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Legal reform and the devolution of the Spanish Port System: An econometric assessment

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ABSTRACT

Successive changes to the legal framework affecting the Spanish Port System have been implemented over the last 25 years, forcing maritime operators to adapt to new rules. Based on a comprehensive literature review of studies addressing Spanish port devolution, our paper provides the most up-to-date evaluation of the impacts of these changes. Apart from the correlation between port activity and the economic cycle, an encouraging finding highlighted here is that legal reforms underpinned by broad political and port community consensus appear to be effective in attracting passenger and container traffic.

1. Introduction

Traditionally, ports have played an essential role as centers of cultural exchange and hubs for the transfer of merchandise from one mode of transport to another. They have made trade possible, enabled sought-after products to be obtained and, at the same time, served as an outlet for the surplus that a country or city's economic system has produced at a given moment in time. However, as Brooks and Cullinane (2007) and, Ferrari et al. (2015), and others have pointed out, there has been a root-and-branch change in Port Economics over the last three decades, with a substantial increase in the duties undertaken by ports. Ports have become complex conglomerates of service companies, triggering a variety of industrial and commercial activities, advocating private participation and forming part of multi-modal transport chains, and setting themselves up as *bona fide* integrated logistics facilities.

As Woo et al. (2012) state, this paradigm change, characterized by scale economies, growing "containerization," and vertical and horizontal company integration, and driven by the technical revolution and recent expansion of global trade of recent times, has not been limited to the restructuring of port activities. There has also been a sea change in Port Authority (PA) ownership, goals, and management strategies (Chen, 2009). New lines of research have therefore sprung up around port governance. Brooks and Cullinane (2007) highlight the multidimensional nature of port governance in terms of systems, structures, and processes as well as the rules and regulations surrounding the broad array of public and private activities that take place in ports.

In response to the need to improve transparency of operations, optimize spending and management efficiency, and find alternative means of funding in the current context of competitiveness and the internationalization of stakeholders (Castillo-Manzano et al., 2008), diverse port governance models have evolved worldwide based on the combination of spatial and temporal elements (following Estache et al., 2004; Verhoeven, 2011; Verhoeven and Vanoutrive, 2012). These include the level of functional autonomy; the current degree of regulation; port authority (PA) size; the economic context, and financial performance. As Castillo-Manzano and Asencio-Flores (2012) and Castillo-Manzano and Fageda (2012) suggest, on occasion port governance reform programs can be forced by political authorities, on the grounds of efficiency, budgetary restrictions, or simply ideology.

In short, port governance has become increasingly complex and not always as a result of evolving maritime traffic, but due to the influence of external factors embedded in the existing political, economic, and administrative organization found in any given place at any given time. In many instances, this has prevented the pursued objectives being fully achieved (Brooks and Pallis, 2008). Port sector devolution (considered as a decentralization or deregulation port governance process within a wider context of port evolution, according to González Laxe et al., 2016), usually denotes a gradual transfer of functions and responsibilities from central governments to minor administrative levels that decreases government financial and administrative involvement and increases the participation of the private sector (Brooks and Pallis, 2008).

However, as Debrie et al. (2013) and Cullinane and Song (2002)

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state, the changes have not all been the same and the result has not been one single, dominant model in all the countries affected by the process. The outcomes of port devolution depend on both internal and external factors. Internal factors that stand out include their historically established management types (a form of *path dependence* as was described by Notteboom et al., 2013). Among external factors that can be highlighted are the socio-economic context, the presence of reluctant lobbies and interest groups directly affected by the reforms (Gong et al., 2012), the capital market and the country's transportation policy.

The well-known World Bank (2007) guide distinguishes between four basic port administration models, in turn separated into different varieties depending on the PA's legal status (Ferrari et al., 2015)[1]: *service port, tool port, landlord port* and *private-service port*. However, as the literature highlights, these differences cannot be discerned in the majority of the objectives pursued by port governance reforms (see for greater detail: González Laxe, 2011; Pallis et al., 2011; Woo et al., 2012; among many others). The prevailing trend has been toward the popular *landlord model*, with its blend of public and private initiatives, where the PA owns and maintains port spaces and infrastructure (Chen, 2009) and certain services are leased out as total or partial concessions to private firms (Xiao et al., 2012).

A management model has thus progressively been implemented that leans toward the facility's economic performance, creating a two-way feedback relationship between governance and performance, in the sense that any change in the governance model affects port performance, and port performance drives reforms in port governance (Brooks and Pallis, 2008). A number of academic studies (Chen, 2009; Cullinane and Song, 2002; Pallis et al., 2011; Woo et al., 2012) bear witness to the success of these policies (in the form of major improvements to productivity and financial sustainability, and a substantial reduction in port tariffs, for example). However, rather than the theoretical legal issues that reforms seek to implement in port governance, it is the influence of external factors (Bergantino and Musso, 2011; Ng et al., 2010), that might eventually impact port performance in one way or another, and lead to results not meeting expectations (Verhoeven, 2011).

This research addresses the port governance and devolution processes that have affected the Spanish Port System. This is a relevant case study because of the importance of some of the ports in the system and the large number of legal reforms that have been implemented for the sector over the last quarter of a century. Our first objective was to undertake the most comprehensive systematic literature review to date of works that have dealt with Spanish Port System reforms. Second, we aimed to provide estimations of the impact of each of the law reforms on the Spanish Port devolution process, measuring the effects on port activity in terms of total traffic and container traffic. The broad time period of the analysis and its complexity and the wide variety of the legal reforms meant that the most logical and best-suited methodology to meet our objective was advanced econometric time-series analysis. As the law reforms overlapped with each other and other factors, such as the economic cycle, also affected the evolution of Spanish ports, these had to be isolated.

This paper is organized as follows: Section 2 describes the successive changes to the law implemented in the Spanish Port System during the 1992 to 2014 period and provides what we believe to be the most comprehensive systematic review to date of the prior literature directly or indirectly addressing the port devolution process in Spain. Section 3 states our research questions and sets out the methodological framework. Section 4 presents the main findings and discussion. Finally, Section 5 includes concluding remarks and presents our research implications and our specific contribution to the literature.

