators and their relevance in port efficiency were identified through:

- Literature survey,
- Collection of data from various major ports of India, and other stakeholders such as shipping lines and freight forwarders
- Discussions with expert groups comprising stakeholders such as importers, exporters, shipping lines, freight forwarders and ports.
Step 2

Benchmarking the efficient ports

Benchmarking has been proposed to be done using Data Envelopment Analysis (DEA). This step led to the following results:

i. Efficient ports

ii. The input and output bundles corresponding to the efficient ports

iii. The reason for low efficiency, i.e., segregating it as technical and managerial efficiency.

iv. Identify the peers who can be emulated by the inefficient ports

v. The slacks or the inefficiency proportion against each input or resources

Step 3

Identification of the dimensions, variables and the relationship

This step constitutes two sub-steps, namely, identification of dimensions and the associated variables, and the relationships between the dimensions. Relationships refers to the degree and direction of association amongst the variables, and dimensions (factors)

Step 3a

Identification of the dimensions and the variables

Identification of dimensions and the associated variables were done using Principal Component (Rotated-Factor Analysis) analysis. The factors represented the dimensions and each dimension, being rotated, is distinct encompassing the associated variables. The naming of each dimension is proposed to be done using the variables and their loadings associated with them. The validity of labels is proposed by taking expert opinion.

Step 3b

Identification of the relationships between dimensions
The use of Multiple-regression is suggested to identify the degree and direction of association amongst dimensions (factors). This step provides the linear relationship with weightages of each dimension. The significance of the dimensions and their weightages are expected to vary with data set. In this research two major dimensions relevant to major container handling ports in India were identified. However, the results of multiple-regression showed that one of the factors is significant in the Indian context.

**Step 4**

**Policy experimentation**

This step comprises two sub-steps. One, development of a causal model and second, simulate the model to identify the impact of policies taken by the decision makers to improve port efficiency.

**Step 4a:**

The research proposes use of System Dynamics approach for the development of the causal model. The factors obtained from Factor Analysis were used for the purpose of identifying the sectors in the system dynamics model. The variables under each factor formed the sectors, the results of multiple-regression aided in defining the mathematical expression describing the association amongst the variables and the factors. The findings of literature review, data analysis of major container handling ports in India and expert group discussions can be considered along with the results of DEA, Factor Analysis and Multiple-Regression to identify level, rate and auxiliary variables; and their relationships and thus validate the causal model.

**Step 4b**

*Simulation of the Causal Model*
Simulation of the causal model so developed is proposed to be done using System Dynamics software such as Stella or Vensim. In this research Vensim software version has been used to observe how various efficiency level (of the port) policy decisions could be taken to influence the overall performance of the port and logistic chain.

II. Analysis of Indian Ports

Step 1

Identification of the port performance indicators (covering inputs considered for DEA and associated variables)

The following port performance indicators were identified for analysis (DEA and Factor Analysis) on the basis of literature survey, expert group discussion and availability of data.

- Traffic: Container traffic in ,000 TEUs
- Vtraffic: Number of Container vessels
- APS: Average Parcel Size in tonnes
- AOPSBD: Average Output per ship berthday in tonnes
- PNWTSP: Percentage of non-working time to ship’s time at port
- APBT: Average Pre-berthing time in days
- Draft: Draft in metres
- Crane: Number of cranes handling containers
- Berth: Number of berth dedicated to handle containers
- Capacity: Capacity of handling containerized cargo (in m tonnes)

For the purpose of DEA input and output variables with publicly available data, as used by many other authors were included. The inverse of Turn Round Time per thousand TEUs i.e., 1/TRT/1000 TEU is taken as the sole output variable. Turn round time (TRT) of ship has a direct effect on the total logistics costs. Hence an increase in the value of inverse of TRT as a result of more efficient system can actually decrease the total logistics costs. Three input variables Draft, Cranes (number of) and Berth (number of) are considered for the analysis.
Step 2

