PORT OWNERSHIP AND PRODUCTIVE EFFICIENCY: THE CASE OF KOREAN CONTAINER TERMINALS

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Abstract

In an effort to improve efficiency and economic performance of a port industry, a number of countries have considered or have already undertaken institutional reforms that may include policies of commercialisation and/or privatisation. Economic theories and existing empirical studies, however, fail to provide clear-cut evidence that the economic performance of private ports or terminals is better than their public sector counterparts. This paper proposes the econometric method of the *frontier model* as an appropriate analytical tool for the measurement of container terminal efficiency.

INTRODUCTION

Just as the 1970s and the 1980s were the era of enormous capital investment in the port industry, it seems certain that the late 1980s and the 1990s will become known for port sector reorganisation. In an effort to improve efficiency and performance and to reduce the government's financial burden in supporting a very capital intensive industry, a number of countries have considered, are in the throes of or have already undertaken institutional reform (e.g. commercialisation and privatisation) of their port industry.

Korea is no exception to this prevailing trend. Parallel with the Korean government's general economic policies of privatisation and liberalisation, as a means of solving problems related to port congestion and other sources of inefficiency, the port authority of that country has launched several new port and terminal development schemes aimed at attracting private and foreign finance (Cullinane and Song, 1998). As the government implements its plan to bring private capital into both existing and future port facilities, new policies are opening up Korean ports to competition. In addition, a degree of privatisation is sought whereby the costs and returns to port operation can be shared between the government and private sector concerns.

The motives for privatisation are complex and varied, but one important claim made is that the transfer from public to private ownership improves economic efficiency and hence financial and operational performance. Economic theories and existing empirical studies, however, fail to establish clear-cut evidence that private enterprises perform better than their public counterparts. This phenomenon may reflect, to some extent, a paucity of performance indicators which can be systematically applied across enterprises and industries to allow a comparative analysis of performance to be undertaken. It is essential, therefore, to have a system of privatisation impact evaluation which can be widely applied and to provide a systematic and practical analytical framework to assess the results of privatisation.

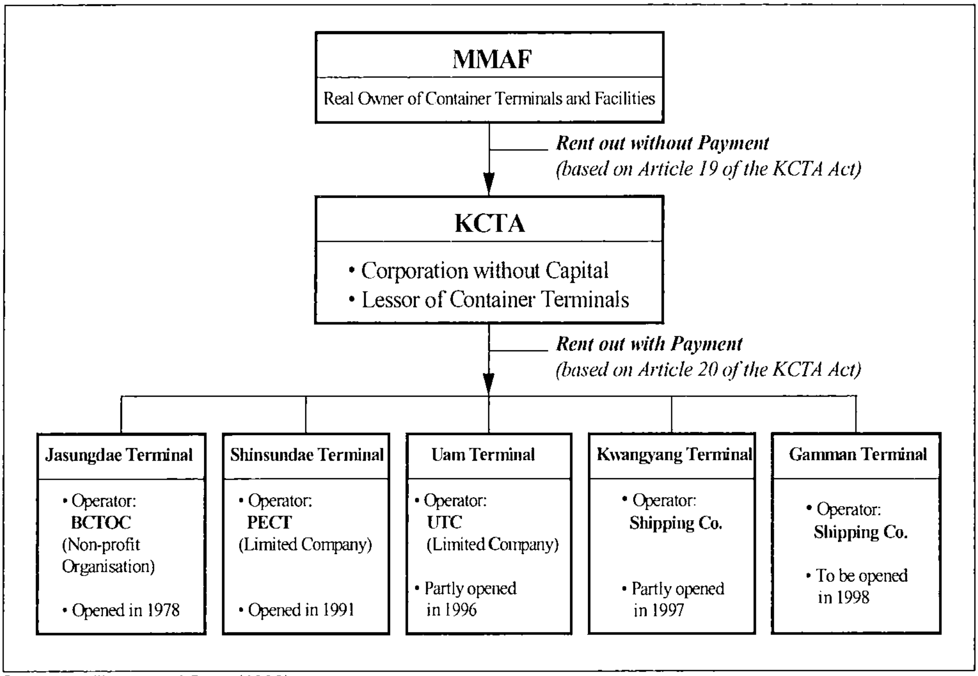
In this context, this paper critically reviews the administrative and managerial characteristics of Korean container terminals and proposes the use of an econometric method known as the *frontier model* as an appropriate analytical tool for measuring the relative efficiency of terminals. This resulting measures provide, therefore, some insight into whether or not container terminals which are privately owned and operated perform better than public ones.