2. Spanish port devolution process

Although the vast majority of European countries have opted for the landlord model, according to Verhoeven (2011) among many others, the range of models that exists follows a spatial pattern with a geographical subdivision into the three traditional port models. This is not so different from the pattern resulting from the roles played by PAs (traditional, mediating or entrepreneurial): Hanseatic (local or municipal governance, around the Baltic and the North Sea); Latin (dominant in Mediterranean regions and characterized by central governance), and Anglo-Saxon (typical of the United Kingdom and Ireland and based on independent governance).

Similarities can be found among the proposals that sparked port devolution processes at European ports, although several authors, including Notteboom (2010) and Verhoeven and Vanoutrive, 2012, have highlighted the complex variety of governance practices implemented by different countries. Moreover, major changes have taken place in port governance throughout Europe as a result of actions taken by the European Commission to put a European port policy in place.

Although all ports currently face the same main challenges and objectives, the particular reforms vary. In general terms, the deregulation and decentralization processes implemented in the European Union (EU) follow models that adopt the premises of the market economy, with a redistribution of functions between the public and private sectors. However, the changes made have not been the same, and no predominant model has emerged (Debrie et al., 2013). For instance, Ng et al. (2010) observed asymmetries in port governance in Holland and Greece based on differences at the institutional level. The main difference observed between the European models seems to be related to the role given to the municipal administration in port organization: in some cases, the port authority's is the primary overseer, while in others it is just another member of the management board (Debrie et al., 2013; Ferrari et al., 2015).

Nevertheless, it is possible to identify a series of characteristics that exhibit a common pattern in EU reforms in southern port systems, as is illustrated by France (Cariou et al., 2014; Debrie et al., 2013), Italy (Di Vaio et al., 2011; Parola et al., 2012), and Portugal (Castillo-Manzano and Asencio-Flores, 2012): (1) laws, decrees, and legal changes implemented to decouple the control of port operations from port services; (2) the sharing of roles with a separation between infrastructure and superstructure, with the public sector regulating the activity and the private sector responsible for port operations (the former is usually financed with public funds and the latter through private means); and (3) a general tendency toward the liberalization of transport services through varieties of concession or delegation, which allows private operators to manage their activities within their own facilities and port authorities to organize and regulate the port without participating in commercial activities.

The focus of our paper is the Spanish General Interest Port System, which is comprised of 28 PAs and 64 ports in all. These are currently individual management units coordinated and supervised by the State Ports Public Body, which is responsible for executing and putting into practice central Government-designed port and investment policy (González Laxe, 2011; 2012).

There have been six waves of legal reform (1992–2014) during the past three decades of the Spanish democratic era, included in Table 1 with their specific framework and objectives. All had the common goal of adapting the regulatory framework to ports' new organizational forms and management structures in order to address emerging challenges derived from greater competitiveness, opportunities to improve efficiency, and their wider position on the world stage.

Various studies have listed the difficulties encountered in various areas (economic, political, labor by pressure groups, such as stevedores) during this period to fully achieve the goals set (Castillo-Manzano and

[1] This dichotomy is established depending on the characteristics and distribution between the public and private sectors of property and management, and service operations and delivery. For further details of each, see Brooks and Cullinane (2007) and Debrie et al. (2013), among many others.

Table 1
Spanish port reforms.
Source: Prepared by authors from legislation.

Legal Reform	Main Purposes	Key Changes
Law 27/1992	- New organization structure, autonomy and decentralization - Financial autonomy under business and efficiency criteria. Individual budgets and proposals for self-funding - Transition from a service system to a landlord system	- Creation of the State-owned Enterprise of National Ports (SENP) to coordinate national ports; unification of management regimes (Port Assemblies and Autonomous Ports) into public, but autonomous, Port Authorities - Replacement of civil servants with private sector workers (State-owned stevedore company).
Law 62/1997, which modifies Law 27/1992	- To reinforce the autonomy of SENP and Port Authorities: increased participation of the regional governments in the structure and organization of ports. - Self-financing and *proposal* of freedom of tariffs. - Convergence to a "subsidiary" Landlord system.	- Construction of new infrastructure and basic services, and for the first time, the need for management to adapt to vessels and cargo. - Moved the administrative devolution process forward by establishing a special "Spanish port model", in which Regional Governments (Autonomous Communities) (participating in port structure and organization and allowed to appoint members on the PA governing council) fomented private sector involvement in port activities.
Law 48/2003	- To improve tariff freedom applicable to port services by fomenting private investment in infrastructure in order to drive up inter-port competition. - To mitigate economic dependence by considering other forms of port revenue through the increased involvement of private agents in service delivery with Public-Private Partnerships (PPPs) and concessions.	- Ports began to be regarded as service delivery units. - Restriction of tariff flexibility and inter-port competitiveness combined with relaxation of PAs' commitment to economic efficiency.
Law 33/2010, which modifies Law 48/2003	- Port integration (intermodality) and environmental sustainability. - To resolve economic shortcomings, labor difficulties, the little attention thus far given to environmental issues and the required consideration of the port as an essential link in global supply intermodal chains.	- Ports began to be considered to have to behave like enterprises. - Consolidation of PAs' financial self-sufficiency with the goal of achieving an annual profitability of 2.5% through flexible tariffs and greater managerial discretion. - New labor regime for the Stevedoring Industry. - Significant liberalization of port services to achieve inter-port competitiveness and address new international competition. - Stable and long-lasting legal framework: one of the main benefits of Port Law 33/2010 was that it was passed with a large majority and a broad consensus in the Spanish Parliament.
Royal Legislative Decree 2/2011 (approves the consolidated text of the Spanish State Ports and Merchant Marine Act)	- Reinforcement of key issues: Autonomy, Decentralization, flexibility for a self-financing, liberalization of port services, intraport and interport competitiveness. - Integration of matters included in preceding regulations, such as port taxes and port services, which were separately regulated.	- Reconstituted Text of Port Law: an attempt to include, order and lay down all port-related provisions in a single text.
"Omnibus Decree" (Decree Law 8/2014)	- In the framework of the economic crisis in Spain, the goal was to foment and incentivize the presence of private investment,[2] replace the State's and the State Public Port Authorities' roles in port management, and consequently steer port management toward a concession model designed to outsource services (very typical of Hanseatic countries).	- Consolidation of private investment through the concession of port services, envisaging the possibility of extending concession periods up to a maximum of 50 years. - Concessionaire has to commit to at least one of the following: making an additional large investment in the port area; contributing to financing ports' landside communication links, or offering a reduction on the maximum tariffs charged for its services.

