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Off-peak truck deliveries at container terminals: the "Good Night" program in Israel

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Abstract

Purpose – Avoiding truck congestion and peaks in landside activity is one of the challenges to container terminal managers. The spreading of truck arrivals at terminals can be facilitated by widening the opening hours of terminals at the landside. Israel's Ministry of Transport has instituted the "Good Night Program", involving monetary incentives for importers and exporters who deliver containers to ports at night.

Design/methodology/approach – This paper aims to quantitatively examine the market utility resulting from shifting traffic from daytime to nighttime, and analyzes customer considerations regarding nighttime transportation.

Findings – The external utility found in the traffic-economics model is quite similar to the economic incentive given to customers. Therefore, a significant increase of the incentive is not feasible.

Originality/value – Furthermore, it seems that an incentive method by itself is not effective enough, and does not motivate customers to act and find creative solutions to the obstacles they face. To achieve a considerable change in nighttime transport to Israeli ports, more effective methods should be examined.

Keywords Container terminal, Off-peak truck deliveries, Traffic mitigation fee, Truck appointment system TAS

Paper type Research paper

1. Introduction

A vast literature deals with the optimization of container terminal operations; see, e.g., Stahlbock and Voss (2008) for an overview. Efficient terminals seek a balance between ship-to-shore, yard and landside operations to create an integrated system without bottlenecks. This objective is difficult to achieve in practice, given the uncertainty in the

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arrival pattern of deep-sea vessels as a result of schedule unreliability issues (Notteboom, 2006; Vernimmen *et al.*, 2007) and peaks in landside activity, particularly at the level of trucks arriving at the terminal to pick-up or deliver containers. These trucks are referred to in literature as external trucks (in contrast to internal or yard trucks which are used to support yard movements between quayside and stacking area). As a result, terminal operators rarely ever manage to utilize the intrinsic terminal capacity to the fullest. In this paper, we focus on policies concerning one aspect of terminal operations, i.e. the optimal use of the container terminal gate capacity for external trucks.

In general terms, container terminal operators seek to maximize gate capacity, but without incurring waiting times for trucks. The trucking industry operates in a very competitive environment, so gate congestion is detrimental to their economic well-being. In case congestion at the truck gates exists, terminal operators can resort to a range of measures which can be combined if necessary:

- Increasing the physical capacity of the gate complex by increasing the number of gates and lanes available to external trucks.
- Increasing the capacity of the gate complex by speeding up the truck turnaround time (also called the gate service time) at the terminal through the use of managerial and technological solutions such as business process redesign, automated truck registration and container identification systems, cameras for checking the physical condition of the container, etc.
- Spreading truck arrivals through the introduction of a truck appointment system to regulate the number of trucks that can enter the terminal and/or by extending the opening hours of the gate system (e.g. keep gates open at nighttime). These measures can be combined with a differentiated pricing system to discourage trucks from arriving during peak hours or daytime hours. Empirical evidence shows that the effectiveness of such pricing measures is not guaranteed, as we will demonstrate in the literature review section.

This study looks at a facet of the third range of measures by quantitatively examining the market utility resulting from shifting truck traffic at deep-sea terminals from the daytime to the nighttime. Using a case study on the Israeli port of Haifa, we qualitatively examine the considerations affecting customers to shift transports to the night. The study seeks to find an answer to the research question:

RQ1. Is it worthwhile to increase the subsidy under Israel's "Good Night" program for diverting truck trips from the daytime to the nighttime?

The paper is organized as follows. The first section provides a literature overview of existing cases of truck appointment systems combined with off-peak (nighttime) landside operations of container terminals. The second part presents the operational and policy background on the case study on the port of Haifa. The remaining sections discuss the interim results of the "Good Night" program and present an economic evaluation on a possible further continuation of the program.

2. Literature review on off-peak deliveries at deep-sea terminals

Quite a few studies have looked at truck appointment systems as a way to reduce gate congestion and encourage off-peak deliveries of containers. Guan and Liu (2009) developed a multi-server queuing model to analyze marine terminal gate congestion. They used an optimization model to balance the gate operating cost for the terminal operator and truckers' costs associated with excessive waiting times. The authors recommend that a truck appointment system is the most viable way to reduce gate congestion, increase system efficiency and reduce total system costs. Longbotham (2004) demonstrated that both the terminal operator and the trucking companies are better off if truck arrivals are uniformly distributed throughout the day. By developing a case study on the US West Coast ports, Morais and Lord (2006) argued that truck appointment systems can have varying impacts on reducing truck congestion. In contrast to successful experiences with appointment systems in ports like Hong Kong (Murty *et al.*, 2005), Giuliano *et al.* (2006) showed that there is no evidence that the appointment system in Los Angeles and Long Beach has affected queuing at marine terminal gates. Namboothiri and Erera (2008) analyzed the impact of appointment systems at US port terminals on drayage fleet efficiency. They show that vehicle productivity can be increased by 10 to 24 per cent when total access capacity is increased by 30 per cent and that the selection of access appointment timeslots by drayage firms may substantially reduce the number of customers that can be served.

An accurate monitoring of truck arrival, waiting and turn times at terminals is a key ingredient for the implementation and evaluation of any truck appointment system (Lam *et al.*, 2007). The availability of truck arrival information can increase terminal efficiency and reduce container re-handles at the terminal, as illustrated by Murty *et al.* (2005) in the case of Hong Kong. However, Zhao and Goodchild (2010) demonstrate that a complete truck arrival sequence is not required to substantially reduce re-handles, as significant benefit can also be obtained when having small amounts of information. Huynh *et al.* (2011) point to the value of webcams as a source of information on truck queuing patterns and truck processing time. Sharif *et al.* (2011) look at the role of dispatchers in reducing gate congestion. The results of an agent-based simulation model reveal that truck depots can help to limit gate congestion by relying on real-time gate congestion information and simple estimation methods for the expected truck waiting time.

