NORTH AMERICAN CONTAINER PORT CAPACITY

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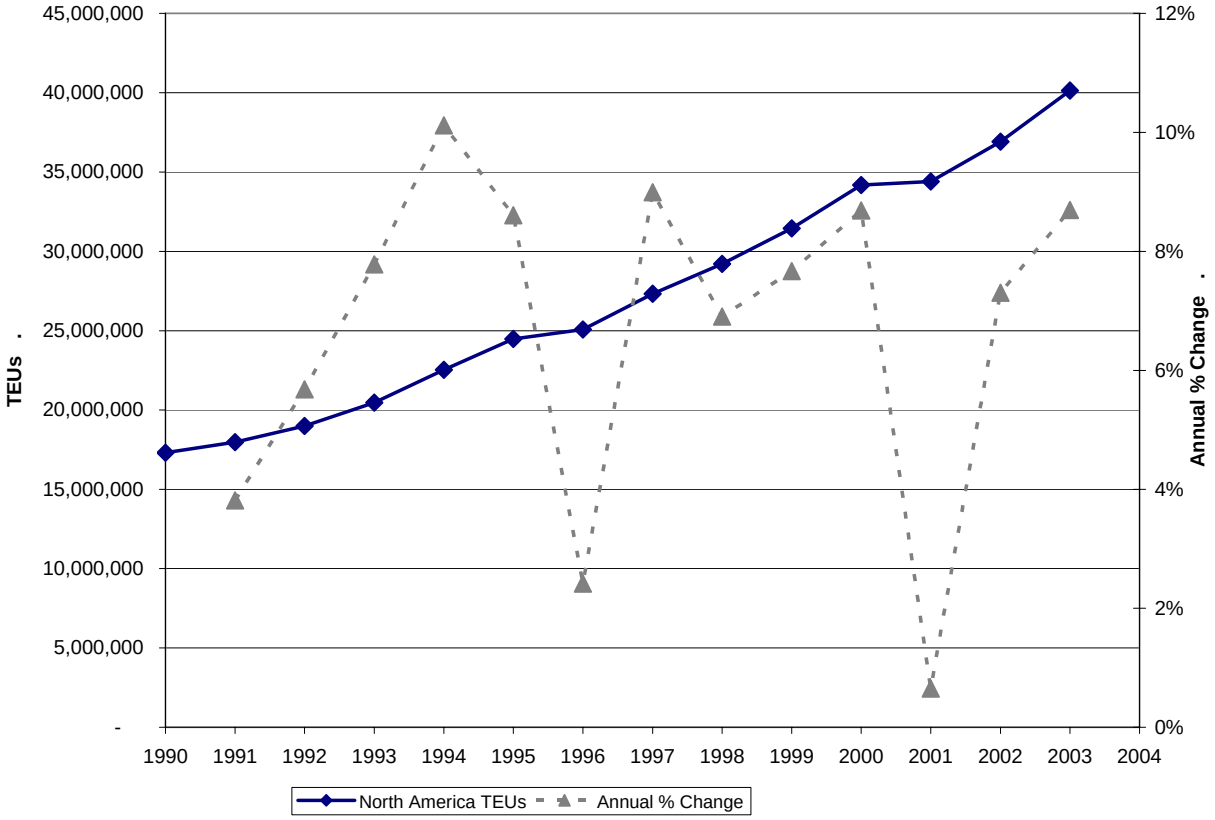
Abstract

Container volumes through North American ports have been rapidly increasing each year. The ports and supporting rail and truck infrastructures have not expanded accordingly, however, and significant capacity issues are now developing. This research offers an initial exploratory assessment of current and future port capacity problems including timing of capacity shortages, key capacity drivers, and resolution strategies. In doing so, this research finds that many critical capacity factors are beyond port control and require coordinated strategic and tactical planning with numerous stakeholders.

