Container terminal productivity: A perspective

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The increasing competitiveness of the marine transportation industry has brought about demands that container terminal productivity be improved. MARAD, in cooperation with the National Research Council, has responded by developing a number of quantitative measurements for container terminal productivity. In this paper we discuss the problems and prospects of using such measurements to estimate or compare the productivity of terminals or ports. Because physical or institutional factors, or a combination of the two, act to limit the productivity of every container terminal, quantitative productivity comparisons among terminals or ports may lead to misplaced efforts to improve the productivity of particular operational elements in piecemeal fashion. By contrast, a sensible strategy for managing productivity would involve the linking of productivity and cost data, so that existing productivity constraints can be intelligently shifted from one area of operations to another.

1. Introduction

This paper provides a perspective on us container terminal productivity - how it is measured, the validity of the measurements used, and the factors that affect the elements of productivity [1].

The tremendous capital outlays, coupled with shippers' demands for faster, cheaper delivery of cargo, that built up the pressure for improved productivity led the National Association of Stevedores in April, 1984 to ask the us Maritime Administration (MARAD) to undertake a study of marine container terminal productivity. MARAD contracted with the Marine Board of the National Research Council (NRC) to undertake the study, which culminated in a report issued in the summer of 1986 [2]. The research project described in this paper was designed to explore the problems and prospects of using the container terminal productivity measurements cited in the NRC/MARAD study.

2. Containerization

Containerization, the movement of cargo in containers, is a system with an ocean component and a land component. A container terminal is a facility which provides a package of activities and services to handle and control container flows from vessel to rail, or road, and vice versa [3]. The container terminal is the physical link between ocean and land modes of transport and a major component of the containerization system. The latter is a dynamic system within which various enterprises (carriers, terminal operators, stevedores, labour, port authorities, shippers, railways, truckers, government and others) interact. Each influences productivity and at one time or another may be the primary determinant or constraint on control of productivity at a specific terminal or within the entire system. As new components enter into this system the balance of power may shift. For instance, when us stack car unit trains came on the scene rail operating requirements and scheduling caused significant changes and railways assumed a more influential role in the system.

A potential imperfection of the system is that individual enterprises react according to their own self-interest or what they perceive their best interests to be at any given moment-often with little or no regard for the entire system or, more exactly, for the overall efficiency of the system. With the advent of the logistically oriented carrier in recent times (e.g. American President Companies, CSX-SeaLand), the effect of this diffusion of self-interest has been lessened because a single organization controls a number of segments within the system.

There is a tendency to assume that if the terminal works at maximum efficiency, then the entire system benefits. According to our observations, it appears that maximizing terminal efficiency might only shift the bottlenecks to some other element within the system. For example, if terminal efficiency was increased to a point where all intermodal import containers were processed in half the current time, the real value of this increased terminal efficiency would depend on whether the intermodal transfer facility could accommodate the increased volume. In effect, the real value of an increase in terminal efficiency depends on whether it increases the efficiency of the entire system instead of just creating bottlenecks in some other element of it.

From the standpoint of terminal productivity, each player has his own self-interest and his own definition of productivity [4]. For the terminal operator the main goal may be to reduce or stabilize the cost per container handled and thus maximize profit per unit. For the port authority the main goal may be to increase the annual throughput per acre of its leased terminals and thus avoid having to build new facilities until all the current facilities are fully and

efficiently utilized. For labour the main goal may be to increase union jobs and total cargo handled by its members. For the carrier, the main goal may be to minimize ship in-port time and so facilitate the expeditious handling of all loads, especially 'hot' containers [5]. All these are reasonable, but often conflicting, goals. It is within this arena of conflicting self-interest that container terminal productivity should be interpreted.

Often the terminal operator (a term that includes the carrier's stevedoring subsidiary) is caught in the middle of this arena of conflict. To complicate things further, the terminal operator's performance is normally judged by productivity measurements that are heavily dependent on factors over which he has limited or no control.

3. Terminal productivity: the limiting factors

In the most general sense productivity measures output per unit of input. Container terminal productivity deals with the efficient use of labour, equipment and land. Terminal productivity measurement, as discussed later, is a means of quantifying the efficiency of the use of these three resources.

