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CONCEPTUAL FRAMEWORK FOR THE EVALUATION OF CONTAINER TERMINAL'S EXPANSION BY MARGINAL APPROACH

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ABSTRACT

Most of the container terminal's expansion models are focused on fulfillment of future throughput demand. The purpose of expansion only described overall terminal expansion with respect to increase in demand. At this moment, container terminal's expansion models did not consider small changes in commercial viability with small changes in expansion magnitude over time. Therefore, this study intended to look at the alternative ways of container terminal's expansion model. Critical reviews are presented to compare the existing approaches and underlined the merits, drawbacks and specify area for that approaches. At the same time, an alternate approach would be highlighted for further study. It expanded from existing approaches and draw attention to marginal approach by using Net Present Value (NPV) to evaluate the increment requirement for future throughput demand. The positive NPV represent the significant of increment of the expansion component and magnitude respectively for each expansion period. The purpose of using marginal approach is to assure a sustainable and economical effective expansion plan.

Key words: container terminal, expansion model, marginal approach, net present value, expansion component and magnitude, suitable and economical effective.

1. INTRODUCTION

90% of cargoes were likely to be containerised. In highly developed trades, it was estimated that some 70% of containers move in Full-Container-Load (FCL) basis; and the remaining by Less-Than-Container-Load (LCL) shipments (Branch, 1986). Likewise, more than 90% of international trades move through seaports and 80% of sea cargoes move in containers through major seaports (Won et al., 1999). The study has proved that the worldwide container throughput increases approximately 10.7% annually. Hence, the development and expansion of container terminal has become crucial in order to meet the demand for container traffic.

To meet the container terminal's development and expansion requirement, physical port layout is one of the important, such as seaside and landside. To ensure a well coordination, reliability of operation, in favor for profit and benefit, the port layout, networking, etc also must be designed to fix to the expected future demand (Chalid, 2009). To be success to support the additional capacity throughput, features of port expansion normally including extra shipping berths, terminal land, depth of dredging area, road and rail connection, additional facilities and etc.

As its importancy and needs, a lot of studies and scientific methods have been proposed to solve the port development and expansion problems. To be clear and value on it, this paper has be underlined and elaborated details on port development and expansion, past and current design approaches in section 2.

2. LITERATURE REVIEW

To ensure a well manner, several of study has been done. UNCTAD, 1985 used the planning chart concept to leaded the different facilities or infrastructure. The formula has been converted into chart for immediate use. Frankel, 1987 employed mathematical techniques to familiarize with the issues and methods of port planning and development. Thomas, 1999 specified on container handling system, by given significant efficiency and competence to that container terminal selected. Zamani, 2006 utilize fuzzy methods to development planning model. He tries to improve the lack of human modes in planning approaches. Dekker, 2008 apply marginal approach to determine when, size and interval expansion time in such method. Figure 2.1 shows the existing and current port development and expansion approaches

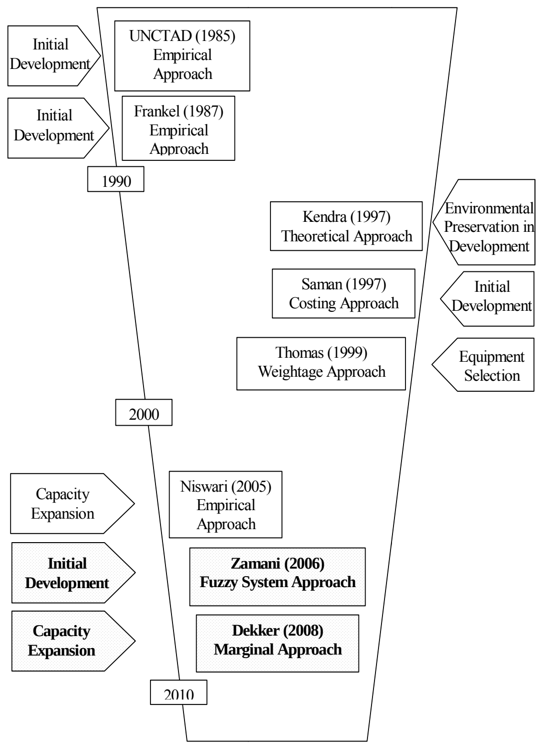

Figure 2.1 Existing and Current Port Development and Expansion Approaches

Table 2.1 Discrepancy between Existing and Current Port Development and Expansion Approaches

