SUSTAINABLE CONTAINER TERMINAL OPERATIONS: CHALLENGES AND ENHANCEMENTS

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ABSTRACT

Maritime transportation has the largest share of all other transportation modes with its cost effectiveness. Regarding growth in container traffic, ports business has grown into a much more challenging environment. One of the biggest issues to rise in port business in twenty-first century has been 'sustainability'. Due to harsh competition in port business, it is not easy to talk about triple bottom line in efficient and sustainable port operations. Most of the upgrades in container terminals are technology dependent. While this is pushing the financial limits, adding environmental, social, efficient and productive measures into the equation opens up multidisciplinary research field of study. Researchers embraced performance measuring techniques extensively in earlier studies. It is not so easy to find a study on enhancing performance sustainability. There are commonly known temporary techniques for productivity increase in port business but during the literature reviews around sustainable operations of seaport – supply chain integration, there came across no studies explaining all aspects of the subject. This study aims to clarify the path to sustainable advancements and challenges in efficient and sustainable container terminal operations.

Keywords: Container Terminal, Terminal Operations, Terminal Performance, Sustainability, Performance Enhancement.

ÖZET

Deniz nakliyesi, maliyet etkinliği ile tüm diğer ulaşım modları arasında en büyük paya sahiptir. Konteyner trafiğindeki büyümeye ile beraber limancılık işi de çok daha zorlayıcı bir hale bürünmüştür. Yirmi birinci yüzyılda limancılık işletmelerinde gözlenen en büyük sorunlardan biri 'sürdürülebilirlik' olmuştur. Limancılık işindeki yoğun rekabetçi ortam nedeniyle etkin ve sürdürülebilir limanlardan bahsetmek pek de kolay olmamaktadır. Konteyner terminallerindeki gelişmelerin çoğu teknolojiye bağımlıdır. Bu durum finansal sınırları zorlarken, denklemin içine,

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çevresel, sosyal, etkin ve verimli tedbirlerin eklenmesi çalışmanın çok disiplinli araştırmalar alanına açılmasını sağlamaktadır. Araştırmacılar önceki çalışmalarda performans ölçüm tekniklerini yaygın bir şekilde işlemişlerdir. Performansın sürdürülebilir bir şekilde artırılması hakkında bir çalışma bulmak o kadar kolay değildir. Limancılık işinde verimliliğin arttırılması için kullanılan kısa süreli yöntemlerin olduğu bilinmektedir, ancak liman - tedarik zinciri entegrasyonu alanı ile ilgili yapılan literatür araştırmalar sırasında konuyu tam anlamı ile kapsayan bir çalışmaya rastlanamamıştır. Bu çalışma, etkin ve sürdürülebilir konteyner terminal operasyonlarına giden sürdürülebilir gelişmelere giden yolu aydınlatmayı amaçlamaktadır.
Anahtar Kelimeler: Konteyner Terminali, Terminal Operasyonları, Terminal Performansı, Sürdürülebilirlik, Performans Geliştirme

The concept of sustainability for the first time in 1982, described by the International Union for Conversation of Nature (IUCN) in World Charter for Nature as “mankind is a part of nature and life depends on the uninterrupted functioning of natural systems” (The History of Sustainable Development in the United Nations, n.d.). The concept of sustainability today as we use have been mentioned as the term “sustainable development” rose to significance after it was used by the Brundtland Commission in its 1987 report Our Common Future. In the report, the commission coined what has become the most often-quoted definition of sustainable development: “development that meets the needs of the present without compromising the ability of future generations to meet their own needs (Sustainable Development, n.d.).

In the root of welfare increase of nations, productivity and efficiency play a major role. Especially in recent years in all developed and developing countries, as well as nationally at the company level, sustainable performance growth is emerging as an important goal. With the increase in business’ productivity and efficiency, the national income and gross national product revenue is increasing rapidly. This along brings an increase in disposable income and standard of living. Today, it wouldn’t be wrong to say that efficiency and productivity are the actual resources of real economic development, social progress and rise in standards of living (Prokopenko, 1987, Usta, 1991, Gurak, 2003).

Ensuring the level of efficiency and productivity at the enterprise level will not only raise prosperity of the country but will also increase the competitiveness of products of that enterprise. If the same goods – producing enterprises compared, the decline in the performance would lead to a decline in the competitive power. Together with the drop in performance cost per unit will rise as well. Directly reflecting the increase in production costs

to the prices would cause the customers to look for the enterprises that provide goods or services more cheaply. Not reflecting the high costs to the prices would cause in fall in profits.

