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A global model for the estimation of transport costs

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ABSTRACT

This paper presents a model of transport cost determinants that corrects the specification problems observed in the transport cost equations in previous literature. The model includes freight transport supply and demand, as well as infrastructure quality and non-time-varying fixed effects related to the route, the exporting company, its strategy and the product. In addition, when defining the origin-destination routes, the model more appropriately accounts for economies of network and economies of scale. In order to build the database, 583 personal interviews were conducted over the course of 2011 with producing companies that ship goods and with the logistics operators. As a result, 305 routes between the Valencian Community and Europe were identified, from which 6390 observations were obtained. The results show that distance is a determining factor in the cost of transport, notwithstanding the infrastructure coverage and improvements in quality. At the same time, the analysis confirms that transport cost is more sensitive to the degree of competition on the route, the volume of freight on the route and the volume of goods shipped on the route by the exporting company, the configuration of the supply chain, the company strategy and the coverage and quality of transport infrastructure.

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1. Introduction

In an ever more globalised world with increasingly open economies and regions, artificial barriers to entry in international markets have been reduced to levels never seen before, reflecting a worldwide drop in average effectively applied tariffs and non-tariff trade costs (International Monetary Fund (I.M.F.), 2016, p. 90). Transport costs, which represent the main component of non-tariff costs (Anderson & Wincoop, 2004), have fallen in absolute terms. This reduction in transport costs per kilometre is due to technological improvements in both the means of transport and transport infrastructure, which have increased the efficiency of the physical distribution function (Glaeser & Kohlhase, 2004). The share of transport in logistics costs, however,

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had increased to almost 44% by 2002 (Davis & Drumm, 2002). The relative importance of transport costs compared to non-tariff costs and trade costs has grown. This is because transport costs have not fallen as sharply as the other artificial barriers largely swept away by trade liberalisation (Amjadi & Yeats, 1995; Radelet & Sachs, 1998). Transport costs have emerged as the main non-tariff barrier to trade; it is often the case that the effective rate of protection provided by transport costs even exceeds artificially created protections, as has been empirically shown by the World Trade Organisation (W.T.O.) (2013) for the U.S.A., by Micco and Pérez, (2002, p. 43) for most Latin American countries, and by De (2006) for Asia. The United Nations Conference on Trade and Development (U.N.C.T.A.D.) (2015, p. 64) has estimated that, during the period 2005–2014, a country's international transport costs accounted for approximately 9% of the value of its imports, ranging from 6.8% in developed countries to 11.4% in developing countries.

Therefore, of all the trade cost components, transport costs are the strongest determinant of foreign direct investment flows and firms' capacity to access foreign markets (Djankov, Freund & Pham, 2010; Hummels, 2007). Econometric estimates suggest that if the transport costs for exporting companies in a country doubled, it would cut their trade by 80% or more, whereas a 10% reduction in those costs would boost the volume of trade by 20% (Hummels, 1999; Limão & Venables, 2001). Generally speaking, logistics costs represent a critical element of companies' financial position and cost structure (Stepien, Legowik-Swiacik, Skibinska, & Turek, 2016; Toyli, 2008). Therefore, if companies were able to systematically reduce these costs, it could represent a decisive step towards maintaining and even bettering their competitive position (Chow & Gill, 2011; Smith, Miller & Parhizkar, 2008; Song & Na, 2012; Zamora & Pedraza, 2013). Further support for this claim is provided in the report *Global Supply Chains, Transport and Competitiveness*, from the United Nations Economic Commission for Europe (Pesut, 2009). This justifies the interest in determining the amount of transport costs exporting companies face and how they can change over time in response to shifts in transport conditions and the nature of the agents involved in the process.

There are, however, some important research gaps when it comes to addressing this question. The vast majority of studies related to transport costs are based on the gravity approach to international bilateral trade (e.g., Limão & Venables, 2001). This macro approach may be useful with respect to international trade research, although Obstfeld and Rogoff (2000) have argued that the costs of trade are the biggest problem yet to be solved in international economics. Further, it has little to offer at the microeconomic level when attempting to determine the real price a company has to pay for transport and the factors that determine it. This is because the gravity approach omits a significant group of variables that have a proven effect on logistics efficiency, but whose impact on transport costs has not yet been empirically demonstrated. Very few of the existing macro models of transport cost have explored possible nonlinear relationships with the explanatory variables, nor interactions between explanatory variables. An additional limitation of the models is that they have estimated the cost of each mode of transport independently, without considering intermodality (combined use of several modes). Lastly, classic models deal with nonmeasurable fixed effects for a route or product by defining the routes and the goods traded between origin–destination countries. This aggregate methodology does not allow an estimation of the transport cost function for individual firms and their distribution routes.

The objective of this paper is to present a model of transport cost determinants that corrects the specification problems observed in the transport cost equations in the previous literature. In order to build a database for the specification and estimation of the freight transport cost function model, primary research was conducted with producing companies that ship goods and with the logistics operators that handle those shipments. As a result, 6390 observations were obtained on 305 routes between the Valencian Community and Europe. By incorporating the determining factors of transport costs with microdata at company and route level, the model enables the calculation of economies of scale, economies of networks and the average marginal cost of the service for each route and each firm. Together with these methodological innovations, the results of this research provide some valuable contributions to the state of the art.

The first theoretical contribution this paper makes towards correcting the specification problems observed in previous transport cost equations is that it jointly incorporates the influence of freight transport supply and demand, infrastructure quality and non-time-varying fixed effects related to the route, the company and its products, and supply chain strategy and configuration. The selection of the variables used to explain the transport cost has been dictated by the theories of industrial economy, transaction costs and regional economy. Taken together, these theories have allowed us to design a theoretical framework with a high potential for predicting economies of scale and flexibility in the configuration of the logistics flows. This is confirmed by the high value of R^2 reported from the econometric models estimated in the empirical analysis.

By examining the transport supply and demand along each route, we have been able to identify the effects of logistics agents' management practices on transport costs. Furthermore, we have been able to provide a degree of disaggregation unusual in the literature. Thus, the research conducted has allowed us to calculate the impact of the interdependencies between operators of each transport mode and the frequency of intermodal transport routes on the price-setting process for freight transport services. The analysis confirms that the degree of rivalry between logistics operators on the route and the economies of scale and flexibility derived from both the volume of freight on the route and the firm's value chain design and production strategy have a more powerful effect on transport costs than the geographical distance variable.