INTRODUCTION

North American ports moved more than $1 trillion of goods in over 40 million TEUs (twenty-foot equivalent unit containers) in 2003 (National Chamber Foundation of the U.S. Chamber of Commerce 2003; American Association of Port Authorities 2004). This represents a 9% increased from 2002 and essentially matches the 7% average increase over the last 15 years (see Chart 1). Industry experts forecast no decline to this growth (National Chamber Foundation of the U.S. Chamber of Commerce 2003), and in fact, even larger increases are expected on some trade lanes (Mongelluzzo 2004). For the most part, the ports have been able to support this growth but not without difficulty. During the 2004 peak volume season (mid-summer to early fall), the two largest North American ports, Los Angeles and Long Beach, were overwhelmed with container volumes. Many vessels had to wait several days at anchor before berthing, and turnaround time for many tripled to as much as ten days (Mongelluzzo 2004). Many ships were also diverted to other ports, causing record setting volumes along the West Coast ("Transpacific Diversions from L.A.-Long Beach Confirmed"; Leach 2004). As volumes continue to rise each year, these congestion problems will worsen, and global supply chains will consequently be highly susceptible to container network service disruptions.

Chart 1: North America TEU Volumes, 1990-2003 (American Association of Port Authorities)



Container capacity is constrained by numerous factors both internal and external to port control (see Table 1). Internally, a port facility has fixed capacity driven primarily by berth space,

handling equipment, and terminal space. Internal port capacity is further heavily impacted by terminal operators and longshore labor (usually unionized) that perform the actual dockside operations. Externally, railroads and dray truck carriers serving the ports are constrained by limited port access, equipment, and labor on regional and national levels. Ocean carriers also affect port capacity by driving the location and timing of container flows as well as affecting port facility requirements with vessel sizes. Local and federal governments will impact capacity too through security, environmental, and other regulations as well as access to expansion capital. Even local communities have capacity influences through public pressure regarding environmental and livability concerns. Finally, the parties directly responsible for the container flows, including shippers and ocean transportation intermediaries (freight forwarders, customs brokers, and non-vessel owning common carriers) will affect container capacity not only through volume but with operational and documentation efficiency as well. In all, nearly a dozen stakeholders may impact container shipments. Although they are linked by a common goal of supporting container flows, these stakeholders tend to plan and operate relatively independently of one another.

Table 1: Stakeholders Influencing Container Capacity

Container Capacity Stakeholders
Port Authorities
Terminal Operators
Longshore Labor
Ocean Carriers
Freight Forwarders
Customs Brokers
Non-Vessel Owning Common Carriers (NVOCCs)
Shippers
Consignees
Local, State, National Government
Local Community

Several studies indicate that many North American ports are already at or close to full capacity and will have sufficient capacity deficits within the next 5 to 15 years (Wilbur Smith Associates 2001; National Chamber Foundation of the U.S. Chamber of Commerce 2003). The rail and truck carriers serving the ports also face both capacity issues ("Capacity Crunch Continues" 2004; Kulisch 2004) and severe local congestion (Federal Highway Administration 2004; Texas Transportation Institute 2004). Imminent security regulation changes will further aggravate capacity concerns. On a basic level, container capacity problems will not only lead to higher transportation costs as carriers capitalize on their bargaining power but also cause shipment delays and other service issues. These service breakdowns will disrupt retail and manufacturing operations, necessitating higher inventories and longer lead times. At a macro level, extreme capacity shortages will hinder world trade and impact economic stability (Leach 2004). Given such significance, it is critical to assess current container capacity issues and facilitate resolution strategies and planning if needed. With the numerous, disparate stakeholders, such analyses must assess the topic from a system-wide view.