S/N	Approaches / Models	Applied	Features
1	Empirical Approach		
	i. UNCTAD Model 1985	Initial Development	Capacity Planning
	ii. Frankel Model 1987	Initial Development	Capacity Planning
	iii. Niswari Model 2005	Expansion Estimation	Capacity Planning
2	Theoretical Approach		
	i. Kendra Model 1997	Environmental Preservation	Environment Protection
3	Costing Approach		
	i. Saman Model 1997	Development and Expansion	Cost Effectiveness
4	Weightage Approach		
	i. Thomas Model 1999	Equipment Selection	Approximation Multi Container Decision Making
5	Fuzzy System Approach		
	i. Zamani Model 2006	Initial Development	Approximation Uncertainly
6	Marginal Approach		
	i. Dekker Model 2008	Expansion Estimation	Cost Optimum Control

Table 2.1 shows the discrepancy between existing and current port development and expansion. UNCTAD Model (1985), Frankel Model (1987), and Zamani Model (2006) are special for initial port set up. Niswari Model (2005) and Dekker Model (2008) are particular for port expansion estimation. However, Saman Model (1997) is used for port initial development and expansion planning. But, it unique for inland water way designs. On the other hand, Kendra Model (1997) and Thomas Model (1999) are specific for environment protection during port development and approximation multi container decision making respectively.

2.1 EMPIRICAL APPROACH

2.1.1 UNCTAD MODEL, 1985

Container terminal development and expansion planning need to consider the container traffic demand with the terminal capability. First, its need to determine the annual throughput followed by terminal productivity, facility amount and size, and level of service provided. The main consideration of UNCTAD model is to relate the terminal capability with the level of service provided.

The development and expansion model of UNCTAD is focused on five elements. The first element is to determine the container traffic demand and is stated in TEUs (Twenty-Foot Equivalent Units). Container traffic demand is the total container throughput handled by terminal. The other elements are container park area, container freight station area, berth-day requirement, and ship's cost at terminal.

The size of container part area is determined by total container throughput, average transit time of container, area requirement per TEU, container stacking height, and safety factor. Next, the size of container freight station area is determined by container throughput, average stacking height of general cargo, access area, and safety factor. Subsequent, the annual berth day requirement is determined by average ship operating hour per day, average number of container units per hour per crane, number of crane per ship, average number of moves per ship, and number of ships per day. Finally, the ship's cost at terminal is determined by annual berth day requirement, number of berth tariff days per year, berth utilization, and average daily ship's cost. All of these elements are converted in the form of planning chart.

Application: Particular in seaport development.

Merits: To determine the capacity requirement to support future demand based on four variables, they are container park area, container freight station area, berth-day requirement, and ship's cost at terminal.

Drawbacks: Lack of control on uncertainly. Some more, doesn't detail out container handling system and terminal other areas.

2.1.2 FRANKEL MODEL, 1987

Frankel model taken on the same standard with UNCTAD model, and agreed that the container terminal layout and equipment is important in container terminal planning and is depending on container moves, terminal layout, equipment performance, and operation strategy. Frankel Model considers for four main elements, there are container demand, area required, equipment selection and system's cost. But, it provided details in calculation of container part area and calculation of number of berth.

Application: Particular in seaport development.

Merits: Provide the details algorithm calculation in container part area and number of berth requirement.

Drawbacks: Lack of control on uncertainly. Some more, doesn't detail out container handling system and terminal other areas.

2.1.3 NISWARI MODEL, 2005

This model related the operational capacity and financial requirement with cost expansion. It's considered that the expansion plan is a manner to build up the operation capacity. It is assumed that the container terminal's capacity is determined by total quay moves, based on the total of container handle each year.

Application: Particular in container terminal expansion.

Merits: Evaluate the operation and financial needs in expansion.

Drawbacks: It's focus on berth and yard expansion needs only.

2.2 THEORETICAL APPROACH

2.2.1 KENDRA, 1997

This study point out that most of the seaport expansion is underlying the environmental consideration. So, this model links the development of dry cargo and container terminal with environmental consideration. This theoretical model identifies the different style of addressing coastal and terminal conservation. It is tied into concepts of sustainability and environmental control in terminal development and expansion needs.

Application: Application in dry cargo and container terminal.

Merits: Provide foundation understanding in coastal management and preservation.

Drawbacks: Lack of association between theoretical and practical control.