Asencio-Flores, 2012; Castillo-Manzano and Fageda, 2012; Castillo-Manzano et al., 2016; Castillo-Manzano et al., 2013; Díaz-Hernández et al., 2010, 2012; 2014; Fageda and González-Aregall, 2014; González Laxe, 2011; González and Trujillo, 2008; Núñez-Sánchez and Coto-Millán, 2010, 2012; Rodríguez-Álvarez and Tovar, 2012; Tovar and Wall, 2014, 2015; 2016). PAs have concentrated on maximizing investment to expand facility capacity with the goal of attracting greater cargo and passenger traffic, which has resulted in excess capacity and economic deficits without any effective political decentralization of functions from the State to the regional authorities.

Table 2 summarizes the key empirical studies on Spanish Port System legal reforms published during recent decades.

3. Research questions and method

Based on our review of the literature, there can be little argument about the fact that one of the main objectives of the Spanish port reforms was to capture traffic; this is stated in the preambles of the Acts themselves. For example, the currently in force Royal Legislative Decree no. 2/2011 justifies its existence in terms of first and foremost countering the effects of "*national and international inter-port competition in attracting international maritime traffic*." Our policy analysis seeks to answer the following research questions: Which specific Laws in the Spanish port devolution process have had a statistically significant effect on port traffic? And, to the contrary, which Laws have not managed to have an impact? What kind of impact have they had on traffic? Homogeneous? Increasing? Or decreasing? Given its current importance, have the impacts on container traffic been similar to the mean for traffic as a whole? Do these impacts justify the need for so many changes to be made to the law or, if they have lost strength, in combination, do they point to a process of over-regulation? Do the findings

[2] See Cabrera et al. (2015), for an analysis of framework and consequences of the PPPs in the Spanish Port System.

Table 2
Overview of academic literature on spanish port law reforms.
Source: Authors.

Study	Methodology	Focus of analysis	Main findings	Port reform considered
Coto-Millán (1996)	Descriptive analysis.	Discussion of decisions on both European and Spanish Maritime Transport Policy, 1974–1995.	Spanish Port System with excessive business atomization (preventing "cost economies"), extremely dependent on public investment and developed in line with protectionism, debt, and decapitalization.	- 1992
Castillo-Manzano et al. (2008)	Structural change analysis for time series.	Impact on maritime traffic for all Spanish ports of general interest, 1966–2003.	The effect of the Law 27/92 reform was greater and immediate, although the impact was asymmetric: large ports in the Mediterranean seemed to be more favored.	- 1992 - 1997
Díaz-Hernández et al. (2008)	Data Envelopment Analysis and Malmquist indexes for panel data.	Productivity changes in cargo handling operations (Stevedoring Industry) in 21 ports observed from 1994 to 1998.	An improvement in productivity was wholly attributable to technical change (without correcting for technical efficiency).	- 1992 - 1997
González and Trujillo (2008)	Parametric model (translog distance function) for panel data.	Technical efficiency in infrastructure service provision in major container port authorities, 1990–2002.	The reforms resulted in significant improvements in technical change and efficiency within ports, but technical efficiency changed little on average.	- 1992 - 1997
Castillo-Manzano et al. (2009)	Multicriteria decision-making method (Promethee Analysis) for panel data.	Analysis of a port competition index from 1992 to 2003 for all Spanish ports of general interest.	A port ranking in which the three largest ports (Algeciras Bay, Barcelona, and Valencia) were ranked among the top ports for competitiveness, although with significant efforts made by other ports.	- 1992 - 1997
Castillo-Manzano et al. (2010)	Unobserved components model for time series.	Measuring the possible costs of political coordination derived from the Spanish port devolution process, through the evolution of maritime traffic.	The transfer of political control of ports to regional authorities did not seem to influence port traffic. Neutral effect of the devolution process.	- 1997
Núñez-Sánchez and Coto-Millán (2010)	Multi-output translog input distance function for panel data.	Technical and allocative efficiency measures in Spanish port infrastructure services, 1986–2005.	Post-1992 reform there was a large capital injection and a decrease in consumption and labor, but during regulation in 1997 and 2003 the importance of capital declined and did not seem to have affected input cost share trends.	- 1992 - 1997 - 2003
González Laxe (2011)	Descriptive analysis.	Reasons for and outcomes of Spanish Port System reform process.	A new entrepreneurial culture in port management in Spain based on autonomy, self-financing, liberalization of services and more flexible port taxes.	- 1992 - 1997 - 2003 - 2010
Castillo-Manzano and Fageda (2012)	Multivariate regressions for panel data.	The determinants of investments in port infrastructure by the Spanish central administration and regional governments, 1982–2005.	The regional allocation of port investments depends on the use of infrastructure in relation to capacity, specialization in containers, efficiency considerations and political strategies.	- 1992 - 1997 - 2003
Castillo-Manzano and Asencio-Flores (2012)	Bivariate unobserved components model for time series.	Effects of the devolution process on port traffic in Spanish and Portuguese seaports, 1970–2008.	The over-investment process derived from the Spanish devolution process illustrates the need for reflection before any additional change in port governance mode.	- 1992 - 1997 - 2003
Díaz-Hernández et al. (2012)	Non-parametric Data Envelopment Analysis method for panel data.	Economic Efficiency (technical, allocative and cost efficiency indexes) in the Stevedoring Industry for 19 Spanish Ports, 1990–1998.	Technical inefficiency led to an average cost increase of 7%. Allocative inefficiency resulted in an overuse of the labor factor. The largest ports had the highest efficiency indexes.	- 1992 - 1997
Núñez-Sánchez and Coto-Millán (2012)	Parametric distance function approach (multiproduct translog input-oriented) for panel data.	Evolution of total factor productivity and its decomposition, 1986–2005.	Technical progress and scale efficiency gains improved the total productivity factor, whereas technical efficiency losses reduced the total productivity factor.	- 1992 - 1997 - 2003
Rodríguez-Álvarez and Tovar (2012)	Short-term total cost function for panel data.	Economic efficiency of 26 Spanish Ports of general interest, 1993–2007.	The impact of legislative reforms was not evenly distributed: the most significant reform took place during the first period; the results were also positive for the second reform although with more modest efficiency gains; the third legal reform seems to have had a contrary effect on economic efficiency.	- 1992 - 1997 - 2003
Díaz-Hernández et al. (2014)	Dynamic and static Data Envelopment Analysis cost model.	Analysis and comparison of efficiency (Spanish Port Authorities' provision and utilization of infrastructure), 2000–2007.	Inefficiency due to quasi-fixed inputs and nonoptimal infrastructure investments. Excessive docks and port surface area with costs transferred to users, reducing Spanish ports' competitiveness.	- 2003 - 2010
Fageda and González-Aregall (2014)	Multivariate model for panel data.	Analysis of port charges between 2004 and 2010 to determine the impact on traffic, and examination of price competition framework.	Evidence of local port competition. Higher port charges are associated with lower volumes of traffic and thus, a lower level of competitiveness.	- 2003 - 2010
Tovar and Wall (2014)	A cost function using panel data techniques.	Study of the effects of demand variability on port costs for 26 Spanish port authorities, 1993–2007.	A significant effect was found on Spanish port costs due to variable demand, especially regarding the non-containerized general cargo service.-	- 1992 - 1997 - 2003
Tovar and Wall (2015)				