Benchmarking the efficient ports

<table>
<thead>
<tr>
<th>PORT/Terminal</th>
<th>OTE Score</th>
<th>OTIE(%)</th>
<th>PTE Score</th>
<th>PTIE(%)</th>
<th>SE Score</th>
<th>SIE</th>
<th>RTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>KDS</td>
<td>0.491</td>
<td>50.9</td>
<td>0.926</td>
<td>7.4</td>
<td>0.435</td>
<td>56.5</td>
<td>DRS</td>
</tr>
<tr>
<td>HDC</td>
<td>1.000</td>
<td>0.0</td>
<td>1.000</td>
<td>0.0</td>
<td>1.000</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>VPT</td>
<td>1.000</td>
<td>0.0</td>
<td>1.000</td>
<td>0.0</td>
<td>1.000</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>ChPT</td>
<td>0.494</td>
<td>50.6</td>
<td>0.498</td>
<td>50.2</td>
<td>0.994</td>
<td>0.6</td>
<td>IRS</td>
</tr>
<tr>
<td>TPT</td>
<td>1.000</td>
<td>0.0</td>
<td>1.000</td>
<td>0.0</td>
<td>1.000</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>CoPT</td>
<td>0.817</td>
<td>18.3</td>
<td>0.875</td>
<td>12.5</td>
<td>0.934</td>
<td>6.6</td>
<td>DRS</td>
</tr>
<tr>
<td>JNPT</td>
<td>0.314</td>
<td>68.6</td>
<td>0.319</td>
<td>68.1</td>
<td>0.983</td>
<td>1.7</td>
<td>DRS</td>
</tr>
<tr>
<td>NSICT</td>
<td>0.610</td>
<td>39.0</td>
<td>0.610</td>
<td>39.0</td>
<td>1.000</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>GTICT</td>
<td>1.000</td>
<td>0.0</td>
<td>1.000</td>
<td>0.0</td>
<td>1.000</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>KPT</td>
<td>0.241</td>
<td>75.9</td>
<td>0.249</td>
<td>75.1</td>
<td>0.969</td>
<td>3.1</td>
<td>DRS</td>
</tr>
<tr>
<td>MEAN</td>
<td>0.697</td>
<td>0.706</td>
<td>0.706</td>
<td>0.985</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Authors’ own calculations

Notes: OTE= Overall technical efficiency, OTIE%= Overall technical inefficiency=(1-OTE)×100, PTE= Pure technical efficiency, PTIE%=Pure technical inefficiency=(1-PTE)×100, SE= Scale efficiency, SIE(%)=Scale inefficiency=(1-SE)×100, RTS=returns-to-scale, IRS= increasing returns-to-scale, CRS=constant returns-to-scale; and DRS=decreasing returns-to-scale

The result of DEA (Table 5.1 of Chapter 5 reproduced above) shows that of the 10 ports/terminals, HDC, VPT, TPT and GTICT (four) were found to be technically efficient since they had OTE score of one. The remaining ports have OTE score less than one which means that they are technically inefficient. OTE scores among the inefficient ports range from 0.241 for KPT to 0.817 for CoPT. This finding implies that KPT and CoPT can potentially increase their current output levels by 75.9 percent and 18.3 percent, respectively while leaving their input levels unchanged. This interpretation of OTE scores can be extended for other inefficient ports in the sample.

Among the efficient ports GTICT and TPT, which appeared in the reference sets of inefficient ports relatively more frequently than other efficient ports were considered to be highly robust ports. Their frequency counts have been observed to be 5 and 4 respectively. On the basis of such a high frequency count, they have been appropriately considered as global leaders of Indian port sector.
HDC was considered to be a marginally robust port due its low frequency count. It is interesting to note that although VPT was found to be an efficient port yet it did not exemplify any best practices (as indicated by zero frequency count) to be followed by the inefficient ports.

It is also observed that overall technical inefficiency in the Indian port sector is due to both poor input utilization (i.e., pure technical inefficiency) and failure to operate at most productive scale size (i.e., scale inefficiency).

**Step 3**

*Identification of the dimensions, variables and the relationship*

**Step 3a**

*Identification of the dimensions and the variables*

Principal Component Analysis was done with the variables identified (as mentioned above) resulted in two factors.

Factor 1 (51%) was loaded with traffic, capacity, crane, vessel traffic, average output per ship berth day, average parcel size and berth. This factor explains the port’s capacity dimension.