2.3 COSTING APPROACH

2.3.1 SAMAN, 1997

Saman model highlighted cost estimate based on physical component development or expansion. The cost estimate model is useful for preliminary evaluation of inland waterway terminal's cost investment judgment. This model focused on track cost model, vessel cost model, and terminal cost model. Track cost model direct with waterway and land constructions cost; like dredging the channel, construction of locks, bridges, levees, bank strengthening, bank and bottom protection, road construction, landscaping, plantation, and fencing. Vessel cost model determined with traffic flow projections, vessel capital requirement plus operating cost. Terminal cost model can be classify in fixed and variables costs based on terminal operating needs.

Application: Unique in inland waterway transport systems

Merits: To understand in preliminary cost requirement in development or expansion of inland waterway terminal.

Drawbacks: Lack of control in profitability and investment return.

2.4 WEIGHTAGE APPROACH

2.4.1 THOMAS MODEL, 1999

Thomas model highlighted that the selection of container handling system is an important issues in determine the efficiency and cost effective of a container terminal. This model given summary of container handling system based on their features; like land utilization, terminal development costs, equipment cost, equipment maintenance costs, manning level, and operating factors. Thomas model has proposed six handling system; like tractor-trailer system, straddle carrier direct system, straddle carrier relay system, yard gantry system, front-end loader system, and combination system.

Application: Particular in seaport development.

Merits: It's has classified the handling system performance based on their features.

Drawbacks: Lack of control on uncertainly and future demand need.

2.5 FUZZY SYSTEM APPROACH

2.5.1 ZAMANI MODEL, 2006

Zamani model expanded from UNCTAD model, Frankel model, and Thomas model. It's included four of the elements mention by UNCTAD model and Frankel model, 1 element from Thomas model, and adds in 1 additional element. The six elements are container part area, container freight station area, ship's cost at terminal, berth-day requirement, container handling system, and terminal other areas.

Application: Specific in container terminal development.

Merits: Zamani model used fuzzy expert system to overcome the short of the conventional methods of container terminal development planning. The conventional methods used planning charts and mathematics formula to determine the port develops needs. Zamani model improved the conventional methods by apply the natural modes of reasoning that involves approximate, imprecise, linguistic and subjective values.

Drawbacks: Lack of control on financial and economical.

2.6 MARGINAL APPROACH

2.6.1 DEKKER MODEL, 2008

Dekker model important the issues of when a terminal need to be expand, what size should be expand, what is the interval capacity the terminal should be expand. This model used marginal approach to analysis the needs of expand. The optimal expansion of a container terminal is determined by the steady demand growth. Then, it's related the expansion needs of container terminal with TEU forecasting. Where, a container terminal achieves a certain TEU throughput that desires the needs of expansion.

Application: Specific in container terminal expansion.

Merits: Related the future demand need with financial control.

Drawbacks: Lack of control on expansion component and magnitude.

3. MAPING THE DIRECTION

Since 2000 until 2010, the container terminal development and expansion approaches are more concerned about financial and economic impact. It shows that the future diagram is started giving their attention and interest in this area.

Frankel (1987) clarified that the objective of port development and expansion is to maximum net profit or minimum cost of expenses. For economic point of view, a port authority should meet the port service requirements with minimum cost expenses or maximum profit. With limited resources and supplies, the port authority should depend on availability of resources allocation to plan for development and expansion needs.

On the other hand, most of the container terminal's expansion approaches are focused on fulfillment of future throughput demand. The purpose of expansion only described overall terminal expansion with respect to increase in demand. At this moment, container terminal's expansion models did not consider small changes in commercial viability with small changes in expansion component and magnitude over time.

The expansion cost for expansion component is spent based on change in demand dQ, but some expansion component could sustain dQ will others will not, eg. Storage area may need to be expanded will the number of quay crane can still be maintained. This sustenance period will continue until dQ further increase to a new level to justify for the next expansion, eg. storage and quay crane. Container terminal expansion will be more accurate if dQ and periods of sustenance for each expansion component could be identified so that the expansion of expansion component is at correct magnitude and at the correct time.

Therefore, this study intended to look at the alternative ways of container terminal's expansion model. It expanded from existing approaches and draw attention to marginal approach by using Net Present Value (NPV) to evaluate the increment requirement for future throughput demand. The positive NPV represent the significant of increment of the expansion component and magnitude respectively for each expansion period. The purpose of using marginal approach is to assure a sustainable and economical effective expansion plan.