Designing an effective truck appointment system that, by spreading truck arrivals, lowers truck time and increases equipment utilization at the terminal is not easy. Huynh and Walton (2008) proposed a methodology to determine the optimal number of trucks to accept for the appointment system that is beneficial for both the terminal operator and the trucker. They develop a particular focus on the use of a cap on the number of trucks that can enter a zone in the yard per time window. If such caps are not set properly, it could be detrimental to both the terminal and the truckers. Huynh (2009) went a step further in analyzing the impact of scheduling rules on resource utilization and truck turn time by linking appointment-scheduling rules to a variety of operating scenarios. The study reveals that individual appointment systems are preferred over block appointment systems even in case a considerable number of truck arrivals are walk-ins, no-shows or late. Chen *et al.* (2013a) developed a "vessel dependent time windows" method to reduce gate congestion. Trucks are assigned to groups with different time windows. Using a case study for a Chinese port, they demonstrate that the method can flatten truck arrivals and reduce gate congestion significantly. Also, Zhang *et al.* (2013) propose an optimization model for truck appointment using a method based on genetic algorithm and point-wise stationary fluid flow approximation. An empirical application showed that the model provides good estimates of truck queue length and can help to reduce truck turn time. Chen *et al.* (2011) analyze time-dependent truck queuing processes at terminal gates. The authors use a two-phase optimization approach to design a time-varying toll system that leads to a system-optimal truck arrival pattern. Zehendner and Feillet (2014) developed a tool in view of using the truck appointment system to increase not only the service quality of trucks, but also of trains, barges and vessels. A mixed-integer linear programming model is used to minimize overall delays at the terminal by simultaneously determining the number of truck appointments to offer and allocating straddle carriers to different transport modes. Chen *et al.* (2013b) analyze static terminal appointment systems (STAS) and dynamic terminal appointment systems (DTAS). Next to optimizing the hourly quota of entry appointments in STAS under the assumption of knowing truckers' preferred arrival pattern, the study introduces a higher system flexibility through DTAS which takes into account trucks' real-time estimation of waiting time based on existing appointments.

The spreading of truck arrivals with or without a truck appointment system can be facilitated by widening the opening hours of terminals at the landside. Extended opening hours, even throughout the night, in theory leaves more room for trucks to reschedule their trips to the deep-sea terminal from peak hours to off-peak hours. However, the decision on when to arrive at a terminal is not always under the control of truckers or trucking companies. The most common exogenous factors to truckers explaining why they eventually end up arriving during peak hours include:

- specific demands and supply chain management practices of the cargo-owner;
- the opening hours of distribution centers or manufacturing sites, typically implying that trucks can only pick up cargo at specific periods during the day;
- a periodical ban on trucks using (part of) the road network (e.g. in France, trucks above 7.5 tons are not allowed to drive during the weekends, which prevents container deliveries by truck at French container terminals during the weekend); and
- legal labor stipulations on driving and rest periods for truck drivers and on night work.

Various initiatives have been taken around the world to encourage off-peak deliveries of containers by trucks to limit road loads and air pollution from traffic. In some cases, the programs concerned had a specific focus on encouraging nighttime transports. We discuss a few early adopters of such programs.

The *PierPASS Off-Peak Program* at the Ports of Los Angeles and Long Beach is a landmark effort to resolve chronic congestion and air quality issues (Mani and Fischer, 2009). A Traffic Mitigation Fee (TMF) was issued for cargo movement through the ports during peak hours (Monday through Friday, 3 am to 6 pm). The TMF per TEU started at $40 and rose gradually to $66.50 today.

A second example is the *Gate Appointment System* at the ports of Los Angeles and Long Beach. A California state regulation was imposed on port operations in an effort to mitigate congestion and air pollution associated with increased port-related trade. The legislation permitted terminals to adopt either gate appointments or off-peak operating hours as a means of reducing truck queues at the gate (Giuliano *et al.*, 2008; Giuliano and O'Brien, 2007).

HIT (Hong Kong International Terminals) was another early adopter of truck appointment systems (Murty *et al.*, 2005). In 1997, HIT established an advanced booking system for pickups between 8 am and 5 pm. As Chinese drivers have no control over the time needed to cross the border between mainland China and Hong Kong SAR, the truck appointment system does not apply to export containers. In every 30-min time slot, each block has a certain preset quota for container pickups. The quota is set so that it minimizes a combined penalty for yard crane idle time and for the fraction of time during which the queue of trucks waiting at the block for service from the yard crane is too large. HIT's target is to keep the number of trucks waiting for service at a container block at six or fewer.

An *Off-Peak Pilot* program was conducted in New York in 2007 to calculate the economic benefits of off-peak deliveries. The research concluded that financial incentives to receivers were effective in inducing a shift of carriers to the off-hours. The optimal financial incentive was approximately $10,000 a year per receiver. This incentive was obtained by about 7,600 establishments in New York at a total cost of $76 million. The economic benefits would range between $83 million and $129 million per year (Veras *et al.*, 2011).

The *PANYNJ 's (Port Authority of New York-New Jersey*) introduced the E-Z Pass in 2002, a toll-pricing plan that varied according to the time of day to reduce congestion and facilitate commercial traffic management at the port. Weekday truck traffic would show a significant shift to pre-peak hours (5-6 am) and to post-peak hours (7-8 pm). Truck traffic would decrease for all peak periods, both weekdays and weekends (Veras *et al.*, 2005). In a preparatory study, Vilain and Wolfrom (2000) argued that peak-period demand for commercial users of the interstate crossings is rather inelastic. Still, they are not against pricing tools, as the main goal of pricing should be to make users pay a charge that approximates the marginal cost of their trip, even if this would not significantly alter traffic demand.

