CHAPTER THREE
Port Performance Monitoring and Evaluation

J.A. Ojekunle

3.0 Introduction

Performance evaluation is critical to effective and efficient management of any organization. Performance evaluation helps the management of an organisation to monitor the performance of its organisation. Monitoring and evaluation of an organisation performance provides useful input for management decisions. It forms a reliable basis for corporate planning, as well as identifying areas of improvement in the entire operation of the organisation.

Performance evaluation of port operation needs to be carried out from time to time to ensure optimum performance and efficient management of port. However, to carry out port performance evaluation certain indicators of port performance must be identified. These indicators are the measurable standards through which port operation performance is evaluated.

In this chapter, various port performance indicators are identified and discussed. In addition, some examples are given to enable us understand how to measure these indicators and how these indicators can be applied for evaluation of port operational performance.

3.1 Port Performance Indicators

Port Performance indicators are simple measures of various aspects of ports operation. To fulfill their purpose, such indicators should be easy to calculate and simple to understand. They should provide insight to port management into the operation of key areas. They can be used, first, to compare performance with a target and secondly, to observe the trend in performance levels. For example, the productivity for handling general cargo for the first month might be 15tons per gang-hour. If successive monthly figures show a decline from this value, clearly

actions to determine the reason for the decline and measures to remedy it will be necessary. The indicators can also be used as input for negotiations on port congestions surcharges, port development, port tariff considerations and investment decisions.

3.2 Operational Indicators

Perhaps of more direct concern to port management than financial indicators are operational ones. If port charges have been well thought out and actual traffic follows the projected figures, then through the control of the operational performance, management will control the financial performance of the port as well. The indicators presented are not exhaustive but it is felt they are the most important ones for port management initially to select for medium-term planning and control.

Important information to maintain is the number of ship arrivals and a breakdown of the ships' time in port for each class of cargo. These data are of prime concern to the ship owners and operators for the setting of freight rate and thus of direct concern to shippers and consignees who must pay the freight rate. Perhaps the most complicated and intricate problem existing in the transport field today is the turn-round of ships in ports.

An excellent indicator to maintain of port effectiveness is the quantity of cargo worked per ship hour in port with a high figure being desirable. To maintain this indicator, information on the arrival time, departure time and ton of loaded/discharged for each ship must be recorded. In addition, the time of berthing, ship length and location of berthing should be noted. The various ship times must be accurately defined and then consistently recorded. In addition to the above information, data on the total hours at berth during which the ship was worked and on the total gross gang-hours worked should be recorded, to permit measurement of the intensity of working.

From these records, the following averages can be calculated on a monthly basis for each berth group servicing a cargo class:

(a) Arrival rate: Number of ships arriving during a month divided by number of days in the month;

(b) Waiting time: Total time between arrival and berthing for all berthing ships, divided by number of berthing ships;

(c) Service time: Total time between berthing and departure for all ships, divided by the number of ships;

(d) Turn-round time: Total time between arrival and departure for all ships, divided by number of ships;

(e) Tonnage per ship: Total tonnage worked for all ships, divided by number of ships;

(f) Fraction of time berthed ships worked: Total time that berthed ship were actually worked, for all ships, divided by the total time between berthing and departure of all ships;

(g) Number of gangs employed per ship per shift: Total gross gang time, divided by the total time that berthed ships were actually worked;

(h) Tons per ship hour in port: Total tonnage worked, divided by total time between arrival and departure;

(i) Tons per ship hour at berth: total tonnage worked, divided by total time between berthing and departure;

(j) Tons per gang-hour: Total tonnage worked, divided by total gross gang time;

(k) Fractional of time gangs idle: Total idle gang time, divided by total gross gang time. Table 3.1 shows the list of data needed for calculating operational indicators of port performance.

Table 3.1: Summary of operation Data Required for Measuring Operational Performance

Indicators	Units
Arrival late	Ships/day
Waiting time	Hours/ship
Service time	Hours/ship
Turn-round time	Hours/ship
Tonnage per ship	Tons/ship
Fraction of time berthed ships worked	-
Number of gangs employed per ship per shift	Gangs
Tons per ship-hour import	Tons/hour
Tons per ship berthed	Tons/hour
Tons per gang-hour	Tons/gang-hour
Fraction of time gang idle	-

Source: J.C. Telfer 1972

3.3 Indicators of Utilization

Indicators of utilization are measures of how intensively berth facilities are used. There are two important indicators in this group.