The third contribution of this research is to introduce the possible quadratic effect of distance on transport costs and its effect for each modal choice. The diversity of factors that determine transport costs explains why distance alone cannot strictly be considered a good approximation of transport costs. The scarce existing literature on the subject (Cho, 2014; Wilmsmeier & Martínez-Zarzoso, 2010; Yoko, Mun, Yoshihiko & Sung, 2012), moreover, has assumed a linear relationship between distance and transport costs, presuming the effect to be homogeneous among the different modes of transport. This presumption is flawed because, as this paper reports, the modal benefits vary according to the length of the route. It is therefore interesting to confirm whether the preference for a means of transport varies non-linearly as a function of distance.

Previous literature has examined the effect of the quality of transport infrastructure on the cost of physical distribution, although typically by means of indexes, which makes it impossible to know the impact of each individual attribute of infrastructure quality on the cost. Each mode of transport has different features in terms of these attributes. Thus, the fourth contribution of this study is to propose an econometric model capable of isolating the individual effect of six attributes of network quality (speed, frequency, timeliness, safety, traffic volume and regulatory burden) on the price of the service. The results show that the speed and frequency of the service and the volume of goods shipped on the route are the attributes that have the greatest effect on transport cost.

The rest of this paper is structured as follows. Following this introduction, Section 2 outlines the theoretical framework that underpins the model and introduces the theories, their basic concepts and their applicability to the research questions. Section 3 models the transport cost function and theoretically justifies the hypotheses set out. Section 4 details the methodological aspects in terms of the database, the variables and the empirical analysis. Section 5 presents the findings. Lastly, we lay out the conclusions drawn from the research, along with the academic and practical implications.

2. Theoretical framework

Transport costs are defined as the price the shipper must pay to the carrier or logistics operator for the freight transport service. The basic equation for modelling transport costs estimates them as the sum of the marginal costs borne by companies to transport the goods and their profit margins on a particular route. They include the direct charges for freight and insurance and the indirect costs generated by the movement of goods in transit, their storage along the commercial distribution network, the loading of containers and other concepts.

These marginal costs and profit margins depend on a vector of explanatory variables that can be classified into five categories: the route; the economies of the origin and the destination market; the characteristics of the mode of transport; the transport market; and the firm (Table 1). The selection of variables included in the first transport cost models was largely based on the gravity approach, which focussed on aspects related to the route (mainly distance) and the economies of the origin and destination markets of the goods being transported. Regional economy theory, in addition to emphasising the importance of the inter-territorial asymmetries derived from geography and countries' degree of economic development and internationalisation, added the infrastructure endowments for the different modes of transport as an additional explanatory factor. Our theoretical framework incorporates new variables that draw on theories of the industrial economy and transaction costs. This choice of complementary theoretical perspectives is aimed at capturing transport cost determinants related to the structure of the transport industry, the competition between supply and demand within the industry, the negotiation of transport service contracts, and firms' and logistic agents' factor endowments along the routes.

Table 1. Studies of determining factors of transport costs.

Authors	Area	Determining factors
Limão and Venables (2001)	International transport from Baltimore	Geography of the countries (distance, whether they are an island and sharing a border) and quality of their transport infrastructures (combined index of rail, road and density of telecommunications)
Micco and Pérez (2002)	Maritime transport to the U.S.A.	Distance, value/weight, containerisation, volume of traffic on the route, flow on the route as a share of GDP, port efficiency, infrastructure index, trade policy between the exporting country and the U.S.A.
Smith, Miller and Parhizkar (2008)	U.S. forest products industry	Costs of the different means, infrastructures (road, ports and rail)
Pesut (2009)	European Union	Modal indicators, capacity indicators, performance indicators and environmental indicators
Wilmsmeier and Martínez-Zarzoso (2010)	International maritime transport between Latin American countries	Distance, unit value of the product, refrigerated cargo, shipment volume, number of service providers, connectivity on the route, characteristics of the ship and use of open records
Chow and Gill (2011)	Canada	Container transport, container capacity, number of competing companies in the transport industry, average time and maximum duration of service
Song and Na (2012)	Maritime and rail transport between North-East Asia and Europe	Distance, journey time, load or tonnage and costs of the different means
Yoko et al. (2012)	Japanese interregional trade	Wage rate, transport time, vehicle weight, fuel costs, shipment size, distance, rail use, neighbouring countries, market competition, 'iceberg' transport costs, trade imbalance between country of origin and destination, motorway tolls
Zamora and Pedraza (2013)	International transport for 29 countries in America, Europe and Asia	Distance, export costs, transport time, trade (% G.D.P.), quality of infrastructure and related activities, container traffic in port, transport connectivity, goods transported by road, ship and air, rail network, weight of exports and imports in the balance of payments
W.T.O. (2013)	International transport worldwide	Product characteristics (quality and value/weight ratio), geographical location (maritime access and distance to markets), quantity and quality of infrastructure, market competition, technological changes in transport, ease of trade and fuel costs
Cho (2014)	Maritime transport of 125 countries	Quality of port infrastructure, port services, port connectivity, maritime uncertainty, labour market uncertainty (organisation of work in ports) and institutional uncertainty (regulation, laws)

Source: Authors.

The *gravity model of international trade* has been the most widely used macro approach to identify the determinants of trade costs, due to its focus on the relationships between transport costs, bilateral trade, trade barriers and economic growth (e.g., Anderson, 1979; Baier & Bergstrand, 2001; Clark, Dollar & Micco, 2004; Deardorff, 1998; Hummels, 1999; Limão & Venables, 2001; Márquez, Martínez, Pérez, & Wilmsmeier, 2007; Martínez-Zarzoso, García, & Suárez, 2003; Martínez-Zarzoso & Suarez-Burguet, 2005; Micco & Pérez, 2002; Wilmsmeier & Pérez, 2005). The central postulate of the gravity equation describes the value of bilateral trade between two economic areas based on the distance that separates them and their respective masses (measured by the size of their economies). The transport cost equations constructed in this literature usually include relatively few macro-level variables related to geographical factors, route infrastructure, transport conditions required by the product, factors related principally to economies of scale, and issues related to the exporting and importing countries (such as regulation, macroeconomic conditions and trade imbalances).

From the outset, regional economics has been concerned with the interaction between space and economic activity. Transport economics has mainly addressed three aspects: the choice of transport mode; improvements in transport infrastructures and their impact on non-market resources such as time; and the institutional and commercial arrangements regulating transport. This discipline has tended to view transport as a perfectly competitive black box, prompting it to focus its analysis on distance and time, thereby overlooking the matter of how the prices and costs of the service are fixed and how these magnitudes vary with different structures of the transport market and its regulation. On the other hand, transport economics has developed an analysis that recognises the imperfections of the transport market, albeit within models of perfect competition in which the user's demand for transport exactly reflects the price they are willing to pay (Rietveld & Vickerman, 2004, p. 230). The new economic geography (Krugman, 1991a, 1991b) has reconciled these two traditions by developing models where production and location decisions are guided by, among other factors, the costs of moving goods in space.

