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LOGISTICS MANAGEMENT OF PROCESSES ENSURING THE OPERATIONS OF OIL DERIVATIVES CHAIN

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Abstract

This article examines an approach towards logistics supply chain management of oil derivatives. All constituent systems of a logistics chain are analyzed altogether with their parameters and connections and their weak links. Criteron for process optimization of these units is: a high degree of service of the end customers and optimal costs to ensure reliable operation with the necessary resources for this purpose. The three main constituent phases of a logistics chain with their relevant parameters are discussed. In the third phase of the different subsystems are determined safety stocks to ensure flawless service to the end users.

Keywords: *management, transportation, terminal, stocks, distribution, technology, logistics*

1 INTRODUCTION

Being a major sector of the national economy, transport creates conditions of normal functioning and development of the economy itself and it is an important factor to achieve efficiency of production systems. The present article aims to describe a part of the decisions and algorithm of logistics supply chain management of oil derivatives.

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In this case *the logistics chain* consists of *multiple units (sites) related to transport services.* The sites are places where material flow is processed and passes to the next stage of the process.

Transport services move material flows between sites using transport systems of different modes of transport, sometimes as a part of ***a logistics chain***. The supply chain of main raw materials for oil industry should meet the requirement of high reliability. Its provision with resources and way of transportation directly affects the production process due to the technological requirements of continuity and commitment of the logistics system structural units. The technological description of the activities and their synchronization in a supply chain require different time and resource characteristics in the various states in which system might be. These conditions examine: the irregularities in pessimistic and optimistic scenarios, identification of the key dependencies and connections in the logistics chain (LC), simulation of different strategies when choosing operation and analysis of extreme conditions that result in a failure in the end customer services. On this basis a common concept for operation of the chain with provision of necessary reserves of power and resources is being developed which helps for the predicted extreme conditions and determining the value of total logistics (business) cycle.

In the presented case the logistics management encompasses all activities in a corporate supply chain and distribution of oil derivatives, which properties are: a port terminal 'Petrol', a regional base for distribution, a chain of gas stations and specialized road transport for supplies. This means that the subject of study and optimization are the external parameters for the chain, which cannot be influenced by managerial decisions, such as: the supplies and the work of maritime transport at the beginning of the logistics chain, railway carrier which is a link to the port and a base for distribution and the rate of consumption by the end users of oil products through the chain of gas stations. In this case, the railway transport and the working options in various irregularities of the process are extensively researched and described in (Borisov, 2015). Its technological parameters can reliably be determined and regulated in contracts with transport companies for freight services, which ensures low fluctuations in supply. The situation with supplies at the port is similar, as these processes are subject to long-term contracts. An occurrence of possible extreme conditions in the system is taken into consideration. Bottlenecks in the logistics chain are: the pace of realization of oil derivatives, their uniformity, rhythm (frequency) of reloading gas stations and determining the necessary product inventories to ensure quality and timely customer services.

The purpose is the absence of failures in customer services due to lack of derivatives at optimal costs. This optimization process requires detailed market research by regions within which the gas stations are situated, classification of objects by volume and variations of the sales on daily and annual terms.

2 CONCEPT FOR ACHIEVING THE PURPOSES

Step 1. Research, analysis and structure of the logistics chain. Description of the process.

It includes the functional structure of the logistics system with different phases of material flow service which is shown in Fig.1 Description of activities and actors in the process with their connections.

- ***Phase 1*** – includes the processes of arrival of ships in the water area of the port of Varna, unloading and departure. Technology and organization of load-unload processes with the corresponding derivative. Organization of wagon flows for transporting the requested freight out of the port. Determining the technological parameters of the process;
- ***Phase 2*** – technology and organization of main rail transport. Train Traffic Schedule (TTS) and reservation of routes on the National Railway Network. Development of technology for exploitation and signing a contract with a railway transport carrier serving the logistics chain;
- ***Phase 3*** – determining the volumes in terminal 'Oil Derivatives', rhythm of entry, safety stock, distribution and service of end users– chain of gas stations.

Step 2 Analysis of random parameters affecting the performance on the entry of the logistics chain– maritime transport (intensity of the incoming flow, variation in intervals and volume, duration of handling the ships).

The 'Petrol' tanker port is located in the region of Varna port complex served by Varna railway region. It is equipped with three overpasses for unloading oil derivatives (fuel oil, diesel, gasoline and oil) of three quays as Quay-3 is specialized for unloading diesel and base oils, which is the aim of this study.