KOREAN CONTAINER TERMINALS

As far as the administration of container terminals in Korea is concerned, the Korea Container Terminal Authority (KCTA) has played a central role. All of the container terminals in Korea are controlled, managed, operated, and supervised by the KCTA, a public organisation. Before the KCTA was established, the development and operation of ports in Korea was entirely dependent upon government funds. This system caused problems because of the inflexibility of the budget and the bureaucratic procedures for obtaining the funds necessary for port development and maintenance, thus resulting in a situation where the required financing had neither been provided in sufficient quantity nor at the right time.

In order to overcome this shortfall in available finance, the government passed the KCTA Act and in 1990 established the KCTA on the basis of the legislation embodied in this Act. One of the main objectives of creating the KCTA was to ensure that profits accruing from the operation, management, and development of a container terminal should be reinvested into the further development and maintenance of that container terminal, and that the sources of finance be sufficiently diversified to facilitate the efficient development and operation of container terminals.

The KCTA currently controls and supervises the Jasungdae, Shinsundae and Uam terminals in Pusan together with the Kwangyang terminal located in the South-West of the country. These are all leased without payment by the KCTA from the government (i.e. from the Ministry of Maritime Affairs and Fisheries, MMAF). The KCTA then rents out these terminals to each terminal operator in return for payment: the Jasungdae terminal to the Busan Container Terminal Operation Corporation (BCTOC), the Shinsundae terminal to the Pusan East Container Terminal Company (PECT), the Uam terminal to the Uam Terminal Company (UTC), and other terminals to private companies, mainly shipping and transportation companies. A schematic of this administrative system is shown in Figure 1.



Source: Cullinane and Song (1998)

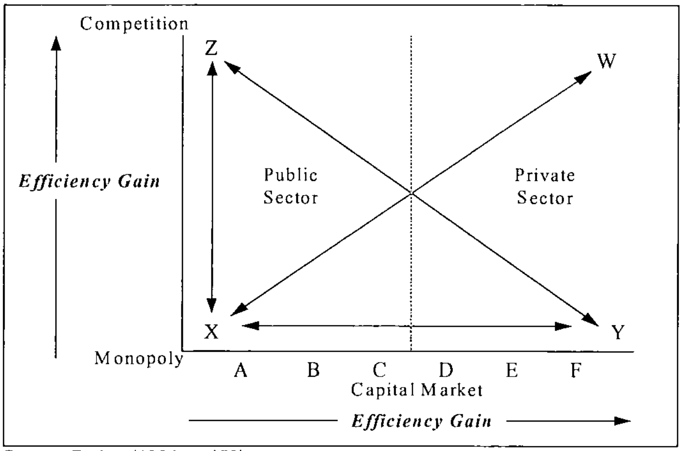
Figure 1 - Korea's Container Terminal Administration

As can be seen in Figure 1, the Jasungdae container terminal is operated by the BCTOC, which was founded in 1978 as a non-profit making public organisation and was the first organisation to introduce the container terminal concept to Korea. On the other hand, limited companies (i.e. the PECT and UTC) operate the Shinsundae and Uam container terminals. Figure 1 shows that there are three different entities which are influential in controlling container terminal operations in Korea; the terminal operators themselves (i.e. BCTOC, PECT, UTC and other private companies) who are subject to the supervision of the KCTA, which is in turn dependent upon the MMAF. This hierarchy gives much power to the MMAF acting on behalf of the government, indicating that the government has been and remains heavily involved and wielding much influence over the processes of management, operation and development of container terminals in Korea.