Economic analysis of transport has also benefited from the application of the industrial organisation concept to characterise this industry as compared to other economic activities, following the theory and methodology developed by the new industrial economics (Scherer & Ross, 1990; Schmalensee & Willig, 1989) and in line with the firm's strategy (Porter, 1980). As such, a set of factors related to transport supply and demand have been studied; these include costs, demand, technology, pricing, investment decisions, regulation, externalities and the structure of competition in the transport market (Aggelakakis et al., 2015; Porter, 1983; Quinet & Vickerman, 2005; Saeedi, Wiegmans, Behdani, & Zuidwijk, 2017).

Transaction cost theory (Williamson, 1985, 1986) represents an interesting contribution to the economic analysis of companies and markets. The main idea of this approach is that markets are imperfect, since transactions are not fully cost-free. Transaction costs are the charges incurred by making transactions in the market, in contrast to the coordination costs borne by the firm as a result of its internal organisation. The central postulate of the approach is that the higher the transaction costs, the lower the likelihood of exchanges between firms. Transport costs are a major component of transaction costs. The choice of the optimal governance structure, that is, the one that minimises transaction costs, is explained by three variables: the specificity of the asset; the degree of uncertainty; and the frequency with which the main transactions are made, which in turn depends on the configuration of the value chain and the level of vertical integration of the company.

3. Modelling the transport cost function

Within the container management industry, there has traditionally been strong competition between operators, who, despite their large size, operate globally and yet at the same time face intense local competition for shorter journeys (W.T.O., 2013). The growth of freight flows on a route has historically led to a greater concentration of freight in the hands of large operators (Merikas, Merikas, Polemis, & Triantafyllou, 2013; Sys, 2009; U.N.C.T.A.D., 2010). Large trade flows could, however, simultaneously result in an increase in the degree of competition on that route (Kumar & Hoffmann, 2002) by attracting new competitors from different transport modalities (Laroche, Sys, Vanelslander, & van de Voorde, 2017). The greater competition along routes with growing volumes of traffic allows container operators and service users to save on transaction costs. Other links in the distribution chain, such as land transport by truck or the non-regular shipping lines, are more fragmented industries in which service providers have low bargaining power with distributors, resulting in intense price competition (Clarkson Research Studies, 2004). Moreover, having more operators along a route will result in a higher number of regular services, which in turn means more choice for the user and greater competitive pressure. Within the transport industry, the companies contracting the service will gain negotiating power when their firm size is relatively greater than that of the logistics operators working on the route. Therefore, the following hypothesis is proposed:

Hypothesis 1: A firm's transport costs for a particular route have a negative relationship with both the firm's size relative to that of the logistics operator and the number of operators on the route.

A second determining factor of transport costs is the economies of scale that can arise both from the volume of operations of the contracting company and the logistics operator, and from the flow of goods transported along the route (Caves, Christensen, & Swanson, 1981). The standard way of calculating traffic volume along a route is the number of standard-size containers travelling in both directions (Jara-Díaz & Cortés, 1996). A larger volume is expected to generate greater economies of scale in modal contracting, as well as in the costs for access and transit to the facilities (Filippini & Maggi, 1992; Gagné, 1990).

Trade flows between the origin and destination regions of the route involve another range of aspects significantly affecting transport costs, which are ultimately driven by economies of scale. The volume of exports will be directly associated with the traffic volume along the routes connecting the two regions, and therefore with the economies of scale that the exporter can take advantage of (Clark et al., 2004; Hummels, 2001; Limão & Venables, 2001; Márquez et al., 2007). It should, however, be borne in mind that, along a single route, journeys are made in either direction, and therefore the volume of traffic in each direction can affect transport costs. When there is a negative trade balance between the origin and destination regions, a reduction in the price of the service for exporters can be expected (Hoffmann, 2005; Márquez et al., 2007; Micco & Pérez, 2002) due to the strong competition among the logistics operators seeking to capture business on the routes with less traffic (in this case, the export or outward journey). Operators that fail to secure such business would be underutilising their carrying capacity.

The size of the operator itself is another source of economies of scale in transport management (Márquez et al., 2007). There are two elements to these economies of scale. The first is the vehicle's transport capacity: an increase in load capacity enables a direct reduction in the unit cost of freight. The second is operator size, whether direct (transport company) or indirect (port, dock or loading platform): at this level, increasing returns stem from a more optimised use of assets thanks to the greater volume of goods to be handled and the availability of infrastructure on the loading platforms (Bougheas, Demetriades, & Morgenroth, 1999; Fernández, Arruñada, & González-Díaz, 2000).

Increased efficiency along a route stemming from improvements in this set of factors in turn enables operators and their service users to save on transaction costs, thanks to the economies of scale generated. Therefore, the following hypothesis is proposed:

> **Hypothesis 2**: A firm's transport costs on a particular route have a negative relationship with the scale economies generated by both the size of the logistics operator as well as the volume of traffic on the route, exports and the negative trade balance between the origin and destination regions.

The volume of goods for distribution that the firm handles, as well as the average size per shipment, can be considered proxy variables for the firm's logistic capabilities (Memedovic, 2008; PwC, 2016). An exporter that has to transport large volumes of freight and handle ever-bigger orders will be forced to invest in assets and logistics skills that enhance its efficiency in physical distribution. How that firm configures its logistics system also influences the efficiency of its distribution process. Opting for vertically integrated production and distribution reduces the need for external supplies, thus resulting in a reduction in transport costs linked to supply.

The search for economies of scale or density can lead to the creation of vertically integrated structures that facilitate the coordination of more concentrated loads and traffic flows (Chang & Friedlaender, 1984; Corsi & Grimm, 1987). To prevent problems of moral hazard, firms need effective safeguards requiring substantial investments (for training and supervision of employees and monitoring compliance with their obligations to customers). All these tasks are subject to significant economies of scale that are inseparable from the size of the firm (Fernandez et al., 2000). The following hypothesis is therefore proposed:

> **Hypothesis 3**: A firm's transport costs on a particular route have a negative relationship with the volume of cargo contracted, the average size per service and its degree of vertical integration.

