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A Simulation for Optimum Terminal Truck Number in a Turkish Port Based on Lean and Green Concept*

Soner ESMER**, İsmail Bilge ÇETİN***, Okan TUNA****

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Abstract

Ports, from the simple physical sea/land interface they once used to be, have successively turned into commerce and industrial centers, then into logistics and distribution platforms, and are now becoming intermodal nodes in international supply chain networks, the efficiency of which now drives trade competitiveness.

With her distinguished location, logistics infrastructure and well qualified manpower, Turkey has the potential of being a hub country in her region.

However, in order to achieve this potential, Turkish ports have to consider both lean and green approaches in their business strategies. Lean system design is the most important initial step for cargo handling operation in order to reach green operation.

At this point, the study has aimed to analyze a Turkish container terminal both in terms of lean and green dimensions. Due to the constraints of data, however, the study has only focused on the cargo handling operations. A simulation model has been used to determine the optimum number of container handling equipment to increase the lean capabilities of a Turkish port. Besides, the environmental damage caused by handling equipment in cargo handling operations has been discussed through the study, and the optimal number of equipment minimizing the environment damage has been reached.

Key words: Green port, Lean port, Supply chain, Simulation, Turkish ports.

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I. Introduction

Ports are of critical importance to the logisticians as the nodal points in terms of connecting sea with surface transport modes.\(^1\) The port services may be regarded as a chain of interlinking functions, while port as a whole is in turn a link in the overall logistics chain.\(^2\) Ports, from the simple physical sea/land interface they once used to be, have successively turned into commerce and industrial centers, then into logistics and distribution platforms (third generation ports), and are now becoming intermodal nodes in international supply chains networks, the efficiency of which now drives trade competitiveness.\(^3\) Marlow and Casaca supported this fact with the agility concept and described the ports as transport solution providers (fourth generation ports).\(^4\) Ports are expected to be not just a transferring point between different modes but an integrated logistics center in the seamless transport chain.\(^5\) Hence, supply chain orientation is necessary for the facilitation of the port and terminal functions required for servicing the needs and demands of the users and for achieving port competitiveness.\(^6\) Although the ports are considered as the nodal points within the supply chains, they have also their internal supply chains producing value-adding functions.

Receiving of the goods, giving value-adding functions such as container freight station (CFS) services, product mixing, postponement, cross-docking, consolidation-deconsolidation of the cargoes and delivering of the goods can be regarded as the processes of the internal supply chains of ports.

On the other hand, increasing sustainable logistics initiatives are becoming another challenging issue for the ports. Although in-port emissions make up a small percentage of the overall emissions from shipping, ports attract shipping traffic and inevitably constitute sources (points) of concentrated ship exhaust emissions.\(^7\) Hence, green approaches are required by both legislations

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\(^1\) Tuna (2002).
\(^3\) World Bank(2002).
\(^4\) Marlow and Casaca(2003)
\(^5\) Inoue(2002)
\(^6\) Tongzon et.al( 2009)
\(^7\) Tzannatos(2010)
A Simulation for Optimum Terminal Truck Number in a Turkish Port Based on Lean and Green Concept

(international/national) and customers for the sake of lower greenhouse gas emissions.

Considering the new role of ports within the framework of supply chain concept, changing expectations of shippers in terms of customer service and costs, and challenging sustainable logistics initiatives, ports need to apply lean and green strategies.

Applying lean and green strategies are inevitable for the Turkish ports. As far as the Turkey’s land-bridge position in global supply chains is considered, ports have the vital importance on the efficiency of logistics activities of Turkey. Although Turkey has a strategic position in terms of logistics and shipping, Turkish ports have insufficient capacity in terms of infrastructure, superstructure, equipment etc. for transit cargoes, so they hardly compete with the international competitors. This paper attempts to approach this problem by considering two challenging dimensions namely lean and green initiatives for a Turkish container terminal located in Marmara Region.

For this reason, the purpose of the study is to analyze a Turkish container terminal both in terms of lean and green dimensions. Even though a conceptual model has been developed both covering the lean dimension and green dimension within the framework of ports, due to the constraints of data, the study has only focused on the cargo handling operations. Through the study, the environmental damage caused by handling equipment in cargo handling operations has been discussed and a simulation model has been used to determine the optimum number of container handling equipment to increase the lean capabilities of the container port.