PRIVATISATION AND EFFICIENCY

The Central Hypothesis

In simple terms, to privatise is to transfer the ownership of an asset to private hands from public ones. Smith (1776) argued that the economy was led, as if by an invisible hand, to produce what was desired and in the best possible way. This perspective implies that private ownership improves productivity and efficiency, hence enhancing economic performance. While advocating only a limited role for government, he attempted to show how competition and the profit motive would lead individuals, in pursuing their own private profit objectives, to serve the public interest. As illustrated in Figure 2, Parker (1994) attempt to set up a framework for testing the importance of ownership.



Source: Parker (1994, p. 153)

Figure 2 - A Conceptual Mapping of Efficiency Improvements

Point A represents the position of a firm which is directly controlled by a government department. Point B represents an activity undertaken by a government agency which has some, if limited, autonomy from the political process. Public corporations can be placed at point C. Points D, E and F correspond to forms of ownership in the private sector. Point D includes those private sector firms which are close to the public sector because of government funding or a reliance on government contracts. Point E is a joint stock company, while point F represents private ownership where property rights are least attenuated, particularly the owner-manager company.

With regard to the vertical axis, movement upwards corresponds to a shift away from monopoly towards competition and, thus, towards greater pressure in the product market to be efficient. Figure 2, therefore, provides a mapping of the expected relationship between ownership and performance, drawn from the theories of public choice and property rights, and competition and performance. The largest efficiency gains are likely to be associated with movements from X to W where there is a simultaneous movement towards both private ownership and greater competition. Any movement between Z and Y (in either direction) implies an ambiguous result arising out of the conflicting influences on managerial behaviour brought about by simultaneous, though contradictory, changes in both the product and capital market.

Empirical Evidence

After testing the hypothesis that ownership affects economic performance, Parker (1994) concludes that although it is dangerous to draw firm conclusions from a small sample, the results do not contradict the view that privatisation improves performance and they provide some support for the argument that political intervention in an organisation's operations damages efficiency. In contrast, Hutchinson (1991) reports that the empirical evidence gives mixed results as to the effects of ownership on the performance of firms in the UK. After testing several industries in several countries, Millward and Parker (1983) draw the conclusion that there is no systematic evidence that public enterprises are less cost effective than private firms. Table 1 provides a summary of the empirical evidence on the relative performance of different ownership types. Although the table suggests an 'edge' for the private sector, the results vary considerably across the sectors.

Table 1 - Results on Relative Efficiency of Public and Private Enterprises

Sectors	Public Company More Efficient	No Difference or Ambiguous Results	Private Company More Efficient
Electric Utilities	3	5	6
Refuse Collection	1	3	5
Water Supply	2	1	4
Health-related Services	-	1	11
Airlines	-	3	2
Railroads	-	2	-
Financial Institutions	-	1	1
Fire Services	-	-	1
Nonrail Transit	-	-	3
Total Number	6	16	33

Note: Figures in cells indicate the number of empirical results available in each industry sector.
Source: Compiled from Boardman and Vining (1989, p. 6)

From the above discussion, the evidence does not establish a clear-cut superiority of private ownership over its public counterpart. The highly political nature of privatisation makes it difficult to assess the truth of many claims made for and against it. As Liu (1995) points out, the problem of determining the relative efficiencies of alternative forms of ownership is, therefore, solved through empirical analysis.

ECONOMIC EFFICIENCY

In economic theory, costs can exceed their minimum feasible level for one of two reasons. One is that inputs are being used in the wrong proportions, given their prices and marginal productivity. This phenomenon is known as *allocative inefficiency*. The other reason is that there is a failure to produce the maximum amount of output from a set of given inputs. This is known as *productive inefficiency*. Both sources of inefficiency can exist simultaneously or in isolation. These sources of inefficiency can be easily explained by using the concept of a production function.

