CONTAINER TERMINAL PRODUCTIVITY:

EXPERIENCES AT THE PORTS OF LOS ANGELES AND LONG BEACH

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Keywords: International trade, container terminal operations, terminal congestion, terminal processing speed, terminal productivity, intermodal operations, and productivity measures.

1. Introduction

Throughout most of maritime history, the competitiveness of a commercial port has been collectively determined by its geographic location, its physical characteristics, and its relationship to landside transportation systems and urban centers. And while these factors remain important, today's ports must also integrate and balance a number of dynamic market-place processes—including globalization, containerization, and modern logistics—as they work to define their particular competitive position. These dynamic processes demand that ports improve their operational and managerial efficiencies and overall productivity, whereas earlier challenges could often be met with physical expansion and engineering.

Port terminals function as nodal points within a global system of ocean and landside modes of transport. As the demand for international trade and global logistic services continues to increase, substantial investments and improvements in both physical capacity and operational efficiencies are necessary to enhance terminal productivity.

To meet growing demand, ports need to enhance capacity. Pure physical expansion is constrained by a limited supply of available land, especially for urban center ports, and escalating environmental concerns. In this context, expanding port capacity by improving the productivity of terminal facilities appears to be the only viable solution. How to improve productivity sufficiently to accommodate a large portion of the anticipated increase in container traffic, however, presents a particular challenge to terminal operators and port authorities.

The key objective of this study is to assess the productivity of the Los Angeles and Long Beach ports, and, where possible, compare these measurements with those of other major container ports in the U.S. and overseas. This study is currently ongoing, but at this stage of investigation, a preliminary analysis of the productivity of the ports of Los Angeles and Long Beach has been conducted. In this paper we present a brief survey of port facilities and cargo handling characteristics at the ports of Los Angeles and Long Beach, along with similar information on other leading world container ports, to provide the background for a discussion on container terminal productivity. The productivity of the ports of Los Angeles and Long Beach is evaluated in terms of indicators commonly used by the shipping industry. These particular measurements in turn provide the basis for a broader discussion that considers why productivity, as measured by these indicators, varies so significantly between different ports. The analysis also takes into consideration whether maximizing the value of these productivity indicators is the most appropriate goal for terminal operators, given the unique operating environment of their particular port. The answers to these questions provide a proper frame of reference for an evaluation of the ports of Los Angeles and Long Beach, assist in highlighting bottlenecks that impede productivity, and help to identify appropriate improvement strategies.

2. Terminal Operational Goals and Productivity Measures

The basic function of a container terminal is the transfer and storage of containers. Terminal operators are accordingly concerned with maximizing operational productivity as containers are handled at the berth and in the marshalling yards, and with efficiently utilizing available ground space. Container handling productivity is directly related to the transfer functions of a container terminal, including the number and movement rate of quayside container cranes, the use of yard equipment, and the productivity of workers employed in waterside, landside, and gate operations. The efficient use of available ground space relates to the number of containers stored in a given area of the terminal. Improving the utilization of ground space typically reduces the operational accessibility to containers; that is, ground space utilization and container accessibility are inversely related. The challenge is therefore to define container accessibility in relation to ground space utilization based on a terminal's operational targets and unique physical characteristics.

The productivity of a container terminal is influenced by a range of factors, only some of which can be controlled by terminal operators (DOWD at el, 1990). Factors internal to the terminal and under the control of the operator include terminal configuration and layout, capital resources invested, and, to a certain extent, labor productivity. External factors beyond the control of operators include trade volumes, shipping patterns, and the ratio of import to export containers (which influences the number of empty containers handled at a terminal and the availability of container chassis). The size and type of ships accommodated by a terminal, as well as the landside capacities and performance of intermodal rail and highway systems, are additional external factors affecting the productivity of terminal operations.