II. Lean and Green Approaches in Ports

Taiichi Ohno defined seven common forms of waste, activities that add cost but no value: production of goods not yet ordered; waiting; rectification of mistakes; excess processing; excess movement; excess transport; and excess stock. Lean supply chain strategies focus on waste reduction,
helping firms eliminate non-value adding activities.\textsuperscript{10} Such strategies enable firms to improve quality, reduce costs, and improve service to customers as traditional batch and queue mass production and supply chain approaches are transformed.\textsuperscript{11} Lean approaches can be categorized as “push-pull”, “postponement”, “six sigma”, and “JIT” in various studies.\textsuperscript{12} Lean practices are becoming increasingly difficult to implement and sustain as supply chains increase in complexity and length.

As already mentioned, ports turned into transport solution providers and agile logistics applications are the focal point of the effectiveness and efficiency of the ports. It is inevitable for ports to apply lean approaches to become more agile in the transport chain. By using lean production theory, a whole range of benefits such as reduced customer lead-times, steady or reducing prices, increased market share, reduced time to launch new services, increased service diversity, productivity and profit can all be achieved.\textsuperscript{13}

Because of the widespread acceptance of lean supply chain practices and the growing pressure for environmental management, firms have started to incorporate environmentally friendly practices into their waste reduction schema.\textsuperscript{14}

A lean port is a business unit, which makes effective use of its available resources (tangible and intangible assets and capabilities) and, by eliminating all port wastes along the physical and informational flows of the processes, achieves superior customer service in the provision of transport solutions.\textsuperscript{15}

Needless to say, streamlining flows is seen as crucial step towards making ports both more effective and efficient. Hence, the implementation of agility in ports supports itself on the concepts of lean, flexibility, just-in-time and business process redesign. The challenge for a lean port is to move cargo quickly and smoothly delivering a service in alignment with market demand while eliminating waste within the processes.\textsuperscript{16}

\textsuperscript{10} Corbett and Klassen (2006)
\textsuperscript{11} Larson and Greenwood (2004)
\textsuperscript{12} Mollenkopf et al. (2010)
\textsuperscript{13} Paixao and Marlow (2003)
\textsuperscript{14} Mollenkopf et al. (2010)
\textsuperscript{15} Paixao and Marlow (2003).
\textsuperscript{16} Marlow and Casaca (2003)
Green supply chain strategies refer to efforts to minimize the negative impact of firms and their supply chains on the natural environment. In the wake of concerns regarding climate change, pollution, and non-renewable resource constraints, firms are heeding stakeholder demands regarding corporate citizenship behavior and performance.\(^{17,18}\) Creating a green culture often involves reinforcing behavior that people already want to adopt, but there is still a need for the appropriate tools and training in order to change.\(^{19}\)

A green supply chain focus requires working with suppliers and customers, analysis of internal operations and processes, environmental considerations in the product development process, and extended stewardship across products’ life-cycles.\(^{20,21}\)

Logistics and supply chain managers have to balance efforts to reduce costs and innovate while maintaining good environmental (ecological) performance.\(^{22}\) Green supply chain management has emerged as an approach to balance these competitive requirements.\(^{23}\)

Ships with huge engines running on bunker fuel without emission controls, thousands of diesel trucks per day, diesel locomotives, and other polluting equipment and activities at modern seaports cause an array of environmental impacts that can seriously affect local communities and marine and land-based ecosystems throughout a region.\(^{24}\) The major air pollutants related to port activities that can affect human health include diesel exhaust, particulate matter (PM), volatile organic compounds (VOCs), nitrogen oxides (NOx), ozone, and sulfur oxides (SOx). Other air pollutants from port operations, such as carbon monoxide (CO), formaldehyde, heavy metals, dioxins, and pesticides used to fumigate produce, can also be a problem.\(^{25}\)

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\(^{17}\) Sarkis(2001)  
\(^{18}\) deBurgos Jiménez and Ce’pedes Lorente(2001)  
\(^{19}\) Olson (2008)  
\(^{20}\) Corbett and Klassen(2006)  
\(^{21}\) Mollenkopf(2006)  
\(^{22}\) Pagell et al.(2004)  
\(^{23}\) Narasimhan and Carter(1998)  
\(^{24}\) Bailey and Solomon(2004)  
III. Methodology

This part of the study attempts to analyze a leading Turkish container terminal located in Marmara region considering the lean and green approaches.

