Transportation Research Part E 88 (2016) 1–10

Contents lists available at ScienceDirect

Transportation Research Part E

journal homepage: www.elsevier.com/locate/tre

Port economic cost functions: A service perspective

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ARTICLE INFO

Article history:
Received 17 July 2015
Received in revised form 5 December 2015
Accepted 7 December 2015
Available online 13 February 2016

Keywords:
Quality of port services
Port cargo throughput production function
Port service economic production function
Port cargo throughput cost function
Port service economic cost function
Port longrun multi-service economic joint cost function

ABSTRACT

Ports provide services rather than producing physical products. However, port cost functions specify port cost as functions of physical products, e.g., port cargo throughput long-run cost is a function of port resource prices and cargo throughput (a physical product). In comparison, port cargo service long-run cost is a function of port resource prices, cargo service and shipper cargo received. The shipper provides cargo that is serviced by the port. A service cannot be touched and its user is involved in its provision. This paper derives port cost functions for which port outputs are "service outputs", e.g., cargo, vessel and vehicle services.

1. Introduction

The port cost literature describes port outputs as "service outputs" but measures port outputs as "physical outputs" in empirical port cost functions. Jara-Diaz et al. (2002), for example, describe port outputs as representing "port activities, and they include the movement of containerized general cargo, non-containerized general cargo, dry bulk and liquid bulk" (p. 423) but measure port outputs in thousands of tons of cargo received by a port in an empirical port cost function. Jara-Diaz et al. (2005, p. 275) describe port outputs in terms of cargo handling in ports being "a multioutput activity as freight can arrive in many forms such as containers, bulk, rolling stock or con-containerized general cargo" but measure port outputs in thousands of tons of cargo received by a port in an empirical port cost function. The cargo handling service provided by the port in passing cargo through the port is not considered.

This paper derives port cost functions for which port outputs are "service outputs". For example, port cargo service, port vessel service and port vehicle service long-run economic cost functions are derived and compared to port cargo throughput, port vessel throughput and port vehicle throughput long-run economic cost functions for which port outputs are "physical outputs." A port multi-service long-run non-joint economic cost function is also derived and compared with a port multi-throughput long-run non-joint economic cost function. A non-joint economic cost function has the restrictive assumption that the multiple outputs of a firm do not share the firm's resources in their provision (Talley, 1988, p. 82). A port multi-service joint long-run economic cost function for which the services are port cargo, vessel and vehicle services is also derived. An underlying assumption of a multi-service joint economic cost function is that the firm's multi-services share one or more of the firm's resources in their provision. Since port services share port resources in their provision (Talley and Ng, 2015), a port multi-service joint economic cost function is more representative of a port's multi-service economic cost function than a

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http://dx.doi.org/10.1016/j.tre.2015.12.002
1366-5545/

port non-joint multi-service economic cost function. The paper also provides a logical approach for selecting quality-of-service measures (or operating options) for port cargo, vessel and vehicle services.

The following section distinguishes between a port cargo throughput and a port cargo service economic production function. In Section 3, port throughput long-run economic cost functions for cargo, vessel and vehicle throughputs are derived. In Section 4, port service long-run economic cost functions for cargo, vessel and vehicle services are derived. A logical approach for selecting port quality-of-service measures is used to select specific port quality-of-service measures for port cargo, vessel and vehicle services. These measures may, in turn, be used as port performance indicators for evaluating the performance of a port in the provision of cargo, vessel and vehicle services. In Section 5, port multi-throughput and multi-service long-run economic non-joint cost functions are derived and compared. In Section 6, a port multi-service long-run economic joint cost function is derived, followed by conclusions in Section 7. It is to be noted that derived cost functions are general, and are thus independent of port cargo, vessel and vehicle type, and so on.

2. Port cargo throughput and service economic production functions

A port is technically efficient when it utilizes its resources to maximize output (as exhibited by a port economic production). The dependent variable of port cargo economic production functions appearing in port DEA studies (Cullinane, 2010; Cullinane and Wang, 2010; Cullinane et al., 2006) is port cargo throughput, i.e., the amount of shipper cargo that enters and then leaves the port or passes through the port. The DEA port cargo economic production function may be written as:

$$Port\ Cargo\ Throughput = f(R_1, R_2, \ldots R_j \ldots R_J) \tag{1}$$

where R_j is the port's jth resource.

A theoretical shortcoming of port cargo throughput economic production function (1) is its literal interpretation of a port producing output, i.e., port resources are used to produce (or manufacture) port cargo throughput. This interpretation is supported by the fact that production functions of the form of production function (1) are production functions that appear in economics textbooks for firms that produce or manufacture outputs (McGuigan et al., 1999). However, we do not observe ports producing (or manufacturing) throughputs, but rather providing services (Talley et al., 2014). In empirical DEA container port throughput production function studies utilizing production function (1), the cargo throughput output of a container port is measured by the number of TEUs of cargo received by the port and passed through the port, i.e., port TEU throughput (see Cullinane et al., 2006). However, there is no measure of the service provided by the port in passing cargo through the port.

Services (or service outputs) have four characteristics that distinguish them from goods (or physical outputs) as found in Baltacioglu et al. (2007), Cho et al. (2012), Sampson and Froehle (2006) and Van der Valk and Rozemeijer (2009). First, a service is *intangible*, i.e., a service cannot be touched, seen, tasted or smelt (e.g., "the transportation service" of cargo via ship from port A to port B cannot be touched). Second, a service is difficult to standardize and thus has the characteristic of *heterogeneity*, since its quality can vary in its provision (e.g., the quality of the transportation service of cargo via ship from port A to port B may be slow or fast). Third, a service is *perishable*, i.e., if not consumed when available, it cannot be saved for future use (e.g., if a shipper's cargo is late in arriving at a port and thus being placed on a ship and the ship departs without the shipper's cargo, then this ship trip is perishable for the shipper since it cannot be saved for future use by the shipper). Fourth, a service has the characteristic of *simultaneity*, i.e., at least two distinct parties must be involved in its provision. Alternatively, if either party is unwilling to be involved in the provision of a service, then the service will not occur or be provided, i.e. in order for port cargo service to occur, a "shipper" must be willing to provide cargo via a carrier to a port for port service and the "port" must also be willing to accept this cargo and provide it with port cargo service. Similarly, in order for passenger transportation service to occur, for example, a carrier must be willing to transport an individual as a passenger and the individual must be willing to be transported by the carrier as a passenger.

A firm economic production function for a "service output" relates the maximum amount of the "service output" provided by the firm to the amounts of resources utilized by the firm in its provision and what "customers usually contribute to the production process" (Baltacioglu et al., 2007, p. 109). For a Port Cargo Service production function to exist, the shipper must be willing to provide cargo to a port via a carrier and the port must be willing to accept this cargo for which it provides port cargo service.

A port cargo service economic production function "denotes the maximum cargo service that can be provided by a port, given the amount of cargo received by the port to be serviced and the amounts of various resources utilized by the port in the provision of the port cargo service" (Talley et al., 2014, p. 237). A port cargo service economic production function thus may be written as:

$$Port\ Cargo\ Service = cs(R_1, R_2, \ldots R_j \ldots R_J; Cargo\ Received) \tag{2}$$

The difference between the explanatory variables appearing in functions (1) and (2) is that the Port Cargo Service production function (2) has the additional explanatory variable, Cargo Received. The latter represents what the shipper contributes to the provision of Port Cargo Service and the resources in production function (2) are what the port contributes to the provision of Port Cargo Service. Thus, Port Cargo Service production function (2) adheres to the service characteristic of "simultaneity."