Suppose that a firm's frontier production function, as depicted in Figure 3, is $Y = f(x_1, x_2)$, where two inputs, x_1 and x_2, are used to produce one output, Y, and that the function is characterised by constant returns to scale. The isoquants, Y_A and Y_B, indicate all possible combinations of x_1 and x_2, which give rise to the same level of output. Assume that the firm's efficiency is observed at point A, rather than C. This position is neither allocatively nor productively efficient. Its level of *productive efficiency* is defined as the ratio of OB/OA. Therefore, productive inefficiency is defined as 1-(OB/OA). The level of *allocative efficiency* is measured as OD/OB (or C_1/C_2). Thus allocative inefficiency is defined as 1-(OD/OB).

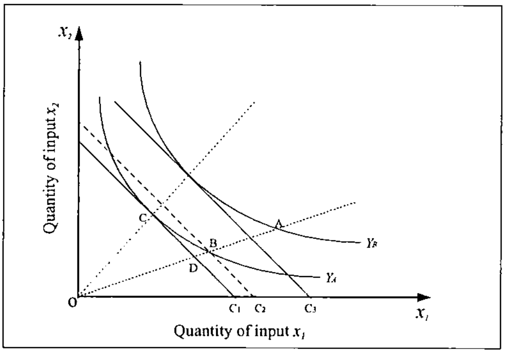


Figure 3 - A Firm's Production Function Frontier

Consider position B. At this point, the firm is allocatively inefficient since it can maintain output at Y_A but reduce total costs by changing the input mix to that which exists at point C. At point B, however, the firm is productively efficient since it cannot increase output with this input combination of x_1, x_2 and given a suboptimal input mix (i.e. allocative inefficiency), the firm has minimised the cost of producing this level of output.

THE FRONTIER MODEL

Over the last decade a number of methods for measuring efficiency have been proposed, all of which have in common the concept of the frontier; efficient units are those operating on the cost or production frontier, while inefficient ones operate either below the frontier (in the case of the production frontier) or above the frontier (in the case of the cost frontier). Bauer (1990) pointed out reasons why the use of frontier models is becoming increasingly widespread. One of them is that deviations from a frontier have a natural interpretation as a measure of the efficiency with which economic units pursue their technical or behavioural objectives.

The literature on frontier models begins with Farrell (1957), who suggested a useful framework for analysing economic efficiency in terms of realised deviations from an idealised frontier isoquant. A distinction exists between the methods employed to derive the specification of the frontier model: either *statistical* or *non-statistical* methods may be used. The former technique makes assumptions about the stochastic properties of the data, while the latter does not. Another difference concerns whether the chosen method is *parametric* or *non-parametric*. While the former imposes a particular functional form, the latter approach does not. The non-parametric approach revolves around mathematical programming techniques which are generically referred to as data envelopment analysis (DEA). The parametric approach, on the other hand, employs econometric techniques where efficiency is measured relative to a frontier production function which is statistically estimated.

Econometric approaches have a strong policy orientation, especially in the assessment of alternative industrial organisations and in the evaluation of efficiency in government and other public agencies, while mathematical programming approaches have a managerial decision-making orientation (Fare et al., 1994; Lovell, 1995). This property of the econometric approaches more closely supports the purpose of this paper, especially since they have a more solid grounding in economic theory (Forsund et al., 1980; Pitt and Lee, 1981; Bauer, 1990). In addition, several studies (e.g. Oum and Waters, 1996) have compared the performance of alternative methods for measuring efficiency, focusing on the econometric method (in particular, the stochastic frontier model) and the mathematical programming method. The results show that the stochastic frontier approach generally produces better estimates than the latter approach, especially for measuring firm-specific efficiency when panel data are available.

The Stochastic Frontier Model

The econometric approach involves the specification of a parametric representation of technology which itself can be divided into two different models; either *deterministic* or *stochastic* frontiers may be specified according to whether or not certain assumptions are made concerning the underlying data.