• Model of the Study

Paixao and Marlow proposed two major stages for the port integration (See Table 1). The first stage, embracing three phases, aims at putting ports to work in a just-in-time (JIT) environment to support lean production theory; whereas the second stage (embracing two phases) aims at implementing lean and agile theories in ports.26 First dimension of our model is based on the integral integration where effectiveness of the container terminal has been analyzed.

(Table 1) Stages and Phases of Port Integration

<table>
<thead>
<tr>
<th>Stages of integration</th>
<th>Phases of integration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Internal integration</td>
<td>1. Identification of the port’s current and redesign</td>
</tr>
<tr>
<td></td>
<td>of future processes</td>
</tr>
<tr>
<td></td>
<td>2. JIT preparation phase</td>
</tr>
<tr>
<td></td>
<td>3. The running of JIT operations phase</td>
</tr>
<tr>
<td>External Integration</td>
<td>4. The lean phase</td>
</tr>
<tr>
<td></td>
<td>5. The agile phase</td>
</tr>
</tbody>
</table>

Source: Paixao and Marlow, 2003

On the other hand, second variable of our model namely green dimension is based on three components; vessel operations, services given in marine facilities, and cargo handling operations at the terminal area.
However, we only focused cargo handling operations in this study. Needless to say, to reach sustainable environment and minimize the damage made on the environment, ports have to minimize the activities polluting the atmosphere. Equipments used at container terminals are mostly operated by electric power. On the other hand, MTT’s which are used for inland cargo movement, especially between apron and storage areas in container terminal are generally motor vehicles. For this reason, reaching the optimal number of MTT in container operations is a basic point to minimize the damage on the environment.

**• Description of the Port**

The pilot model of this research has been developed on the basis of the data gathered from a Turkey based modern container port. The two factors that encourage the choice in favor of this particular port are as follows:

• The design of the terminal and the equipment being used there are quality as those available at the worldwide modern container terminals through which customer satisfaction and cost opportunity can be reached.
Due to its critical location in terms of transshipment traffic for the Black Sea countries as well as the regional (Marmara Region) cargoes, the terminal is of great importance within both supply logistics and physical distribution.

Some further detailed specifications of the terminal chosen are as follows:
- It is the second largest terminal in Turkey in terms of having the capacity of handling the highest number of containers (1.5 million TEU/year),
- The SSG handling speed it can achieve in terminal operation is the best extend in Turkey,
- It’s one of the deepest container terminal in Turkey with a depth of 14.5 m.

The terminal, chosen for the above mentioned specifications, is different from the other container terminal located within the Marmara Region in terms of various aspects. The foremost difference is regarding the operations in particularly. It is the first time in Turkey that a container terminal has been established through working on the infrastructure of the port. Not only is the infrastructure but also the superstructure the equipments in hand are directly intended for container handling. The terminal uses RTG handling system.

The container terminal chosen is not only the port of call of the vessels providing intercontinental services but it is also a port convenient for transshipment activities. It has been well known for years that one of the shipping related problems of Turkey is that her share in transshipment traffic has been very little. Out of 1.2 million TEU transit TEU handled in 2008, a considerable amount of 732,000 TEU was handled by the container terminal chosen as a case for this research. This figure corresponds to 61% of the total transit cargoes handled in Turkey. The number of containers handled at the mentioned terminal in 2008 is 1,252,936 TEU, which had been the highest number handled by one terminal in Turkey.

The only access to the hinterland is through highways. Despite this particular disadvantage, the port mentioned has managed to have gained a very important acceleration, becoming in a very short time one of the most important and most modernized container terminal in Turkey. Besides, the terminal chosen is located in Istanbul and quite close to İzmit city, both of which are the entrance to the Black Sea, is quite suitable for the biggest
vessel sailing through the basic trade routes to choose the terminal as a transshipment point for their Black Sea cargoes. All in all, the terminal is of a great importance for the Marmara Region, the most important industry-involved region of Turkey, for it is chosen by mother ships as a port of call.

In the terminal chosen, sub-contractors provide container freight station (CFS) services. These services including yard cargo stuffing/unstuffing, customs inspection and sampling, and a full range of other services as needed. The terminal’s CFS has 4 main sections: warehouse and LCL (less than container load cargo) cargo, export and import containers, hazardous cargo and a covered area for weather-sensitive cargo. The terminals also provide warehousing and storage service for LCL cargo in 2,256 m² warehouse area.