1. Berth occupancy – the proportion of time a berth is occupied by vessels.
2. Berth working time-the proportion of ship's time at berth for which labour is scheduled to work.

3.4 Berth Occupancy

Berth Occupancy effectively indicates the level of demand for port services. It can be measured over time intervals, (a week, a month, a year) and is normally expressed as a percentage; the number of (or days, when calculating over very long periods) the berth is occupied in a given period (whether cargo is being worked or not) divided by the total number of hours (or days) in the period, multiplied by 100 percent.

$$\text{Berth Occupancy:-} \quad \frac{\text{Hours for days) berth is occupied}}{\text{Total possible hours (or days) in period}} \times 100$$

Example 1

What was the Berth Occupancy for the period that ships were at your berth on 275 days last year?

Answer: Berth Occupancy = $\frac{275 \text{ days}}{365 \text{ days}} \times 100 = 75\%$

Berth Occupancy is often misunderstood and misused by port managers and unless it is fully understood; it is a particularly dangerous basis for decision making. This is so because the tendency is to think that a high Berth Occupancy value is desirable, and that it indicates high berth efficiency. The operational disadvantages of High Berth Occupancy include:

1. Little or no time to plan and prepare cargo handling operations
2. There is insufficient time to consolidate exports
3. There is not enough time to clear imported cargoes from quays, sheds and yards before next ship arrives
4. Working under this sort of pressure puts considerable strain on labour, management storage space and equipment.

So high berth occupancy causes quality of service to decline. It signals congestion, and the danger that ships might queue for a berth, putting costs through increased turnaround time, congestion surcharge, demurrage charges, etc. But low Berth Occupancy or 50% of less indicates that resources are being underused, perhaps lying idle for much of the time and that there is spare ship and cargo handling capacity.

Berth Occupancy values within the range of 60% and 70% are perhaps the safest to aim for, and depend on four main reasons.

1. The arrival pattern of general cargo ships

2. The number of general cargo berths in the ports
3. How effective the berth allocation system is and
4. The average ship's time at those berths

High Berth Occupancy may be tolerated on the condition of ships arriving at regular pattern, with a few day interval between the departure of one vessel and the arrival of the next, giving time to plan effectively and to prepare for the next vessel while the berth is vacant.

The second factor, the number of general cargo berths available is linked closely to the first, the more berths there are available, the more easily can ship arrivals be distributed to ease pressure and allow berths to recover.

The third factor encompasses the advantage of a flexible responsive Berth Allocation Policy (BAP). This has to do with the flexibility at which vessels can be allocated to different. In a situation where only a particular type of vessel can be allocated to a particular berth does allow for flexibility and cause undue pressure on some berth facilities while others are idle or underutilized.

The fourth factor deals with the question of ship's time berth, which is really a matter of how much cargo passes through the berth and how quickly it is handled.

To reduce high Berth Occupancy to an acceptable level adopt the following measures:

1. Speed up cargo handling; either by using more gangs and equipment or more shifts and overtime
2. Work vessels at an anchor via barges, to reduce the number of vessels waiting for berths.
3. Improve Berth Allocation policies to ensure fair distribution of vessels and appropriate matching of ship to berth

4. If bunching of ship arrivals is the cause, bring it to the attention of senior management, so that they can try to persuade ship-owners and agents to even out vessel arrivals.

The over-riding solution is a reduction in the time wasted at the berth – an increase in Berth Working Time.

3.5 Berth Working Time

It is that part of ship's time at berth for which labour is scheduled to work. It is usually expressed as hours or days, it can also be expressed as a percentage of the hours available for working in the period that is, as a percentage of ship's time at berth.

Berth Working time = hours available for working in the period

Ship's time at Berth

= % of ship's time at Berth

There are three components of Berth Working Time:

1. Non operational time that is, time when the berth is not scheduled to work e.g. Sundays, public holidays, meal breaks
2. Idle time: Time due to unscheduled interruption to cargo handling at a berth due to bad weather, various stoppages resulting equipment breakdown and non-availability of cargo.
3. Operational Time: Time that cargo is actually being worked at Berth, after all delays have been deducted.

This can be summarized as follows

- Ship's Time at Berth Minus Non-Operational Time Equals Operational Time

Berth Working Time and Berth Occupancy give useful indication of how effectively the Berth and its resources are being used. These also consist of non-operational Time and idle Time that both represent berth capacity that is not being

used and also contribute to the unnecessary costs for handling cargo due to surcharges imposed on Idle time.