(*continued on next page*)

Table 2 (*continued*)

Study	Methodology	Focus of analysis	Main findings	Port reform considered
	A frontier technique (directional technology distance function).	A measurement of technical efficiency of 20 Spanish Port Authorities, 1993–2012.	Evidence was found of technically inefficient port management by comparing levels of quasi-fixed inputs (buildings, infrastructure, and surface areas) to levels of remaining outputs (traffic).	- 1992 - 2010 - 2011
Castillo-Manzano et al. (2016)	Multivariate analysis for panel data.	Examination of the impact on traffic of recent legislative measures involving increasing liberalization of port charges, 2003–2012	The Law of 2003 seems to have had no significant impact on traffic while the impact of the 2010 legislation seems to have been greater. Lack of political consensus on the passing of the 2003 legislation plus a clear decline in tariff freedom to some extent canceled out the inter-port competition promoted by earlier laws.	- 2003 - 2010 - 2011
Coto-Millán et al. (2016)	Stochastic Frontier Analysis.	Analysis of correlation between law reforms and changes in Port Authority efficiency for a sample of 26 Port Authorities, 1986–2012.	Legislative reforms had a positive impact on the technical efficiency of the Spanish port system: specifically, two (1997 and 2003) were found to be statistically significant.	- 1992 - 1997 - 2003 - 2010
Tovar and Wall (2016)	An input-oriented directional distance function, using parametric methods.	A measurement of the technical dynamic efficiency of 26 Spanish port authorities, 1993–2012.	If ports improved their efficiency, an average 38% long-term cost savings could be achieved. Evidence of dynamic technical inefficiency: ports could increase investment in capital and simultaneously decrease variable input usage while maintaining the same output levels.	Reforms between 1993 and 2012

obtained with this methodological focus agree with the prior literature or contradict it?

In answer to these questions, we collected time series data for a period of approximately 30 years period. The breadth and complexity of the process under study makes an advanced time-series approach ideal for analysis of the issue in question.

From a modeling point of view, changes to the law can be treated as dummy or artificial variables, with discrete switches from zero (inactive) to one (active). Other possibilities, such as ramps, are useful, implying amplification effects over time.

We also had to address the problem of spurious regressions typical of non-stationary data (i.e., the fact that the time series are always trending). An innovation of this paper is that, instead of removing any non-stationarity by differencing, the trends are modeled by direct estimation using a state space framework. The data and models used, and the results, are given in the following subsections. A full discussion of the technical details is included in the Appendix.

3.1. Data

Data used in this study as annual time series are as follows:

1. Endogenous variables: (1) Total Annual Traffic in the Spanish Port System, measured in metric tonnes; and (2) Total Annual Container Traffic in the Spanish Port System, measured in TEUs. The data source is the statistics section of the State Ports website (see http://www.puertos.es/en-us). Two separate models were estimated for each of these variables. Fig. 1 shows both.
2. Exogenous variables:
   a. Spanish Gross Domestic Product (GDP): The strong similarity between GDP and the endogenous variables (especially total traffic) suggests that income is an important driver of maritime traffic (see Fig. 1). Therefore, GDP was also included in the model as an exogenous variable. Rapid growth was seen in maritime traffic from 1993 onwards, coinciding with legal changes, followed by a sudden halt in about 2008; this momentum was shared by the GDP. We let the models decide which part of the momentum was due to GDP and which to changes in the law.
   b. Legal changes included as dummy variables. Alternative specifications were tried for each of the changes to the law. Those reported in the results below are the best according to model interpretability, statistical significance, and statistical adequacy. The legal changes considered were (1) Law 1992, as a ramp starting in 1993 (i.e., a sequence of increasing integers starting on 1); (2) Law 1997, as a step starting in 1998 (i.e., zeros before and ones from the year 1998 onwards); (3) Law 2003, as a step starting in 2003; and (4) Law 2010, as a step starting in 2011.