**Simulation Method for Port Operations**

Simulation is most often used method of the decision support system.\(^{27)}\) Simulation is a scientific instrument used in investigating analyzing the complex issue. By means of the simulation, the best alternative solutions to the problems of the modeled system can be chosen.\(^{28)}\)

A simulation is preferred in port operation issues, particularly in analyzing the terminal data and optimizing the investment in port equipments.\(^{29)}\)

Simulating port processes can be utilized to reach such diverse objectives as port designing, port planning, increasing the port capacity and efficiency.

In the analyses and planning of port operations, simulation models are widely preferred.\(^{30)}\) It has now definitely been proved that simulation models are highly practicable and reliable decision support instruments for the decision makers at ports.

An overall literature review reveals that most of the relevant researchers so far carried out are mainly about container terminal operating issue. The fact that container terminal operations are more complex than are the other cargo operation seems to have increased the interest in using simulation method with the former. The literature review also reveals some common points of

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\(^{27)}\) Turban and Aronson(1998)

\(^{28)}\) Hassan et al(1993)

\(^{29)}\) Hayuth(1996)

\(^{30)}\) Dragovic et. al.(2005)
assessment with regard to container terminal simulation models. Some of these main points are that models support the decisions made by the port managers and that they evaluate diverse operation alternatives and also that they provide the port managers with a flexible device needed to access the most appropriate solutions.  

**Modeling Approach**

The method used in this research is simulation and for modeling, ARENA 12.0 simulation software has been used. The simulations models developed theoretically comprise such processes as cargo handling, intra port transportation and warehousing following the completion of the ship’s berthing activities. Therefore, the inputs of the model are the cargoes (container) discharged, the infrastructures such as the berth used and the stowage area and the equipments used for such activities as loading, discharging, transporting (moving) and stowing. The cargoes handled at ports are exposed to three likely logistical processes such as:

- Cargo handling processes comprising either loading the cargoes on board or discharging the cargoes from the ship.
- Intra port movement which means the movement of the cargoes within the port.
- Warehousing and stowing.

The output gained through the model could discussed in the following three categories:

- The data related with the total operation period,
- The date related with the period and utilization regarding the SSG (Ship to Shore Gantry) used for loading and discharging, the terminal tractor used for the transport at the terminal and RTG (Rubber Tired Gantry) used for warehousing/stocking the containers at the warehousing are.
- The data related with determining the bottlenecks to be encountered during such operations as loading, internal transport and warehousing.

Any manager who has analyzed these performance indicators will get able to see under that circumstances and how the logistics activities, related with

31) Esmer et.al.(2008)
the cargo handling within the terminal, internal movement and warehousing will response and reach the process optimization through the assessment of these performances.

The quantitative approach based process was carried out basically within the frame of two simulation models, pilot model and universal model. The basic activities fulfilled with each of these models are briefed as follows:

**Pilot Model** : Designed to get prepared for the universal model; the modeled aspect are physical structure of the port involved the logistics process with in the terminal and the equipments used at the terminal. The samples gathered in compliance with the data collection from developed, were checked through the model and the reliability and validity analyses of the model were carried out. The cargo handling structure the validity and reliability of which have been verified is “crane handling system” used at the leading container terminals in the world. The basic aspects of model are similar to those of all the world terminals except that the information related with the physical infrastructure and the equipment was adapted to the terminal involved in the research.

**Universal Model** : through the pilot project work at the port involved in the research, the validity and the reliability of the model has been verified.

The difference to be noted with the universal model was that the data inputs related with the whole infrastructure and the equipment were made flexible and this becomes adoptable to all the ports in the world. Besides, through the scenarios formed, the container terminal processes were observed and scrutinized.

**The Pilot Model Inputs and Validity-Reliability Analysis**

In the model of the port involved, there are 3 SSG in operation at the berth. The data collected from the port revealed that the container loading/discharging operations of the SSG was held on for about 24 hours. In other words, each movement of gantry crane completed in about 2,5 minutes.
Although the number of RTG available at the port is 18, the number of those active in operation is 16. The remaining 2 RTG are spare and put into operation when needed. According to the operator experiences, the speed rate at which the RTG’s handle the container is about 15 movements per hour. In other words, each RTG completes its circle in around 4 minutes.

