Port management performance and contextual variables: Which relationship? Methodological and empirical issues

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ABSTRACT

This paper applies the production framework associated with a mixture of data envelopment analysis (DEA) and stochastic frontier analysis (SFA) to evaluate the relative efficiency of port management across countries. Differently from previous studies, a three stage approach is adopted in order to identify the role of contextual factors on an input-by-input basis. It involves using DEA for evaluating efficiency in the I and in the III stage, and SFA, carried out through fixed-effect estimators, in the II stage. The latter for controlling the role of external environment in determining input-specific efficiency differentials across ports. The sample is composed of 30 ports observed over the period 1995–2009. The outcome of the DEA applied in the III stage shows that netting inputs of the impact of factors considered outside direct ports' managers control, relative performances of ports change significantly. Any evaluation procedure of port performance should take into account the effect of contextual variables, as identified not only through overall efficiency, but also through input performance. Only in this way, performance measurement of ports is.

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1. Introduction

Port management performance is an important issue in current transport policy.[1] Ports are, in fact, the backbone of international trade since over 90% of the global movement of cargo is seaborne (UNCTAD, 2012). They represent the nodes of the international network of connections, relating long-haul routes to national and local transport and logistic systems. The current outlook and the increasing globalisation of the economies are calling for higher efficiency from all actors of transport and, especially ports, where there is a massive use of public input in their production processes. Furthermore, the increasing participation of private stakeholders in managing ports or relevant portions of them (entire terminals) and the entrance of new ports on the scene, entirely financed by public money in countries with weaker budget constraints with respect to traditionally maritime ones, have increased the competitive pressures in the whole sector. This is particularly true for areas where proximity plays a role.

Weaknesses in trade-related transport and logistics, particularly in developing countries, but also within more developed economies, impose costs on producers that erode the margins and determine shifts in competitive positions among operators and entire geographical areas. Among these, port inefficiencies may be the most serious and least understood, as it resulted from the EU study PPRISM coordinated by ESPO (2012a), which surveyed 58 European ports and 338 business and societal stakeholders with a direct and indirect interest in the performance of ports.

Port costs represent, in fact, about 8–12% of total transport costs from product origin to destination (Kent & Fox, 2004).[2] Shippers, who consider port costs as one of the very few, if not the only, controllable costs in the logistics chain, make shipping decisions in part based on these costs (PRSA, 2013; Tongzon, 2008). To the extent that port costs are a proxy for port performance (efficiency), then port performance influences shippers' choice of markets. Improving ports can lower total transaction costs and boost's the competitiveness of a country's exports and, in the long run, create jobs, spur growth and improve general welfare (Kent & Fox, 2004).

There is a wide body of literature that shows how transport inefficiencies affect development, trade success and foreign investments. Hummels (1999, 2001) provides evidence of the impact of high transportation cost on development. Henderson, Shalizi, and Venables (2001) explore how transport costs influence trade and welfare. Limao and Venables (2001) show that increasing transport

[2] More recently, PRSA (2013), confirmed that the incidence of overall port cost is in the order to 10–15% but that there are large variations among ports of different countries.

costs by 10% can reduce trade volumes by 20%. With specific references to maritime transport, shipping and ports, Hoffmann and Kumar (2002) identify the relationship between trade and maritime transport and their interplay with globalisation and Radelet and Sachs (1998) calculate that a doubling of shipping costs can slow annual economic growth by about 0.5%. Clark, Dollar, and Micco (2001) declare that port efficiency can affect transportation costs and that an inefficient port can increase the distance to a shipper's export market by 60%. Finally, Wilson, Mann, and Otsuki (2003) explore the importance of port efficiency relative to other factors, such as customs performance, the regulatory environment and e-business. They find that improvement in port efficiencies yields the largest increases in trade flows: specifically, an improvement of just 0.55% in the port efficiency indicator has the same impact as a 5.5% and 3.3% improvement in customs performance and e-business, respectively.

In this context measuring the performance of port management and its evolution over the medium to long term becomes pivotal. Information on ports' efficiency and its evolution is essential in evaluating both managerial strategies and port planning, at local and national levels. This is more so in the presence of policy changes that might influence the governance structure of ports (Verhoeven, 2010). However, performance cannot be considered as depending uniquely on management capabilities.

A number of contextual factors might play a role in determining the true performance of ports. Not only through a direct effect but also indirectly. While the first can be easily picked up inserting ad hoc variables in production or cost functions, the second is more tricky to estimate. In particular, since inputs employed by ports can be rationalised to different extents, changes in regulation, accessibility and/or in other non-discretionary characteristics effecting port activities, may induce higher efficiency in the use of more controllable inputs compared to less controllable ones. Capital and labour, for instance, might be influenced differently by different forms of regulation or different economic conditions.[3] The overall effect on the technical efficiency of the port might differ, independently of the managerial capacity of the authorities.[4] Our empirical exercise, thus, aims at giving insights on the varying extent to which single inputs of overall port's production function are influenced by contextual factors and how, removing these effects for each input, it is possible to obtain a clearer index of managerial performance in port management.