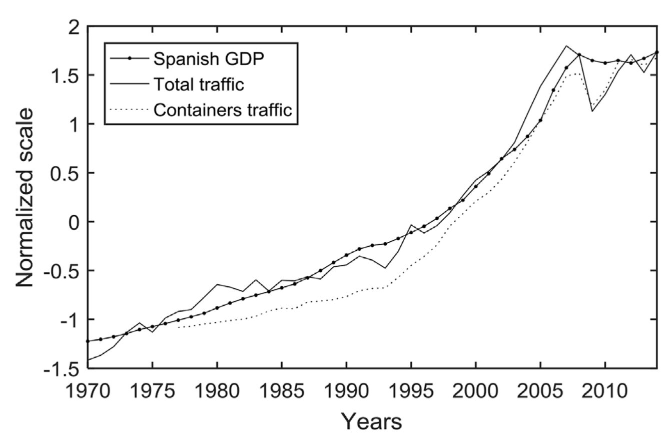

Fig. 1. Annual Spanish GDP and maritime traffic from 1970 to 2014 on a normalized scale.

Table 3
Estimation results.

	Model 1: Total traffic	Model 2: Container traffic
Law92 (ramp)	0.014*	0.085**
Law97 (step)	0.075*	0.796***
Law03 (step)	0.002	0.006
Law10 (step)	0.247**	0.994***
GDP (1970–1993)	0.235***	0.843***
GDP (1994–2007)	0.266***	0.938***
GDP(2008–2014)	0.239***	0.894***
year09 (impulse)	−0.370***	−1.115***
Q(1)	0.253	1.692
Q(4)	4.601	3.614
Q(8)	6.509	8.917
Jarque-Bera	1.568	0.615
	(0.457)	(0.735)
H	0.639	0.618
	(0.259)	(0.402)

Endogenous variable in columns. One, two and three asterisks indicate statistical significance at 10%, 5% and 1% levels, respectively. Q(p) is the Lung-Box autocorrelation portmanteau test for p lags under the null hypothesis of Independence. Jarque-Bera is the gaussianity test under the Gaussianity null hypothesis (p-value in brackets). H is a variance ratio test between the first and last thirds of the sample under the null of homoscedasticity (p-value in parenthesis).

3.2. Models

The models used in this paper are of the class of Unobserved Components models (UC) long used by authors such as Harvey (1989), Pedregal and Young (2002), and Durbin and Koopman (2012).

UC models consist of decomposing a time series into unobserved, though economically meaningful components, such as trend, seasonal component, and irregular component (see the Appendix for a general presentation). The trend takes into account the long-term behavior of the series; the seasonal component deals with annual cycles; and the irregular is the rest of the information not explained by the previous components, with purely stochastic random noise assumed. Usually, both linear and non-linear input-output relations are also allowed. For annual data such as the series used later in this paper, the seasonal component, understood as an annual cycle, is nonexistent, and therefore the model simplifies to trend, irregular and a mixture of linear and non-linear input-output relationships.

More specifically, the UC model used below in this paper for annual data is as in the following equation (1).

$$y_t = T_t + \boldsymbol{D}\boldsymbol{u}_t + I_t \quad (1)$$

y_t, and T_t denote the endogenous time series and a trend, respectively. I_t is an irregular component, i.e., purely stochastic noise with no serial correlation, zero mean and constant variance. $\boldsymbol{D}\boldsymbol{u}_t$ stands for the effects of k explanatory variables[3] in matrix $\boldsymbol{u}_t$ through a linear regression model, defined by a vector of coefficients $\boldsymbol{D}$. Typically, y_t are the maritime traffic variables, and $\boldsymbol{u}_t$ are the Spanish GDP and the dummy legal change variables.

Looking at (1) in other terms, we can say that it is a regression equation in which the nonstationary properties of the series (see Fig. 1) are taken into account by introducing a trend variable in the model.

The fact that the trend term was estimated simultaneously with the other regression parameters affects the exogenous variables and means that, strictly speaking, model (1) is not a pure regression model and cannot be estimated by simply regressing y_t on $\boldsymbol{u}_t$. The proper way to deal with such a model is to apply a discrete-time state space framework (SS). In this particular case, such a model is composed of equation (1), known as the *observation equation*, and the dynamics of the trend component through a *state* or *transition* equation. The trend is called a state of the system because it is an unobservable variable that is estimated from the observed data.

One common way to model the trend is as an Integrated Random Walk (equation (2); see Pedregal and Young, 2002). This model implies that a second trend difference is purely stochastic white noise.

$$T_t - 2T_{t-1} + T_{t-2} = \varepsilon_t \quad (2)$$

Some details are necessary to complete the model. Variable GDP is divided into three regimes related to the expansion and contraction of the Spanish economy (i.e., three separate regression parameters are estimated instead of only one): i) from 1970 to 1992; ii) from 1993 to 2007, and iii) from 2008 to 2014. It was also necessary to include an additional impulse dummy variable in the model (1 in the year 2009 and zero otherwise) to contend with the disastrous year of 2009, which was a constant outlier in every model tried (clearly visible in Fig. 1).

Equations (1) and (2) form the full model for the analysis, which has to be adapted to the general SS form, and in which the unknown parameters are all the coefficients in vector D and the variances of the noises, namely ε_t and I_t. For a model of this type, the general theory of SS systems applies: in particular, the Kalman Filter (Kalman, 1960) and the Fixed Interval Smoother (Bryson and Ho, 1969) produce the optimal estimates of the trend, and the unknown parameters are estimated by Maximum Likelihood. The general technical details of this approach and those specific to the model (1)–(2) are given in the Appendix (see also Durbin and Koopman, 2012; Harvey, 1989; Pedregal and Young, 2002).