Table 1: Common Productivity Measures of Container Terminals

Element of Terminal	Measure of Productivity	Measure
Crane	Crane Utilization Crane Productivity	TEUs/year per Crane Moves per Crane-Hour
Berth	Berth Utilization Service Time	Vessels/year per Berth Vessel Service Time (hrs.)
Yard	Land Utilization Storage Productivity	TEUs/year per Gross Acre TEUs/Storage Acre
Gate	Gate Througput Truck Turnaround Time	Containers/hour/lane Truck Time in Terminal
Gang	Labor Productivity	Number of Moves/man-hour

All of the indicators of terminal productivity presented in Table 1 are used in one fashion or another in conducting productivity analysis. However, obtaining reliable and consistent data for many of these indicators presents a continuing challenge. A uniform system for evaluating the productivity of container terminals would require the disclosure of a substantial amount of data, data which terminal operators generally consider to be proprietary in nature. Moreover, no public mechanism or set of regulations has been established for the monitoring or reporting of terminal performance.

Because of this, comparisons of productivity between major container ports and terminals are usually made at a high level of aggregation. Counts of total throughput, such as TEUs per year, or TEUs per acre of terminal area, for example, are commonly used to gauge the relative productivity of a port. Less aggregated measures, such as “average service time,” often lack uniformity. Some terminals measure “service time” as the total time a vessel is berthed at the terminal. Other terminals only count the time a ship is actually worked, excluding waiting time and shift breaks. And shift break rules can vary between terminals, all of which cause "service time" to be an inconsistent measure of relative terminal productivity.

At this stage of investigation, a preliminary analysis of the productivity of the ports of Los Angeles and Long Beach in comparison with other leading container ports will be conducted using the following aggregated measures:

- TEUs per foot of container quay (Berth Length Utilization Rate)
- TEUs per container gantry crane (Crane Utilization Rate)
- TEUs per container gantry crane-hour (Crane Productivity)
- TEUs per acre of terminal area. (Land area Utilization Rate)

3. Terminal Productivity

Overview of Port Facilities and Operating Characteristics

In 2004, the ports of Los Angeles and Long Beach, as a complex, were the busiest container port in the United States, and the 5th busiest in the world. Although these ports also handle non-containerized cargo, they are primarily container ports, with containers representing 76% of all cargo handled (PMA Statistics, 2004). In 2004 these ports handled about 13 million TEUs of exports, imports and empty boxes. About 78% of the ports' containerized cargo was inbound (Port Statistics 2004).

In contrast with the major transshipment centers of Hong Kong, Singapore or Rotterdam, where a large share of containerized cargo is transshipment (www.singaporepsa.com), most containerized cargo currently handled at the ports of Los Angeles and Long Beach is destined for the U.S. market, with a small percentage destined for Canada and Mexico. This being the case, the ports of Los Angeles and Long Beach can be characterized as origin-destination type ports, as opposed to the transshipment-center type container terminals like Hong Kong and Singapore.

For origin-destination type ports, landside operations and facilities are the most important factors of productivity. In particular, the capacity and efficiency of terminal gates, interchange slots, and marshalling yards determine the performance level of a terminal. Conversely, for load-center ports, the waterside operation of berths and quayside container cranes are the more important determinants of productivity.

Table 2: Characteristics of the Selected Leading Container Ports (2004)

Ports/Terminals	Throughput (TEUs, 2004)	No. Berths	No. Terminals	Gantry Cranes	Berth Length (ft)	Terminal Area (acre)
Los Angeles	7,321,440	29	8	69	31,930	1,686
Long Beach	5,779,852	48	7	68	27,529	1,284
Kwai Tsing (HK)	13,425,000	24	9	86	27,986	704
Singapore	20,600,000	37	4	118	33,838	838
Rotterdam	8,300,000	N/A	8	93	33,038	1,158
Antwerp	6,063,746	44	7	62	30,886	1,203
Hamburg	7,321,479	30	6	58	26,978	1,005
Tacoma	1,798,000	11	6	22	9,460	511
Klang (Malaysia)	5,243,593	15	3	44	15,456	387
Barbour's Cut Terminal (Houston)	1,440,478	6	1	12	6,000	250

Source: Container International Year Book, 2004 and Ports' documents.