LITERATURE REVIEW

A review of relevant academic research regarding container capacity and associated stakeholders yields a broad and diverse set of literature. Although a detailed review is beyond the scope of this paper, another work by the authors doing so is currently under review. Table 2 summarizes its results, representing a count of works categorized by general capacity topic and stakeholder focus. While the quantity of works is encouraging, none actually offer the coordinated, cross-stakeholder approach required by container capacity problems. The research tends to apply only to individual elements of capacity drivers, and furthermore, little identifies or addresses the scope of the actual industry problem. From government and industry perspectives, a few prominent though isolated projects highlight the causes and impacts of capacity issues (United States Marine Transportation System Task Force 1999; Wilbur Smith Associates 2001; National Chamber Foundation of the U.S. Chamber of Commerce 2003), but even these do not offer tactical resolution planning.

Table 2: Count of Academic Research Impacting Container Capacity by Topic and Stakeholder

Capacity Topic	Ports	Railroads, Truck	Ocean Carriers	Govern-ment	Ocean Trans. Intermidiaries	Shippers
Congestion		5				
Environmental issues	2					
Expansion, development	14	2				
Facilities, capacity	7	3				
Inland, short-sea facilities	3		1			
Labor	8		1			
Operations, productivity	43	16	8		1	11
Planning, policy	6		1	1		
Port competition	12		6		1	
Pricing, costs	2		4			1
Security	4		1	2		
Service issues, impacts	3	2	3		4	
Stakeholder interaction	3					
Technology	6				6	1

RESEARCH OBJECTIVES AND METHODOLOGY

The research presented here offers an initial, exploratory investigation of container capacity issues and opportunities in North America by assessing the perceived urgency of capacity problems, key capacity drivers, and expansion planning efforts. To address these research objectives, port authorities of the largest North American ports were surveyed for opinions of capacity issues. While the ports only offer a single-stakeholder view, they are in the unique position of having direct visibility to and relationships with nearly all invested stakeholders. The research scope was limited to U.S. and Canadian ports since they handle almost 98% of North American container shipments (American Association of Port Authorities 2004), and Mexico ports are currently only used on a national basis. Table 3 shows the largest U.S. and Canadian

ports. Since San Juan, Honolulu, and Anchorage do not serve continental North America, these ports were omitted from the survey. In this initial research, smaller ports were also not surveyed since most of the volume growth tends to be handled by the top ports. In all, seventeen ports were surveyed, representing a combined 81% (33 million TEUs) of all North American container flows.

Table 3: 2003 North American Port Volumes (American Association of Port Authorities 2004)

Port	St/Prov	Country	2003 TEUs	% of Total	Cumm. %
Los Angeles	CA	US	7,148,940	17.8%	17.8%
Long Beach	CA	US	4,658,124	11.6%	29.4%
New York/New Jersey	NY/NJ	US	4,067,812	10.1%	39.6%
Oakland	CA	US	1,923,104	4.8%	44.3%
Tacoma	WA	US	1,738,068	4.3%	48.7%
Charleston	SC	US	1,690,847	4.2%	52.9%
San Juan	PR	US	1,665,765	4.2%	57.0%
Hampton Roads	VA	US	1,646,279	4.1%	61.1%
Vancouver	BC	Canada	1,539,058	3.8%	65.0%
Savannah	GA	US	1,521,728	3.8%	68.8%
Seattle	WA	US	1,486,465	3.7%	72.5%
Houston	TX	US	1,243,706	3.1%	75.6%
Montreal	QC	Canada	1,108,837	2.8%	78.3%
Miami	FL	US	1,028,565	2.6%	80.9%
Honolulu	HI	US	980,840	2.4%	83.3%
Jacksonville	FL	US	692,422	1.7%	85.1%
Port Everglades	FL	US	569,743	1.4%	86.5%
Halifax	NS	Canada	541,650	1.3%	87.8%
Baltimore	MD	US	536,078	1.3%	89.2%
Anchorage	AK	US	521,993	1.3%	90.5%
All North American Ports			40,132,313		