4. Results and discussion

The regression coefficients that affect the exogenous variables in model (1)–(2) in the previous section when applied to both endogenous variables are given in Table 3. This table also shows the significance level of the coefficients and standard statistical tests of serial correlation, gaussianity and heteroscedasticity.

The most important conclusions drawn from the findings in Table 3 are:

- Regarding total traffic, the change to the law that had the greatest influence was Law10 (with an annual increase of 24 million metric tonnes), followed by Law92 (average 16.1 million metric tonnes per year[4]) and Law97 (7.5 million). The joint effect amounted to a 6.86% increase from 1993. Fig. 2 is a counterfactual exercise based on Model 1, giving a visual impression of the time series together with the actual data assuming that none of the legal changes had occurred.
- Container traffic increased by about 997 thousand TEUs per year on average as a result of Law92; 994 thousand TEUs per year as a result of Law10, and 796 thousand as a result of Law97. The total increase in container traffic from 1993 to 2014 was 19.24%. Fig. 3 shows the corresponding counterfactual exercise.
- All models are correctly specified from a statistical point of view,

[3] In this sense, when we work with such a long time series, there cannot be a huge number of explanatory variables for the simple reason that they do not exist for such a long time span. Also, technical problems exist when a large number of explanatory variables are included, the most important of these being collinearity and the loss of degrees of freedom in a model with fewer than 50 observations with the consequent loss of statistical power. However, this does not specifically mean that other factors are not taken into account, as GDP (which is modeled as a piece-wise regression) and the trend included in the model are in fact proxies for omitted variables. A thorough automatic outlier detection procedure was implemented, and the process consistently identified 2009 as an outlier, with no other outliers observed. Had any omitted variable had a sudden effect on the endogenous variable, it would have been detected by this procedure.

[4] As this effect is measured by an artificial ramp variable with a slope of 0.014 for all the years from 1993 to 2014 (22 years), average reported measurement per year = $\sum_{t=1}^{22} 0.014t/22$.

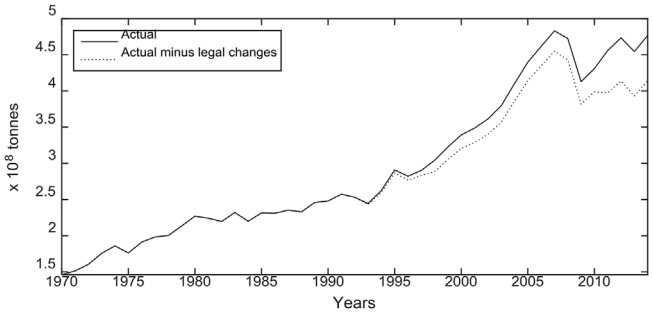

Fig. 2. Total traffic in hundreds of thousands of metric tonnes from 1970 to 2014 and series reconstruction without any changes to the law from 1993.

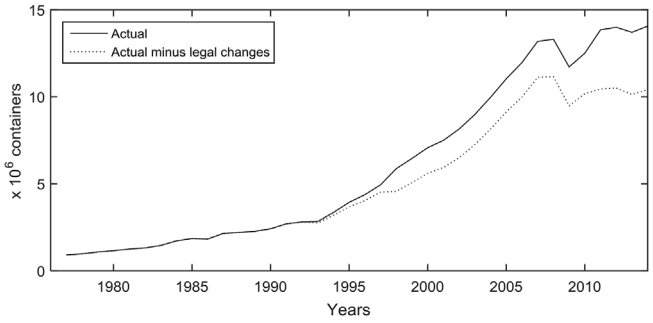

Fig. 3. Total container traffic in millions of TEUs from 1976 to 2014 and series reconstruction without any changes to the law from 1993.

since there is no autocorrelation left in the residuals and there are no gaussianity or homoscedasticity issues.

Comparing the findings in Table 3 with previous results from recent research (see Section 2, Table 2), the positive impact found for Law92 can be seen to agree with much of the prior literature, such as Castillo-Manzano et al. (2008), González and Trujillo (2008) and Rodríguez-Álvarez and Tovar (2012). The impact of Law97 is also positive and consistent with findings by Castillo-Manzano et al. (2008), Coto-Millán et al. (2016) and González and Trujillo (2008).

The null effect of Law 2003 is consistent with Castillo-Manzano et al. (2016) and, in a way, also with Rodríguez-Álvarez and Tovar (2012), who even describe a negative effect. Lastly, the positive effect of Law 2010 is consistent with Castillo-Manzano et al. (2016) but disagrees with Coto-Millán et al. (2016). For this last study, there is only agreement on the results for Law97. These disparities could be due to the methodologies used, which are *de facto* measuring different factors.

In any event, all of the previous studies share a finding that at least some of legal reforms aimed at the Spanish port devolution process have achieved their intended impacts to a significant degree and can be considered successful from this perspective.

5. Concluding remarks

Continual changes were made to the legal framework of the Spanish Port System during the 1992–2014 period, with the renunciation of stable legislation and maritime operators forced to adapt to new rules every few years. These successive changes created a new context with three dimensions: a new management model, in which efficiency and profitability are key objectives; a new business perspective with two levels of competition (among the PAs themselves and among operators in the same port) and the increased private sector involvement; and a relationship model based on a gradual reduction in the role of the State based on an expansion of PA' competencies and the decision-making power of sub-central governments.

Considering these developments, we applied an econometric model for an advanced analysis of time series data. This enabled us to isolate trends in Spanish Port System traffic with the goal of assessing the impact of the legal changes implemented since 1992. Our main result points to Law 33/2010 as having the greatest apparent influence in terms of cargo and passenger movements to Spanish ports.

The key to success seems to lie not only in the climate of political and social consensus in which this legislation was passed, but also in the content of the law, which was designed according to the premise of a harmonious balance among objectives. *A priori* these could be interpreted as dichotomous criteria that, we suggest, can be successfully combined: self-management vs. State control; tariff moderation vs. profitability; flexibility vs. supervision; free market vs. regulation; and free planning vs. network integration. The results achieved with Laws 27/1992 and 62/1997 can also be highlighted. Law 27/1992, clearly had a ramp effect, as asserted in previous studies (see for example Castillo-Manzano et al., 2008); that is, there is a learning curve for the PAs once the port devolution process begins. In the case of Laws 62/1997 and 33/2010, there are step effects.