3.6 Indicators of Productivity

The two categories of indicators discussed so far provided useful data for a management information system, but do not measure efficiency and cost effectiveness of the Berth Operation; they do not indicate how effectively labour, equipments buildings and land are being used.

Efficiency therefore is defined as the ratio between output achieved and effort put in. In business and industry, 'efficiency' is used in the sense of cost-effectiveness; the cost per unit of production or the profit per unit capital investment. Therefore efficiency in ports operation is the cost of tone of cargo handled.

There is a distinction between productivity and output. A factory may well be able to increase output by building new production lines, buying machinery and employing more labour, but these will not necessarily improve productivity, the extra capital investment and running costs could actually put up the cost of each item manufactured. In other words, increased production does not necessarily improve productivity. But lower costs per tone can be achieved by maintaining output using existing resources to so ORGANIZE and SUPERVISE operation that the same men, with same gang and equipment, handle more cargo per shift.

3.7 Financial indicators

A port authority should be aware of the cost generated by its operations and the revenue resulting from these operations. The bulk of this information must come from the accounting system. The current global trend, even in countries where ports are not treated as autonomous bodies within the national economy, is towards making them increasingly financially viable. Sound financial information is pre requisite to a sound port tariff system.

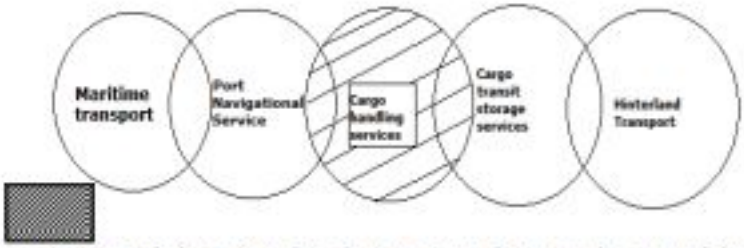

Fig. 3.1: Portion of chain (transfer of cargo to or from vessels) covered by performance indicators

FIGURE 3.1 Functional areas of the transport chain as seen by port management

For the purpose of this discussion only the cost and revenue associated with the transfer of cargo to or from ships are taken into account in the calculation of the various indicators (see figure 8.1). Thus cost and revenue generated from the transit storage and warehousing function and from the delivery and receipt of cargo via these storage areas are excluded. This decision is based on the fact that cargo handling to or from vessels takes place during a well-defined period of time, namely, when the ship is at berth, for the same ship, the delivery of discharged cargo from storage areas within the ports can extend over a period of months. Thus, a separate group of indicators should be developed for the transit storage and warehousing areas that are not linked to the particular ship call.

The port areas should be divided into berth groups which are or sub areas, each handling a different cargo class. The primary financial indicator for each berth group is the contribution per ton of cargo handled over specified time period. To arrive at this indicator, the cost and revenue produced at the berth group are first calculated to indicate the position of each element to the contribution. The elements to be considered for each berth group are:

a. Ship revenue related to the berth group.

b. Cargo revenue related to the cargo handling, services of the berth group.
c. Labour cost.
d. Capital equipment cost.

The ship revenue may come from berth occupancy charges or port dues. Normally, only a portion of the revenue from port dues is set aside to cover the cost associated with the cargo handling service. The assumption is that ship revenue comes from berth occupancy charges. The cargo revenue may originate from charges for the cargo-handling operation from ship to storage area and vice versa. Port authorities may also charge dues to help cover the cost of this operation.

In addition, port authorities may contract private firms to handle one phase of the cargo-handling operation. In this case, only the costs and revenues flowing between the authority and the private firms should be considered when calculating the indicators, but the authority should nevertheless be aware of the charges made by the private firms.

A negative contribution may not necessary be a bad thing provided it has arisen as a result of a policy decision to allow other local or national economic interest to benefit from a port subsidy. If the policy of the port is to operate as a profit centre, the rate of return maybe determined on the total capital employed in the port. Such a measure is perhaps the best single indicator of the financial success of the employment of capital. However, as most ports are justified not on a micro-economic level, the use of the rate of return indicator may not be appropriate for evaluating the financial performance of such port.

An extremely important indicator, both operationally and financially, is the monthly volume of the cargo worked. If, for example the port charges for cargo handling are based on tons of cargo worked, management must be made aware of the variance between the budgeted and the actual quantity handled. This difference

is an indication of the likely revenue variation. With volume variances, ship traffic and cargo projection can be estimated and used to determine the cost of action the port should follow. Figure 8.2 shows an example of trend in labour productivity in a port.