The number of the MTT’s (Terminal Tractor) at the terminal is 35. In practice, however, the number of MTT per each SSG is 5. The speed of the MTT’s within the terminal has been limited to be 20 km\h.

As a principle, in practice for 1 SSG, 5 MTT and 2 RTG are appointed. In such a case, therefore, for a ship on which 3 SSG are involved in operation, 15 MTT and 6 RTG are needed.

The simulation models are separately set so that each functions to a full satisfaction. Through the pilot model the validity and reliability tests have been fulfilled using the loading-discharging operations data gained by means of the data collection form. At the experimental research carried out to measure the reliability and validity of the model a real ship operations was used. The flow diagram of the simulation model shown on Figure 2.
The details of the operations are as follows:

- The total number of container movements is 2157 and the number of containers processed is 2031. The difference, 126 movements, stands for the number of the containers lowered to the apron and then loaded on board the ship (63 discharged and 63 loaded).
- Out of 2157 movements, 1725 is discharged, and 432 loaded.
- Three SSG’s were appointed for the ship.

The model got operated 10 times and the total operation period was compared with those displayed in the following Table 2.

<Table 2> Pilot Model Results

<table>
<thead>
<tr>
<th>SSG 1</th>
<th>SSG 2</th>
<th>SSG 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Real</td>
<td>Sim.</td>
<td>Real</td>
</tr>
<tr>
<td>Total operation time (hour)</td>
<td>34,9</td>
<td>34,8</td>
</tr>
<tr>
<td>Total movement (unit)</td>
<td>687</td>
<td>687</td>
</tr>
</tbody>
</table>

In Table 2, the total time of the operation, waiting time and time percentages provided from the statistical figures related with the operation of the each berth crane. The results gained from the model match these data.

The share of errors, deviations, between these two periods is less than 5 %. The container appointments were fulfilled at 100 % match. Through such a pilot study, the validity and reliability of the model have been verified.

- **Experimental Studies (Outputs)**

  In order for the model to get a kind of international dimensions, the validity and reliability of which were analyzed and tested through pilot models, a new model was developed.

  The model, developed to reach a flexible simulation model and on which a series of experiments have been carried out, involved a RTG handling system, a single handling line and 1 SSG along with 2 RTG simultaneously. Besides, on the number of the MTT used a great number of scenarios were tired.

  Furthermore, the model got operated at each experiment 1000 containers were sent to the system.
Table 3 indicates the inputs of the model experiments along with the relevant outputs. The main focus of such experiments was on the analysis of the effect of changes in the number of the MTT and the speed of the SSG.

As can be seen in Table 3 in the models the operation speed of RTG was limited to 15 movement per hour. This implies that at the limited speed, in every 4 minutes the RTG either stowed one container or got ready to load the container stowed to MTT. The reason why in the model the operation speed of the RTG was kept fixed is that the changes within this period have too little effects on the steady run of the system.

As also shown in Table 3, changes in the handling speed of SSG and the number of MTT have effect on the total operation time, RTG utilization, average number of MTT, MTT queue under SSG and average waiting time of MTT which support the lean approaches can be adopted by using such simulation models.

The findings of the experiments indicate that the changes in the handling speed of SSG and the number of MTT used in the internal transport have considerable effect on the performance of the system.
## The Results of the Experimental Study

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of MTT allocated</td>
<td>SSG handling speed (move/min)</td>
</tr>
<tr>
<td>2</td>
<td>2.2</td>
</tr>
<tr>
<td>2</td>
<td>2.3</td>
</tr>
<tr>
<td>2</td>
<td>2.4</td>
</tr>
<tr>
<td>2</td>
<td>2.45</td>
</tr>
<tr>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>4</td>
<td>2.5</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
</tr>
</tbody>
</table>
V. Findings: Lean Dimension

Finding 1: The increase in the number of MTT, following the appointment of 2 MTTs has no effect on the time of the end of the operation period that the speed of SSG is limited with 24 movement per hour. In other words, the increase in the number of MTTs has no effects on the period of operation.

Finding 2: The increase in the number of MTTs has no effect on the rate of efficient use of SSG. SSG is not affected by the changes in the 2-5 numbers of MTT nor is it affected by the changes in the speed of the SSG handling.