There are also more general programs to incentivize trucks to shift to nighttime transports. Many of these programs are linked to some forms of differentiated road pricing systems.

For example, *Inner-City Night Delivery* was a pilot program which terminated in 2006. It aimed at reducing delays by offering logistical service providers free road capacity in city centers across Europe, such as Barcelona, Dublin and The Netherlands, at night. This initiative focused mainly on the need to lower noise in urban neighborhoods caused by night deliveries. Several measures were suggested, such as low-noise trucks and equipment, respecting existing noise limits and reviewing nighttime local access regulations for trucks (Forkert and Eichhorn, 2014). Other examples include the London Congestion Charge and Singapore's Road Pricing System. Since 2003, the city of London has been charging a fee of about £10 (in 2011) for driving a private vehicle in its central area during weekdays. From 2003 to mid-2005, congestion in the center of London dropped by 30 per cent. Bus delays, which had been caused by congestion, declined by 50 per cent. Bus and subway ridership increased by 14 and 1 per cent, respectively. Taxi-ride costs declined by 20-40 per cent owing to reduced delays (Leape, 2006). The introduction of a road pricing system in Singapore led to a reduction and redistribution of vehicle flows. A permit applicable only during the morning peak period was developed in 1975. By 1988, the drop in traffic entering the restricted zone was 31 per cent, despite the growth by a third in employment in the city and by 77 per cent in vehicle population during the same period. In 1998, electronic road pricing began, based on a smart card. Traffic in the central business district was reduced by 10-15 per cent, as office workers no longer used their cars to attend mid-day meetings or lunches and, instead, relied more on public transport (Goh, 2002).

The above examples demonstrate that pricing tools are often used to encourage a shift from peak periods to off-peak periods. Such pricing tools in some cases were combined with a cap on vehicles entering a zone (here a container terminal) during a specific period. In the remainder of this paper, we develop a case study on the use of pricing tools to encourage nighttime deliveries of containers at the port of Haifa.

3. Background to the case study on Israeli ports

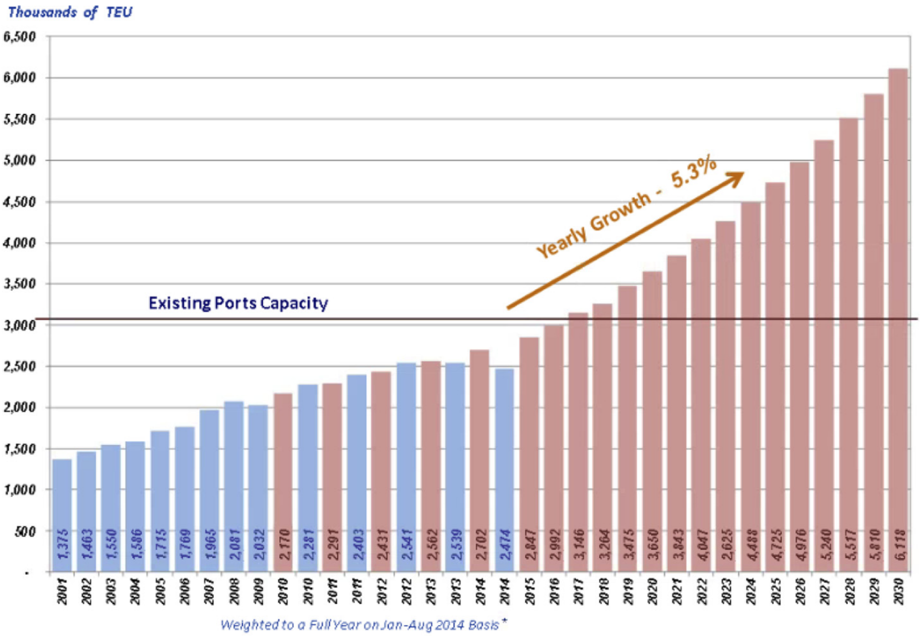
Israel's maritime trade is a crucial factor for the country's economy and for the competitive ability of Israeli exports in the global market. Some 98 per cent of the country's imports and exports pass through its maritime ports. The scope of this trade amounted to 48.8 million tons of cargo in 2013.

In 2007, the world economy flourished; the trade lanes to Asia and North America were loaded with containers, but the ports of Israel faced difficulties in absorbing the large scope of activity. Heavy traffic was created in the ports' hinterlands and on the sea lanes, and hefty congestion surcharges were levied by international shipping lines. In light of the situation, a government committee was appointed to investigate the blockages to maritime trade. This committee recommended diverting part of the container traffic to the night hours, thereby leveling out the traffic load in the ports and on their approach roads throughout all hours of the day.

This recommendation accorded with the Ministry of Transport's need to cope with increasing distress affecting land transportation in Israel. Imports and exports to/from Israeli ports are expected to increase by 5.3 per cent per year in the foreseeable future (Figure 1), thereby putting more and more pressure on heavy road traffic.

In addition, data from the Ministry of Transport hint that the fleet of trucks is significantly larger than what is required and that it burdens traffic at peak hours. The annual average mileage for trucks of over 10 tons was 50,500 km in 2012-2013; for taxis, it was 79,100 km. Unlike taxis, which work 24 h a day, trucks, which cost some $200,000 per piece, are used only 12 h a day.