Possible alternatives to improve cash flow when the quantity of cargo handled is lower than expected are:

a. Port marketing promotions to increase traffic and revenue.
b. Increase in tariff to increase revenue.
c. Measures to increase productivity and increase the variable cost per ton.
d. Re-adjustment of deferrable budgeted expenditure.

The following indicators should be calculated each month for the ship sailing from each berth group;

a. Total tonnage worked;
b. Berth occupancy revenue per ton of cargo: total berth occupancy revenue produced, divided by tonnage worked;
c. Cargo handling revenue per ton of cargo: total revenue produced from transferring cargo to or from ships, from or to storage areas, divided by tonnage worked
d. Labour expenditure per ton of cargo: total direct labour expenditure for transfer of cargo to or from ships, from or to storage areas, divided by tonnage worked.
e. Capital equipment expenditure per ton of cargo: total amortization and interest allocated to and maintenance and operating costs incurred for the berth group, excluding the costs of transit sheds and warehouses, divided by tonnage worked.

f. Total contribution: berth occupancy and cargo handling revenues minus labour and capital equipment expenditure.

g. Contribution per ton of cargo: total contribution divided by tonnage worked.

h. Number of gangs employed per ship per shift: Total gross gang time, divided by the total time that berthed ships were actually worked;

i Tons per ship hour in port: Total tonnage worked, divided by total time between arrival and departure;

j Tons per ship hour at berth: total tonnage worked, divided by total time between berthing and departure;

k Tons per gang-hour: Total tonnage worked, divided by total gross gang time;

l Fractional of time gangs idle: Total idle gang time, divided by total gross gang time.

Berth group : General Cargo

Period : February 1975

a. Av. Tons/hr. : 22.5tons/hr. (21.5 tons/hr. previous period)

b. Number of Ships : 103

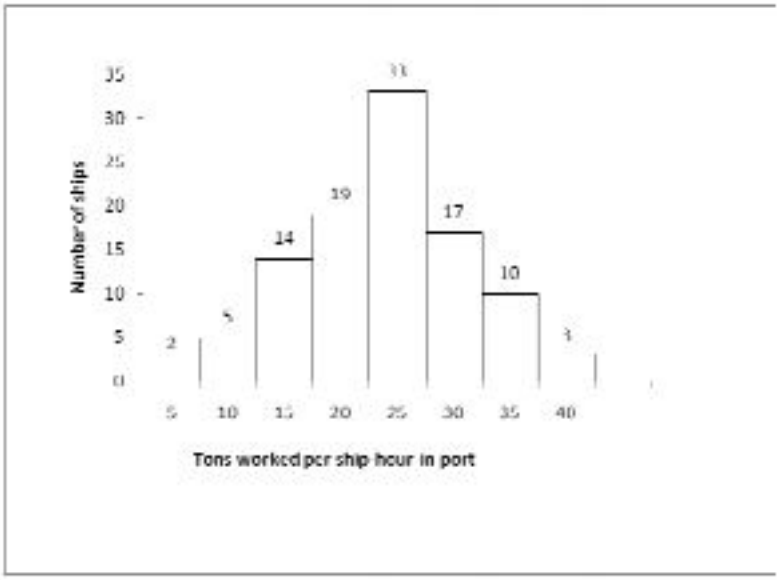

Figure 3.2 showing trend in labour productivity in a port

In addition to the calculation of the above average figures, it is important that certain indicators be calculated on an individual ship-call basis and plotted as a frequency distribution. Figure 8.2 illustrates such a distribution for the tons per ship-hour in port.

One aspect of port operation that management should carefully monitor and take steps to correct when unfavourable trends appear, is the productivity per gang. The maintenance of the tons per gang-hour indicator will supply the index for monitoring this important phase of port operation. The actual figure could also be compared with standards established by application of such methods as work study. Action should follow if values are outside an established range, to determine the reasons for this variation, and steps should be taken to correct the deviation.

The indicators that have been proposed are summarized in the tables 8.1 and 8.2. These indicators allow port manager to measure, first, the quality of the service their ports supply and secondly, the demand for these port services. The fact that an indicator does not vary over time does not mean that the performance measured by that indicator is necessarily good. It may be consistently bad! Thus the need exists to establish standard or norms.