Conversely, transport costs are driven by the adoption of flexible production and distribution systems, one element of which is the outsourcing of components. Although the system is set up to ensure a flexible supply that reduces delivery time and the cost of non-moving inventory, as well as preventing breaking points in the supply chain, another consequence is that it drives up transport costs by increasing the traffic of inputs required for assembly of the end product. As such, it is to be expected that a firm demanding greater load flexibility, whereby it is allowed to make shipments without filling the vehicle or container to its load capacity, will face a higher unit cost of transport, reflecting the unused capacity. If the firm requires more time flexibility, allowing a greater number of orders to be sent on a route, this would typically result in a reduction in the average size of the shipment, meaning it misses out on the economies of scale achievable by concentrating the service (Russell, Coyle, Ruamsook, & Thomchick, 2014). The development of global value chains has multiplied the volume of goods traded between companies that make up the network (Stock, Noel, & Kasarda, 2000), and led to an increase in transport costs due to firms importing various inputs from a wide range of supplier countries. It is therefore expected that:

Hypothesis 4: A firm's transport costs have a positive relationship with the adoption of a lean production system, and the demand for time flexibility and load flexibility.

According to Button (1993, p. 49), modal choice is no longer governed by price; these days the determining factors are how well the vehicle meets the cargo requirements and the dependability of the delivery date. The fact that the demand for freight transport is strongly dependent on the service quality has important implications for its cost (Kumar & Hoffmann, 2002; Márquez et al., 2007). Ideally, in an environment of perfect information or unlimited rationality, contracts between customers and transport service providers would allow strategic adaptation to any type of contingency. Transaction costs arise when contracts are not fulfilled due to the impossibility of foreseeing all possible future circumstances in a relationship (Coase, 1937). This opens the door to potential opportunistic behaviour by one of the parties involved (Williamson, 1979, 1985). Transaction costs linked to freight transport include both the ex-ante costs associated with drawing up the contracts and the ex-post costs arising from fulfilling these contracts (Cho, 2014). According to the theory of transaction costs, these costs will be higher when specific assets are involved in the transactions. When transport operators – whether land, sea or air – wish to provide a quality service (approximated by their speed and timeliness), they must commit to investing in specialised or non-standard physical assets, whose recovery value is low or almost non-existent. They also have to hire specific, highly qualified human resources or train them up through learning-by-doing processes. This gives rise to a bilateral dependence that increases the contractual risks of opportunistic behaviour (Williamson, 1991, p. 114), due to the difficulty of drafting a contract that ties the parties to one another over the long term. Information asymmetries also arise between the agents, which tend to lead to problems with selecting and managing the most appropriate suppliers (Bradley, 1995). The transaction costs linked to transport will increase in both cases due to the complexity of the ex-ante and ex-post mechanisms needed to prevent such failures. The creation of effective safeguards requires substantial expenditures in the form of prior compliance with obligations, disclosure, and employee training and supervision structures. It is therefore expected that:

Hypothesis 5: A firm's transport costs have a positive relationship with the speed and timeliness of the transport service.

On the other hand, greater frequency entails more traffic on the route, which gives the firm contracting transport services more options for sending their products at the desired time. This helps it reduce storage times and achieve more efficient management, resulting in economies of scale (Djankov et al., 2010; Márquez et al., 2007). A more frequent service on a route can also give rise to intense competition between operators and therefore a downward pressure on the price (Francois & Wooton, 2001). Savings in transport costs can likewise occur when the number of stopovers on the route increases. This means a longer transit time and therefore a poorer quality service, which would force the operators on the route to lower their prices to offset said disadvantage (Hummels, 2001). A third dimension of service quality similarly affecting transport costs is safety. A reduction in the accident rate has an immediate positive effect in terms of lowering the costs related to material losses, service breakdown, and other insurance and contract contingencies (Baumol & Vinod, 1970). Consequently, the related hypothesis can be stated as follows:

> **Hypothesis 6**: A firm's transport costs have a negative relationship with both transport service frequency and safety, and the number of stops on the route.

Regulatory intensity refers to the number of controls and procedures involved from the initial contracting of the service until the journey along the route has been completed. This institutional burden has a direct monetary cost, which is the price for all the certificates and documents that need to be filled out, and another indirect monetary cost, which is the time lost on the trip due to intermediate procedures at checkpoints, transshipments or cross-border points (Griliches, 1972; Levin, 1978). Therefore, the expected sign of the relationship between this factor and transport costs is positive:

> **Hypothesis 7**: There is a positive relationship between the regulatory burden of the transport service and transport costs.

In the classic gravity model, distance is the variable used to capture the transit time on a route and its effects on the cost of transport. Following the study by Bougheas et al. (1999), however, it is now assumed that this cost also depends on the infrastructure in place along the route. The geographical location of supply and demand cannot be changed in the short term,[1] but its economic effects can be alleviated by improving the infrastructure along the route. Since in real terms making improvements to infrastructure means cutting transit times and ensuring greater efficiency on the journey, it can be considered as equivalent to shortening the actual distance of the route. The operators could then be expected to transfer at least part of the cost savings derived from the new transport alternative to the price of the service. The coverage and quality of transport infrastructure covering a route is a determinant of the accessibility of destination markets for the exporting company (Albarrán, Carrasco, & Holl, 2013; Francois & Manchin, 2007; Xu, 2016). The lower the accessibility, the more difficult the negotiation will be for the parties involved in the transport. Any increase in the variability of, and therefore the uncertainty about, the service provision conditions can drive up the costs of negotiation (Hallikas, Virolainen, & Tuominen, 2002). This is due to the fact that the firm contracting the transport services would need more time for negotiation and bargaining, and because it would want to ensure that safeguards are included in the contract to protect its shipments from opportunistic behaviour and service breaches by operators (Cho, 2014). Furthermore, the improvement and expansion of transport infrastructure helps to reduce the costs inherent to transit time (Limão & Venables, 2001; Golub & Yeaple 2002), can increase the volume of freight flow along the route generating economies of scale (Lakshmanan, 2011), and can attract a greater number of operators seeking to tap into the demand along an improved route offering new benefits. The related hypothesis can thus be expressed as follows:

Hypothesis 8: A firm's transport costs have a negative relationship with the quantity and quality of infrastructure on the route.

The transport requirements specific to the product being transported can also influence the costs involved in moving it. The unit value of the goods transported is expected to be positively related to transport costs (Hummels, 1999, 2007; Kumar & Hoffmann, 2002; Martínez & Suárez, 2005), even with the inclusion of a dummy variable for refrigerated cargo (Márquez et al., 2007). This is because exporters of high value-added products will tend to select transport services that offer better quality in terms of packaging, speed, timeliness and safety, which generally cost more, as well as insurance that is more comprehensive and thus more expensive. On the other hand, firms shipping lower value-added goods that compete on the basis of price will choose transport services largely according to cost (Feo, García, Martínez, & Pérez, 2003). The following hypothesis can therefore be proposed:

Hypothesis 9: A firm's transport costs have a positive relationship with both the unit value of the goods being shipped and the requirement for refrigerated transport.