The government makes large efforts to ease the heavy road traffic through investment in infrastructure. Nevertheless, the level of service per mile has been decreasing. One reason for this decrease is the country's population rate, which has been growing at an annual rate of 2 per cent. In comparison, population growth for the European Union is 0.3 per cent per year. The attempt to supply traffic infrastructure and enable a high level of service at Israel's growth rate in demand is difficult to achieve unless there is a change in driving habits. Therefore, the Ministry of Transport has supported a policy of encouraging night transports and has instituted monetary incentives for importers and exporters who deliver containers to the ports at night, when traffic is light.



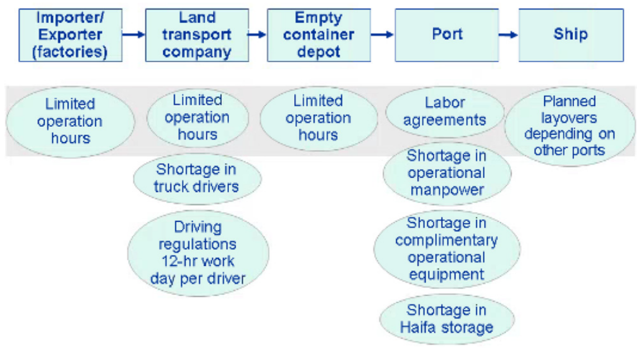
Source: Economic Models (2014)

Figure 1.
Past and projected container movement in Israel's ports (Haifa, Ashdod, Eilat), in 1,000 TEU, including transshipments

4. Logistic chain constraints

An examination of the logistic chain in Israel's maritime trade brings out a number of obstacles hampering the development of a more efficient sea–land transport system, as detailed in Figure 2.

Among the leading obstacles, we find three principal factors related to the supply chain that dictate the operating hours for the entire chain and limit landside transport of maritime flows to the daytime only:



Source: Own compilation by authors

Figure 2.
Blockages in the supply chain of Israel's maritime trade

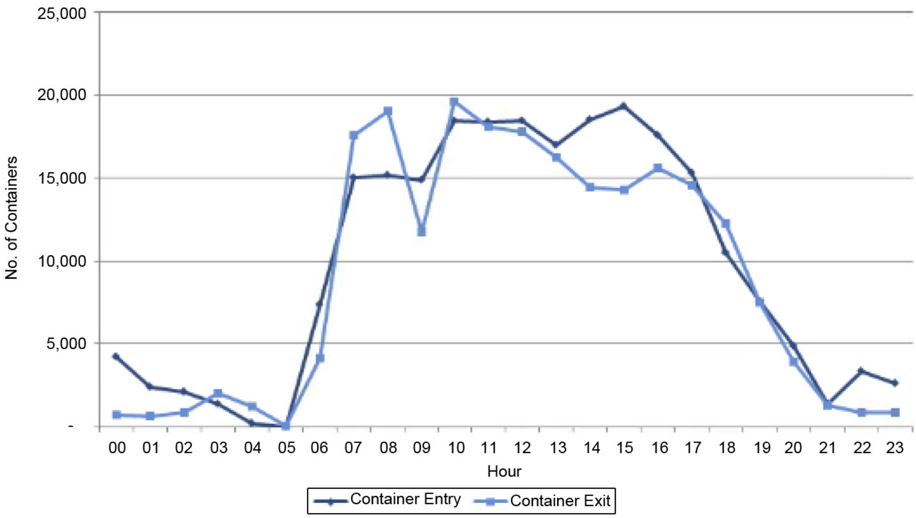
(1) most firms/factories receive cargo only during daytime;
(2) empty container parks (ECPs) do not operate at night; and
(3) truck companies work in 12-h shifts owing to legal restrictions on driving hours.

The limited working hours created bottlenecks during the course of the day, with heavy truck traffic reported at the entrance to the Israeli port of Haifa, from 7 am to 5 pm. Almost all demand for truck services drained into these hours. At the same time, storage areas in the port were occupied at night because of ships' daytime unloading, but there was no cargo flow out of the port during the night hours. The cargoes were picked-up only during daylight hours, with a lot of container-shifting taking place at the overused container terminal stacking areas in view of picking the right containers. Similarly, heavy truck traffic lowered quayside terminal productivity.

In addition, because of the concentration of truck transportation during a part of the day, infrastructure resources, personnel and expensive equipment in the storage areas were not exploited either in the port or by transport companies for large parts of the day. Figure 3 shows the distribution of container movements at Haifa Port during the various hours of the day in 2006, or right before the introduction of the "Good Night Program".

5. The "Good Night" program

A pilot project was initiated at the Port of Haifa on February 3, 2008, with the objective of achieving a temporal spreading of traffic flows at the port. During the pilot, the Israel Ports Company financed night operations at three empty container depots (ECPs) in the Haifa bay area. This enabled truckers to undertake full roundtrips: after bringing export containers to the port, the trucks loaded empty containers at the ECPs, and after unloading empty containers at the ECPs, they loaded import containers from the port.



Source: Haifa port

Figure 3. Distribution of the entry and exit of containers at the gates of Haifa Port, by hour of the day averages, for 2006

The pilot project lasted one year and proved the feasibility of nighttime operations. Container movements through the port at night doubled.

The Israel Ports Company then established the "Good Night Program" in 2010. Lively discussions were held regarding the best method to encourage night transport. The most recommended method was a fine–reward system, in which a day fee would be charged to customers transferring containers to the port during daytime, and a monetary incentive would be given to customers transferring containers during nighttime. This alternative was dropped due to strong opposition of the Manufacturers Association of Israel. Although the association was in favor of night transport, due to the heavy constraints on transportation during the daytime, it claimed that the import–export transportation costs were already too high and charging an extra mitigation fee would not be acceptable.