The limits on the productivity of a container terminal may be imposed by either physical or institutional factors or a combination of both. Physical limiting factors include the area, shape and layout of the terminal, the amount and type of equipment available, and the type and characteristics of the vessels using the terminal. For example, our observations suggest that labour productivity in terms of moves per ganghour is definitely affected by vessel type and characteristics. A vessel or vessel class that the terminal operator has experience with can usually be worked more efficielltly than one that is on her first call.

Of course, there are more obvious physical limiting factors: for example, a terminal that is run as an on-chassis or a wheeled operation that lacks sufficient chassis. This causes the operator to 'ground' containers in order to have sufficient chassis to put against the ship when she arrives - an action that obviously limits the productivity of the container yard. Lack of cranes, insufficient land, odd-shaped container yards, inadequate berthage, inadequate gate facilities, and difficult road access are all physical limiting factors. Institutional limiting factors are more difficult to define. Institutional factors may be imposed on a terminal operator by any of the enterprises in the containerization system.

Institutional factors include such things as union work rules, import/export mix, container size mix, container availability, stow of arriving vessels, customs regulations, intermodal train scheduling, safety rules, and various requirements imposed on the terminal operator by the carrier.

For example, a carrier may require that the terminal operator accept containers at any time before the ship sails. This necessitates terminal provisions for late-arriving containers and last-minute adjustments to the stow plan. Some foreign terminals that have exceptionally high productivity bar delivery of containers to the terminal as much as 24 hours before the ship docks. This allows for more efficient pre-planning of the terminal, vessel loading and stowage.

Another example of the carrier limiting terminal productivity is a requirement to expedite lifting off 'hot' containers as soon as possible after the ship arrives. This forces the terminal operator to establish initial crane placements to coincide with the locations of these 'hot boxes'. Normally these containers are not block stowed, they are located in several places on the vessel- some on deck and some below deck. Only after the 'hot boxes' are lifted off can a more efficient systematic crane placement schedule be undertaken. Another example of an institutional limiting factor would be a union work rule that requires the entire gang to take coffee breaks or meal breaks as a group or at a specific time rather than allowing such breaks to be taken individually while work continues. If a carrier allows its customer, without penalty, to deliver export containers to the terminal far in advance of ship arrival, or to leave import containers on the terminal long after the ship sails, thus increasing the terminal dwell time, this is also an institutional limiting factor.

If there was one area whose effect on productivity we initially underestimated it was these institutional factors. Our research indicates that the institutional factors, especially the requirements of carriers imposed on the terminal operator, are just as constraining as the physical factors.

In many instances, these limiting factors can be mitigated or eliminated. However, it usually takes an increase in costs or a rearrangement of priorities to do that. For example, if a labour work rule that limits productivity is amended or abolished, it may require an increase in manning, or compensation of the existing gang. There must be some calculation on the part of the carrier or terminal operator as to the benefit of eliminating or amending that specific work rule versus the cost in money or adjusted priorities and its ultimate effect on the system.

The same is true of equipment. It may be possible to increase productivity by adding another piece of equipment, or by replacing a serviceable piece of equipment with a newer, more efficient model. But a decision to do so means that the carrier or terminal operator has determined that it is worth the added cost in dollars, or in an adjustment of priorities, and that the system would benefit. Decisions on increasing productivity are not likely to be indiscriminate.

4. Measuring productivity

The factors limiting terminal productivity can be considered, figuratively, as variables in a formula to measure a terminal's productivity. As such, these factors or variables influence productivity measurement and render it difficult (if not impossible) to compare strictly any two or more terminals, or establish valid standards for terminal productivity. There is yet another variable that affects the measurement of terminal productivity - semantics! Our research suggests that the measurement of container terminal productivity has more in common with a commercial art form than with science! The lack of uniformity in the data used for productivity measurement is enormous. For example, some terminals count container rehandles and hatchcover removals as 'moves', whereas others do not. This lack of uniformity renders difficult valid comparison of the measurements of two terminals and the formulation of uniform standards for international, national, regional or portwide application.

