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The impact of demand uncertainty on port infrastructure costs: Useful information for regulators?

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ABSTRACT

Recent changes to regulation legislation permit Spanish ports more autonomy and a degree of control over pricing policy. This implies a shift in emphasis away from investments in new infrastructure and towards focusing on demand and taking full advantage of existing assets. The degree to which ports can modify tariffs depends, among other things, on forecasts of traffic, debt levels, objective annual profitability and reasonable yields on assets. Insofar as demand uncertainty affects ports' costs, this will affect ports' ability to meet efficiency and profitability targets. We analyze the effects of demand uncertainty of port costs using a panel data set of 26 Spanish port authorities observed over the period 1993–2007. Estimating a cost function using panel data techniques, we find a significant effect of demand on costs. Non-containerized general cargo was the service whose demand variability most affected port costs. We quantify the effects of demand variability on costs using a simple counterfactual exercise. On the basis of our results we find that if ports in Spain faced the same relative demand variability as the port with the lowest relative demand variability, as measured by coefficients of variation of demand, costs would be an average of 2–3% lower depending on the specification of demand. Different demand variabilities among ports should therefore be taken into consideration by regulators for pricing policy and when imposing minimum profit requirements on ports.

1. Introduction

The Spanish state-owned port system comprises 46 general interest ports which are managed by 28 port authorities. Coordination of these port authorities is the responsibility of the public organism *Puertos del Estado* (State Ports) though it should be noted that the port system does not receive direct subsidies from the Spanish government, financing itself instead from the income it generates, external debt and special European Union subsidies. This policy aim of self-financing has meant that increasing emphasis has been placed over recent years on measures to improve the management and efficiency in ports in order to increase their competitiveness. Indeed, Spanish port law has enshrined this since a major reform in 1992 (Law 27/1992) which established that port authorities' management should be based on criteria involving efficiency, economy, productivity and safety.[1]

In spite of the emphasis on efficiency and self-financing and the consequent requirement that port authorities must generate a sufficient level of income to cover current as well as capital expenditure, until very recently port authorities had virtually no control over pricing policy.[2] Law 27/1992 was modified in 1997 by Law 62/1997 which introduced a degree of port autonomy but control over pricing remained almost completely beyond the control of ports. The consequence of this was that ports could not compete on price and instead competed on capacity, leading to large investments in capacity from the 1990s up to the beginning of the present economic crisis. In 2003, a degree of control over prices was introduced by Law 48/2003 but only for specific services related to the use of cranes, storage or energy supplies and which have relatively little weight in port revenue. In 2010, port authorities were given increased autonomy and control over pricing policy through Law 33/2010. Thus, port authorities can

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[1] In what follows we focus our attention on the aspects of Spanish Port Authorities which are of most direct relevance to the objectives of our study. For a (*footnote continued*) more detailed analysis of the evolution of the port management model in Spain, see Rodriguez-Álvarez and Tovar (2012).

[2] A detailed analysis about pricing in the Spanish port system is beyond the scope of this paper but a good summary can be found in Núñez-Sánchez (2013).

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now tailor their policies to a certain extent to differentiate themselves according to their needs and rely less on investments in infrastructure. However, port authorities' freedom of action is limited by the legislation. In particular, the degree to which port authorities can modify their prices depends on forecasts of traffic, level of debt and investment requirements, management objectives and the achievement of a reasonable return on net capital assets in order to guarantee self-financing. Moreover, the law establishes a minimum target of 2.5% profitability for the system as a whole and the scope of individual ports to change tariffs is made conditioned on their profitability.

In turn, the degree to which port authorities can modify prices and the profitability they can achieve will depend on their cost structure and the nature of their demand. The setting of common profitability targets is potentially problematic if ports' cost and demand structure differ substantially and these idiosyncrasies cannot be fully taken into account when setting prices. For example, expected demand will determine expected revenues and will also require certain endowments of fixed and quasi-fixed assets to satisfy this demand. However, ports differ in terms of the uncertainty[3] of the demand they face and this may lead to ports with similar average demands having different costs due to different variabilities in this demand. If ports with higher demand uncertainty face need extra inputs to deal with possible peaks in demand and therefore face higher costs, this should be taken into account by regulators when fixing profitability targets. This issue is the focus of the present paper, where we attempt to quantify the effects of demand uncertainty on Spanish port authorities in order to determine whether or not this should be taken into account by port regulatory authorities.