Finally, the method accepted was a monetary incentive without any kind of fee for day entrance to the port. This agreement was anchored in the government's tariff law. The monetary incentive was awarded to both importers and exporters moving containers to/from the port between 10 pm and 6 am. The incentive was set at $26.30 (equal to NIS 100[1]) per full container. The target was to have 20-25 per cent of the total container flows taking place during the night.

The results of the program were examined over the course of three years (2011-2013) in Haifa Port. The port mainly serves foreign trade of northern Israel. Container movements through the port amounted to 1,357,000 TEU or a total of 908,000 containers in 2013, of which 36 per cent were imports, 36 per cent exports and 28 per cent transshipments. Prior to the Good Night project at Haifa Port, the amount of containers at night (between 10 pm and 6 am) was 3.7 per cent. In 2013, an average of 150 containers per night moved in or out of the port, giving a yearly total of 37,600 containers or 7.9 per cent of the total container traffic at Haifa Port that year (Table I).

During the three years of the "Good Night Program", incentives were paid for 34,600 containers, amounting to 92 per cent of the total container traffic that passed through the port's gate at night. Thus, full containers that received an incentive contributed to the movement of other containers that were not entitled for such an incentive.

Although it seemed worthwhile in economic terms to all parties, customers, truckers, ports and the entire market, the project results were quite consistent for three years (2011-2013), and not satisfying enough compared to the target (20-25 per cent at night). The question was raised whether it makes sense in economic terms to continue operating the "Good Night Program".

Table I. Results of the "Good Night" project at Haifa Port (in units), 2011-2013

Year	Container quantity at night (full and empty)	Total container quantity (full and empty)	% at night
2011	31,186	392,629	7.9
2012	41,646	490,138	8.5
2013	37,619	474,286	7.9

Source: Data processed from periodic reports from the Port of Haifa

5.1 Market utility analysis

This study examines the market utility of diverting traffic to nighttime transport by applying a traffic-economics model. The market utility calculated is composed of two elements: external utilities for all road users and savings to the economy from truck operations.

The external utilities are:

- an easing of road congestion and a time saving for road users;
- a reduction in vehicle operating costs: the fewer road sections with a low speed (under 60 kph), the higher the savings;
- safety utility as a result of the reduction in the risk of collisions between trucks and light vehicles; and
- a reduction in air pollution as a result of a lower fuel consumption and a lower exposure to pollution.

The savings from truck operations are:

- a reduction in the truck time spent at the port; and
- possible performance utilities at the port.

The truck-related savings are manifested through a better exploitation of truck capital and an increase in annual mileage, as well as lower operating costs owing to faster traveling speeds. Contrary to these utilities to truckers, cargo owners and shippers might incur larger direct costs due to the need to open warehouses at night and to pay additional wages for night shifts. Truckers companies might also incur additional driver costs for night shifts. However, these costs were not included in the utility calculations, as these additional wage costs might differ from company to company. Noise costs at night were also not included in the utility calculations, because most truck traffic at night occurs on the main roads and highways connecting port areas and industrial/logistics zones in the hinterland, thereby having a minor impact on more urban areas.

The utility calculations demanded a detailed database regarding the profile of truck movements at the port of Haifa. This database was collected through a traffic survey conducted at the Haifa Port entrance over the course of five full continuous days during one week, beginning at 8 am on Sunday, 10 March 2013, and concluding at 8 am on Friday, 14 March 2013. The survey period represents a standard work week, with no unusual events, such as uncommon loads, worker strikes or sanctions and so forth. A total of 14,149 truck appearances were sampled, of which 12,763 called at the port during the daytime, or 90.2 per cent of the appearances between 6 am and 7 pm. There were 1,363 trucks that called at the port during the night hours, between 7 pm and 6 am, or 9.6 per cent of the total. Another 23 trucks were sampled but not classified. The origins and destinations of the trucks that called at Haifa Port were divided into 33 traffic areas in accordance with the National Model of Travel Demand, used by the Ministry of Transportation. The Port of Haifa was found to serve mainly the northern region of Israel, with light changes according to the hour of the day (Figure 4). The percentage of trips to and from destinations close to the port, within a range of 20 km, amounts to 45.8 per cent during the day and 43.7 per cent at night. The average distance being 3 km from the port, as detailed in Table II.

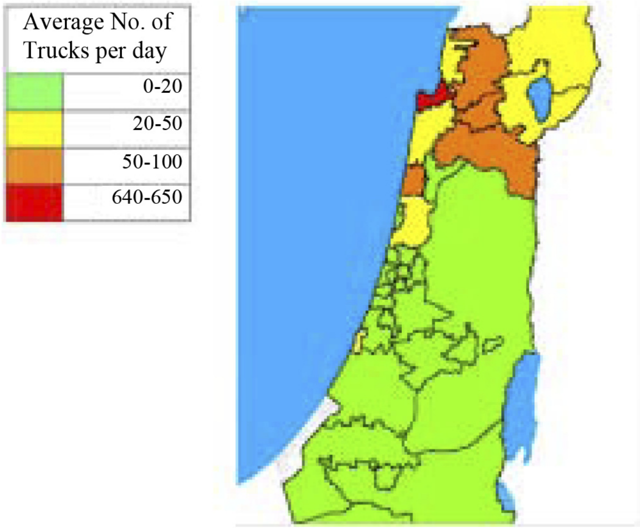


Figure 4.
Areas of truck traffic to and from the Port of Haifa (average per direction)