It is extent from Dekker (2008) model. But, Dekker (2008) model lack of concentrated on small changes in expansion component and magnitude. So, this paper tries to overcome the limitation and take on the expansion component variables into account. The expansion component variables adopted from Zamani model (2006). Zamani model (2006) is the recent and more absolute version that using fuzzy system approach with completed expansion variables.

4. CONCEPTION FRAMEWORK FORMULATION

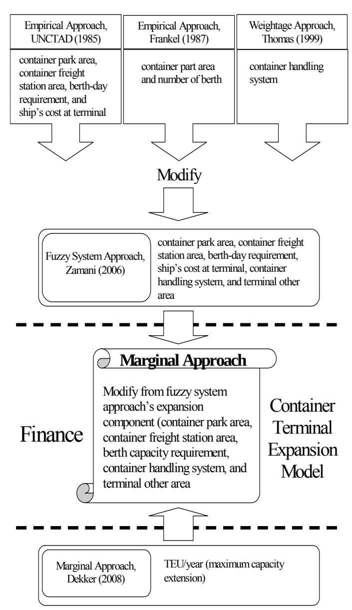

Figure 4.1 Conception Framework Formulations for Container Terminal Expansion Model

Most of the conventional models used the empirical approach to describe container terminal development or expansion (UNCTAD, 1985 & Frankel, 1987). Thomas's model (1999) focused on container handling system. Zamani's model (2006) modifies UNCTAD (1985), Frankel (1987), and Thomas models (1999); while trying to overcome the lack of human approximation style by using linguistics terms in conventional models. It considers on container part area, container freight station, berth-day requirement, ship cost at terminal, container handling system, and terminal other areas.

Dekker model (2008) highlighted the lack of marginal cost in conventional models. This model used marginal approach to control the optimal expansion in between marginal investment costs and marginal benefits.

For marginal approach definition, Roger (2004) expressed marginal approach is the additional cost of produce an extra unit of production. It's also can be used for cost saved by producing one less unit. So, marginal approach is the method of cost incurred or cost saved in the produce of the marginal unit of production.

5. PRELIMINARY MODELING EVALUATION

Before any expansion plan taking action, the future throughput demand needs to be determining first. After that, current capacity for each expansion component needs to be matching with the future throughput demand. If the current capacity is biggest than future demand, then that component not need to expand. But, if the current capacity is smaller than future demand, then that component needs to be expanding. Figure 5.1 show the mapping of preliminary modeling evaluation. The future throughput demand, time, expansion size and significant of expansion will discuss in next section.

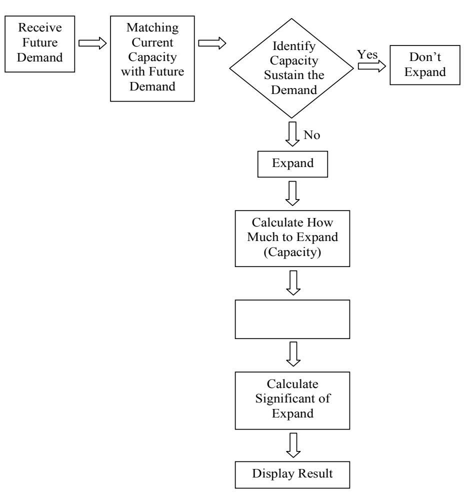

Figure 5.1 Map of Preliminary Modeling Evaluation

Based on the recent study, Zamani's model (2006) and Dekker's model (208), the expansion component variables are based on each infrastructure component that need to analyze. It is focus on 5 variables, there are container part area, container freight station, berth capacity, container handling system, and terminal other areas.

$$cte = \int (cpa, cfs, bcr, chs, toa)$$

Where,

cte - container terminal expansion
cpa - container part area
cfs - container freight station
bcr - berth capacity requirement
chs - container handling system
toa - terminal other areas

Insist of the unit for all infrastructure components is in unit $, therefore berth-day requirement (in Zamani's model, 2006) is changed to berth capacity requirement. Ship cost at terminal using by Zamani's model (2006) no take in account, because is the ship tariff paid by shipping line by using port service. But, it will calculate in next section, as one of the variables in marginal approach formula. The further details of calculate method is discuss on next section.

Current container terminal expansion model only describe overall terminal expansion with respect to increase in demand. Incremental expansion of individual infrastructure taking into account, and its ability to sustain increase in demand has been neglected.

