APPLICATION OF THE METHODOLOGY FOR CALCULATING CARGO HANDLING TARRIFS AT RIVER PORTS

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Abstract: *In this paper, we will discuss several methodologies for calculating cargo handling tariffs at river ports. We will present port tariffs calculations based on the Principle of total costs and present the methodology. We will apply described methodology on one case study: Port "Danube" Pancevo.*

Keywords*: River ports, Cargo handling, Port tariffs*

1. INTRODUCTION

Port pricing issues are often analyzed in the context of port revenue and cost recovery. However, the process of privatization, introduction of competition and liberalization is forcing these tariffs be determined according to market mechanisms. Growing number of ports are implementing market pricing when determining tariffs. Market pricing is the method of associating port tariffs to potential market demand and sensitivity in order to maximize cash flow, attain good utilization of facilities, counter competition, stimulate market growth and improve profitability. When implementing market pricing, it is important to guarantee that the full rate traffic is not diverted to the lower rate in an attempt to generate a higher volume of business. Existing tariff levels, costs, competition, agreements with shipping companies and market sensitivity should be carefully evaluated (Trujillo and Nombela, 1999).

Port operators are required to establish a detailed and precise tariff structure. Frequent changes can be a source of confusion for port users. Therefore, the structure of port tariffs should be designed to last for a long period of time (ESCAP and KMI, 2002).

Ports tend to follow the following goals when determining tariffs (ESCAP and KMI, 2002):

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- Promote the most efficient use of facilities - the main goal of port charging is to ensure that port facilities are used in the most efficient way.
- Retain the benefits that results from investments within the country - the goal of setting port tariffs is of particular interest to ports in developing countries.
- Return sufficient revenue to meet financial goals - this goal relates to the construction of financial reserves to prepare for unexpected revenue losses or an increase in costs.

Also, the important objectives that the tariff system needs to fulfill are (ESCAP and KMI, 2002):

- Establishment of a clear structure for the fair and flexible business relationship between port operators and users.
- Prevention of double payments.
- Development of congestion prevention mechanisms: Port congestion can occur when traffic is increasing, and the port's capacity remains unchanged. In this situation, congestion can be prevented by introducing tariffs to prevent congestion.
- Simplification of the tariff system of the port, from which it is easy to find out who pays and how much.

The main objective of this work is to determine port tariffs based on the Principle of total costs, which is discussed in the following section. We will present it on one example: Port "Danube" Pancevo.

2. DESCRIPTION OF THE EXISTING METHODOLOGIES FOR CALCULATION OF PORT TARIFFS

For all port tariffs charged for specific services or for the use of a clearly identified port's infrastructure, it is proposed that the term: *specific port tariff (tarif portuaire specifique, tarifa portuaria especifica)* should be used. This general term will apply to such varied tariffs as: berth occupancy; berthing/unberthing; pilotage; towage; mooring, stevedoring; cargo-handling on quay; receiving/delivery, storage; warehousing; rent of equipment, etc. These tariffs are usually based on the costs incurred in providing the services and are dependent on types of costs taken into consideration (United Nations Report, 1975).

There are three basic groups of tariffs: tariffs associated with the provision of services; tariffs associated to the provision of facilities; and general tariffs (Value-based, corresponding to the value of the vessel, and cargo). These three groups of tariffs can be determined by different cost-based pricing approaches, average cost pricing, variable cost pricing, marginal cost pricing, and total cost pricing:

(a) Average cost pricing: This pricing approach is based on the average cost determined by adding the total fixed and variable costs and dividing this sum by the projected demand for the service. Port tariffs so derived have the advantage of assuring that the revenues collected will equal the total costs, assuming that the projected demand is realized. This approach gives priority to achieving an overall financial target, namely a nonsubsidized price. For ports with a high proportion of fixed costs, increasing the throughput may significantly decrease the average or per unit cost. A disadvantage of average cost pricing is that there is a tendency to set prices higher when demand is weak, and lower when demand is high. Furthermore, this approach excludes those clients that cannot afford to

pay a given price, but might be able to pay a lower one, perhaps one based only on the variable cost (United Nations Report, 1975).