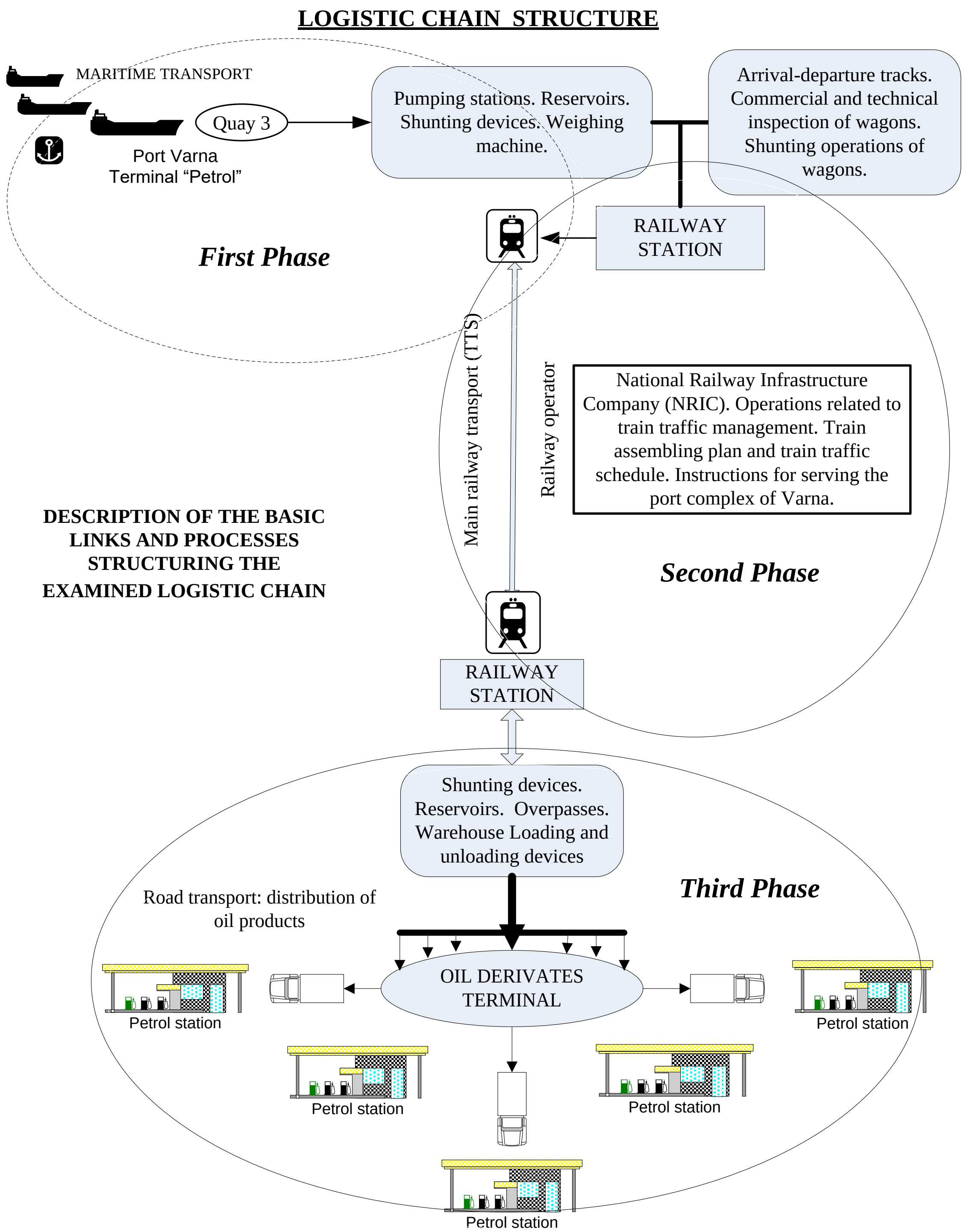

Fig.1 Description of the basic links and processes structuring the examined logistic chain

The load-unload system is run through pumps with processing capacity for diesel of 250 t/h. For safety reasons diesel is unloaded by ‘tanker-tank-wagon‘ scheme. These processes are governed by regulations ruling all activities in the port complex related to handling vessels with dangerous goods according to IMDG Code and IBC Code of IMO.