Finding 3: The increase in the number of MTTs appointed has effect on the waiting period of the MTTs in the system and also on decreasing effect on the RTG efficiency, which is indicated in Figure 3. As can be seen in figure 3, the optimal number of MTT, when 1 SSG and 2 RTG are used in the operations is 2.

This implies that the increase in the number of MTT has no effects on the time of the operation.

<Figure 3> The effects of the number of the appointed MTT on the RTG and MTT waiting period.
Results of the Model: Lean Dimension

The number off-work days in 2009 at the port involved in this research, due to certain national holidays and certain winds too strong to allow port operations, is 9. During the actual Works day, 256 days corresponding to 8,544 hours, around 600 vessels were serviced at the port mentioned, which in turn corresponds to 14.2 hours of service per vessel (8.544/600). The vessels having called the sample port of this research, however, could not be serviced for about 18.66% of the period during which they waited at the piers because of such unavoidable intervals as shift changes, opening and closing hatch covers, and having meals, etc. As a consequence, the net period of receiving services for each vessel throughout one year turns out to be around 11.6 hours (14.2 – (18.6 X 0.142)).

For each SSG at the involved in this research, 5 MTT where employed throughout one year. This means that throughout the average 11.6 hrs of ship servicing, 5 MTT were kept at work for a total 58 hours (11.6 h X 5 MTT).

This figure corresponds to 34,800 hours for 600 vessels (600X58). In other words, the MTT’s serviced throughout one year for 34,800 hours.

This simulation model conducted has revealed that for the port chosen for this research the optimal number of MTT’s is 2 in case of SSG handling speeds up to 2.5 minutes. In case not 5 by 2MTT’s are used for each SSG throughout the year, the total workload of MTT, according to the above stated calculation, would be 13,920 hours for one year. In such a case, then, there would be a decrease in the environmental damage displayed in Table 4.

<Table 4> Green Impact of the Simulation Model

<table>
<thead>
<tr>
<th>Number of MTT allocated</th>
<th>Annual working hours of MTT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Real</td>
<td>5</td>
</tr>
<tr>
<td>Simulation</td>
<td>2</td>
</tr>
<tr>
<td>Differences</td>
<td>3</td>
</tr>
</tbody>
</table>
VI. Conclusions and Implications

This study has aimed to analyze a Turkish port both in lean and green dimensions. A conceptual model has been developed both covering the lean dimension (JIT, Postponement and, cross-docking) and green dimension (vessel operations, services of marine facilities and, cargo handling) within the framework of ports. However, due to the constraints of our data, we only focused on the cargo handling operations of our sample. We assumed that, selecting cargo handling operations are both related to the green dimension and lean dimension (in terms of effectiveness) of a container port.

A simulation model has been applied. It has been found that changes in the handling speed of SSG and the number of MTT used in the internal transport have considerable effect on the performance of the system. Those findings reveal that such cargo handling vehicles have an important effect on the effectiveness of a container terminal. On the other hand, changing the handling speed of SSG is a short term decision for terminals in many cases.

Container terminals, by using the simulation models, can easily find easy ways to shift their strategies to lean strategies. Needless to say, although it requires capital, increasing the number of MTTs can be easily applied in many container terminals to apply the lean strategies.

On the other hand, one of the basic objectives of any port operator must be to create sustainable environment. To reach such an objective and minimize the damage made on the environment, any port is to minimize the activities polluting the atmosphere. This could be possible by using environment-friendly equipment. The SSG’s and RTG’s used at container terminals are mostly operated by electric power, whereas the MTT’s used at internal transport are generally motor vehicles. Reaching the optimal number of equipment at port operations minimizes the damage made on the environment this means that the number of the MTT’s is to be optimal. Simulation modeling is one of the most proper means of achieving the optimum in this regard. We have also revealed that simulation models are highly practicable and reliable decision support instruments for the decision makers at ports.
Lean systems do not always green, but it is the most important step for cargo handling operation in order to reach green operation. We only focused effectiveness of the container terminal cargo handling operations in terms of lean dimension. Further studies should cover the other components of the lean and green dimension in order to increase the efficiency of the current model.
A Simulation for Optimum Terminal Truck Number in a Turkish Port Based on Lean and Green Concept

Reference


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