Source: Compilation by authors

Table II.
Distribution of trips by distance, day and night

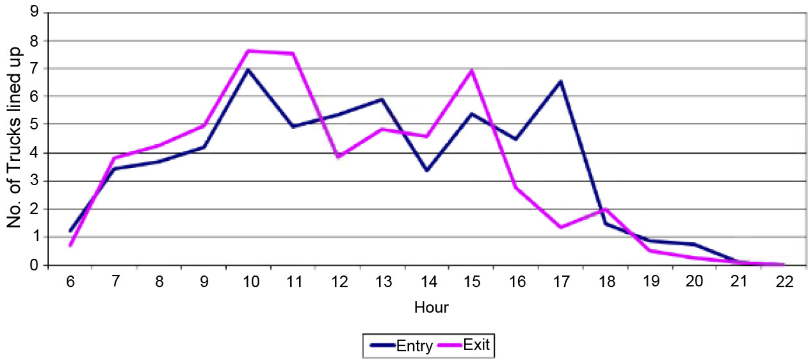
Period of day	Day	Night
% nearby destinations (up to 20 km from port)	45.8	43.7
Avg. distance to nearby destinations (km)	3.2	3
% far destinations (more than 20 km from port)	54.2	56.3
Avg. distance to far destinations (km)	64	89

In the course of the project, the claim was made that nighttime trips were mainly related to short-distance trips to the port. This argument was based on the multiplicity of cases in which plants moved containers to warehouses in the vicinity of the port during the day, and the movement to the port itself was undertaken at night. This claim proved to be unfounded when analyzing the survey findings. The profile of short trips during the day was seen to be similar to that at night, as seen in Table II. It was further found that trips to more distant destinations were characterized by a larger distance at night than during the day (89 km vs 64 km).

The number of trucks, on average, in queue at the gates during daytime amounts to six in each direction (Figure 5). At night, there is no queue.

The traffic survey supplied data on the spread of the origins and destinations of trucks and examined performance aspects of truck traffic at the port gate and inside the port. The survey findings enabled an analysis of the scope of traffic to the port according to a regional and an hourly cross-section. The distribution of mileage distance and traveling hours served as inputs for the traffic-economics model.

5.1.1 Traffic-economics model principles. The main utility of diverting trucks to nighttime trips is to ease road congestion and, as a result, increase travel speed and produce a saving in road users' trip times. An evaluation of the utility to the economy



Source: Compilation by authors

Figure 5.
Average number of trucks lined up hourly to enter and exit the Port of Haifa

from diversions of container-carrying trucks to nighttime deliveries was calculated using a national traffic simulation conducted in the framework of the National Demand Model used by Israel's Ministry of Transport (Bekhor *et al.*, 2013; Gur *et al.*, 2010). The simulation replicates the reduction in truck traffic to and from the port at three periods of the day. Each truck was considered as two EVU (equivalent vehicle units), and a distribution of origins and destinations to/from the port based on the traffic survey detailed above was generated.

5.1.2 Benefit from road users' time saving. A saving in hourly EVU translates daily into a saving of 1.8 travel hours. The associated weighted value is worth \$7, as detailed in Table III.

5.1.3 Saving in vehicle inputs. Increasing travel speed reduces per-kilometer operating costs, including fuel, tires, oil, maintenance, amortization and capital costs. Changes in travel lanes during heavy traffic hours may also help to reduce these costs. Almost all the benefit goes to the many road users, who enjoy improvements in speed owing to a reduced number of trucks at peak hours. Only a small proportion constitutes a direct benefit to the trucks themselves.

5.1.4 Reduction in air pollution damage. A rise in travel speed to some 70 km/h brings about a saving in fuel consumption, and thus also a lessening of air pollution. The average benefit from increased travel speed is equal to a value of NIS 1 per liter of gasoline, of which the benefit from a reduction in CO_2 emissions per liter amounts to 10 agorot per liter (100 agorot = NIS 1); the remainder is the value of a reduction in other types of pollution, in particular PM10, PM2.5 and NO_X.

5.1.5 Safety benefit. No clear-cut difference was found in the average cost of accidents per truck-kilometer between daytime and nighttime. Therefore, the model assumes that there is no safety benefit from diverting truck traffic to evening and night hours.

Trip purpose	Work-related trips	Trips to/from work	Trips for other purposes
Distribution (%)	16	48	36
Value of a trip hour in \$	18.5	5.6	3.9
Weighted value in \$		7	

Table III.
Value of a trip hour

5.1.6 Direct saving in truck outputs. The transfer to night deliveries contributes to two kinds of savings in truck outputs:

(1) in operating costs, depending on a rise in travel speed; and

(2) in exploitation of truck capital, which currently is low, at 58,000 km yearly for a 24-34-ton truck and only 54,000 km yearly for a 34+-ton truck.

The possibility of deploying trucks at night will increase output and reduce the need to purchase additional trucks. The average cost of a truck is $200,000, with 60 per cent of the amortization being time-dependent (years), and not distance-dependent.

5.1.7 Saving in entering, exiting and port-stay time. At night, there are no waiting lines at any port gate. As a result, a truck arriving at night saves a waiting time of 6-7 min before entering. In addition, time is saved in the port stay for loading and unloading containers. According to port data, the average saving between night and daytime unloading/loading activity is 10 min. Thus, a truck that enters the port at night saves 16-17 min compared to its daytime performance. The saving to the economy is equal to $6.60 per truck, as seen below (the computations in the model are based on work and trip values acceptable to the Ministries of Transportation and Treasury):

- *Truck driver's salary*: $13.20 per hour.
- *Capital*: $7.90 per hour.
- *Overhead and profit*: $3.70 per hour.
- *Total value of a truck hour*: $24.70.
- *Saving value for 16.5 min*: $6.60.