The handling of ships with hazardous freight is carried according a technology, which is preliminarily developed by the port staff for each load using a technology roadmap agreed upon with competent authorities. Unloading of hazardous freight shall begin immediately after berthing of vessels at the port. The recipients of seaborne hazardous freight are obliged to immediately transport it from the port. If there is a delay in the delivery of dangerous freight, Maritime Administration and competent authorities should be informed.

All time characteristics related to processing of ships are registered in a special document called 'STATEMENT OF FACTS' which has information about: the port, arrived vessels, berthed and commenced vessels, completed, accepted and handed notices, cargo, tons, provided vessels, used time and discharging. These parameters are used as a base to collect statistical information. The average tonnage of all arrived ships at Quay-3 for a period of 18 months was 3600 t, time for unloading (with preparation of hoses) – 16 h, interval of arrival 16.3 hours (min.-7,2; max.-26).

The data about intervals of arrival of 'river-sea' type ships with diesel fuel for Quay – 3 is processed using STATGRAPHICS Plus 5 Professional and after determining the law of distribution of examined variables, the process is modeled for a future period of time. In order to develop the technology of operation at the oil terminal, a pessimistic scenario is created with the compressed intervals by arrival of ships.

Results of the quantity examined in hours:

Analysis Summary: Data variable: Diesel; 17 values ranging from 7.69 to 58.34; Fitted normal distribution: mean= 27.339; standard deviation = 10.1256; fChi-Square= 1.17396 with 6 d.f. P-Value = 0.278588.

Step 3 Implementation of the process of technological design of the transport system 'port – railway transport – oil terminal' (selection of railway carrier).

The process includes the following steps:

- Determination of resources to ensure the railway transport process for 72 hours at a maximum usage of the system;
- Technological design of the system 'main railway transport – port terminal' and selection of optimal version for operation of the railway carrier in the logistics chain;
- Determination of technological parameters of the process (scheduling service, number of wagons, number of trains and shunting sets, duration of operations, number of locomotives, etc.) and resource dimensioning with the examined option.
- Signing a contract with a railway carrier to serve the workflow with previously defined in advance parameters, such as: time and workload of rail transport, volume of traffic flows at the port terminal, regulation of the processes and payments.
- The following results of the rate of incoming freight flow from maritime to rail transport for the busiest period of 3 days were obtained:
- Maritime transport – 5 ships with an average load of 3200 t. In this case the ships are of river-sea type;
- Required number of wagons is 35 wagons/day with load capacity 45 t/wagon;
- The number of trains needed to meet the existing volume of freight is determined (standard for train) depending on the traction characteristics of licensed locomotives used by the railway carrier and the railroad. The maximum gross tonnage in this case is from 685 to 1200 tons with a single traction and 2400 tons for two locomotives. At 75 t gross weight of a wagon there are 32 wagons in train with a length of 544 m (17 m/wagon). This allows to form different train compositions with available rolling stock, with different locomotive resource depending on the of the generated freight flow (for the necessary train gross mass) in the port and different infrastructure charges according to the Train Traffic Schedule (TTS).

Step 4 Service of petrol station chain and end customers in the oil base by road transport. Determination of diesel reserves in the distribution and sales system, supply organization and etc.

The third phase of the process of distribution system is a critical point (the weak link) in the construction of logistics activities management. For its optimization it is necessary to analyse and test:

A. Existing practices in the distribution and realization of oil derivatives in the company;

B. Theoretical models for determining the stock and size of orders to the end users;

C. Determining the level of stocks and organization of supplies in the various units of the final phase of the process;

D. Determining the different types of costs and financial analysis.

In our case we examine the distribution of oil to two types of stations - high turnover and low turnover, generating different types of variations in the consumption of diesel and representing 80% of the total number of sites. The statistical data is for a period of one year, including the amount of annual and average daily sales of diesel from different types of stations, oil base data (with seasonal variation), time for processing the orders to different groups of stations in different periods of the year. The company's network includes 98 stations, 82 of them owned by the company, while other dealers have franchise agreements. Each site of the commercial network is connected to Vendor Managed Inventory (commercial management of inventory), which provides everyday summaries of the quantities that are traded by each site, stocks of different types of fuel and what forecasted sales. The distribution department of the company prepares duty schedules for the reloading of the stations. The duty schedules are prepared 1 day in advance, while on Fridays they are prepared for 3 days in advance. After retrieving the data from the system a model is made. In this model, on the basis of previous sales, forecasted quantities are calculated and they can be applied in the oil base. The organization of supplies by road transport (route, type of vehicle, drivers, load schedule, etc.) is a subject of a specialized software.