As demonstrated in Table 2, in terms of the number of container terminals, berths, and gantry cranes, the ports of Los Angeles and Long Beach are comparable in physical capacities with other leading world ports. These ports however, exceed the other world ports in terms of terminal area. Based on these capacity statistics, productivity measures at an aggregate have been calculated for a select set of leading container ports, and the results are provided in Table 3.

Comparative Productivity Measures

Optimizing the performance of a container terminal as an overall system is challenging, and is particularly critical for ports that frequently receive large vessels with capacities of 8,000 plus TEUs, like the ports of Los Angeles and Long Beach. These mega-vessels require a fast container-handling speed to minimize the time spent at dock and the container yard must be able to accommodate a great influx of containers in a short amount of time. Meeting this demand requires terminal operators to either increase the working time at the berths or increase terminal container handling productivity; that is, the number of containers handled per hour. This productivity depends on the number of gantry cranes available to work a ship as well as the number of containers handled per crane-hour, or ***crane productivity*.** These handling rates are an indication of the crane operator's efficiency, and affect the productivity of the entire terminal operation.

Also, since container terminals actually earn their revenues on containers as they move across the quay and through the storage and marshalling yards, both the number of containers moved per foot of quay length (TEUs/ft, or ***berth length utilization rate***) and the number of containers handled per acre of terminal area (TEUs/per acre, or ***land utilization rate***) are commonly quoted measures of terminal productivity.

Table 3: Productivity Measures of Selected Leading Container Ports

Port/Terminal	Throughput (TEUs, 2004)	"Throughput Density" (TEU's/acre)	Throughput (TEU's)/crane	Throughput/ quay length (TEU's/ft)
Los Angeles	7,321,440	4,342	106,108	229
Long Beach	5,779,852	4,501	84,998	210
Kwai Tsing (HK)	13,425,000	19,070	156,105	480
Singapore	20,600,000	24,582	174,576	523
Rotterdam	8,300,000	7,168	89,247	251
Antwerp	6,063,746	5,041	97,802	196
Hamburg	7,321,479	7,285	126,232	304
Tacoma	1,798,000	3,519	81,727	190
Klang (Malaysia)	5,243,593	13,549	119,173	339
Houston (Barbour's Cut Terminal)	1,440,478	5,762	120,040	240

Sources: From Various Port's Documents and Websites

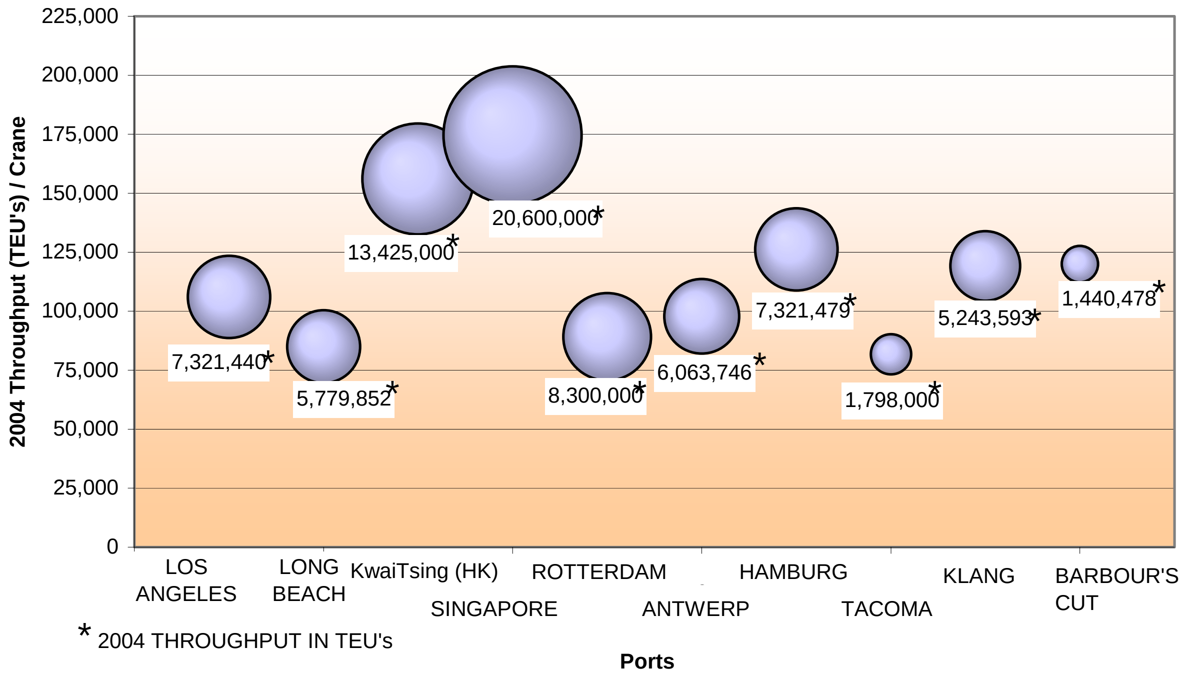
Care should be taken, however, when these aggregate statistics are used to quantitatively measure the performance of different terminals. While the numbers may indicate that a port is underperforming in a certain aspect relative to other ports, a hasty effort to improve the productivity measure of a particular operational element could unintentionally undermine the overall economic efficiency of the entire container handling system. Taking the land utilization rate as an example, a lower number is often interpreted to be less efficient in a comparison chart. The real meaning of this rate, however, will depend on the economic circumstances of a particular terminal. One would expect "lower" land utilization rates in areas where land is relatively cheap and labor expensive. As such, these rates may be of limited value in making straight comparisons of productivity. The ultimate significance of these comparative statistics is that they allow us to understand the operational characteristics of the ports of Los Angeles and Long Beach, as well as the rationale supporting the current productivity achieved by their operations.