(b) Variable cost pricing: Pricing based on the unit variable cost is determined by dividing the total variable costs by the projected demand for the services and the facilities. In general, this approach is only appropriate where variable costs are a large share of the total costs as in labor-intensive break-bulk cargo handling operations due to the use of temporary labor. Tariffs based only on variable costs have generally not been introduced, even though they encourage efficient use of port resources. The reason is that many port services and facilities have variable costs that are too small to serve as the basis for a tariff and to cover the port's expenditures. If a tariff is based on variable costs, the losses incurred need to be offset by other tariffs. However, the pricing based on variable costs can achieve the operational objective of maximizing the use of services and the financial objective of covering the variable costs of these services (United Nations Report, 1975).

(c) Marginal cost pricing: Pricing based on the unit marginal cost is determined by dividing the marginal costs by the projected marginal demand for the services. The tariff based on the unit marginal cost requires that the relationship between variable costs and expected throughput demand be known for the period during which the price will prevail. Therefore, it is necessary to estimate the change in resource productivity as demand increases. This information is difficult and time consuming to obtain. Change in variable costs over a long period of time must be correlated with variations in demand. These inherent problems have led to unit marginal costs not being used to set port tariffs, except where explicit surcharges have been introduced to cover overtime, a third shift, or holiday premiums for labor. It may be useful to set the level of port charges of seasonal traffic on the basis of unit marginal costs because it is inefficient to provide additional capacity for these relatively short periods. Furthermore, there is a tariff ceiling, which is determined by the degree of congestion of the facilities, as users face much higher operating costs than the actual charge applied by the port authority. Marginal cost pricing, however, has some problems. First, it is very difficult to estimate and distribute the marginal costs, particularly the estimation of the short-term and the long-term marginal costs, and the distribution of the marginal costs among the charge items. Second, marginal cost pricing should be based on competitive market principles. But the port industry is characterized by monopoly. Third, if a port authority suffers from a shortage of demand and makes operation losses amounting to the balance between the marginal costs and average costs, then compensation from other sources should be made. For these reasons, marginal cost pricing has some limitations as a basic port pricing theory, even though it is economically efficient, flexible and the fairest pricing tool (United Nations Report, 1975).

(d) Total cost pricing: The Principle of total costs is the method of determining tariffs where both fixed and variable costs are included. It is applied when all services are the same. This principle is often used in the economy sector that is regulated or partially regulated (Bugarinović, 2014). Most costs related to infrastructure are fixed and include the capital costs and the maintenance costs caused by wear and tear during operation. Utilities are also treated as fixed costs, unless they are explicitly related to the activity on the berth, i.e. power for crane operations, or provided to vessels (electricity and water). Capital costs of equipment, salaries and benefits of permanent staff, and administrative expenses are also considered in this category. Variable costs include: expenditures on fuel, lubricants, and other consumables used in the operation of equipment; expenditures on scheduled maintenance and repairs related to equipment use; payments for equipment

rented on a daily or weekly basis; the wages of casual labor hired on a daily or shift basis; and overtime of permanent staff (United Nations Report, 1995).

In this paper, we used the economic principle for tariffs calculation based on total costs.

3. METHODOLOGY APPLICATION. CASE STUDY: PORT "DANUBE" PANCEVO

One of the most important services provided to cargo vessels at ports is what is generically labeled as *cargo handling*. This includes all services related to the movement of cargo from/to vessels and across port facilities. Cargo handling services are very important for port users in terms of total tariffs. Since these tariffs significantly affect a port's competitive position, it is crucial that they are closely related to the real costs of services provided F In other words, the inland port operating companies or port operators are interested in precise calculation of costs of provided port services.

This paper considers Port "Danube" Pancevo which provides a large number of services to port users for different types and sizes of cargo. Different types of infrastructure and suprastructure are used for different services, and considering that different services require a different number of employees, for each individual port service it is necessary to determine a correct tariff.

At the Port “Danube” Pancevo, we looked at the fertilizer unloading service and considered the service of unloading fertilizer in bulk from the vessel by a quay crane. The fertilizer handling technology at the Port "Danube" Pancevo is described in detail in the work of Pjevčević et al. (2013, 2018). Self-propelled cargo vessels bring fertilizer to the port. Vessels carrying capacities are assumed to be 1000 tons. Unloading operations are done at loading/unloading areas using quay cranes. The loading/unloading area is adjacent to the berth which is under the cranes. Once a full vessel is berthed to unload fertilizer, it will remain in its location until an unloading process is completed. Bulk fertilizer is unloaded from a vessel by a quay crane, and loaded into a fertilizer-packing machine, which is placed at the loading/unloading area adjacent to the berth. A fertilizer-packing machine is used to pack fertilizer into plastic bags which weigh 50 kg each. Afterwards, bags are transported by a belt conveyer to the temporary storage area where they are palletized and prepared for further distribution.