As in several other service sectors, providers of port services face uncertain demand. Ports must be prepared to deal with unexpected arrivals and delays in order to avoid ships having to queue for unacceptably long periods of time and thereby facing the danger that shipping companies replace the port with another. Port service providers thus have strong incentives to contract sufficiently fixed, quasi-fixed and variable inputs to ensure that service capacity is capable of meeting variable demand.

While there is a relatively large literature devoted to the effects of demand uncertainty on costs in sectors such as healthcare (Gaynor and Anderson, 1995; Carey, 1998; Baker et al., 2004; Lovell et al., 2009), much less attention has been received to this issue in the ports literature. An exception is the paper by Rodríguez-Álvarez et al. (2011), who analyzed the effect of demand uncertainty on port terminal costs in a Spanish port. In particular, these authors estimate a cost function for three port terminals in the Spanish port of Las Palmas, finding that demand uncertainty has a significant effect on costs and can lead to overestimation of cost inefficiency for terminals which face greater demand uncertainty. Tovar and Wall (2012) used the same data to estimate a cost function in order to analyze the effects of demand uncertainty in determining economies of scale and scope, finding that these measures can change significantly when demand variability is taken into account.

The present paper contributes to this literature by investigating whether the effects of demand variability on port costs found for the port of Las Palmas hold for Spanish ports as a whole. To do so we use a panel data set of 26 Spanish port authorities covering the period 1993–2007 to estimate a cost function which includes a measure of demand variability. We find that these port authorities' costs are significantly affected by the demand variability and we quantify the extent of this. Our results indicate that if port authorities had the same relative demand variability as the port with the lowest relative variability, the average cost reduction would be approximately 2–3% depending on the model estimated. On the basis of this we argue that port authorities with different demand variabilities should be conceded greater flexibility with regard to profitability targets and/or pricing policy.

The paper proceeds as follows. In Section 2 we discuss how demand uncertainty can affect port costs and discuss the theoretical framework used to analyze this. In Section 3 we present the data set and the variables used. The empirical specification of the cost function incorporating demand variability is presented in Section 4. In Section 5 we present and discuss the results and Section 6 contains our main conclusions.

2. Demand variability and port costs

Ports face demand uncertainty and it has been well documented that ships often arrive later than planned, causing disruptions to port operations. Delays in arrivals may arise from several reasons including, among others, adverse weather conditions, delays at previous ports and its consequent knock-on effects, and breakdowns. Indeed, a study by Drewry Shipping Consultants (2006) concluded that shipping companies generally do not make sufficient allowances for such contingencies when elaborating their schedules. Importantly, faced with port congestion or unexpected delays, shipping lines may change the order of ports of call on a certain loop or even omit certain port calls. This can result in ports facing sudden and unplanned increase in volumes, requiring extra factors of production, including manpower, to be hired (Notteboom, 2006; Vernimmen et al., 2007). The fact that shipping companies facing recurrent delays—and its associated cost—at a given port may lead them to drop the port from its routes provides strong incentives for ports to minimize delays, especially if alternative ports are available as this increases the bargaining power of shipping companies (Wang and Cullinane, 2006). The consequence of all this is that ports must have sufficient service capacity to minimize delays by being capable of meeting uncertain demand and providing a sufficiently fast and reliable service.

This need to minimize delays can affect port costs in several ways. To meet variable demand and provide a fast service, ports will invest in service capacity in the form of quasi-fixed inputs which will often be on standby. Moreover, if variable inputs such as supplies or labor have to be contracted on short-term spot markets, ports facing higher demand variability may find it harder to take advantage of long-term contracts, and costs will rise if spot market prices are higher than prices through long-term contracts.[4]

Duncan (1990) provided a theoretical framework for analyzing the effect of demand variability on service firm costs through the contracting of standby capacity. This was adapted by Gaynor and Anderson (1995) in a model of hospital costs and used by Rodríguez-Álvarez et al. (2011) to study the effect of demand uncertainty on costs for port terminals in a Spanish port. In these models, firms first choose fixed and quasi-fixed inputs which define service capacity subject to the constraint that the firm wishes to satisfy all but a small proportion of random demand. Once this has been done, in a second stage they choose variable inputs to meet the actual realized demand.

[3] There is a difference between completely unexpected ship visits (true uncertainty), and a higher than normal level of demand (risk or variability). Both concepts are used interchangeably throughout the paper because although they are not identical our model cannot distinguish between them. However, what is relevant for our analysis and policy recommendations is the existence of variability, not its source.

[4] These ways in which demand uncertainty can affect service firm costs have been discussed in the health economics literature by Gaynor and Anderson (1995) and Baker et al. (2004). See Lovell et al. (2009) for references to this literature.