The early parametric frontier models (e.g. Aigner and Chu, 1968) are deterministic in the sense that all economic units share a common fixed class of frontier. This is unreasonable and ignores the real possibility that the observed performance of the economic unit may be affected by exogenous (i.e. random shock) as well as endogenous (i.e. inefficiency) factors. To allocate all these factors, whether favourable or unfavourable and whether under or beyond the control of the economic unit, into a single disturbance term and to label the mixture as inefficiency is clearly a doubtful and inexact generalisation.

As an alternative, the stochastic frontier model is motivated by the idea that deviations from the production frontier might not be entirely under the control of the economic unit being studied (Greene, 1993). Both Aigner et al. (1977) and Meeusen and van den Broeck (1977) independently constructed a more reasonable error structure than a purely one-sided one. They considered a linear model for the frontier production function as follows:

$$Y_{it} = f(X_{it}; \beta)\exp(\varepsilon_{it}), \qquad i = 1, 2, \ldots, N;\ t = 1, 2, \ldots, T \tag{1}$$

where Y_{it} denotes the appropriate form of output for the ith firm and the tth time period, X_{it} is a vector of inputs associated with the ith firm in the tth time period and β is a vector of input coefficients for the associated independent variable in the production function. Their disturbance term ε consists of the following two parts:

$$\varepsilon_{it} = v_{it} - u_{it} \tag{2}$$

The component v_{it} represents a *symmetric disturbance term* permitting random variation of the production function across economic units due not only to the effects of measurement and specification error, but also to those of exogenous shock beyond the control of the economic unit (e.g. luck, weather conditions, geography or machine performance). The other component u_{it} (≥ 0) is a *one-sided disturbance term* and represents 'productive inefficiency' relative to the stochastic production function. The non-negative disturbance u_{it} reflects the fact that output lies on or below its frontier. The deviation of an observation from the deterministic kernel of the above stochastic production function arises from two sources: (i) symmetric random variation of the deterministic kernel $f(X_{it}; \beta)$ across observations captured by the component v_{it} and (ii) asymmetric variation or productive inefficiency captured by the component u_{it}. The term u_{it} measures productive inefficiency in the sense that it measures the shortfall of output Y_{it} from that implied by its maximum frontier given by $f(X_{it}; \beta)\exp(v_{it})$. The measure of an economic unit's efficiency should be defined, therefore, by:

$$\frac{Y_{it}}{f(X_{it}; \beta)\exp(v_{it})} \tag{3}$$

relative to the stochastic frontier $f(X; \beta)\exp(v)$.

Nevertheless, any estimate of a firm's efficiency level is not consistent, as it contains statistical noise as well as productive inefficiency. In addition, stochastic frontier models suffer from two other difficulties. One is the requirement of specific assumptions about the distributions underlying productive inefficiency (e.g. half-normal and exponential) and statistical noise (e.g. normal). The other is the required assumption that regressors (the input variables X) and productive inefficiency are independent. This may well be an unrealistic assumption if a firm knows its level of inefficiency, this should affect its input choices.

The Use of Panel Data in Frontier Modelling

A further development in the modelling of frontiers lies with the use of estimation techniques which involve panel data. Initially, the stochastic frontier model (1) was developed for cross-sectional data. Baltagi (1995) lists a number of attractive features of using panel data, one of which is that panel data allows for the control of individual effects which may be correlated with other variables included in the specification of an economic relationship, thus making the analysis on the basis of single cross-sections extremely difficult.

With respect to the frontier model, consistent estimates of the productive efficiency of an economic unit can be obtained as the number of time periods tends to infinity. As a result, strong distributional assumptions are not necessary. Moreover, the parameters and the economic unit's level of efficiency can be estimated without assuming that the input variables are uncorrelated with productive inefficiency. Therefore, as Schmidt and Sickles (1984) note, a variety of different estimates will be considered, depending on what the analyst is willing to assume about the distribution of productive inefficiency and its potential correlation with the regressors.