Geographical distance has been empirically demonstrated to be a direct determinant of trade costs in studies based on gravity models (Anderson & van Wincoop, 2003; Bergstrand, 1985; Deardorff, 1998; Limão & Venables, 2001; Márquez et al., 2007). Although the transport service rates charged are primarily determined by the supply and demand conditions, geographical variables undoubtedly have an impact on transport costs as they decisively influence certain essential components of said costs for logistics operators. Such components include the wage costs (linked to transit time), energy consumption and asset depreciation, all of which are directly associated with the length of the route. A clear association is therefore expected between distance and transport costs, regardless of the chosen distribution means. Other geographical barriers that may affect the cost of the service are the degree of adjacency between the points of origin and destination of the shipment (Limão & Venables, 2001; Novy, 2013), and whether the delivery point is an island (Limão & Venables, 2001; Martínez & Hoffmann, 2007). Transport costs would logically be lower when origin and destination countries are near to one another, and also when the destination is an island. In the first case, costs relating to customs and shipping management will be lower because there will be fewer borders to cross. A previous study has estimated the impact of customs delays on the cost to exporters at 0.0007% (Micco & Pérez, 2002). Our model, however, omits this variable because it only deals with the routes between one particular Spanish region and Europe, which are both part of a free trade area where customs barriers and costs are minimal. In the second case, transporting to an island means that most of the journey will be made by sea, which is the most efficient mode. The hypothesis concerning the effect of these two geographical variables can thus be stated as follows:

Hypothesis 10: There is a positive relationship between the length of the route and a firm's transport costs, while the relationship between island destination and transport costs is negative.

The interactions between mode of transport and distance, and mode of transport and the quadratic distance term, are included to explore whether the modal preference based on cost can change with the length of the route. As such, we can examine which modes of transport benefit from long routes. In particular, the quadratic distance allows us to examine the relationship between freight transport costs and distance, and determine whether it follows a linear or logistic pattern. The flexibility of truck haulage makes it the most suitable mode for short distances, although its cost increases continuously and exponentially with the length of the route; this is due to the marginal costs involved, primarily relating to labour (Maddison et al., 1996; Reis, 2014). One might therefore expect to see a curve where transport costs continually increase with distance. On the other hand, the other three means of transport (ship, aeroplane and train) show strong economies of scale with the increase in distance (Forkenbrock, 2001; Rutten, 1995). It is therefore to be expected that the positive effect of the length of the route on transport costs will be mitigated by using one of these other means, such that the resulting increase in unit cost will be less than proportional to the increase in distance. This moderating effect on rising transport costs with distance will, however, reach a limit. After that point, a longer journey will add additional costs to those inherent in distance, meaning that the transport cost function will again start to increase linearly. There may be a number of reasons for this, such as a need for intermodality to complete the journey (Jiang, He, Zhang, Qin, & Shao, 2017; Pellicelli & Chiara, 2010) or problems with traffic congestion on some parts of route (Abe & Wison, 2009) These arguments give rise to the following two hypotheses:

Hypothesis 11: There is a positive linear relationship between the use of truck haulage and transport costs, though beyond a certain distance threshold the costs will start to increase exponentially.

Hypothesis 12: The rise in transport costs with the increase in distance will be moderated by using rail, maritime and air options, though beyond a certain distance threshold the costs will start to increase exponentially.

4. Empirical research methodology

The dependent variable is calculated as the average cost in euros paid by the company per tonne of transport along a certain route, considering all the means of transport used and weighted by the intermodal weight. It was decided not to use independent estimates of transport costs for each mode, in order to take into account the interdependencies between operators of each mode in the process of setting prices and the frequency of intermodal journeys. A firm seeking to transport its goods compares the benefits of the available alternatives and their respective prices, and any changes to one of those characteristics modifies the utility perceived by the user. The price elasticity of substitute products (such as the different means of transport) makes it advisable to work with an aggregate indicator.

Table 2 shows the 27 explanatory variables included in the theoretical model, their measurements and the sources of the data. The last block of variables covers the provision of useful infrastructure for transport, based on the variables included by the World Economic Forum in its Global Competitiveness Index. Given the range and

Table 2. Explanatory variables: definition and sources.

Variable	Definition and measurement	Data source
1. Number of operators on the route NOPER	Number of logistics operators that operate regular transport lines offering a service from the firm's premises to the export destination.	World Bank and U.N.C.T.A.D.
2. Relative size of the firm SIZEFIRM	Firm's volume of net sales in euros relative to the average net sales of the logistics operators on the route.	Sistema de Análisis de Balances Ibérico (S.A.B.I.)
3. Volume of traffic on the route TRAFIC	Volume of the flow of goods moving along the route in both directions. Measured by the number of standard 20 ft containers transported annually.	*Logistics Performance Index*, World Bank
4. Exports	Exports from the Valencian Community to the destination region/country in tonnes.	Eurostat and the Valencian Statistics Institute
5. Foreign trade balance TRADEBAL	Trade imbalance between the Valencian Community and the destination region/country for the exported goods, calculated as the difference between exports and imports.	Eurostat and the Valencian Statistics Institute
6. Size of the operator SIZEOP	Synthetic index providing an equally weighted aggregate of the vehicle capacity (in tonnes of cargo) and the size of the operator in volume of cargo handled annually.	Primary study
7. Firm's load volume on the route LOAD	Volume of goods shipped by the firm to each destination, estimated as the percentage of sales to that destination over total exports. This variable also approximates the product weight factor.	Primary study
8. Average shipment size SIZESHIP	Average shipment volume measured in cubic metres.	Primary study
9. Degree of vertical integration VERTINT	Represents the exporting firm's production and logistics configuration, that is, the degree of internalisation or outsourcing of these stages of the value chain. It is measured as the ratio between value-added and gross production.	Primary study
10. Lean production system LEAN	Dummy variable that takes a value of 1 if the company has implemented a flexible production system such as just-in-time, and 0 otherwise.	Primary study
11. Firm's time flexibility TIMEFLEX	Frequency of shipments of goods by the firm to a certain destination, measured as the average annual number of shipments.	Primary study
12. Firm's load flexibility LOADFLEX	Represents the percentage of shipments by the firm to a destination that do not entirely fill a truck or container.	Primary study
13. Number of stops on the route STOPSROUTE	Number of changes in the means of transport that the goods must go through from leaving the production company to arriving at the buyer's premises.	Foreign Trade Information System (S.I.C.E.)
14. Route speed SPEEDROUTE	The average speed in kilometres per hour the service reaches along the route, weighted by mode. Reflects the door-to-door delivery speed either by a single means of transport or with an intermodal service.	Primary study
15. Route frequency FREQROUTE	Frequency offered by the logistics operator in terms of the number of weekly departures to the destination.	Primary study
16. Route timeliness TIMEROUTE	Variability in journey time, which captures the reliability of the service in terms of the agreed delivery date. It is measured as the percentage of shipments that comply with the agreed delivery conditions.	Primary study
17. Route safety TIMESAFETY	A measure of the risk of accidents operationalised by the accident rate per 1000 journeys.	*Logistics Performance Index*, World Bank
18. Regulatory burden REGUL	The number of controls and procedures that must be complied with to complete the journey.	*Logistics Performance Index*, World Bank
19. Transport infrastructure by road INFROAD	Degree of development of road freight transport infrastructure that can be used by the truck from leaving the Valencian Community to arriving at the delivery point. The infrastructure index for road transport IC_{ij} expresses the relative ease of travelling between locations *i, j*, which depends on the length of paved roads in kilometres, motorways per square kilometre and the land area in kilometres of the countries that must be crossed. Not all roads offer the same ease of travel; since motorways enable faster access to the destination markets, they have been assigned a higher weight of 1, while simple paved roads	*World Economic Forum* and Spanish Ministry of Public Works

(*continued*)

Table 2. Continued.