To summarize, Spanish port devolution has been a long process of reform. Laws 27/1992, 62/1997, and 33/2010 can be seen as three favorable shocks to Spanish Port System competition, especially with respect to container traffic. This is not surprising when we consider that, according to Castillo-Manzano and Fageda (2012), the changes in legislation were accompanied by a planned investment policy designed to favor ports specializing in containers in general and, hubs in particular. There is, therefore, a solid empirical basis for implementing further changes to the legislation, providing that there is a broad consensus for these to be made both among political parties and among operators in the port community, as was the case for Law 33/2010. However, the apparent negligible impact of Law 48/2003 implies that not every law reform is effective.

These conclusions, obtained for the specific case of Spain, could form the basis to replicate this analysis for other, similar port systems (especially those of Mediterranean Europe), whose port devolution processes have also required more than one change to the legal framework. This is the case of the Portuguese (see Castillo-Manzano and Asencio-Flores, 2012) and Italian (see Di Vaio et al., 2011; Ferrari and Musso, 2011) port systems, for example.

Several general policy and management implications can be derived from our study. First, from an institutional point of view, any legislation change should be preceded by a political consensus and the subsequent creation of parliamentary committees to permanently assess the most important aspects (excessive overcapacity or borrowing; negative profits; environmental and social sustainability, and unfair competition in the delivery of port services). The Spanish case demonstrates that this contributes to harmonious implementation, as the aim is to create a process for the approval of any reforms that involve representatives of the main economic agents in the port community. Acceptance by the collective involved will be gained more easily when their interests and expectations are considered.

Second, regarding the managerial implications of port reform and liberalization of services, PAs face significant challenges in terms of their entry onto the international stage, competitive position, and day-to-day management of multiple services essential to the economy. Institutional and business models must be developed both in the short term (legal reforms) and in the medium-long term (maritime strategies). Some major future trends include interport cooperation and partnerships with the private sector as well as regionalization through clustering by coastline, although with differences according to port size, hinterland potential, and intermodality relationships.

In other respects, it is clear that evaluation criteria should be adopted that ensure the reasonable profitability of individual investments in order to prevent "infrastructure bubbles" like those seen in high-speed rail and airports. Grouping ports by seaboard, or in alliances, might be more efficient for the Port System as a whole, rather

than dependence on financial tools (such as the Solidarity Fund for Ports in Spain) that only serve to subsidize languishing small ports infrastructure.

Lastly, the Spanish case is an example of the advantages that changes in the legal framework can have on port-city relations in terms of greater autonomy for PAs and expanded private sector involvement based on the criteria of profitability, competitiveness, sustainability, and a degree of freedom for tariff setting for port-city relations. However, dysfunctions can still arise from the inefficient use of resources by the PAs themselves, precisely due to the nature of their autonomy.

5.1. Original contribution to scholarly knowledge

The originality of our study and its contribution to the prior literature can be summarized as follows. First, our paper offers the fullest literature review to date of all those that have, directly or indirectly, addressed the complex port devolution process in Spain over the six changes to legislation made between 1992 and 2014. Second, our paper offers the most recent comprehensive retrospective evaluation of the Spanish Port devolution process over 25 years.

Third, we applied one of the most rigorous methodologies available in time series analysis. Unobserved components models were written in a state space model framework, in which the Kalman Filter and State Smoothing algorithms were combined with maximum likelihood estimation. The study's long time period and the complexity and variety of the changes to the law make this a logical and suitable methodological approach, considering that the legal reforms overlapped in time and that other factors, such as the economic cycle, also affected the evolution of the Spanish ports.

Precisely because of this methodology's utility for obtaining robust results, we include in the Appendix an annex with the details of our methodological focus to facilitate its extrapolation for future analyses of similar port systems.

Appendix

Unobserved Components models (UC; see Durbin and Koopman, 2012; Harvey, 1989; Pedregal and Young, 2002) allow for a time series to be decomposed into economically meaningful, unobserved components such as those in equation (A.1).

$$y_t = T_t + S_t + \boldsymbol{D}\boldsymbol{u}_t + v_t \tag{A.1}$$

y_t, T_t, S_t and v_t denote the endogenous time series and trend, seasonal and irregular components, respectively. $\boldsymbol{D}\boldsymbol{u}_t$ stands for the effects of k explanatory variables in matrix $\boldsymbol{u}_t$ through a linear regression model, defined by coefficients $\boldsymbol{D}$.

State space models (SS) offer a framework in which models of this kind can be accommodated naturally. Such models are composed of a pair of equations known as *State* and *Observation* equations. Equation (A.1) is actually the *Observation Equation* of such a discrete-time system (see below), and the model has to be completed with the dynamic behavior of the components through stochastic *State Equations*. The state vector is a mixture of unobserved and other components required in order to complete the definition of the components but without straightforward interpretation.

The general SS formulation used in this paper is (bold symbols stand for matrixes or vectors):

$$\begin{cases} \boldsymbol{\alpha}_{t+1} = \boldsymbol{\Phi}\boldsymbol{\alpha}_t + \boldsymbol{\tau}_t & \textit{State equations} \\ y_t = \boldsymbol{Z}\boldsymbol{\alpha}_t + \boldsymbol{D}\boldsymbol{u}_t + \varepsilon_t & \textit{Observation equations} \end{cases} \tag{A.2}$$

where $\boldsymbol{\alpha}_t$ is the n dimensional stochastic state vector; $\boldsymbol{\tau}_t$ and ε_t are an n and *one* dimensional vectors of Gaussian system disturbances, i.e., zero mean white noise inputs with covariance matrix $\boldsymbol{Q}$ and H, independent of each other; and $\boldsymbol{\Phi}$, $\boldsymbol{Z}$ and $\boldsymbol{D}$ are the so-called system matrixes, some elements of which are known, while others need to be estimated.