There is a strong relationship between transport infrastructure and economic development for countries. Ports, in addition to services such like loading / unloading, towing and storage are in close relationship with shippers, exporters, importers, logistics corporations, state authorities, banks, insurance companies and many more corporations. With such legal / commercial transferring and coordinating features, seaports are making significant contributions to the national economy.

Seaports also have very important contributions to competitiveness of the national economies. Cullinane and Song (2002) and Sanchez et al (2003) stated that seaports are a critical link in supply chain, highlighting the level of performance and productivity of the ports is very important at a rate that emphasizes affect the competitiveness of countries. Development of low-performance levels in seaports, low cargo handling costs, obtaining the presence of integrated port services and other elements of a global distribution network is considered as highly important nowadays. With the globalization of national economies, demand is rapidly increasing transport between continents. This condition states that port services are considered in terms of economic superiority (Anderson et. al., 2008)

Ports investments are expensive, risky and long term investments. Instead of improving physical capacity, ports should quest for efficient and productive operations with existing resources. Taken as a whole, seaport efficiency and productivity have so many parameters from organizational structure to port infrastructure, equipment to freight throughput. As being the hub of many transportation modes, seaport productivity and efficiency improvement studies are much more difficult and complex than many other sectors because seaport is not in product but rather in industrial services business.

Methodology

"Sustainable container terminal operations" is a challenging subject to be covered with all its aspects. Although there are studies in the literature about sustainability, port operations, efficiency and productivity in different fields of study, it is hard to find a resource revealing it all together. This study originates with a comprehensive multidisciplinary literature review in port performance. The study continues with a series of interviews investigating areas to look for in sustainable operations both in Turkey. Following, a questionnaire have been in light of the interviews and applied to port managers in Turkey. For an extensive research on enhancing sustainable container operations in container ports, a thorough literature review has been completed followed by port visits and interviews in the USA.

Factors Effecting Sustainable Container Terminal Operations

Besides quantitative operational performance analysis in container terminals, there are many non-computational performance indexes enforcing the operations in seaports. These are not highly mentioned in port literature but immensely important in terms of sustainability in port operations. As it is hard to observe and detect such constraints, a series of predetermined interviews and following questionnaire have been pursued with 14 port managers from major seaports in Turkey. Interview sample list is as shown in Table 1.

Table 1. Sample of Port Managers Interviewed in Turkey

Port Name	Contact	Duty	Date
Evyap	Ali Keskin	Operations Manager	29.06.2012
Yılport	Fahris Tunç	Operations Manager	29.06.2012
Mardaş	Gökhan Bekircan	Port Manager	28.06.2012
Marport	Sait Fazıl Kar	Operations Manager	28.06.2012
Roda Port	Y. Ahmet Yavuz	Deputy Man. Dir.	27.06.2012
Borusan	Arzu Çevik	Business Dev. Man.	27.06.2012
Gemport	Özgür Tangut	Operations Manager	27.06.2012
Kumport	Cenk Kabacaoğlu	Port Director	28.06.2012
Kroman	Cengiz Ergüsel	Port Manager	29.06.2012
Poliport	Erdoğan Akdeniz	Operations Manager	29.06.2012
Solventaş	Mustafa K.Selçuk	Port Manager	29.06.2012
Izmir Als.	Confidential	Confidential	06.07.2012
Nemport	Confidential	Confidential	09.07.2012
Limaş	Oğuz Tümiş	Port Manager	11.07.2012

The questionnaire, derived from the results of interviews, is assembled around 18 questions evaluated with a Likert scale of 5. These 18 questions are e-mailed back at the same managers and the results of answers are presented in Table 2.

Table 2. Questionnaire Statements and Results

	STATEMENTS	Med.	Std.Dev
1	Simultaneous operation of multiple cranes on the same vessel reduces the number of moves per crane hour.	4,14	0,77
2	Existence of pre-gate cargo areas improves affects port activities.	4,71	0,61
3	Existence of parking lot for trucks improves port activities.	4,86	0,36
4	High % freight alongside ship cargo adversely affects capacity.	4,36	0,63
5	Lack of logistics facilities supporting the port may adversely affect port operations	4,29	0,91
6	EDI Systems increase operational efficiency in port operations.	4,93	0,26
7	Insufficient no. of working tug boats decreases port capacity	4,73	0,59