Currently, expansion cost for physical infrastructure is spent based on change in demand but some infrastructure could sustain while others not, eg. container part area may need to be expanded while the container freight station can still accredit the expansion. This sustainance period will continue until TEU increases to a new level to justify for the next physical expansion. Container terminal expansion will be more accurate if the quantity and periods of sustainance for each infrastructure could be identified so that expansion of infrastructure is of correct of magnitude and at the correct time. Figure 5.2 show the container terminal expansion component plan for each variable respectively (cpa, cfs, bcr, chs, toa).

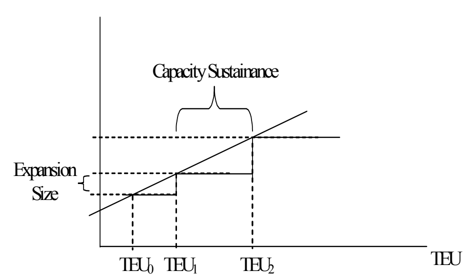

Figure 5.2 Container terminal infrastructure expansion plan for each variable respectively (cpa, cfs, bcr, chs, and toa)

Therefore, each of the infrastructures is independent to deal with future container throughput respectively. The expansion terminal is the combination of each expansion of infrastructure to meet the future demand.

$$\delta cte = \int (\delta cpa + \delta cfs + \delta bcr + \delta chs + \delta toa)$$

Where,

δcte - container terminal expansion

δcpa - expansion of container part area

δcfs - expansion of container freight station

δbcr - expansion of berth capacity requirement

δchs - expansion of container handling system

δtoa - expansion of terminal other areas

Each of the expansion components will deal with the expansion cost and investment return respectively. However, the container terminal expansion model would consider the combination result from all expansion components.

After that, the container terminal expansion model will use the concept of Net Present Value (NPV) to evaluate increment requirement when the NPV = +ve; where the +ve NPV = attractive; the significant of increase the expansion component respectively for each expansion period.

+ve NPV = attractive

$$+ve\ NPV = \sum I - \sum P$$

$$+ve\ NPV = \sum ctri - \sum ctec$$

Where,

+ve NPV - Positive Net Present Value

∑ I - sum of income

∑ P - sum of principle of investment

∑ ctri - sum of container terminal return from investment

∑ ctec - sum of container terminal expansion cost

6. PRELIMINARY ALGORITHM EVALUATION

6.1 FUTURE DEMAND PLANNING

The future demand planning is important in determine a series of future capacity expansion in order to support the future demand. Dekker Model (2008) used steady linear growth to determine future demand pattern. It's also used by Dekker (2005) in determine the port capacity planning. To determine the future demand at time t, Q_t, the following equation is using:

$$Q_t = Q_0 + \boldsymbol{\gamma t} \qquad \text{if } t < h$$

$$Q_t = Q_h \qquad \text{if } t >= h$$

Where,

Q - Quantity Demand

t - Number of Year

h - Planning Horizon

Q_0 - Quantity Demand at Time = 0

Q_t - Quantity Demand at Time = t

Q_h - Quantity Demand at Time = h

γ - Annual Demand Growth Rate

This study would look at the demand pattern of each expansion component respectively. So all of the expansion component would analysis and investigate the future demand needs in that order.

6.2 SIGNIFICANT OF EXPANSION

Thereafter, Net Present Value (NPV) would be use to determine the container terminal capacity expansion. NPV define as rule holding that one should invest if the present value of the expected future cash flows from an investment is larger than the cost of the investment (Robert et al, 2009). Once a company decides to invest a new investment, the future cash flows that the new investment generates would affect the decision making. NPV use to calculate the return from investment and compare with cost of investment. If the output is positive, then the new investment can carry on. Therefore, the formula of NPV is defined as below:

$$NPV = -P + \sum \frac{I}{(1+r)^t}$$

Where,

NPV - Net Present Value

P - Principle of Investment

I - Net Income

r - Discount Rate (Inflation Rate)

t - Number of Year

Then, this part would estimate when t = j, the period that the expansion component need to be expand.

$$\delta I_{i_{t=j}} = \delta(D_{i_{t=j}} - C_{i_{t=j}}) \qquad \text{----- (1)}$$

Where,

I - Income

D – Dues Collected

C – Cost of the Expanded Part of the Expansion Component

Next, this division would discuss on the return from investment and cost of the expansion for the expansion components. Grigalunas et. al. (2001) address that the income for the port should be the revenue received in year t. However, the cost of the expansion should in include operator's investment spend in year t, fees paid by the operator in time t, operating costs in year t, maintenance costs in time t, and mitigation costs in time t.