In order to determine the port tariff, it is necessary to calculate total costs that the Port has when carrying out cargo unloading service from a vessel to the loading/unloading area adjacent to the berth. Total port costs, T (EUR / h), consist of: Berth costs, T_b (EUR / h), Quay crane costs, T_r (EUR / h), Labor costs, T_l (EUR / h), Shipping companies costs, T_s (EUR / h) and Cargo costs, T_u (EUR / h).

The objectives of the pricing system must be related to the strategy of the port. The first task is the estimation of future levels of traffic as it will determine the total revenue generated (United Nations Report, 1995). Therefore, the annual throughput of fertilizer that the Port could expect was forecasted by the Least Squares Method and it was 69889 t (Prskalo, 2018). Assuming that fertilizer is delivered to the Port by vessels of the carrying capacity of 1000 t, we can calculate the number of vessels to be unloaded. It is necessary to unload 70 vessels at the Port.

3.1 Berth costs

We assumed that the inland port operator is the owner of port's infrastructure. Under this assumption, costs of one berth can be calculated as the costs of depreciation and maintenance of the area used for unloading fertilizer. For the calculation of the costs of construction of one berth, we have assumed that the price per working meter of the berth is 25000 EUR / m and the lifetime is N = 50 years. Thus, the costs of constructing one berth in the length of 120m amount to 3 M EUR. We assumed that annual maintenance cost for the berth is 2 % of the construction cost, which is 60000 EUR (Thoresen, 2010).

Costs of depreciation and maintenance of one berth are

$$B = \left[B_i \cdot \frac{i \cdot (1+i)^N}{(1+i)^N - 1} + M_b \right] \cdot \frac{1}{365 \cdot 24} \quad \left[EUR / h \right] \tag{1}$$

$$B = \left[3000000 \cdot \frac{0.12 \cdot (1+0.12)^{50}}{(1+0.12)^{50} - 1} + 60000 \right] \cdot \frac{1}{365 \cdot 24} = 41.24 \quad \left[EUR / h \right] \tag{2}$$

Therefore, Berth costs are equal to 41.24 [EUR / h].

3.2 Quay crane costs

At the Port "Danube" Pancevo, the fertilizer unloading is carried out at one berth with one quay crane. The production rate of the crane in the realization of the considered unloading task is calculated in the work of Prskalo (2018), and it equals 201.33 t / h.

For the calculation of depreciation, we assumed that the price of the crane was 1000000 EUR, and that the lifetime of the crane is 20 years. We assumed that the annual maintenance cost of the crane is 2% of the price of the crane (Thoresen, 2010). Under these assumptions, the costs of depreciation and maintenance of a crane are 17.56 [EUR / h].

3.3 Labor costs

For our calculation, we assumed that the navigation period is 300 days due to unfavorable weather conditions during January and February. We assumed that the fertilizer is unloaded during one 8 hour long shift. When we multiply the navigation period with working hours and the number of shifts, we get the annual working hours of the Port in hours (2400 h).

The vessels' arrival rate, λ, is calculated as 70 / 2400 and is 0.0291 [vessels / h]. The vessel's service time, *t*, is obtained by dividing the self-propelled cargo vessel carrying capacity with the production rate of the crane. It is 4.966 h. The minimum working time of the team of workers by one vessel is 4 h. The paid working time of the team is the maximum of the minimum working time of the team and the vessel's service time, which is 4.966 h.

We calculated the labor costs as the product of the arrival rate of vessels, the paid working time of the team, and the cost of one team of workers, which is assumed to be 35 [EUR / team-hour] (Milešić, 2018). Therefore, labor costs are 0.0291*1*4.966*35, which is equal to 5.05 [EUR / h].

3.4 Shipping companies' costs

The model of the classic single-channel Erlang queuing system is used in order to determine the vessel's average waiting time at the Port. The input parameters are the service rate and the vessels' arrival rate. The M/M/1/∞ queuing system, the simplest queuing system, has a Poisson arrival distribution, an exponential service time distribution and a single channel (one server). It is assumed that there is just a single queue (waiting line) and vessels move from this single queue to the berth (server). The length of the queue is indefinite.