An initial draft of the survey instrument was developed based on the authors' expertise in maritime transportation and was then refined based on input from numerous industry experts. Survey distribution was conducted in several stages. To introduce the project and request port participation, an initial postcard was first mailed to the highest-level executive at each port who is directly responsible for container port strategy and operations. These port officials most frequently held the titles of "Executive Director," "Port Director," "President," and "CEO." Within a week, the survey instrument along with a cover letter and self-addressed, postage-paid return envelope was then mailed to the potential participants. For convenience, participants had the option to respond via mail or the Internet. Follow-up postcards were later mailed to further encourage involvement. Each port was also contacted directly by phone to ensure that the survey was received, assess intended participation, and determine which resource at the port would best be able to respond. In several cases, the highest-level executive did not complete the survey but

authorized a knowledgeable port resource to respond. The authors validated the authority of these resources.

RESEARCH RESULTS

Received survey responses were coded into Microsoft Excel for analysis. At the time of the writing of this paper, thirteen of the seventeen surveyed ports had responded. Two ports declined to participate, citing the strategic and confidential nature of the requested information. The two other non-respondents were still in the process of preparing their responses. In total, the participants represent 76% of both the number and volume of surveyed ports as well as 61% of total North America TEU volume. Given this significance, the research results should at minimum offer a reliable exploration into capacity issues.

Timing of Port Capacity Issues

Survey participants were asked to assess the timing and significance of container capacity shortages at their respective ports based on a 7 point scale, ranging from "strongly disagree" to "strongly agree" with "neither agree nor disagree" representing the midpoint. The responses were standardized and tested for significance from a difference of "neither agree not disagree." The results are displayed in Table 4. Unexpectedly, only two of the items were found to be significant. First, funding for port capacity growth was found to be a perceived important issue. This is most likely a function of both the large amounts of capital required and the difficult of generating funding sources. Specifically, physical port expansion costs can quickly reach multiple billions of dollars given outlays for land, channel dredging, facilities, and equipment, and depending on the governance of the port, this funding can involve government bonds, private investment, and user fees. Such capital may be difficult to raise, especially when investors and constituents may not see benefits for ten or more years.

Table 4: Response to Timing of Capacity Issues

Capacity Timing	t	p-value	# Ports Indicating Agreement	
Capacity shortages this year	-4.00	0.002	2	15.4%
Capacity shortages during peak season	-0.74	0.475	6	46.2%
Capacity shortages worsening in next 5 years	0.77	0.456	8	61.5%
Capacity shortages worsening in next 10 years	0.98	0.347	7	53.8%
Funding an issue	4.20	0.001	8	61.5%

Next, capacity shortages this year was significant but negatively so, indicating that the ports generally disagree with having current capacity shortages. Similarly, perceived shortages during peak season as well as the next five and ten years periods were not found to be significant. This contradicts documented evidence from industry and government studies that predict continually worsening capacity issues. There may be several explanations for this. For one, the ports may be attempting to downplay expectations of capacity problems to minimize customer concerns. As another explanation, the ports may not perceive that their facilities directly have capacity problems though issues may exist with other stakeholders in the system-wide container network. Finally, capacity problems may be isolated at only some ports and are being offset by capacity

surpluses at other ports. To further explore capacity perceptions, the count of the number of ports indicating agreement was calculated (Table 4). While only two ports agree with having capacity shortages this year, approximately half indicate capacity issues in both peak season and future years. Thus, at least some ports do expect capacity problems. This may relate to the stronger volume growth on the West Coast from Asia imports though a geographical breakdown of the responses would unfortunately compromise the confidentiality of the participants.

To evaluate the relative timing and urgency of capacity problems, paired t-tests were run to compare perceptions of capacity shortages now versus those during peak season and in future years. A significant negative (positive) difference would indicate the ports expect their capacity problems to worsen (improve) in peak season, five years, and ten years. Table 5 reveals the results, showing significant negative differences for all. Thus, although ports do not perceive current capacity shortages, they recognize capacity does worsen during peak season and expect similar capacity concerns within five and ten year periods. This does corroborate the industry and government research.