Berth Productivity

Crane Utilization Rate (TEUs per Gantry Crane)

Figure 1 demonstrates the relative level of container handling productivity, measured by the crane utilization rate—the average number of TEUs handled per crane per year—for several leading container ports and terminals. Even though they are operating more or less at the same level of crane intensity as other U.S. and European ports, by this measure the ports of Los Angeles and Long Beach are performing well below the ports of Singapore and Kwai Tsing (Hong Kong).

Figure 1: Variance of Port Productivity
- Throughput Per Crane -

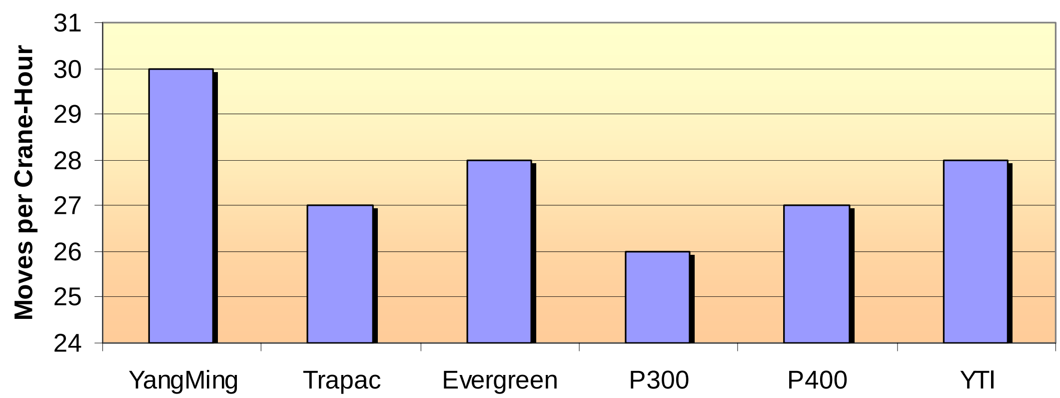


Crane Productivity (Moves per Crane-Hour)

According to interview with terminal operators, on average, container terminals at the ports of Los Angeles and Long Beach operate with approximately 28 to 35 moves per crane per hour. Higher rates of up to 40 moves per hour can be achieved when necessary, in order to meet a pre-set schedule for ship departure, for example, or if export or empty containers arrive late for loading.

In operations theory, crane productivity depends on the number of lifts per vessel in service. This provides the ports of Los Angeles and Long Beach with an advantage since they are currently the only West Coast ports with the water depth necessary for servicing mega-ships. In addition, these ports are generally the 1st port of call, which results in a greater number of containers being discharged and a correspondingly higher theoretical crane rate.