The decision regarding which indicators to maintain depends on the port authorities' particular requirements. Ports which do not have sufficient strength in their statistical sectors to deal with the collection of the data and calculation of the chosen indicators should review the purposes and benefits of other information collected by these sections. In addition, the accounting systems should differentiate between the various berth groups, to allow cost and revenue data to be collected easily. The following chapter proposes a manual system for the collection of the data necessary for the calculation of the indicators.

Table 3.2 Summary of financial indicators*

Indicators	Units
Tonnage worked	Tons
Berth occupancy revenue per ton of cargo	Monetary unit/ton
Cargo-handling revenue per ton of cargo	Monetary units/ton
Labour expenditure per ton of cargo	Monetary units/ton
Capital equipment expenditure per ton of cargo	Monetary units/ton
Contribution per ton of cargo	Monetary units/ton
Total contribution	Monetary units

*Calculated monthly for each berth group servicing a cargo class.

The financial indicators proposed answer the following two questions:

1. What revenue is produced from a service?
2. What is the cost of the service?

With the development of these financial indicators, port management personnel would be supplied with the information necessary for them to take steps to achieve financial viability. If financial criteria for performance are removed, a significant incentive to efficiency also goes. In addition, financial viability criteria are often important when the port has to negotiate loans.

The Nature of Port Cost

The port costs usually consist of two components:-

- Fixed cost and
- Variable costs

Ports costs = fixed cost + variable costs

Fixed costs are independent of the output, performance or utilization. They have to be paid irrespective of the volume of cargo handled. Variable costs are directly related to the output they increase with the quantity of cargo handled.

Fixed costs include:-

- The capital cost of port facilities (or the interest charges on the investment);
- Cost of building sheds and offices
- Salaries of permanent staff
- Cost of ownership of equipment; the purchase cost (or interest in borrowed capital) of cranes, trucks etc; and some routine maintenance costs
- Variable costs consist of
- Wages of casual of hourly paid labour
- Incentive bonus or overtime payment to staff and labour
- Some equipment maintenance and repair cost
- Cost of stationery, electricity, water, etc.

The question of whether equipment maintenance costs are fixed or variable is not a simple one (for its appearance on both headings). Some maintenance certainly has

to be done at regular intervals (daily, monthly, annually, etc) regardless of the mileage or hours of use. On the other hand, the more a vehicle is used the more frequently tyres and other parts have to be replaced and so on. So it is probably wise to apportion them as more routine preventive maintenance under 'Fixed' along with the investment cost, as a 'cost of ownership', and the bulk of them as 'maintenance repairs' under 'variable costs'

Example 1

At the end of last year, the operating records of a berth at Apapa Port that handled 100,000 tones of cargo, were analyzed for planning purposes, and the following cost data emerged:

		Note
Investment costs (buildings, workshop etc)	N500,000	F.C.
'Ownership' cost of equipment including pm	N150,000	F.C.
Maintenance repairs to plant	N200,000	V.C.
Salaries of Management and other permanent Staff	N300,000	F.C.
Wages of Casual and Hourly Paid Labour	N300,000	V.C.
Bonuses and Overtime Payment	N200,000	V.C.
Fuel Power, etc.	N 50,000	V.C.

Use these data to calculate the total fixed and variable costs, the cost per tonne, and the effect of increasing annual throughput from 100,000 tonnes to 150,000 tones using the same resources.

a. Find the total annual fixed cost: N(500,000+150,000+300,000 = N950,000)
b. Calculate the fixed cost per ton $\frac{N950,000}{100,000}$ = 9.50/ton
c. Find the total annual variable cost N200,000+300,000 -200,000+50,000 = N750,000
d. Calculate the variable cost per ton $\frac{N750,000}{}$ = 7.50/ton

100,000

e. Calculate the total cost per ton = (9.50+7.50) = 17.00/ton
f. What would be the total fixed cost if annual throughput were to be increased to 150,000 tones. Answer is same
g. Calculate the Fixed Cost per ton at the increased rate

$$\frac{950,000}{150,000} = N6.30/ton$$

The fixed cost per ton has fallen from N9.50 per ton to N6.30 per ton a 30% reduction following a 50% increase in throughput.

h. Calculate the total variable cost for a throughput of 150,000 N7.50/tonnex150,000 tones = 1,125,000 it means that the total variable cost has gone from N750,000 to N1,125,000, a 50% increase for 50% greater throughout
i. calculate the total cost per ton at 150,000 tone throughput N950,000+N1,125,000 = N2,075,000. Note that the total cost per ton throughput increase is N2,075,000/150,000t = N13.80/t. That is, it has gone down from N17/t to N13.80/t a decrease of 19% for a 50% increase in throughput.