Table 5: Paired t-tests of the Response to Timing of Capacity Issues

Capacity Comparison	t	p-value	Interpretation
Capacity shortages this year Capacity shortages during peak season	-5.01	0.000	*Capacity shortages are worse in peak season*
Capacity shortages this year Capacity shortages worsening in next 5 years	-4.65	0.001	*Capacity shortages will worsen in the next five years*
Capacity shortages this year Capacity shortages worsening in next 10 years	-4.44	0.001	*Capacity shortages will worsen in the next ten years*

Key Capacity Factors

Given the varied stakeholders and influencers of container capacity, survey participants were next asked to evaluate the significance of specific capacity factors affecting their ports. The factors were grouped into categories including port infrastructure, labor, waterways, truck and rail, technology, and government and community. Responses were based on a 7-point scale, ranging from "no significance" to "high significance" with the midpoint indicating "moderate significance." The results were standardized from "no significance," and Table 6 displays the factors sorted within each category by descending significance. All factors were found to be at least minimally significant indicating that the ports find capacity to be a complex and dynamic problem. To further investigate the relative importance of the factors, each was classified based on the degree of significance into three groups labeled as primary, secondary, and tertiary concerns. This basic though effective approach emphasizes the capacity factors of highest perceived anxiety. Table 7 reveals the results in a matrix by category and concern level.

Table 6: Capacity Factor Significance

Category	Capacity Factor	t	p
Port Infrastructure	Terminal space	14.10	0.000
	Gate capacity/congestion	14.03	0.000
	Berth space	12.35	0.000
	Available land	10.19	0.000
	Terminal operator capacity	8.76	0.000
	Port equipment	7.96	0.000
Labor	Longshore cost	14.81	0.000
	Longshore efficiency	13.89	0.000
	Longshore capacity	13.13	0.000
	Other port labor costs	9.44	0.000
	Other port labor efficiency	9.29	0.000
	Other port labor capacity	8.19	0.000
Waterways	Channel depth	9.72	0.000
	Channel width	9.01	0.000
	Channel congestion	7.19	0.000
	Tug and tow	7.19	0.000
	Pilotage	6.91	0.000
	Bridge clearance	4.09	0.001
	Barge, short-sea capacity	4.02	0.001
Truck and Rail	Rail - national capacity	23.45	0.000
	Local road capacity	22.55	0.000
	Truck - local capacity	15.21	0.000
	Truck - long haul capacity	14.70	0.000
	Rail - local capacity	13.39	0.000
	National highway capacity	11.75	0.000
	Rail - on-dock capacity	10.44	0.000
Technology	Container tracking	11.42	0.000
	Scheduling	10.35	0.000
	Gate systems	10.33	0.000
	Data exchange	8.94	0.000
Government and Community	Environmental issues	24.56	0.000
	Local community issues	21.87	0.000
	Federal government issues	18.03	0.000
	Security issues	12.32	0.000
	State government issues	11.22	0.000

The truck and rail category has the most primary concerns, including local road infrastructure as well as rail and truck capacity at both local and national levels. This aligns with current industry press indicating tight rail and truck supply ("Capacity Crunch Continues" 2004; Kulisch 2004) and local port area road congestion (United States Department of Transportation Maritime Administration 2002). Additional external primary concerns include issues driven by federal and local government in addition to environmental interests. Internally, the ports are concerned with

not only longshore labor cost and efficiency but also terminal space and gate capacity congestion.