Pitt and Lee (1981) were the first to develop techniques using panel data to estimate the frontier production function. Jondrow et al. (1982) presented two estimators (i.e. for half-normal and exponential cases) for the firm-specific effect for an individual firm under the assumption that the parameters of the frontier production function were known and cross-sectional data were available for given sample firms. Schmidt and Sickles (1984) suggested three different estimators for individual firm effects and productive efficiencies for panel data. A major breakthrough in the area of panel data models was achieved by Battese and Coelli (1988), who presented a generalisation of the results of Jondrow et al. (1982) on the assumption of a more general distribution for firm effects to be applied to the stochastic frontier model. Suppose that the frontier production function is of the following form:

$$Y_{it} = f(X_{it}; \beta)\exp(v_{it} - u_i), \qquad i = 1, 2, \ldots, N;\ t = 1, 2, \ldots, T \qquad (4)$$

The main difference between models (1) and (4) is the absence of the subscript t associated with u in the latter. Thus, u captures firm-specific time invariant variables omitted from the previous function. The symmetric terms v_{it} are assumed to be identically and independently normally distributed with mean zero and variance σ_v^2, i.e., $v_{it} \sim N(0, \sigma_v^2)$. The one-sided terms u_i (≥ 0) are assumed to be identically and independently distributed non-negative random variables, which captures a *firm* effect but no *time* effect (Schmidt and Sickles, 1984). In addition, the error terms v_{it} and u_i are assumed to be independently distributed of the input variables as well as of one another.

As far as the productive efficiency of a firm is concerned, Battese and Coelli (1988) define it as the ratio of the firm's mean production, given its realised firm-specific effect, to the corresponding mean production with the firm effect being equivalent to zero. The productive efficiency of the ith firm (PE_i) is defined, therefore, as:

$$PE_i = \frac{E(Y_{it}^*|u_i, X_{it})}{E(Y_{it}^*|u_i = 0, X_{it})} \quad (5)$$

where Y_{it}^* represents the output of production for the ith firm in the tth time period, and the value of the PE_i lies between zero and one ($0 \leq PE_i \leq 1$). From the perspective of efficiency measurement, the definition contained in equation (5) has a thread of connection with that of equation (3). If the model (4) is transformed to a logarithm of production function, such as:

$$\ln Y_{it} = \ln f(X_{it}; \beta) + v_{it} - u_i \quad (6)$$

then the measure of productive efficiency for the ith firm is defined by:

$$PE_i = \exp(-u_i) \quad (7)$$

The measure shown in equation (7) does not depend on the level of the input variables for the firm, while the definition provided by equation (5) for calculating the productive efficiency of a firm clearly shows that its estimation depends significantly on inferences concerning the distribution function of the unobservable firm effect u_i, given the sample observations.

The elaborated technique by Battese and Coelli (1988) was, however, for the case where productive efficiency is time-invariant. Regarding this time-invariant model for firm-level efficiency, Schmidt (1985) states that unchanging inefficiency over time is not a particularly attractive assumption. With the assumption that productive efficiency does vary over time, an alternative approach has been adopted by econometricians such as Kumbhakar (1990). None of these studies succeed, however, in completely separating inefficiency from individual firm effects and, in any case, the proposed method is too complicated for empirical application (Ferrantino and Ferrier, 1995).

AN APPLICATION TO CONTAINER TERMINALS

Port Production Functions

Traditionally, the performance of ports has been evaluated by calculating cargo-handling productivity (e.g. Bendall and Stent, 1987), by measuring a single factor productivity (e.g. labour as in the case of De Monie, 1987), or by comparing actual throughput with its optimum throughput for a specific period of time (e.g. Talley, 1988). In an effort to properly evaluate the efficiency or performance of a port, several methods have been suggested, such as estimation of a port cost function (De Neufville and Tsunokawa, 1981), the estimation of the total factor productivity of a port (Kim and Sachish, 1986), the application of DEA for port performance comparison (Roll and Hayuth, 1993), and the establishment of a port performance and efficiency model using multiple regression.