Figure 2: Variance of Berth Productivity among Los Angeles Terminal (Moves per crane-hour)



Source: Port of Los Angeles

Also, a large volume transit through the ports of Los Angeles and Long Beach consists largely of imports, accounting for 78 percent of total amount of container handled. This composition of container flows would again allows for a faster discharge rate as the re-handling of loaded export containers is minimized. However, according to terminal operators interviewed for this study, the more casual rate of 28 to 35 moves per crane hour is acceptable given the manning regulations associated with handling a vessel. Achieving the higher loading rates requires a greater number of stevedoring teams, or labor gangs. The acceptable casual rate, for example can be accomplished with four gangs, whereas the high rate would require six gangs or 6 gantry cranes work on a ship. For terminal operators, the higher productivity rate does not appear to generate sufficient revenues to offset the higher cost of labor.

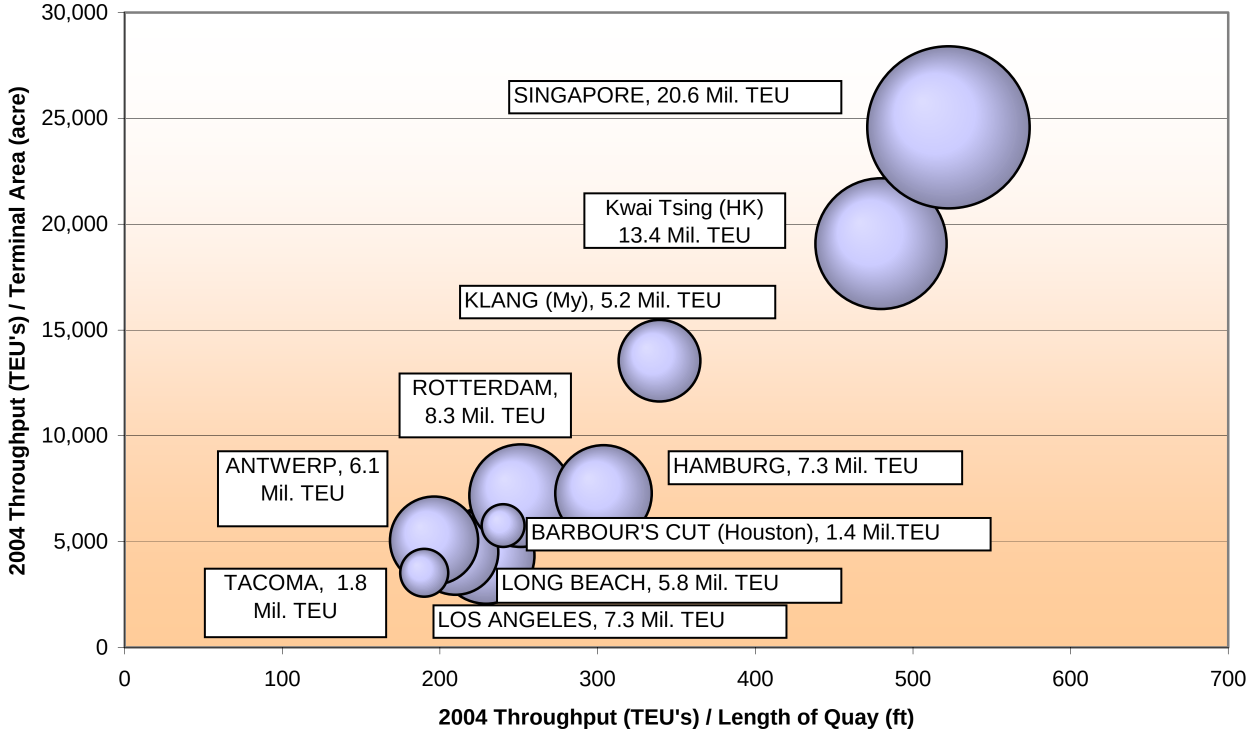
Moreover, as Figure 1 shows the productivity per crane at the ports of Los Angeles and Long Beach is not up to par with that of other world ports in Asia and Europe. This is due to safety regulations as applied by local labor. For example, the higher productivity rate could also be achieved by using fewer cranes equipped with twin spreaders, as demonstrated by operations in Rotterdam. Or, a greater number of cranes could be used per vessel, up to 8 cranes for a 8,000-plus TEU ship. However, terminal operators point out that local safety rules requiring a minimum distance between traffic lanes under a crane limit them here to at most 5 or 6 cranes.