Table 7: Capacity Factors by Category and Relative Level of Concern

Category	Primary Concerns	Secondary Concerns	Tertiary Concerns
Port Infrastructure	Terminal space Gate capacity/congestion	Available land Berth space	Terminal operator capacity Port equipment
Labor	Longshore cost Longshore efficiency	Longshore capacity Other port labor costs	Other port labor capacity Other port labor efficiency
Waterways		Channel depth	Channel width Channel congestion Pilotage Tug and tow Bridge clearance Barge, short-sea capacity
Truck and Rail	Rail - local capacity Rail - national capacity Truck - local capacity Truck - long haul capacity Local road capacity	Rail - on-dock capacity National highway capacity	
Technology		Scheduling Container tracking Gate systems	Data exchange
Government and Community	Federal government issues Local community issues Environmental issues	Security compliance State government issues	

The most notable takeaway from these primary concern factors is that virtually all are beyond port control. The ports retain influence only on gate capacity and terminal yard space. The remaining factors are controlled by other stakeholders including railroads, dray truckers, labor unions, government, and the local community. Clearly, the ports perceive that the ultimate capacity of their respective container networks is by and large out of their control. Such findings may also help explain why the ports do not identify capacity problems with their own facilities in that they may be more concerned with issues of their operational partners. This further strengthens the need for coordinated planning among stakeholders to enable meaningful capacity growth.

Assessing the capacity factors of secondary but still significant concern, each of the categories has at least one factor listed. As an interesting note, security compliance falls as a moderate rather than primary concern. Security is currently a high profile industry topic, but the ports do not appear to be highly anxious with the capacity impact of security compliance. Available land and berth space are also listed as secondary concerns. This may be driven by the fact that many

larger ports have little if no room left to develop on-site facilities. As another significant secondary factor, channel depth concerns result from the constantly increasing vessel sizes, and ports may lose ocean carrier vessel calls without providing deeper draft requirements. Few ports have naturally deep channels to accommodate these ships so many are in the process of or planning to drive costly, long-term dredging projects. Finally, three of four technology factors were found to be secondary concerns. With limited expansion space, many ports are apparently targeting technology improvements in scheduling, container tracking, and gate systems to improve productivity without expansion.

Lastly, the tertiary concerns are dominated by the remaining waterway factors. Most ports do not appear to be highly concerned with channel width and congestion, bridge clearance, pilotage, tug and tow, and short-sea and barge feeders. Other tertiary concerns include terminal operator capacity, port equipment, port labor, and data exchange with operational partners. Many of these factors are relatively controllable by the ports, reinforcing the premise that they have greater apprehension regarding capacity impacts by other stakeholders.

Capacity Expansion Planning

Given capacity factor concerns both within and beyond direct port control, the survey next sought to identify the controllable factors on which ports will be focusing future capacity planning. Port capacity can be expanded several ways. For one, a port can enlarge facilities by adding berth space, dredging channels, increasing existing terminal space, and adding additional terminals. Many ports do not have sufficient land available, however, and the time and capital required for such projects are extensive. Furthermore, there have even been instances of local communities protesting and successfully limiting physical port expansion ("Charleston Eyes Smaller Container Terminal Plan" 2000; Bartelme 2003; Machalaba 2004). A more likely source of port capacity growth is to improve productivity of current facilities by enhancing efficiency of technology, labor, and terminals as well as expanding gate hours to reduce drayage congestion. As a final source of expansion, ports can develop off-site facilities, allowing them to rail or barge containers in mass to alleviate dockside bottlenecks. The Port of Virginia offers one such example, establishing a facility 220 miles inland with full rail, truck, and customs services.

To explore expected capacity expansion planning, survey participants were next asked to consider how they would expand in the next five to ten years. Once again, a 7-point scale was used, ranging from “no expansion” to “significant expansion” with a midpoint of “moderate expansion.” Table 8 displays the results standardized from “no expansion” and sorted in descending order by significance. While all expansion sources are significant, the productivity sources are stronger than the other factors. Facility expansion factors, including adding terminals, terminal space, and berths ranked next in significance. Inland port facilities and short-sea shipping retained the lowest significance results. So, the ports are apparently concentrating primarily on internal efficiency to support volume growth. This may be a direct consequence of the aforementioned funding concerns.