In fact, we question the advisability of formulating 'standards' or 'averages' for terminal productivity on an international, national or portwide basis. Perhaps this is heresy. Almost since the advent of containerization there have been demands for universal standards of terminal productivity. For example, ports supported this effort in the hope of having a benchmark that would show clearly that their facilities, whether operated by the port itself or by a terminal operator, were 'efficient'.

There has also been support for cross-sectional analysis of productivity comparing the productivity of one terminal with that of another terminal, or the productivity of one port's terminals with those of another port. This is often used as 'evidence' of a terminal's or a port's superior productivity by comparison with a rival terminal or port. Our research suggests that there is no universally valid way to compare productivity on a cross-sectional analysis basis. Such comparisons must be made carefully, selectively, on a case-by-case basis. Often it is more appropriate to compare productivity on a sequential basis, comparing productivity at a single terminal over two or more time periods.

Attempts to quantify a single terminal's or port's productivity in order to compare it with that of another port or terminal immediately introduce data comparability and factor commensurability problems. The same is true when one attempts to set standards of productivity or to compute some form of industry or portwide average productivity.

We offer the table, therefore, as a guideline of useful considerations, not universal prescriptions, when considering container terminal productivity. To obtain the maximum value from productivity data, a terminal operator must link cost data with them. By linking the cost and productivity data it is possible to form one of a series of profit centres that allow the terminal operator to manage the terminal. If managing productivity is viewed as a process of shifting existing constraints on productivity from one area to another, then cost information can usefully guide these constraints to an area or areas that minimize the impact of these productivity constraints on overall cost.

On several occasions we were told that a terminal operator had made a concerted effort to improve the productivity of a specific activity, only to see it checked when expenses increased drastically. Yet only a very few terminals, mainly the larger carrieroperated ones, have a sophisticated cost accounting system linked to productivity data.

A number of projects to increase terminal productivity in the us were found to be tied directly to increasing the efficiency of the intermodal activities - that is, to

Productivity measurements and factors affecting container terminal productivity

Terminal Operations Elements	Sytemic factors influencing productivity	Other limiting influences on operations	Productivity measures	Productivity factor measured

Container yard	Area, shape, layout Yard handling methodology Box size mix Dwell time	How many containers must be grouded, stacked (inc. chassis)	TEUs/yr/gross acre TEUs capacity/net storage area	Yard throughput Yard storage
Crane	Crane characteristics Level of skill, training Availability of cargo Breakdowns Breaks in yard support Vessel characteristics	Operational delays	Moves/gross gang or crane hours minus down time Moves/gross gang or crane hours	Net productivity Gross productivity
Gate	Hours of operation Number of lanes Degree of automation Availability of data	How much weighing, inspection, documentation checks are expedited	Container/h/lane Equipment moves/h/lane Truck turn-around time	Net throuhput Gross throughput
Berth	Vessel scheduling Berth length Number of cranes	Extent of berth utilization	Container vessel shifts worked/yr/container berth	Net Utilization
Labour	Gang size Work and safety rules Work force skill, training, motivation Vessel characteristics	General tempo of operations	Number of moves/man-hour	Gross labour productivity

improving 'processes'. Thus it would appear that for many carriers the intermodal activities are the driving force for increases in container terminal productivity. This is an indication that a systems approach is being taken by the more progressive carriers and that the productivity of container terminals is being considered within a system perspective.

Container terminal productivity must be considered in a system perspective for it to be of maximum value to industry. Although we are not optimistic about finding universal standards for terminal productivity we feel that all the players should have an awareness of the entire system and beware of becoming its weak link.

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References and notes

1. NOLAN, R. (International Terminal Operating Co., Inc., New York) commented a few years ago, 'Productivity is important, but in perspective'.
2. NRC/MARAD (1986), Improving Productivity in U.S. Marine Container Terminals (Washington, D.C.: National Academy Press).
3. Liberally drawn from the remarks of Joan Rijsenbrij, Europe Container Terminus, Rotterdam, January, 1986.

4. Dowd reflected on the terminal leasing strategies and on some of the differences in objective between ports and carriers in: DoWD, T. J. (1984), Container terminal leasing and pricing. Maritime Policy and Management, 11 (4),280.
5. 'Hot' containers are containers specifically designated for expeditious handling.