In this paper, we propose a three stage approach, which involves a mixture of data envelopment analysis (DEA) for estimating efficiency at the first and third stages – included input slacks – and a stochastic frontier analysis (SFA) to evaluate the relative efficiency of port management, input per input, at the second stage. The use of DEA is necessary, thus, on two accounts. First, we consider multiple inputs and multiple outputs. Second, for our analysis we need to have information on the role played by each input in determining overall efficiency levels. In particular, we need to obtain indexes of efficiency (inefficiency) for each single input, the so called input slacks.

The SFA, used in the second stage, allows one to control the external environment and thus, the role of contextual factors at input level. Each input slack, is cleaned up of the inefficiency due to contextual variables and the netted inputs are used to re-run the DEA in the third stage. By setting up a port services production framework and using the DEA model and SFA regression iteratively, our three stage approach can identify and separate the intrinsic technical inefficiency in the port process from the external effects stemming from the operating environment, which might differ significantly for the various ports considered.

The omission of some key institutional variables, non-discretionary factors and of a time related approach might distort efficiency comparison (Avkiran & Rowlands, 2006). On the one hand, not taking into account the working environment of the port management might imply a different valuation of performance based on elements which are not under the direct control of managers; on the other hand, not accounting for technical change over time might lead to the assignment of possible efficiency gains to managers, while they stem from the evolution of technology.

Given the relevant role that port performance measurement might play in drafting national and international transport and infrastructure policy and in driving shippers' choices, defining a methodology which can overcome some of the most evident drawbacks of currently used procedures is pivotal. Furthermore, since the methodology yields insights as to which inputs are the most strategic in defining ports' performance and are more directly influenced by contextual elements, it can be used in order to carry out transparent benchmarking activities.

The rest of the paper is organised as follows. In Section 2 we briefly present the mixed DEA–SFA methodology used to take account of input-by-input sources of slacks and how it has been adapted to take account of the panel nature of the dataset. Section 3 details the implementation of our case study with the identification of the variables and the data description. The results of the three-step procedure are presented in Section 4. Section 5 contains a brief review of the main management implications and the contributions to scholarly knowledge and Section 6 concludes the paper.

2. The analytical framework for measuring port performance

Scientific literature on efficiency and productivity of ports all over the world has flourished in the last decades. In the recent past, a number of papers tested terminal or port authorities' efficiency focussing principally on estimating traditional endogenous and time invariant sources of inefficiency at either single- or multi-country level (for a detailed survey of efficiency studies, see Barros, Haralambides, Hussain, & Peypoch, 2011; Bergantino & Musso, 2011a; Gonzalez & Trujillo, 2009).

The role of external factors, however, has been explored only more recently. Since the seminal work of Cullinane and Song (2001) and Cullinane, Song, and Gray (2002, 2005) a number of authors have recognised that governance regimes and policy changes do play a significant role in determining ports' efficiency.[5] These studies, although shedding light on the relevance of the operational and institutional environment in influencing ports' efficiency outcome, show only "aggregated" efficiency results. In fact, while stochastic methods (Stochastic Frontier Analysis—SFA) provide extremely valid insights in identifying the importance of the relationship between factors external to companies' control and their performance, they do not yield indications on how to narrow the efficiency-gaps nor on which inputs are majorly affected by the operating conditions. They fall short of distinguishing the impact of external factors and noise from the effects of managerial skills on efficiency on an input-by-input base. Furthermore, in general, the studies do not adopt a dynamic approach, but evaluate efficiency at a specific moment in time.[6]

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[3] For instance, a change in the regulatory regime which lessens the rigidity of the labour market in a specific port (or sets of ports) might influence differently the labour related inputs as opposed to the capital related inputs.

[4] The impact of the environment on production efficiency was first considered by Charnes, Cooper, and Rhodes (1978). Fried et al. (1999, 2002) proposed a series of approaches for controlling external effects and statistical noise to achieve a more accurate efficiency measure.

[5] Significant empirical studies dealing explicitly with the role played by different administrative and ownership structures in the industry in affecting inefficiency differentials have been carried out, among others, by Tongzon and Heng (2005), Cullinane and Song (2006), Cullinane and Wang (2006), Trujillo and Tovar (2007), Yan, Sun, and Liu (2009) and Cheon et al. (2010). Suykens and Van de Voorde (1998), Bergantino (2002), Heaver (2006), Brooks and Cullinane (2007) and Brooks and Pallis (2008) used a more policy oriented approach to depict the role played by institutional reforms in influencing port performance.

[6] To our knowledge, the only studies bridging this gap are: Bergantino and Musso (2011a,b).