Factor 2 (14%) was loaded with two groups of variables with opposite signs. One group comprising of draft and the other comprising of average pre berthing time and percentage of nonworking time to total ship time at port. This factor explains port’s efficiency dimension.

**Step 3b**

*Identification of the relationships between dimensions*

The sector-wise variables and plausible relationship identified in this research as derived in Chapter 7 (Table 7.2 reproduced below) are as follows:
A Computational Framework for Assessing Impact of Port Efficiency on Maritime Logistics, Mrinal Kumar Dasgupta, IIFT

<table>
<thead>
<tr>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>-.002</td>
<td>.041</td>
<td>-.055</td>
</tr>
<tr>
<td>REGR Infrastructure Dimension</td>
<td>.073</td>
<td>.041</td>
<td>.073</td>
</tr>
<tr>
<td>REGR Efficiency Dimension</td>
<td>.797</td>
<td>.041</td>
<td>.796</td>
</tr>
</tbody>
</table>

Dependant Variable: ATRT

The relationship between dependant variable i.e., ATRT and the dimensions i.e., CD (insignificant) and ED is given by equation 7.1 (Chapter 7).

ATRT = -.002 + .796 ED

The above relation confirms that the efficiency level of the logistics chain is dependent on the efficiency level of the port. The increase in efficiency (i.e., an decrease in the value of ED through a decrease in APBT and PNWTSBD and an increase in Draft) is expected to result in reduction in stay time of ships at the port, that is, decrease in ATRT.

Step 4

Policy experimentation

Step 4a

Develop the Causal Model

The simulation model so developed can be used for the Indian ports for making various policy decisions which may have its effect on the logistics costs and hence on the final price of any commodity traded through ports. But while framing the model one has to be cautious about one important point. There are 12 major ports and more than 150 non major ports in India and many of them differ in nature with others in many respect. For example, Kolkata Port Trust, a major port, is a riverine port and has the typical problems of a riverine port unlike the other major ports of India. JNPT is mainly a container handling port(89.8%) whereas Ennore basically handles coal (79.6%), New Mangalore and Paradip Port Trust mainly handle POL and coal etc. There are other differences in terms of type and number of cranes, equipment used by the ports, their draft, road, rail connectivity with the hinterland etc. So, while measuring the efficiency level different benchmark should be used for different
ports. Benchmark may be set by comparing terminals (both national and international) handling same type of cargo under more or less similar type of conditions. Then only the model may be used more effectively for taking various decisions.

7.2 Recommendations for major Indian ports handling containers

It has been observed that the 4 ports/terminals-HDC, VPT, TPT and GTICT that have Overall Technical Efficiency (OTE) score equal to 1 also acquired the status of ‘locally efficient’ ports because they attained the Pure Technical Efficiency (PTE) score equal to 1 and lie on the efficient frontier under VRS assumption. It has been further noticed that in the remaining 6 ports (having PTE<1) managerial inefficiency exits, albeit of different magnitude. In these ports, except NSICT, overall technical inefficiency stems from both pure technical inefficiency and scale inefficiency as indicated by the fact that these ports have both PTE and SE scores less than 1. For NSICT scale efficiency is 1. Out of the rest five ports, four ports (except KDS) ChPT, CoPT, JNPT and KPT have PTE score less than SE score. This indicates that the inefficiency in resource utilization (i.e., OTIE) in these ports is primarily attributed to the managerial inefficiency rather than to the scale inefficiency. Only for KDS scale inefficiency was more than managerial inefficiency. So, policy recommendation for these ports i.e., ChPT, CoPT, JNPT and KPT, would be to give more emphasis on efficient management system for better utilization of resources.

The results also indicate that five ports (HDC, VPT, TPT, NSICT and GTICT) are operating at most productive scale size and experiencing CRS. Further one port (ChPT) is operating below its optimal scale size and thus experiencing IRS. The policy implication of this finding is that this port can enhance OTE by increasing its size. The remaining four ports (KDS, CoPT, JNPT and KPT) have been observed to be operating in the zone of DRS and, thus, downsizing seems to be an appropriate strategic option for these ports in their pursuit to reduce unit costs.

7.3 Further Scope of Work

The research can be extended to include the causal relationship of variables in each sector and carry out a multi-port simulation to identify the strategy implications per policy variable.