In summary, increasing throughput shoots up total costs (though by proportionately less than the throughput increase) and total variable costs (in direct proportion to the throughput increase but leaves total Fixed cost completely unchanged. For costs per ton, however, the situation is quite different. Total cost per ton falls as output rises, as does Fixed Cost per ton (a more pronounced decrease) but the Variable cost per ton, of course is unchanged.

If labour is paid for overtime at a higher than standard wage rates, then variable cost per ton will increase. The extra wear and tear on equipment might also

increase maintenance costs, adding to this rise in variable cost per ton. That is the extra output has been achieved without additional investment of resources. If some at least of these extra labour costs could have been avoided the benefits of increase throughput, in terms of cost per ton of cargo would have been even greater.

Therefore cost per ton of cargo handled is a good and useful measure of productivity

Another useful productivity indicator is labour cost per ton which is expressed as follows:-

$$\text{Labour cost/ton} = \frac{\text{total labour cost per shift}}{\text{Tons handled per shift}}$$

The savings that can be made in cargo handling by increasing output without employing extra labour and resources, i.e. by improving organization and supervision are very great. They are demonstrated very clearly by the Indicators or Productivity cost per ton and Labour Cost per ton these are two extremely useful measures of cost Effectiveness that are used regularly in monitoring performance in port operations.

Example 2

Over a particular period, Berth I at Calabar Port employed 100 men per shift.

Output was 250t per shift on average and the men were paid N7.50 per shift.

(a) What was labour cost per ton, (b) how would it have changed if output could have been increased to 750t per shift without employing more men and (c) what would it be if the output increase to 759 per shift, was achieved by giving a bonus of 50 kobo per man for every 100t over 250t per shift?

Solution

Total Labour Cost per shift = 100x7.5 = N750

(a) Labour Cost per tonne = N750: 250t = 3/t

(b) Labour cost/t = N750:750 = N1/t

A change = N(3-1)t = N2/t

(c) Every 100t over/shift = $\frac{(750-250)}{100t}$ x 50 kobo = 2.50/man

Total Labour Cost N(750+250) = 1000

Labour Cost per tones = $\frac{1000}{750t}$ = N1.33/t

To improve productivity means increase output substantially with existing resources of labour, equipment and facilities, or with only small increases. It might even be possible to reduce some cost by BETTER PLANNING AND ORGANISATION leading to reduction in cost per ton of cargo handled hereby contributing significantly to reducing overall transport cost.

Example 3

Calculate the cost per ton of cargo handled for our berth operation with annual throughput of (a) 120,000t and (b) 360,000t. Assume fixed costs of N1.5 million per year and Variable costs of N7.50 per ton.

Solution:

(a) Total cost = fixed costs (N1.5 million) + Variable (N7.50x120,000) = N2.4 million Cost per ton = 2.4 million: 120,000t = 20 per ton

(b) Total Costs = N1.5 million + N7.50x360,000 = N4.2 million Cost per ton = N4.2 million: 360,000t = N11.67 per tone

So if cargo throughput is only one-third of capacity, costs per ton are over 70% higher than they should be N20 per ton instead of N11.67 per ton. Therefore higher productivity is the key to reducing cargo handling costs, for it is a measure of cost effectiveness, output in relation to the resources employed.

3.8. Conclusion

This chapter has so far discussed the importance of performance evaluation and how to evaluate port operation performance. It highlights various indicators of port performance and the importance of data gathering, recording and analysis in port planning and evaluation process. The various types of data that can be collected are equally highlighted in order to guide port managers on the process of carrying out performance evaluation in the ports.

REFERENCES

D.R Daniel (1961) "Management Information Crisis" *Harvard Business Review* Boston Vol. 39 No 5 p 113

UNCTAD *Port Pricing Report* (United Nations Publication Sales No E.75.II.D.7) annex V

S.C. Plumlee, (1975) *Port Performance Index Fifth Interim Report* Port Hueneme California, Public Consultants.

UNCTAD; Port Performance Indicators (UN Publication Sales No. 76. II.D.7)

O.O Oyesiku and K.T. Gbadamosi (2008) *Port Administration and Development in Nigeria.* HEBN Publishers Plc, Ibadan.

Ojekunle J.A. (2012) *Port Performance Indicators* (a paper delivered at Port Planning and Management Course in Nigerian Institute of Transport Technology (NITT) in August 2012