As noted by Braeutigam et al. (1984), however, various types of ports are of different size and face a variety of traffic mix. As such, the use of cross-sectional or time-series or even panel data may fail to show basic differences amongst ports, thus leading to a misjudgement of each port's performance. It is, therefore, crucial to estimate econometrically the structure of production in ports at the single port or terminal level using appropriate data such as the panel data for a terminal (Kim and Sachish, 1986). In respect attempts to derive a port production function, Chang (1978) founded on general cargo-handling as a measurement of port performance and assumed that port operations follow the conventional Cobb-Douglas case as expressed by:

$$Y = AK^{\alpha}L^{\beta}e^{\gamma(T/L)} \qquad (8)$$

where Y is annual gross earnings (in real value), K is the real value of net assets in the port, L is the number of labourers per year and the average number of employees per month each year, and $e^{\gamma(T/L)}$ a proxy for technological improvement, in which (T/L) shows the tonnage per unit of labour. Chang (1978) argued that, for the estimation of a production function such as (8), the output of a port should be measured in terms of *either* total tonnage handled at the port *or* its gross earnings. This was to be preferred to port services, since the production function of an organisation involves its internal operation. Bendall and Stent (1987) improve the model (8) to aid policy makers in assessing the merits of different ship types. A more elaborate method of estimating the production function of a port was conducted by Liu (1995) who, under certain assumptions, econometrically estimated the production function of UK ports by employing frontier models such as (4).

Terminal Operator-level Efficiency

From the discussion so far, we can apply the frontier model to the container terminals in Korea so as to measure the relative efficiency of each terminal company. For an international comparison with a nation where port privatisation policies have had more time to work, the main container terminals in the UK are also included in the analysis. The UK terminals selected for inclusion account for a significant proportion of UK container traffic and have different ownership attributes not only amongst themselves but, most importantly, as compared to their Korean counterparts.

Data Sources

The BCTOC, the operating company of the Jasungdae terminal, represents a purely public organisation, while the PECT, an operator of the Shinsundae terminal, is a private company. These two operating companies, however, carry out their activities within a Korean business environment in which the government is heavily involved. The UK side includes the purely private Felixstowe Dock and Railway Company operating the Trinity and Landguard terminals, the Tilbury Container Services Company which was formerly part of a trust port but which is now a private company, the Southampton Container Terminals Company which forms part of Associated British Ports PLC

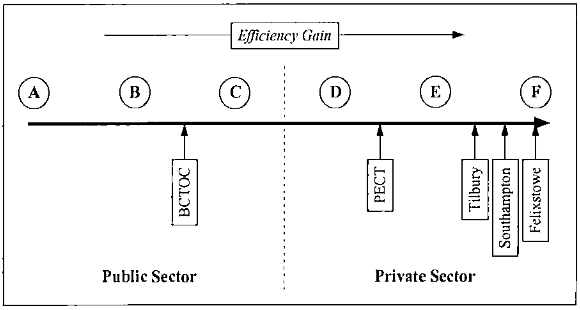


Figure 4 - Terminal Ownership Attributes

The above five terminal companies can be described by borrowing the concepts discussed in Figure 2. Referring to the horizontal axis of Figure 2 and as illustrated in Figure 4, BCTOC may be located between B and C, PECT between D and E, Tilbury and Southampton between E and F, and Felixstowe at F. The data used in this research can be taken from the annual, quarterly or monthly management reports and financial accounts which have either been made available or published by each terminal operating company. The panel observations on output and inputs for each terminal can be established in terms of various terminal attributes according to Figure 4.

The collection and collation of the data for the empirical analysis is currently under way. Hence, a comprehensive application of the methodology and presentation of the results is not yet possible. Alternatively, some practical considerations in applying the frontier model methodology to the container terminal sector may now be addressed.