Given model (A.2), the well-known Kalman Filter (KF, Kalman, 1960) produces the optimal estimates (in the sense of minimizing the mean squared errors) of the first- and second-order moments (mean and covariance) of the state vector, conditional on the information up to the current sample. Fixed Interval Smoother (FIS, Bryson and Ho, 1969) algorithms produce similar estimates based on all the data in a sample. The algorithms used in this paper are taken from Durbin and Koopman (2012) and implemented in MATLAB via the SSpace toolbox (see The Mathworks, 2016).

Forward pass (Kalman Filter)

$$v_t = y_t - \boldsymbol{Z}\boldsymbol{a}_t - \boldsymbol{D}\boldsymbol{u}_t \quad F_t = \boldsymbol{Z}\boldsymbol{P}_t\boldsymbol{Z}' + H \quad \boldsymbol{K}_t = \boldsymbol{\Phi}\boldsymbol{P}_t\boldsymbol{Z}'F_t^{-1}$$

$$\boldsymbol{a}_{t+1} = \boldsymbol{\Phi}\boldsymbol{a}_t + \boldsymbol{K}_t\boldsymbol{v}_t \quad \boldsymbol{P}_{t+1} = \boldsymbol{\Phi}\boldsymbol{P}_t(\boldsymbol{\Phi} - \boldsymbol{K}_t\boldsymbol{Z}_t)' + \boldsymbol{Q}$$

Here $\boldsymbol{a}_t$ and $\boldsymbol{P}_t$ are the optimal estimates of the states and their covariance matrixes given all the information up to time $t-1$, respectively. The only things that are required to run the KF are starting values $\boldsymbol{a}_1$ and $\boldsymbol{P}_1$ (see Durbin and Koopman (2012) for optimal initialization). v_t and F_t are the so-called innovations and their covariance matrixes.

Backwards pass (Fixed Interval Smoother)

$$\boldsymbol{L}_t = \boldsymbol{\Phi} - \boldsymbol{K}_t\boldsymbol{Z}_t \quad \boldsymbol{r}_{t-1} = \boldsymbol{Z}'F_t^{-1}v_t + \boldsymbol{L}_t'\boldsymbol{r}_t$$

$$\boldsymbol{N}_{t-1} = \boldsymbol{Z}'F_t^{-1}\boldsymbol{Z}_t + \boldsymbol{L}_t'\boldsymbol{N}_t\boldsymbol{L}_t$$

$$\boldsymbol{a}_{t|N} = \boldsymbol{a}_t + \boldsymbol{P}_t\boldsymbol{r}_{t-1} \quad \boldsymbol{P}_{t|N} = \boldsymbol{P}_t - \boldsymbol{P}_t\boldsymbol{N}_{t-1}\boldsymbol{P}_t$$

Here $\boldsymbol{a}_{t|N}$ and $\boldsymbol{P}_{t|N}$ are the optimal estimates of the states and their covariance matrixes, respectively, given all the information in the sample. The FIS should be initialized with $\boldsymbol{r}_t = 0$ and $\boldsymbol{N}_t = 0$. The FIS algorithm clearly improves on the KF estimates with the help of all the information provided by the KF.

The unknown parts in the system matrixes $\boldsymbol{\Phi}$, $\boldsymbol{Z}$, $\boldsymbol{D}$, $\boldsymbol{Q}$ and H may be estimated by Maximum Likelihood (ML), computed using the KF via "prediction error decomposition" (see details in Durbin and Koopman, 2012). The log-likelihood for the general model (A.2) is given in equation

(A.3).

$$logL = -\frac{Nm}{2}log2\pi - \frac{1}{2}\sum_{t=1}^{N}(log|F_t| + v_t' F_t^{-1} v_t) \tag{A.3}$$

The likelihood equation (A.3) involves N, i.e., the number of observations and other quantities that are natural outputs of KF, see Durbin and Koopman (2012) for details.

More specifically, each of the two models takes the form of equation (A.4).

$$\begin{bmatrix} T_{t+1} \\ D_{t+1} \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}\begin{bmatrix} T_t \\ D_t \end{bmatrix} + \begin{bmatrix} 0 \\ \tau_t \end{bmatrix}$$

$$y_t = [1 \;\; 0]\begin{bmatrix} T_t \\ D_t \end{bmatrix} + \begin{bmatrix} d_1 & d_2 & d_3 & d_4 & d_{5,j} \end{bmatrix}\begin{bmatrix} Law92_t \\ Law97_t \\ Law03_t \\ Law10_t \\ GDP_t \end{bmatrix} + v_t \tag{A.4}$$

It is easy to check that the system matrixes are those in equation (A.5) by comparing model (A.4) with the general SS system in (A.2). Given all this information, the likelihood may be evaluated and the recursive algorithms may be used to obtain the optimal estimates of the states and their covariance matrixes.

$$\boldsymbol{\Phi} = \begin{bmatrix} 1 & 1 \\ 0 & 1 \end{bmatrix}; \quad \boldsymbol{Z} = [1 \;\; 0]; \quad \boldsymbol{D} = \begin{bmatrix} d_1 & d_2 & d_3 & d_4 & d_{5,j} \end{bmatrix}$$
$$\boldsymbol{Q} = q_{11}; \qquad \boldsymbol{H} = h_{11} \tag{A.5}$$

Parameter $d_{5,j}$ affecting the GDP is divided into three regimes: i) from 1970 to 1992 ($j = 1$); ii) from 1993 to 2007 ($j = 2$); and iii) from 2008 to 2014 ($j = 3$). It was also necessary to include an additional impulse dummy variable to the model to deal with the disastrous year of 2009 (clearly visible in Fig. 1), meaning that the input variables $\boldsymbol{u_t}$ are expanded with an additional variable affected by an additional parameter d_6.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jup.2017.10.003

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