Stock management requires investigation and determination of costs associated with freezing of capital (at large reserve), provision of storage areas (tanks), insurance, fees, contract costs, costs due to deficit/unsatisfied demand etc. In our case stocks are managed by the provider (Vendor Managed Inventory - VMI), and he takes full responsibility to satisfy that demand with minimal costs. One of the main tasks is the determination of safety stock serving as a buffer in case of random variations in demand and uncertainty over the duration of deliveries. It allows the company to satisfy customer demand in case of:

1. Late delivery by the supplier or lack of supply;
2. Industrial action, accident, natural disaster;
3. Poor quality of available stocks;
4. Increased level of demand due to a lack of this product in competition;
5. Random events that influence consumer demand.
6. A fault in the equipment;
7. An unexpected increase in demand.

Most models for stock management are described in (Chopra & Meindl, 2012), (Hugos, 2003), (Karagyozov K. , 2012), (Karagyozov, Razmov, & Varadinova-Milkova, 2012), (Muller, 2011). In practice there are many software products, which cover the entire range of variants of problems, that a logistics system could encounter and equations for: lead time of the order, economic order quantity, safety stock (at different demand and delivery term), re-order point at a different type of demand etc. The model that provides sufficiently reliable solutions in our case is a derivative of 'Economic order quantity and safety stock (permanent monitoring)' EOQ ((Bowersox, Closs, & Cooper, 2012), (Karagyozov K. , 2012), (Lambert, Stock, & Ellram, 1998), (Muckstadt & Sapra, 2010)).

For the purposes of the article the following indicators are used:

Rop - Re-order Point;

SS - Safety stock;

L - Lead time of the order;

Rop-SS – average annual demand during the period of order finalization;

Rop-Dmax- maximum demand during the period of the order finalization;

Rop- Dmin- minimum demand during the period of the order finalization;

PSL- the service level, i.e. the probability of not having a stock-out.;

1-PSL- the probability of having stock out;

d_λ - average consumption per unit of time;

$\sigma d\lambda$- mean square deviation of the demand for a period of time.

The aim is to determine such safety stock, which can provide the lowest mean of the total cost to provide the process.

The base equations of the model are:

Service level:

(1) $z = F^{-1}(P)$ Laplas

Demand for time - L [days];

(2) $D_l = d\lambda \times L$

Standard deviation of the demand for a specific period of time;

(3) $\sigma_{dl}^2 = \sigma_\lambda^2 L + (d\lambda)^2 \sigma_L^2$

Coefficient of variation of the daily demand:

(4) $C_\lambda = \frac{\sigma_\lambda}{d\lambda}$

Coefficient of variation for the lead time of the order:

(5) $C_L = \frac{\sigma_L}{L}$,

Safety stock (in litres):

(6) $$ss = z\sqrt{\sigma_\lambda^2 L + (d\lambda)^2 \sigma_L^2} = = z \times d\lambda \times L\sqrt{C_\lambda^2 / L + C_L^2}$$ [litres]

Re-order point:

(7) $Rop = D_l + ss$,

Fill Rate:

(8) $fr = 1 - \frac{Edef}{Qopt} = 1 - \frac{\sigma_{dl} L(z)}{Qopt}$.

Order size under normal distribution of the demand is indicated with CL = 0, while under uneven distribution - with CL> 0.

2.1 Results

Tables 1, 2 and 3 show the results for three cases: stations with low turnover (the most common case of low consumption), stations with high turnover (the most common case of high consumption) and the Oil base - distribution centre for diesel in the researched area.

Table 1. Main Results for a station with low turover

MAIN RESULTS			
LOW TURNOVER STATION		C_L=0	C_L>0
Economic Order Quantity	Qopt=EOQ	5,047.05	5,047.05
Demand for time L	D_l=dλ*L	4,187.3	4,187.3
Level of Service	z	1.881	1.88
Standard deviation of the demand for a period of time until order finalization	σ_{DL}	592.17	1,276.27
Safety Stock	ss	1,113.76	2,400.39
Re-order Point	Rop	5,301.05	6,587.69
Increase of Qo %			116%
Standard Loss Function	L(z)	0.012	0.012
Fill Rate	fr	0.999	0.997