5.1.8 Benefit to the economy when diverting one truck from day to night. The benefit of diverting a truck to night hours amounts to $50, of which $30 is an external utility, and $20 are savings from truck operations. By the year 2020, the benefit is expected to increase to $65.30, of which $41.30 will be an external benefit owing to the expected congestion on the road system and the increase in the value of a trip hour. Table IV

Table IV. Benefit to the economy from diverting one container from daytime hours to evening and nighttime hours ($)

Hour	8 pm-10 pm		10 pm-6 am	
Year	**2013**	**2020**	**2013**	**2020**
Utility from a saving in time for passengers on the national road network	23.7	28.7	27.9	38.7
Value of a reduction in air-pollution damage	1.8	2.4	2.1	2.6
Total external utility	**25.5**	**31.1**	**30.0**	**41.3**
Saving in truck operating expenses on the road network	7.4	7.6	8.2	11.1
Value of the saving in time for entering, leaving and staying in the port	6.6	6.6	6.8	7.4
Increased capital utilization of the truck	4.7	5.0	5.0	5.5
Saving to the economy from truck operations	**18.7**	**19.2**	**20.0**	**23.9**
Total saving to the national economy per diverted container (in $)	**44.2**	**50.3**	**50.0**	**65.3**

Note: The bold data significance to sub-totals presents the estimated benefit to the economy resulting from diverting one container to the evening and night hours for the years 2013 and 2020.

The external utility value of $30, found in the traffic-economics model, is quite similar to the economic incentive ($26.30) given to the customers. Nevertheless, the results of the good night program were found to be modest (only 7.9 per cent of total volume arrives or leaves at night). So, it was important to understand the reasons affecting customers' willingness to divert container transportation to the nighttime.

5.2 Customers' considerations regarding nighttime transportation to the port

Throughout the research period, meetings took place with various parties in the logistics chain: 51 importers and exporters, 13 transport companies, 13 ship agencies, 8 hinterland terminals and 5 key position-holders at the port. In other words, meetings were held with some 90 parties with some interest in night transport. In addition, meetings were held with professional bodies, such as the Industrialists Association, Chamber of Shipping, Organization of Customs Agents and International Freight Forwarders, Chamber of Commerce and the Road Transport Board. These meetings aired various considerations in regard to nighttime work, as will be detailed below.

5.2.1 Scope of customer activity. Containers may be stored free at the port for no more than four days (i.e. a free time of four days) owing to limitations in storage space. All customers try to move their containers within the time frame allotted to them to prevent incurring high storage costs or dwell time charges. A free time of four days is comparable to what is in place in quite a few global gateway ports. For example, terminals in Antwerp and Rotterdam, the two largest European container ports, apply a free dwell time of 4 to 5 days on average with some differentiation at the level of import, export or transshipment containers. Terminals with a high transshipment incidence and/or a high land productivity (such as Hong Kong or Singapore) typically impose a lower free time. The free time limitation is critical for customers with large scopes of trade, for they have to contend with moving a large quantity of containers within a relatively short time.

Customers with a relatively large scope of activity in Israel (defined as moving some 500 containers a year) and who generate most of the container movements in the ports related in a positive manner to the project and were willing to make efforts in diverting their container traffic to nighttime transport to cope with the large number of container movements. The problem of the scope of movement exists, as well, in the plant yard, not only at the port. Some plants hope to restrict truck movements in their yards during the daytime hours owing to safety considerations.

5.2.2 Export scope. Exporters are required to store containers before the ship's arrival because the time of docking might change owing to schedule unreliability issues caused by external factors such as weather conditions, lateness of sailing time from the previous port, non-availability of piers at the port and so forth. Because of the risk of incurring high storage charges if the vessel is delayed, the exporter must try to introduce containers into the port close to the ship's arrival, when there is more certainty of the vessel's arrival time or ETA (estimated arrival time). Importers, by contrast, know for certain the unloading time of their containers at the port, and prepare themselves accordingly for moving them out of the port. An analysis of container movements during nighttime hours at the Port of Haifa in 2013 shows that 62 per cent of the containers moved at night were for export, 35 per cent for import and the rest were empty containers. It may be concluded that the option of moving containers at night is more in demand among exporters.

5.2.3 Investment required in shifting to night transport. Night work requires logistical capabilities, but not every plant has the requisite arrangements. Three key issues are connected to this capability. First, logistics workers in most plants are stationed only during the day. Night work necessitates a night-duty roster and often comes at a premium, given higher wages to compensate for night shifts. Second, a dedicated storage area in the plant yard is required for containers that have been filled during the day and are to be moved at night. Third, a plant needs mechanical equipment for moving containers in the plant yard (such as a reach stacker or large forklift). For a plant which already has these means, or some of them, it is easier to switch to nighttime transport. Otherwise, a significant initial investment will be needed. For example, a container forklift costs about $500,000, and the salary of its operator runs to about $3,500 a month. The need for a financial investment in logistics capability will dictate to a large extent the economic feasibility of night work for the plant.

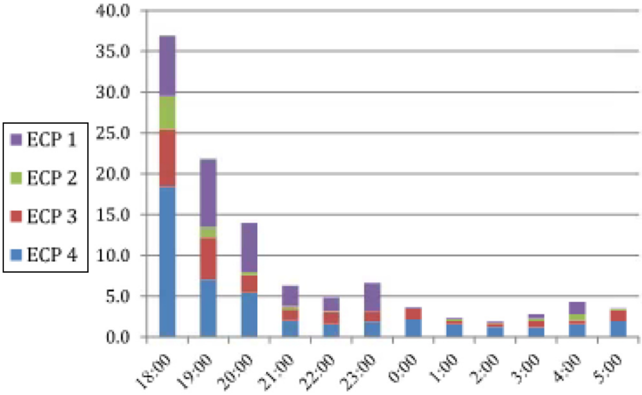
It should be noted that cooperative arrangements can be made with transport companies for the supply of forklift services or even storage. Customers should examine the economic feasibility of these solutions.