The service rate is the number of vessels that the Port can serve per hour:

$$\mu = \frac{1}{t+m} = \frac{1}{4.966+1} = 0.168 \quad \left[vessels/h\right] \tag{3}$$

where *m* is a maneuvering time [h].

We assumed that the maneuvering time was 1h (Prskalo, 2018).

Average vessel's delay or waiting time is calculated as:

$$w = \frac{1}{\mu-\lambda} - \frac{1}{\mu} = \frac{1}{0.168-0.0291} - \frac{1}{0.168} = 1.247 \quad \left[h\right] \tag{4}$$

The total time that a vessel spends at the Port is particularly important because it is the part of the costs of using the vessel, and therefore can affect the ability of the shipping company, to maximally use resources. We assumed that the total agreed-upon time that the vessel spends at the Port is 5 hours (Prskalo, 2018). The cost of any additional hour is 41.67 [EUR / h] (Prskalo, 2018).

In this example, the vessel stayed at the Port 2.199 hours longer than the agreed-upon time:

$$s = w + \frac{1}{\mu} - 5 = 1.247 + \frac{1}{0.168} - 5 = 2.199 \quad \left[h\right] \tag{5}$$

We can calculate shipping companies' costs as follows:

$$T_s = \lambda \cdot s \cdot S \quad \left[EUR/h\right] \tag{6}$$

where:

s - time that a vessel spends at the Port over agreed-upon time [h]
S - unit cost of the vessel at the Port [EUR/h]

$$T_s = 0.0291 \cdot 2.199 \cdot 41.67 = 2.66 \quad \left[EUR/h\right] \tag{7}$$

3.5 Cargo Costs

In our calculation, we assumed that the cargo waiting costs at the Port are 20 [EUR/h]. We calculated cargo costs by multiplying the vessels' arrival rate with the average time that the vessel spends at the Port longer than agreed-upon time, and the unit cargo waiting costs at the Port.

$$T_u = 0.0291 \cdot 2.199 \cdot 20 = 1.28 \quad \left[EUR/h\right] \tag{8}$$

3.6 Total costs

As stated above, the total costs of the Port when unloading the forecasted amount of bulk fertilizer from vessels to the loading/unloading area are:

$$T = 41.24 + 17.56 + 5.05 + 2.666 + 1.28 = 67.8 \quad [EUR/h] \quad (9)$$

3.7 Cargo handling tariff

In order to establish the appropriate tariff for the fertilizer unloading service, it was first necessary to calculate the costs incurred when unloading the fertilizer. The unit total costs of the Port per ton of fertilizer is obtained as annual total costs divided by the annual amount of fertilizer which equals 0.489 [EUR / t].

3.8 Sensitivity analysis

Many variables, including the future performance and prices of the port facilities and services will affect the future tariffs and traffic, and some of them cannot be controlled by the port operator (United Nations Report, 1995).

For example, if the costs of one team of workers increase from 35 [EUR /team-hour] to 45 [EUR / team-hour], labor costs will be 6.5 [EUR /h], and the total costs will be 69.25 [EUR /h]. According to the applied methodology, a tariff based on the unit total costs of 0.499 [EUR / t] would cover expenses incurred in fertilizer handling on quay provided that the annual throughput of fertilizer was at least 69889 t.

For example, if the cargo waiting costs at the Port increase from 20 [EUR/h] to 30 [EUR/h], total costs will be 68.44 [EUR /h]. According to the applied methodology, a tariff based on the unit total costs of 0.493 [EUR / t] would cover expenses incurred in fertilizer handling on quay provided that the annual throughput of fertilizer was at least 69889 t.

4. CONCLUSION

Of the total costs involved in moving goods through a port, cargo handling costs are the most important (between 70% and 90% of the total costs, approximately, depending on the type of cargo) (Trujillo and Nombela, 1999). As cargo handling costs are important to port users, these costs are of utmost importance to port operators as well. Therefore, this is one of the services that must be supervised more closely by regulators in order to ensure cost-efficient port operations. The tariffs have to be correctly calculated so that all incurred costs are covered.

According to the applied methodology, a tariff based on the unit total costs of 0.489 [EUR / t] would cover expenses incurred in fertilizer handling on quay provided that the annual throughput of fertilizer was at least 69889 t.

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