Variable	Definition and measurement	Data source
	are weighted by a factor of 0.75. The calculation can therefore be expressed as follows: $\frac{(0.75\times \text{km of paved roads})+\text{km of motorway}}{\text{Land area in km}}$ Values for this index therefore range between 0 and 1 depending on the quality of the roads along the route.	
20. Transport infrastructure by sea INFSEA	The maritime infrastructure variable that we use is the port efficiency index proposed by Clark et al. (2004), which takes into account values for the general conditions of port infrastructures (metres of berthing line and storage, the maximum berth depth, the number of cranes, the number of lines on offer to each destination and their frequency, the transport capacity of the ships that cover the routes, their speed and the number of stopovers), the degree of regulation of maritime activity and of the existence of organised crime.	*World Economic Forum* and port authorities of the Ports of Castellón, Sagunto, Valencia and Alicante
21. Transport infrastructure by air INFAIR	Measured by taking into account the general conditions of air infrastructures and their degree of regulation. The regional service offering for air freight includes the airports of Valencia and Alicante with indicators such as the number of operators covering the route, the load capacity of the aircraft and their frequency of flights to the destination.	Management organisations of the airports of Valencia and Alicante and airlines
22. Transport infrastructure by rail INFRAIL	Degree of development of rail transport infrastructure from leaving the Valencian Community to arriving at the delivery point. The infrastructure index for road transport IF_{ij} expresses the relative ease of travelling between locations *i, j*, which depends on the length of the route and the nature of the rail network (standard-gauge railway or international gauge), as well as the land area in kilometres of the countries that must be crossed. Since not all railways offer the same ease for freight traffic, a higher weight has been assigned to modern lines, with high-performance railways assigned a weight of 1 and standard tracks weighted by a factor of 0.5. The calculation can therefore be expressed as follows: $\frac{(0.75\times \text{km of paved roads})+\text{km of motorway}}{\text{Land area in km}}$ Values for this index therefore range between 0 and 1 depending on the quality of the railway lines along the route.	*World Economic Forum* and Spanish Ministry of Public Works
23. Unit value of product VALUEPRO	Index of the unit value of the transported goods, calculated as the free on board (F.O.B.) price in euros per kilogram for each export shipment.	Primary study
24. Refrigerated container REFRIG	Dummy variable that takes a value of 1 if the goods are transported in a refrigerated container, and 0 otherwise	Primary study
25. Island destination ISLAND	Dummy variable that takes a value of 1 if the destination point is located on an island, and 0 otherwise	Foreign Trade Information System (S.I.C.E.)
26. Route distance ROUTEDIST	Number of kilometres door-to-door of the route. With intermodal routes, the distance is given by the sum of the kilometres travelled with each means of transport	*Michelin Guide and World Ports Distance*
27. Quadratic route distance ROUTEDIST2	Measures the possible quadratic effect of the variable *route distance*	*Michelin Guide and World Ports Distance*

Note: S.I.C.E.: Sistema de Información sobre Comercio Exterior.
Source: Authors.

variety available, it has been decided to represent this aspect using synthetic indexes, a commonly used technique in this field (e.g., Coca, Márquez, & Martinez, 2005; Limão & Venables, 2001). These synthetic indexes provide an average of the connectivity of a particular route, considering the different components that determine an infrastructure's capacity to handle trade. Four indexes have been built to incorporate the characteristics of the four modes of transport. For each one, it has been guaranteed that the index meets the conditions of stability, neutrality, defined and internally

Table 3. Technical data sheet for the empirical research.

Population	Manufacturing firms that ship goods to Europe and logistic operators that handle those shipments
Sample	583
Reliability (margin of error)	95.5% (±3.1%)
Number of observations	6390
Number of observed routes	305
Data collection method	Personal interview based on a structured questionnaire
Fieldwork period	January–March 2011

Source: Authors.

symmetric range, and simplicity of calculation. These indexes are estimated based on the averages of the data on transport infrastructure between the Valencian Community and the Spanish border with France, in the transit countries and in the destination country; the data have then been adjusted according to the number of borders to be crossed.

In order to construct the database that enables the specification and estimation of the freight transport cost function model, 583 personal interviews were conducted with producing companies that export to Europe and with the logistics operators that manage the exports. The initial sample included 800 firms that were randomly selected from the 2011 Business Census published by the Instituto Nacional de Estadística (Spanish National Statistics Institute): specifically, firms were drawn from the sectors of export companies and logistic and transport operators. Thus, the final rate of participation in the empirical study was 72.9%.

The interviewees were the logistics managers in the exporting companies and general managers in the logistics operators. The personal interviews were conducted from January to March 2011. On completion of the empirical work, 305 routes between the Valencian Community and Europe had been identified, from which 6390 observations of freight transport service users were obtained. Since the analysis only includes routes within the E.U., which have no barriers to transport, it is not necessary to include in the model the number of countries crossed nor their adjacency. Table 3 offers a data sheet of the empirical research.

Although the database is from 2011, it is presumed that the information it contains and the results subsequently obtained remain representative today. The authors have since then carried out another similar study with updated data, and the results obtained did not differ in any meaningful way from those presented in this study.

The transport cost equation relies on a panel data model with a sufficiently long series, which allows us to solve the problems of endogeneity and any heterogeneity not directly observable in the explanatory and/or omitted variables. The use of panel data allows the aggregation of cross-sectional and time-series data, thus making the most of all available information. For this reason, this is the predominant methodology employed in studies of the determinants of the cost of transport. Furthermore, the panel data model enables an analysis of the different combinations between product, route and mode of transport.