8	There is a difference between shifts in realized handling capacity.	4,79	0,43
9	Customs procedures adversely affect port ops.	4,67	0,49
10	Traffic congestion in port exit negatively affects operations.	4,87	0,35
11	Busy gate operations negatively affect port operations	4,80	0,41
12	Inadequate lighting affects the harbor port efficiency negatively.	4,33	0,82
13	Operational organizational structure affects the port efficiency.	4,80	0,41
14	Decision-making process in management affects port activities.	4,80	0,41
15	Negative physical aspects of yard adversely affect efficiency.	5,00	0,00
16	Inadequate training of workforce adversely affects port operations	4,40	0,65
17	Missing incoming information from agencies negatively affect port efficiency.	4,93	0,26
18	Vessel-sourced delay negatively affects the port capacity.	3,53	0,85

There are many internal and external factors affecting port operations. Some of the external factors can be seen, but not limited to, in Table 2. There are other external factors already been detected earlier than this study. The results of interviews and literature review on internal and external factors affecting port operations are aggregated in Table 3.

Table 3. Factors Effecting Sustainable Container Terminal Operations

Internal Factors	**External Factors**
• Equipment Choice and Investments • Infrastructure Investments • Port Gate Logistics • Port Traffic • Operator Skills • Scheduling • Equipment and Operator • Allocation • Port Automation and IT Level • Port Lighting Deficiency • Crane Conflict • Load Acceptance and Delivery Area • Truck Parking Areas • Organizational Structure • Ship Handling Time • Additional Time Permits • Storage Area • Costs	• Customs Regulations • Insufficient Data from Ship • Agents • Tugboat Amount • Freight Alongside Ship • Intermodality Investments • Road Traffic Outside of Ports • Load / Unload Amount Per • Vessel • Seasonality (Peak Factor) • Ship Interarrival Distribution • Dwell Time • Geographical Location

It is possible for port operators to control internal factors but external factors are somewhat unalterable. Both internal and external factors are affecting container terminal operations. All these stand as a challenge towards sustainability and as the terminal is a system forming out of many parts, none is more or less important than the other.

Performance Enhancements in Container Ports

There are thousands of studies about port performance and thousands of studies about sustainability. But it is fairly hard to find sustainable port performance enhancement studies in the literature. In quest of sustainable port performance enhancement studies hundreds of publications have been viewed and 57 of them have been chosen for primary research resources as shown in Appendix 1. The studies on the subject are not limited to these 57 but a new researcher would not do wrong to start reviewing these publications first. Following a thorough literature review on performance enhancements in container ports, six container ports are visited in USA and interviews are conducted with various personnel. Name of ports visited in USA are as seen in Table 4.

Ports Interviewed
Port of Miami
Port of Savannah
Port of New York / New Jersey
Port of Seattle
Port of Charleston
Port of Tampa

There are three main sections in container seaports suitable for efficiency and productivity advancements. Insignificantly, these are Quay Side, Yard and Supply Chain Integration zones like gates and railroads. According to studies conducted, these are the main areas creating challenges in sustainable container terminal operations. Advancements in these zones would make the greatest effect in efficiency and productivity increase in container seaports.

In this respect, increasing efficiency and productivity in these sections has some sort of similarities. One major similarity is that all sections in seaports have two main ways of performance increase, technology based and operational based as seen in Figure 1.

Enhancing performance in terminals, without any question, requires multidisciplinary studies between technological fields like computer and communication sciences, operations research and operations management. Neither field solely would have a marginal benefit on seaport performance.