Land Utilization

In terms of annual volume handled, the container terminals at the ports of Los Angeles and Long Beach have consistently ranked among the world's top ports through the last decade. Nonetheless, as demonstrated in Figure 1, by other common measures of productivity these same ports are seen to be not the most efficient in handling containers. For instance, in terms of annual throughput per container terminal acre, a higher number of TEUs per acre represents a higher level of efficiency. By this measure, ports like Singapore with 24.5 thousand TEU/acre in 2004 are seen as very efficient container terminals. Typically ports achieving this level of efficiency employ dense and high-stack container storage configurations.

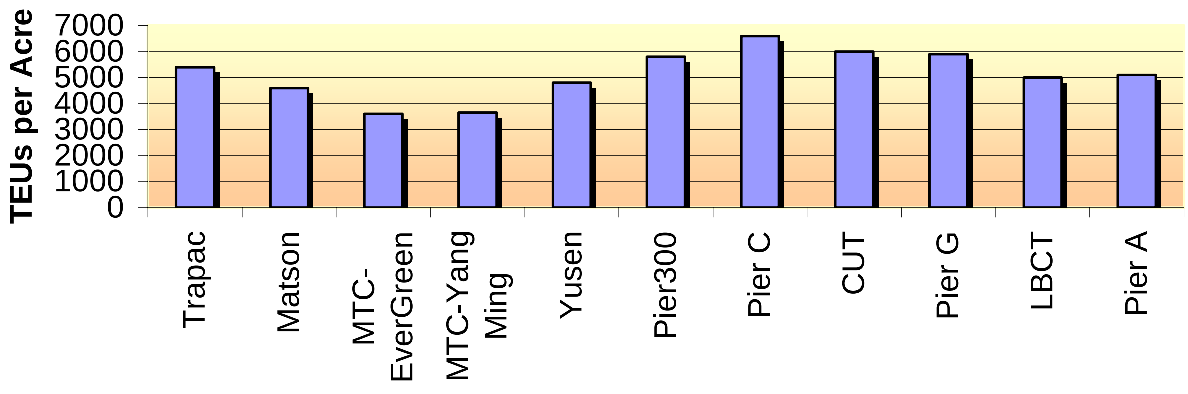
In their marshalling yard operations, the container terminals at the Ports of Los Angeles and Long Beach currently rely more on wheeled operations than on dense stacking. According to our survey, up to 70 percent of some terminal operations are wheeled. Since wheeled operation takes much more land space, the number of TEUs that can be accommodated per acre is much lower. A rule of thumb at the port of Los Angeles is that wheeled operations can handle 50 TEUs/acre (JWD, 2003). Also, as layouts in the wheeled handling system are based on ground slots for 40-ft containers, or two TEUs, a number of ground slots will be underutilized when occupied by just a 20-ft container. This space wasting situation does not occur in stacked systems. The land utilization rates of the wheeled system are rather low compared with stacking systems. This is one reason why the wheeled container handling system is rarely adopted in Asia or Europe, where terminal land is treated as a scare resource and more flexible manning regulation are applied.

Figure 3: Variance of Port Productivity - TEUs per Terminal Acre and TEUs per foot of Berth Lenght



It has been acknowledge also that U.S. terminals are operated under more restrictive regulatory and labor conditions than most foreign container terminals (Productivity Commission, 2002) eventuating in a lower average throughput per terminal acre. Land utilization rates vary between container terminals even of the same port. A higher average in the U.S. would be between 3500-6500 TEUs per acre and the lower average figure would be at 2000-3000 (Alderton, 2003). As shown in Figure 4, container terminals at the ports of Los Angeles and Long Beach operated at 3500 to 6000 TEUs per acre per year.