In the first step, an econometric model is proposed, which is capable of isolating the effect of the set of determining factors on the price of the service at the present time. The vector of explanatory variables covers a series of variables that are time invariant and whose effects are assumed to be fixed during the period under analysis. Specifically, data regarding the structural aspects of the product (need for refrigerated containers), the firm and its transport demand (variables 6–12), are assumed to be constant, as well as other variables related to geography, such as distance and island destination. The rest of the factors take variable values as a function of time, with the series comprising the years 1990–2011.

In order to determine the specification of the transport cost function with the best fit, eight models have been estimated, progressively introducing the explanatory variables. The estimation strategy is based on a model that aggregates all temporal and individual information – without differentiating between individuals and periods – in a data pool, and estimating it by means of ordinary least squares (O.L.S.). Starting with this basic model, which includes the classic supply and demand variables for freight services, additional models are then estimated that incorporate variables relating to the means of transport, the route, the market and the product. In an eighth model, the same equation with interaction effects is estimated usinginstrumental variables (I.V.) in order to correct the endogeneity of one explanatory variable. The variable considered endogenous is the volume of exports and, as in previous studies (Márquez et al., 2007), the population in the destination country has been used as an instrument.

The estimated model determines the function of the transport costs in euros per tonne of the load k from the location of firm i to country j (points defining the route) using the mode of transport m along route x, part of the vector of the 27 identified variables that characterise the problem, thus ensuring that it is a perfectly specified model. The transport cost function (COSTTE) is as follows:

$$\begin{aligned}\mathrm{COSTTE} = {} & \beta_0 + \beta_{\mathrm{NOPER}}(NOPER_{ijx}) + \beta_{\mathrm{SIZEFIRM}}(SIZEFIRM_i) + \beta_{\mathrm{TRAFIC}}(TRAFIC_x) + \\ & \beta_{\mathrm{EXPORTS}}(EXPORTS_{ij}) + \beta_{\mathrm{TRADEBAL}}(TRADEBAL_{ij}) + \beta_{\mathrm{SIZEOP}}(SIZEOP) + \\ & \beta_{\mathrm{LOAD}}(LOAD_{ij}) + \beta_{\mathrm{SIZESHIP}}(SIZESHIP_{ij}) + \beta_{\mathrm{VERTINT}}(VERTINT_i) + \beta_{\mathrm{LEAN}}(LEAN_i) + \\ & \beta_{\mathrm{TIMEFLEX}}(TIMEFLEX_{ij}) + \beta_{\mathrm{LOADFLEX}}(LOADFLEX_{ij}) + \beta_{\mathrm{STOPSROUTE}}(STOPSROUTE_{mx}) + \\ & \beta_{\mathrm{SPEEDROUTE}}(SPEEDROUTE) + \beta_{\mathrm{FREQROUTE}}(FREQROUTE_{mx}) + \\ & \beta_{\mathrm{TIMEROUTE}}(TIMEROUTE_{mx}) + \beta_{\mathrm{TIMESAFETY}}(TIMESAFETY_{mx}) + \beta_{\mathrm{REGUL}}(REGUL_{mx}) + \\ & \beta_{\mathrm{INFROAD}}(INFROAD_{ijm}) + \beta_{\mathrm{INFSEA}}(INFSEA_{ijm}) + \beta_{\mathrm{INFAIR}}(INFAIR_{ijm}) + \\ & \beta_{\mathrm{INFRAIL}}(INFRAIL_{ijm}) + \beta_{\mathrm{VALUEPRO}}(VALUEPRO_i) + \beta_{\mathrm{REFRIG}}(REFRIG_i) + \\ & \beta_{\mathrm{ISLAND}}(ISLAND_{ij}) + \beta_{\mathrm{ROUTEDIST}}(ROUTEDIST_{xm}) + \beta_{\mathrm{ROUTEDIST2}}(ROUTEDIST2_{xm})\end{aligned}$$

The partial models show that the explanatory power of the model improves in all cases with the inclusion of additional variables other than those covered in the basic model. This indicates that the freight transport market is subject to numerous distortions that lie outside the free interplay of supply and demand. Nevertheless, given that the values and signs of the estimated coefficients do not differ substantially in the different models, we limit ourselves to presenting the results of the three global models (Table 4). The regression in the first stage of the I.V. procedure confirmed the significance of the instrument for the endogenous explanatory variable. Hansen's J test of over-identifying restrictions was not significant, which confirms the validity of the selected instrumental variable. In addition, the Hausman test confirmed that

Table 4. Empirical model results.

Variable	O.L.S. Coeff.	O.L.S. S.E.	O.L.S. with interactions Coeff.	O.L.S. with interactions S.E.	I.V. model Coeff.	I.V. model S.E.
1. Number of operators on the route	−0.312	0.819	−0.562**	0.222	−0.521*	0.352
2. Relative size of the company	−0.401***	0.088	−0.946**	0.464	0.727	1.125
3. Volume of traffic on the route	−1.104**	0.916	−1.131**	0.440	1.295**	0.558
4. Exports	−0.767**	0.466	−1.068***	0.415	−0.953*	0.525
5. Foreign trade balance	−1.245***	0.087	−1.237***	0.260	−1.701***	0.428
6. Size of the operator	0.805	0.015	−0.802***	0.000	−0.802***	0.000
7. Firm's load volume	−1.282**	0.476	−1.079***	0.754	−1.007*	0.927
8. Average shipment size	−1.577***	0.110	−1.119***	0.385	−0.936*	0.467
9. Degree of vertical integration	−0.003	0.185	−0.786***	0.230	−0.467	0.302
10. Lean production system	0.463*	0.334	0.779**	0.348	0.421	0.607
11. Firm's time flexibility	1.454***	0.506	1.424***	0.314	−1.135***	0.444
12. Firm's load flexibility	0.134**	0090	1.243***	0.364	1.249**	0.504
13. Number of stops on the route	−0.341***	0.120	−0.674**	0.333	−0.486	0.317
14. Route speed	0.031***	0.033	0.037**	0.149	0.039*	0.169
15. Route frequency	−0.097***	0.090	−0.020***	0.004	−0.019***	0.006
16. Route timeliness	0.103***	0.092	0.018***	0.005	0.017**	0.008
17. Route safety	1.004***	0.104	1.259***	0.442	0.956	0.610
18. Regulatory burden	−0.003	0.045	−0.033*	0.019	−0.038	0.024
19. Transport infrastructure by road	−0.204*	0.230	−0.479**	0.224	−0.007*	0.004
20. Transport infrastructure by sea	−0.178*	0.888	−0.555**	0.359	−0.533***	0.347
21. Transport infrastructure by air	−0.212**	0.089	−0.101	0.992	−0.518**	0.619
22. Transport infrastructure by rail	−1.005***	0.208	−1.412***	0.347	−1.327***	0.507
23. Unit value of product	0.107**	0.029	0.102***	0.003	0.102***	0.006
24. Refrigerated container	0.112	0.039	0.121	0.247	0.681	0.537
25. Island destination	−0.204	0.620	−1.501	0.992	−1.528	1.184
26. Route distance	0.131**	0.167	0.166***	0.055	0.132*	0.070
27. Quadratic route distance	−0.089	0.342	−0.067	0.047	−0.067	0.050
28. Distance × truck mode			0.168***	0.156	0.142***	0.275
29. Distance × ship mode			−0.156***	0.128	−0.139	0.255
30. Distance × aeroplane mode			−0.455*	0.238	−0.726*	0.399
31. Distance × train mode			−0.180***	0.876	−0.122***	0.380
32. Quadratic distance × truck mode			0.403***	0.303	0.453***	0.418
33. Quadratic distance × ship mode			0.088	0.118	0.451	0.403
34. Quadratic distance × aeroplane mode			0.005*	0.003	0.052	0.239
35. Quadratic distance × train mode			0.272*	0.255	0.275	0.325
Adjusted R^2			0.759		0.814	0.717
Test for instrument validity			$p = 0.000$***		$p = 0.000$***	
Hansen's *J* test of over-identifying restrictions			$p = 0.817$		$p = 0.608$	
Hausman test of O.L.S. model compared to I.V. model			$p = 0.443$		$p = 0.751$	