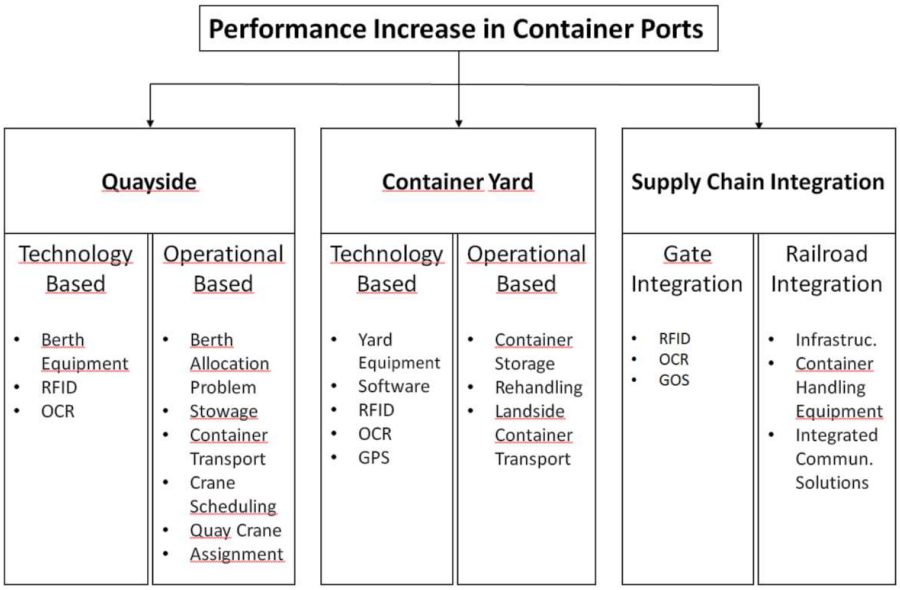

Figure 1. Performance Increase in Container Ports

Discussion and Results

With the increase in global maritime transportation, sustainable terminal operations gain importance. Yet this concept solidified its position in literature, container terminal industry needs researchers working on up to date studies to enhance the knowledge base both for operational and technological developments.

Technology developers have advanced a long way in container terminal equipment. As shown in figure 1. These technologies operate on every part of a terminal and most importantly they are creating an integrated solution to port operational difficulties. Figure 1 also shows the fields of studies mostly operational research enthusiasts would be interested in. There are many optimization algorithms existing in the literature for seaports. At first sight these may look enough but with developing technology the need of new researches would be obvious. Figure 1 mostly gives an overall insight about research fields for interested academics. Still, there is couple of important subjects to be mentioned.

Cloud computing is one of the main issues to be discussed. Cloud based computers are in use years now but the advanced cloud architecture supporting large – scale parallel computing power is a fairly new concept. Such a powerful processor infrastructure can run enormous amounts of algorithms with big-data infrastructure and may come up with ideas that would take days, weeks, months and even years with a single computer. With appropriately designed cloud architecture, a complex system can be resolved much faster than a simple computer because cloud can turn on hundreds of

computers upon an automatic request and turn them off when the job is done. As an example, if a stand-alone computer can solve a very complex allocation algorithm in 30 minutes, theoretically the power of 30 computers processors (turned on in cloud upon request) might solve it in 1 minute. Since the terminal will not be processing so much data for 24 hours, costs will be very low in contrast to owning such a strong server.

Cloud technology also opens up new horizons for decision support systems in container terminals. Since cloud could also and most commonly used for data storage and sharing, it is quite possible to share and store logistics data of inter terminal operations and third party logistic information in cloud. This data could also be processed in cloud environment and by automatically turning on and off processors important decision support information may be produced in seconds with very low costs.

Thinking about large container terminals with numerous berths, yard, types of containers, equipment and all that decisions to be made every minute, it is quite impossible to assume that optimization priorities would be stayed faithful. As no algorithm or system is perfect, every decision should go through a manager and every manager needs information to support their decision making process. Recent technology listed in figure 1 and cloud computing architecture provides opportunities for real time decision support systems. A real time decision support system would probably become the most collective technological development in container terminals as well as a very big leap in technological developments. This might even open up for doors to studies on artificial intelligence in logistics.

A recent technology that terminal operators can benefit greatly is Discrete Event Simulations (DES). DES is simply a computer program that models the operation of a system as a discrete sequence of events in time (Robinson, 2004). Once the system is formed, it mainly stays as is and created jobs can be simulated fast in time. A container terminal is not so hard to simulate with today's technology and once the terminal is simulated as a complete system, terminal operators can even use the simulation for their incoming jobs. They can test their approaches and choose an optimum scenario for future scheduling in every aspect of their operations.

Today, container ports in USA are investing in yard, gate and quay equipment that is integrated with up-to-date IT technology. But according to face to face interviews, technological developments alone are not enough for sustainability in container terminal business. Ports are international gateways and most importantly they need connectivity for competitive superiority.

Majorly every idea that has been discussed through this study can be related to connectivity. From railroads and gate technologies to approach channel depth and even customs regulations have influence on connectivity of seaports. Every possible problem stated in table 2 and research area in figure 1 is an important field of study in terms of sustainable container ter-

minal operations. These subjects shouldn't appear to a researcher as problems but effective areas to work on for increasing performance and enhancing sustainability in container terminal operations.

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Appendix 1. Literature on Sustainable Performance Enhancements in Container Ports

Name of Publication	Author(s)	Year
Decision Support System for Container Terminal Planning	K.M. Van HEE, R.J. Wijbrands	1988
The Crane Scheduling Problem	Carlos F. Daganzo	1989
Efficient Planning of Berth Allocation for Container Terminals in Asia	Akio Imai, Ken 'Ichiro Nagaiwa, Chan Weng Tat	1997
Mega Ports and Load Centers of the Future With The Port of Houston as the Baseline Port	Arthur P. James, John P. Basilotto, Heather Harbottle	1997
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