Figure 4: Variance of Land Utilization Rate among Los Angeles and Long Beach Terminals (TEUs/Acre)



Source: JWD Study, 2003

Yet there is a perfectly good reason for why the high throughput container terminals in Los Angeles and Long Beach are using the seemingly less-efficient wheeled operation, and that is labor costs. The cost of labor for the ports of Los Angeles and Long Beach is higher than that of high-performing container terminals located in other parts of the world (Productivity Commission, Australia, 2002). An important characteristic of wheeled operation is that it is much less labor intensive than stacked operations, and therefore incurs lower labor costs. As noted by JWD study in 2003, one reason that the APMT moved from the port of Long Beach to Pier 400 at the port of Los Angeles was to avoid the high costs associated with running a grounded operation of 6000 TEUs per acre per year, as they would have had to do at the Long Beach, compared to a predominantly wheeled system of about 4000TEUs per acre per year at Los Angeles.

Safety regulations also impede the maximum height that containers can be stacked at the ports of Los Angeles and Long Beach, with higher than five or six containers being considered unsafe. Other world ports do not have such limitations imposed on their container storage operations. Additionally, the cost of land (to lease or own) at the ports of Los Angeles and Long Beach is less than at other ports, like Hong Kong and Singapore. The combination of these attributes make wheeled operations a cost-effective choice for terminal operators at the ports of Los Angeles and Long Beach, even though it may not be the most efficient use of container terminal space.

Gross Labor Productivity

Gross labor productivity is a measure of gang productivity which defined by number of moves per man-hour. With the standard annual labor of one person equating with approximately 2000 man-hrs a year (a full-time equivalent or FTE), marine container terminals generally achieve an annual throughput of 800-1500 TEUs per FTE. This means a labor productivity of 0.4-0.75 TEUs per man-hr (MARAD, 1989). According to interviews with terminal operators at the ports of Los Angeles and Long Beach, a little higher labor productivity of 0.8 TEU per man-hour is achievable level for their terminals. This labor productivity level equates to 1600 TEUs per FTE.

How Port Can Improve Productivity

Whether the ports of Los Angeles and Long Beach should adopt higher stacking operations depends upon how the trade-off between ground space utilization and the accessibility of containers in a stack is calculated. From the perspective of terminal operators, stacking reduces land costs while it increases handling costs. There are also business considerations that tend to trump straight accounting calculations of cost. Factors such as customer service, rated by the quick receiving or delivery of containers from the stacks, is often one such consideration. Also, as mentioned earlier more than 70 percent of containers handled at the ports of Los Angeles and Long Beach are inbound: accessibility to containers is more important when handling imports as opposed to exports or empty containers.

Forecasts of growing container volumes at the ports of Los Angeles and Long Beach will eventually require greater ground space utilization. With this situation, continued use of wheeled operations will greatly limit future container terminal capacities. According to one terminal operator, going with high density stacked operations will likely be the last option considered, and only after all other possible alternatives are exhausted. Some other operating initiatives are already being pursued. Including:

Reduced Container Dwell Time

The port of Long Beach has shortened the amount of free time allowed for each container in an effort to free up container storage space. The term "free time" refers to the number of days a container can remain at a container terminal once it has been unloaded from a ship before incurring a storage fee. The port recently lowered its free time allowance from five to four days, and also changed its method of calculating free time. Previously free time for all of the containers unloaded from a ship was calculated from the day that the last container was unloaded from the ship (even if the first container unloaded was four days prior to that). The new method counts free time for each container starting the day that it is unloaded from the ship, irrespective of when the last container is unloaded. As such, containers coming off of the ship first are not receiving as much free time as before, and carriers have started to remove them from the container terminals sooner to avoid incurring storage fees. In turn this frees up some of the wheeled container slots and effectively increases the capacity of container storage yards.