In table 2, there are shown the results for high turnover station

Table 2. Main Results for High Turnover Station

HIGH TURNOVER STATION		C_L=0	C_L>0
Economic Order Quantity	Qopt=EOQ	7,181.06	7,181.06
Demand for time L	Dl=dλ*L	8,476.88	8,476.88
Service level	z	1.881	1.88
Standard deviation of the demand for a period of time until order finalization	σDL	1,198.81	2,583.71
Safety Stock	ss	2,254.72	4,859.42
Re-order Point	Rop	10,731.59	13,336.3
Increase of Qo %			116%
Standard Loss Function	L(z)	0.012	0.012
Fill rate	fr	0.998	0.996

Table 3. Main Results for Oil Derivatives Base

OIL DERIVATIVES BASE		C_L=0	C_L>0
Economic Order Quantity	Qopt=EOQ	50,873	50,873
Demand for time L	Dl=dλ*L	106,359	106,359
Service Level	z	1.881	1.88
Standard deviation of the demand for a period of time until order finalization	σDL	12,281	31,233
Service Stock	ss	23,099	58,743
Re-order Point	Rop	129,458	165,102
Increase of Qo %			154%
Standard Loss Function	L(z)	0.012	0.012
Fill Rate	fr	0.997	0.993

The presented results were obtained from the data for past periods of time and cost parameters.

The costs that the oil company has for safety stock maintenance and the total costs in inventory management in the oil base are presented in Table 4. In Table 5 the possible costs for different service levels (1) for normal distribution of random variables are calculated.

Table 4. Costs in the oil company

Costs	CL=0	CL>0	Currency
Order Costs	7,631	7,631	BGN/year
Holding Costs	7,631	7,631	BGN/year
Safety Stock Costs	6,930	17,623	BGN/year
Total Warehouse Costs	14,561	25,254	BGN/year
Total Costs	22,192	32,885	BGN/year

Table 5. Possible costs for different service levels

P, Service level	0.8	0.85	0.9	0.95	0.999
z	0.842	1.036	1.282	1.645	3.09
ss(C_L=0) liters	10,336	12,728	15,739	20,200	37,952
Total Costs BGN/year	18,363	19,081	19,984	21,322	26,648
ss (C_L>0) liters	26,286	32,370	40,027	51,374	96,517

3 CONCLUSIONS AND RECOMMENDATIONS FOR THE LOGISTICS CHAIN OPERATIONS

For the presented model the following results are obtained:

1. For low turnover station – the number of orders per year at constant and fluctuating demand is 121.41; the interval between two orders at constant and fluctuating demand is three days, the total costs of inventory management at constant demand are 7392.97 (BGN), while at fluctuating – 8,936.93 BGN;

2. For high turnover station – the number of orders per year at constant and fluctuating demand is 1,755.43; the interval between two orders at constant and fluctuating demand is two days; the total costs of inventory management at constant demand are 11,322.94 BGN, while at fluctuating– 14,448.59 BGN.

3. For the oil base – the number of orders (supplies) per year at constant and fluctuating demand is 254.36; the interval between two orders at constant and fluctuating demand is 1.43 days; the total costs at constant demand are 22,191.53 BGN, while at fluctuating– 32,884.77 BGN.

4. While keeping greater safety stock, the share of the satisfied demand is also increasing, but this leads to increased warehouse stocks. The costs taken into consideration are only associated with inventory management in the different units of the final stage of supply chain. These costs compared to total operating costs of the company (related to product acquisition, transport, opening and closing operations in the different subsystems of the logistics chain, excise taxes, insurance, etc.) could help its strategic and financial management.

5. The annual costs could increase by 24% at low turnover station, by 33% at high turnover station and by 45% at the oil base, when selecting service levels between 0.8 and 0.999%. Calculations show that the costs are increasing progressively, but upon reaching the 0.95% percentage of service and at a very high confidence coefficient of probability the costs increase sharply until they reach 0.999% of service. So if the managers of company want to have a maximum level of service, they should make huge investments.

6. In the first and second phase of the logistics chain the transport systems have sufficient capacity to satisfy supplies for the oil base in the worst case of scenario - maximum demand with a high level of service;

7. Maritime and railway transport systems with their connecting units can operate with a high degree of reliability within the investigated variations and described technological solutions, which ensure the competitiveness of the company.

8. The concept of an integrated approach to logistics management of processes in the chain allows the identification of weak points and also simulation of different strategies for their management.

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