5.2.4 The need to alter labor agreements. In some plants, the existing labor agreements can form an obstacle, which will require altering. Plants in which the operating hours of every link are defined and anchored in a labor agreement will find it difficult to effect changes. The extent of the rigidity of the labor agreements, management–employee relations and the cost of altering agreements all constitute significant considerations in deciding on a transition to nighttime logistics.

5.2.5 Flexibility of the transport company. The traffic-economics model showed that transport companies have an economic benefit to the extent of $20 per container moved at night (in 2013). Nevertheless, there are added expenses at night, such as higher salaries and internal logistics that have to be covered. A sufficiently large work scope is required to cover the costs of a night shift if it is to be permanent. The larger the quantities of containers that a transport company can devote to night moving and the more of a logistics capability that it possesses, the more it will tend to respond positively to night work.

5.2.6 Daytime level of service at the port. The level of service at a port during daytime depends on the workload as manifested in the availability of storage space, number of ships at the piers, availability of work crews, availability of cranes, the truck situation at the port gate, etc. Large workloads in the port lengthen the duration of truck turnaround time. A container-movement rate that harms the customer's commercial obligations encourages nighttime transport as a solution to low outputs and non-supply of services during daytime. A typical case that corroborates this assumption occurred during the period August-September 2008, when the port suffered from work sanctions by the striking workers. Output during the day was badly hurt, whereas night movements rose by 50 per cent.

5.2.7 Availability of empty containers at night. The movement of export containers generally involves removing empty containers from the ECP to stack other containers for export. The movement of imports generally involves a return of the empties to the ECP. In interviews conducted with customers and transport companies, the shortage of empty containers at night was identified as an obstacle to night work. The Israel Ports Company in 2011 undertook a pilot program financing the opening of ECP's at night; however, the number of calls was poor and the pilot project was soon halted (Figure 6).



Source: Compilation by authors

Figure 6. Containers calling at night at container terminals

With the establishment of the Good Night project, interim solutions were created, such as the opening of container parks (empty and full) by several transport companies.

Similarly, shipping companies enabled customers and transport companies to convert import containers to export, without the need for passing through an ECP for the purpose of cleaning and repairing damage. This solution makes the need for the ECP link at night unnecessary. Furthermore, if critical mass transactions of large-scale importers/exporters were to switch to nighttime, ECPs would be obligated to serve those customers at nighttime as well.

Each one of the above considerations has a distinct influence on each and every customer. Each customer is required to make a different investment, either economic or organizational, to shift transports to nighttime. Therefore, the breakeven point differs from one customer to another.

Although the existing incentive of $26.30 is almost equal to the market external utility, we see that it meets the breakeven point of only a few customers. The considerations detailed above are meaningful obstacles. The customers who reach a breakeven point are having the following characteristics:

- a relatively large scope of activity (about 500 containers a year);
- large-scale exports;
- adequate logistics facilities for container stacking, adequate illumination and safety requirements;
- flexible labor agreements; and
- innovation spirit and broad vision on future developments.

6. Conclusions

The spreading of truck arrivals at container terminals can be facilitated by widening the opening hours of terminals outside the ports. Extended opening hours during the night hours, in theory, leaves more room for trucks to reschedule their trips to the ports from peak hours to off-peak periods. However, the decision on when to arrive at a terminal is not always under the control of truckers or trucking companies. This paper presented a case study on the Israeli port of Haifa by examining the market utility resulting from shifting truck traffic at the ports from daytime to nighttime. The paper focused on the question whether it is worthwhile to increase the subsidy under the "Good Night Program" for diverting truck trips from daytime to nighttime.

The external utility value of $30, found in the traffic-economics model, is quite similar to the economic incentive ($26.30) given to customers. Therefore, a significant increase of the incentive is not feasible. Nevertheless, the results of the "Good Night Program" were found to be modest (only 7.9 per cent of the flows arrive or leave at night) and constant over three years (2011-2013).

According to the study, only a few customers meet a breakeven point with this level of incentive. There are meaningful obstacles that customers are facing when considering diverting container transport to the nighttime. Only large-scale customers are able and willing to invest in this matter, and hence enjoy the benefit of the added "window" of working hours at night. These large-scale customers also have the necessary impact and influence on their suppliers, and can demand night services from them. Large-scale exporters would be more motivated than importers to invest in this diversion because they face the risk of incurring high terminal storage charges. Large-scale customers who suffer from rigid labor agreements or inadequate logistics facilities for night work won't necessarily reach an economic feasibility by shifting to night work.

A significant increase of the incentive is not recommended, as it cannot exceed the market utility value. Furthermore, it seems that an incentive method by itself is not effective enough, and does not motivate customers to act and find creative solutions to the obstacles they face. To achieve a considerable change in nighttime transport to Israeli ports, more effective methods should be examined.

A mitigation fee is a method that can urge and encourage more large-scale customers to act on this matter. In this case, it is important to take into consideration the small- and medium-scale customers when imposing a mitigation fee. It would be very difficult for small- and medium-scale customers to cope with a mitigation fee. Although these customers represent about 80 per cent of the total customers, they transit only 20 per cent of the containers. These customers could not cope with night transport, and should not be hurt by a mitigation fee. Other methods to be examined could be truck appointment system at the gate port and a periodical ban on trucks at certain road networks.

Further research can be directed to the examination of the impact of night transportation on clearing storage areas in ports and on ships' stays at berth. These future research avenues are relevant especially in view of the need for larger discharging and storage areas created by the growth in container ship size and growing container volumes.

Note

1. All dollar figures are based on the shekel-to-dollar exchange rate on 1 January 2014.

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