For return from investment, it determine by the dues collect from revenue

$$\delta D_{i_{t=j}} = \sum_{t=j}^{T} \delta D_t \quad \text{----- (2)}$$

Where,

D_t is total dues (revenues, tariff, etc) collected after expansion of expansion component

For cost of the expansion, this part more concern the cost after initial principle investment

$$\delta C_{i_{t=j}} = \sum_{t=j}^{T} (\delta OI + \delta FP + \delta OC + \delta MC + \delta MIT) \quad \text{----- (3)}$$

Where,

OI - Operator's investment (e.g. training) spend in year t

FP - Fees (e.g. salary) paid by the operator in time t

OC - Operating costs in year t

MC - Maintenance costs in time t

MIT - Mitigation (other costs) costs in time t

Insert equation 2 and 3 into equation 1.

$$\delta I_{i_{t=j}} = \sum_{t=j}^{T} \delta D_t - \sum_{t=j}^{T} (\delta OI + \delta FP + \delta OC + \delta MC + \delta MIT) \quad \text{----- (4)}$$

After the total net income has obtained, insert equation 4 into NPV values.

$$\delta NPV = -\delta P + \sum \frac{I}{(1+r)^t}$$

$$\delta NPV = -\delta P + \sum \frac{\sum_{t=j}^{T} \delta D_t - \sum_{t=j}^{T} (\delta OI + \delta FP + \delta OC + \delta MC + \delta MIT)}{(1+r)^t}$$

UNCTAD (1985) suggested that the development of a port consists of a combination of medium term and long term planning of new facilities plus. For the existing port, short term actions also need to improve the management and present facilities and their used. It's recommended that planner needs to place 20 years and draw a consistent picture of that entire he find at the long term planning. So this study would set 20 year as the time horizon. Then, the sustainance and expansion period in between the time horizon would be determine in nex section. Each of the investment of expansion component for the expansion period would be decide by NPV. If the output value is positive, then the expansion project is significant for expand.

6.3 TIME CONSTRAINT

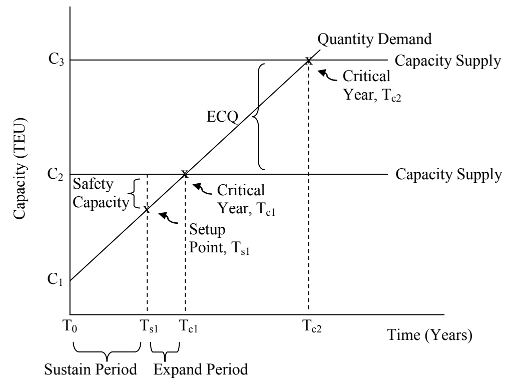

Figure 6.1 Time Frames for the Demand and Install Capacity

Figure 6.1 show the time frame for the demand and install capacity. A new expansion component is start to install at time T_{s1}, another at time T_{s2}, and etc. By setup point and economic capacity quantity approach, the expand size and time can be determine. But, it strongly recommends that the second onward setup point and economic capacity quantity can be review from time to time. Because some uncertainly may affect the output result; like politics, economic, technology, and etc.

Economic Capacity Quantity (ECQ) is the minimum or economical capacity expansion. Fawcett et. al, (2007) proposed that

$$ECQ = \sqrt{\frac{2AS}{CP}}$$

Where,

A - Time Horizon Demand

S - Cost per Setup

C - Costs per Unit of Infrastructure

P - Carrying Costs as a Percentage

Normally, the carrying costs are in between 20% to 30% of the value of the product.

After determination of capacity of increment, the second question is to determine sustain and expand times for the expansion component. The critical point in between the sustain time and expand time is call setup point (SP).

First, calculate the daily demand.

$$DD = \frac{AD}{BD}$$

Where,

DD - Daily Demand

AD - Annual Demand

BD - Number of Days Open for Business

Second, calculate the setup point.

$$SP = DD \times LT$$

Where,

SP - Setup Point
DD - Daily Demand
LT - Lead Time

7. CLOSING

This study intends to develop a generic container terminal expansion model for the entire expansion component in a container terminal. It is also determine the magnitude, sustain period, and expand period for each expansion component in particular time.

Therefore, this study would contribute an expansion model for container terminal in developing countries. The output of study would produce a multi container decision making tool for port planner in expansion estimation to meet the future throughput demand

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