Extended Hours of Operations

The ports of Los Angeles and Long Beach have also been experiencing greater difficulty in acquiring additional land; not so much due to the increase in cost, but rather owing to increasingly strict environmental regulations. Essentially these ports are no longer able to continue to expand their terminal space in order to handle increasing container volumes. To handle these greater volumes, terminal operators will have to find ways to improve their efficiency. One method has been to increase number of hours and shifts that terminal gates are open. Terminal gate operations have been expanded during the traditional workweek and for the weekends as well. Gate hours have often been a limiting factor, because even though ships can be unloaded 24/7, the flow of containers through the terminal stops in the container yard if the gates are not available to release boxes to the carriers.

Inland Container Yard

Terminal operators will need to improve their capacity while avoiding higher handling costs. One method of accomplishing this is to move some containers to holding sites outside of the terminal area, farther inland, where there is more land available for storage. SSA, a terminal operator at the port of Long Beach, is doing this for some of its containers. They employ their own staff to transport the containers to off-site storage yards (ShipperExpress.com), from where private carriers can pick-up the containers. Of course, this method incurs the added cost of transporting containers to an off-site container storage yard.

The operational efficiency of yard storage is becoming increasingly important, especially for the ports of Los Angeles and Long Beach where terminal physical expansion is essentially impossible. The degree of ground space utilization that any particular terminal should achieve depends on the economic calculations of that container terminal operation. With existing technologies and equipment employed at Los Angeles and Long Beach, higher ground space utilization rates require more man power and an increase in unproductive lifts and moves to access containers when called for. It follows therefore that higher ground space productivity is more suitable where labor costs are relatively inexpensive and land costs are high. This situation is found in Asian ports such as Hong Kong or Tanjung Perapas, Malaysia, but not at Los Angeles and Long Beach. It is widely accepted that in the U.S. container terminal operating environment as ground space density increases, the manning costs for stacking operations also increase dramatically, making such operations uncompetitive once density exceeds 200 to 300 TEUs/acre (JWD, 2003).

4. Conclusion

Substantial investments and improvements in both physical capacity and operational efficiencies are necessary to accommodate ever greater volumes of containerized cargo being handled by the ports of Los Angeles and Long Beach. However, physical expansion is currently constrained by the limited supply of available land in close proximity to urban center ports and the escalating environmental and community concerns related to port development. All of this leaves the ports and terminal operators with the challenge of expanding terminal capacity by improving the productivity of operations, rather than through physical expansion.

The ports of Los Angeles and Long Beach handle mostly imports destined for regional and national markets. For this type of market operation, the capacities and performance of marshalling yards and transfer to landside transportation systems are particularly important factors of terminal productivity. The productivity of a container terminal is influenced by a range of factors; both external and internal. Accordingly, terminal operators can control some of these factors, but others are beyond their control. In particular, terminal operators have only a degree of control over labor costs. Work rules and safety regulations that apply to terminal operations are established through local institutional arrangements and establish operating conditions over which an individual operator has a minimal ability to negotiate.

Four commonly used aggregate measures of productivity are used as initial points of comparison between the ports of Los Angeles and Long Beach and a number of leading container ports around the world. These comparisons suggest that the ports of Los Angeles and Long Beach are underperforming relative to other leading container ports in terms of these measures of productivity. Further consideration of these factors reveals that the terminal operators at these ports are aware of the technologies and practices used at other world ports that would allow them to achieve a higher level of performance. However, the present operating agreements between terminal operators and port labor prevent the implementation of such technologies and practices. The absence of these technologies and practices in the container handling systems currently employed at the ports of Los Angeles and Long Beach results in higher handling costs, and these costs escalate even higher when these terminals seek to operate at the higher levels of productivity regularly achieved at other leading world ports.

Proceeding from this initial analysis of container terminal productivity factors, this study will develop additional details on measures of productivity, both quantitative and qualitative. Specifically this study will review cargo handling technologies presently in use in other U.S. and world ports, and investigate provisions of labor agreements that support the implementation of these more productive cargo handling technologies. An understanding of these technologies and work rules, and how they affect measures of productivity at the ports of Los Angeles and Long Beach, will facilitate the eventual implementation of strategies that improve productivity in a manner consistent with the fundamental interests of all port stakeholders.

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