Table 8: Sources of Expansion Planning

Category	Expansion Planning Focus	t	p-value
Producitivity	Increase efficiency via technology	26.89	0.000
Producitivity	Increase labor efficiency	17.53	0.000
Producitivity	Increase terminal efficiency	17.17	0.000
Producitivity	Increase gate hours	15.72	0.000
Expansion	Increase berth space	13.63	0.000
Expansion	Add terminals	10.37	0.000
Expansion	Increase channel depth	10.17	0.000
Inland Ports	Expand short-sea, barge feeders	7.70	0.000
Inland Ports	Expand Inland ports	7.41	0.000

Mixed support exists for the potential of port efficiency improvements, however. Several recent analyses indicate that the efficiency of North American ports lags behind that of European and Asia (National Chamber Foundation of the U.S. Chamber of Commerce 2003; 2004), and historically, longshore labor unions have often impeded technology upgrades that threaten to compromise jobs (Schwarz-Miller and Talley 2002). Thus, significant opportunities for efficiency gains apparently exist, but the labor unions may hold the key to the ultimate impact of such improvements. Even if the ports make large efficiency advances, such capacity improvements still will not address the ports' primary capacity concerns, which were shown earlier to lie with other stakeholders. While the ports may improve their technology, labor, and facilities within the next decade, these improvements may not be able to make a considerable impact on overall system-wide capacity since other stakeholders must support expansion to resolve the primary concerns.

Conclusions and Future Research

The North American marine container network faces significant capacity challenges to meet surging volume growth. With many independent yet inter-related stakeholders, the maximum capacity of the network is defined by its weakest link and will not expand without coordinated capacity enhancements across all stakeholders. Container capacity issues have already disrupted supply chain flows this year. As volumes increase without a comparable capacity build, such disruptions will become more severe and may cause the container network to, in turn, become the weakest link in global supply chains.

Given this importance, the research presented here sought to provide an exploratory work to assess capacity concerns from the viewpoint of the ports. There are several key findings from this research. For one, at least half or more of the respondents perceive some degree of worsening capacity issues at their ports within the next five to ten years. This supports both conclusions from government and industry as well as anecdotal evidence found in trade journals. Second, more than thirty capacity factors are significant to some degree with many of these concerns out of port control. This indicates that all stakeholders must identify their control points and synchronize capacity planning efforts. Finally, this research finds that ports are primarily focusing on increasing their capacity by enhancing productivity of existing facilities, labor, and technology more so than on physical expansion.

While these results are extremely compelling, this research retains several limitations. First, the findings represent only one stakeholder, the ports, and the collected data is perception and opinion rather than fact. Thus, the inferences discussed here may present a biased view of the container industry. Furthermore, although the collected information represents a significant portion of North American container volumes, the sample size is still small. So, arguments could be made against the validity of the findings, and input collected from additional major ports could sway the research results. Despite these limitations, the findings presented here at least establish a reasonable basis for container capacity concerns and strongly suggest a need for additional research.

Network container capacity is clearly a multi-faceted, complex challenge. Likewise, researchers can pursue many diverse and rich research streams. In general, any research that helps identify container capacity problems and promotes cross-functional resolution planning would prove extremely valuable to the industry. As one example, researchers could survey other key stakeholders, including terminal operators, labor unions, railroads, truck carriers, ocean carriers, intermediaries, and government to assess their views of capacity issues and contrast these findings to the port perceptions. Such investigation could be performed by concentrating on individual stakeholder sectors or by utilizing case study methodology to focus on multiple stakeholders involved at one or a few ports. Another research area could include assessment of smaller but growing ports to measure how they may fill critical capacity gaps. Researchers could also supplement all results with actual capacity data to better verify the causes, timing, and location of future capacity problems. Finally, researchers can target studies to validate specific capacity factors and investigate potential solution strategies.

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