Model Specification and Assumptions

The estimation of relative terminal operator efficiency is conducted by assuming the appropriateness of the Cobb-Douglas case. The frontier model specified for the container terminal operating sector is, therefore, defined by:

$$\ln Y_{it} = \ln f(L_{it}, K_{it}; \beta) + v_{it} - u_{it}, \qquad i = 1, 2, \ldots, N;\ t = 1, 2, \ldots, T \qquad (9)$$

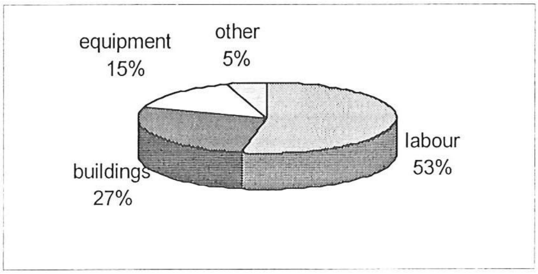
where Y_{it} represents the output of the ith terminal operator and the tth time, L_{it} and K_{it} denote labour and capital inputs respectively, associated with the ith terminal operator in the tth time and β is a vector of input coefficients for the associated independent variables in the model. Based on the model (9), the productive efficiency of each terminal operating company can be measured using equation (5) or (7).

For the purpose of the empirical analysis, some assumptions also have to be made. The overall objective of terminal operators is assumed to be the maximisation of their profits stemming from operational activities. In other words, a terminal operating company is regarded as a profit-maximiser. The terminal operators are also assumed to be price takers in their input markets. Hence, input prices may be treated as exogenous. Another assumption necessary for operationalising the models given in (9) is that it is a single-output production function. This is justified on the basis that the main operational function of container terminals and the main issue of policy interest is *container handling*. Thus, earnings from sources such as the sales of terminal property are not classified as output and do not effect the production function frontier.

Description of the Variables in the Model

Dowd and Leschine (1990) argue that the productivity of a container terminal depends on the efficient use of labour, land and equipment. It seems logical, therefore, to take labour and capital (including land, buildings and equipment) as the input variables for a terminal production function. An analysis of an expenditure structure of a port over time to a conventional division among inputs is shown in Figure 5. As a proxy for the capital input variable, the combined values of buildings and equipment (mainly cargo-handling equipment) accounts for 42% of total expenditure. Thus, the labour and capital costs of a port or terminal together comprise 95% of the total cost structure of port or terminal operations. It seems reasonable enough to assume that this can be taken as sufficient to describe the whole cost account.

Labour input can be defined as an aggregate of the number of employees in a terminal operation. This will likely relate to two complementary, but fundamentally different groups of labourers: those hired directly by the terminal company and the stevedores employed by stevedoring companies who work on a sub-contract basis. With regard to the level of skill of labourers, the total wage bill (payments made for labour) which is quoted in value terms rather than in physical terms (the number of employees) may, to some extent, be a preferable input variable. The input *Capital* variable can be taken as the aggregated value of fixed capital assets including land, buildings and equipment. As far as the *output* of a container terminal is concerned, there are two alternatives: a proxy either in value terms or in physical units. Financial output may be measured in terms of 'turnover', while physical units such as 'TEU throughput' may also be used since the unit of container TEU is regarded as a homogeneous product which, in practice, is a very realistic assumption to make. The output of a terminal can, therefore, be measured in TEU throughput over a given time period and, in the future, it seems likely that this will increasingly be the case. Finally, where relevant, the data for all variables collected may need to be deflated by appropriate price indices to incorporate real values in the analysing and ensuing model estimation.



Source: Drawn from Sachish (1996, p. 347)

Figure 5 - A Port/Terminal Expenditure Structure

CONCLUSION

There has been little research involving the application of the chosen methodology to the port or container terminal sectors. The proposed analytical technique as a means of port or terminal efficiency measurement, however, has great potential and may provide governments, port authorities and other interests with information on and guidelines for the implementation of port policies and organisational reforms. Moreover, the potential for extending this method to other transport industries is enormous.

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