*$p < 0.1$;
**$p < 0.05$;
***$p < 0.01$.
Source: Authors.

the O.L.S. model (more efficient) is preferable to the I.V. model, and thus supports the exogeneity of the potentially endogenous explanatory variable. Therefore, our subsequent analysis uses only the O.L.S. version with interaction variables.

5. Results

The results are extremely encouraging as they generally allow us to confirm the hypotheses set out in the theoretical model. The model shows excellent goodness of fit ($R^2 = 0.814$),[2] and most of the explanatory variables are statistically significant in the expected direction.

First, the study confirms H1, showing that the intensity of competition between operators on the route is related to lower transport costs. These costs are especially sensitive to the negotiating power held by the exporting firms due to their greater relative size (-0.946, $p < 0.05$), although the competition linked to the number of established competitors on the route is not negligible (-0.562, $p < 0.05$).

The research also confirms the impact of a series of factors identified in H2 and H3 as sources of economies of scale that help reduce transport costs. Economies of network linked to the volume of traffic on the routes are just as important as the internal economies that the firm achieves by concentrating its cargo on one route and the goods to be transported in as few shipments as possible (the coefficients of all these factors are higher than 1 and their level of significance $p < 0.01$). The size of the operator is another determinant of lower transport costs, albeit less influential (-0.802, $p < 0.01$). It is interesting to note that an alternative way to reduce transport costs is cutting out the need for this service by internalising production. Vertical integration thus contributes to greater logistic efficiency, driving a reduction in transport costs in absolute terms (with an elasticity of -0.786, $p < 0.01$).

On the other hand, the benefits of organising the supply chain according to the principles of flexibility and production outsourcing rather than internalisation and volume are offset by the higher transport costs, as predicted by H4. Both the adoption of a lean production system (0.779, $p < 0.05$) and physical distribution models aimed at tailoring delivery time and order volume to customers' needs (1.424 and 1.243, $p < 0.01$, respectively) are associated with an increase in logistics costs.

Empirical tests also confirm the twofold and contradictory effect of freight service quality variables on transport costs. The first block of quality aspects, including speed (0.037, $p < 0.05$) and timeliness (0.018, $p < 0.01$), drive up the cost of transport (H5), while other factors related to frequency (-0.020, $p < 0.01$), safety – measured inversely by the accident rate – (1.259, $p < 0.01$) and stopovers at service points (-0.674, $p < 0.01$) all contribute to a cost reduction (H6).

Regulatory intensity (-0.033, $p < 0.1$) and a high-value product (0.102, $p < 0.01$) are other drivers of transport cost increases, whereas no significant effects (0.121, n.s.) are reported for another product-specific feature: the need for refrigerated transport. Therefore, H7 is confirmed (albeit only weakly significant) while H9 is only partially corroborated.

The last propositions of the theoretical model point to the effects of physical assets, whether natural or artificial, on the cost of transport. The availability of extensive, good-quality infrastructure, especially rail infrastructure, helps reduce transport costs. The exception is air transport infrastructure, which does not appear to have an impact. Thus, the empirical tests partially confirm H8. As for the natural geographical factors, an island destination (-1.501, n.s.) does not seem to lead to lower transport costs, contrary to what was expected; conversely, the distance of the route does have a significant and notable effect (0.166, $p < 0.1$). H10 is thus only partially corroborated. The study also finds support for the moderating effect of the type of transport on the effect of distance on transport costs, largely confirming H11 and H12. Empirical evidence is provided of the continuous increase in costs with the use of truck transport (the coefficient of the distance $\times$ truck mode interaction is 0.168,

$p < 0.1$), and this increase becomes exponential beyond a certain limit (the coefficient of the quadratic distance × truck mode interaction is 0.403, $p < 0.1$). On the other hand, using any of the other three transport options mitigates the increase in cost with distance, up to a certain length of route, after which point costs increase exponentially with distance.

6. Discussion and conclusions

The findings of this study are much more useful to logistics decision-makers than the information yielded by traditional aggregate models. The transport cost equations proposed in the previous literature typically include a limited set of factors as explanatory variables. As a result, the models tend to suffer from specification problems; they do not entirely capture the complexity of the interplay of supply and demand of this service, nor the fixed effects of the non-time-varying variables related to the route, the company and the product. The modelling approach proposed and empirically tested in this paper corrects these specification flaws and provides interesting and novel evidence about the determining factors of transport costs. To that end, an innovative criterion has been applied, consisting of calculating the average unit cost of transport for each route, on the basis of which we can more reliably estimate economies of network by defining origin–destination routes rather than simply between countries or regions. A key factor in opting for this level of analysis has been the information provided by the primary study, which enabled the parameterisation of the model of freight transport demand and its cost for each of the 305 routes identified between the Valencian Community and Europe.

Overall, this study confirms the importance of the factors related to geographical elements, such as distance (Brun, Carrère, Guillaumont, & de Melo, 2005; Rietveld & Vickerman, 2004), which exerts a continuous and at times exponential upward pressure on some components of the logistics cost, whether by extending the transit time (and thus wage costs), increasing energy consumption or depreciating assets. A 10% increase in distance raises costs by 1.7%. The coefficient of the distance variable in the different models ranges between 0.13 and 0.17, in line with previous values reported in the literature; several studies estimate a 0.25% increase in freight rates for each 1% increase in kilometres per trip (Márquez et al., 2007; Micco & Pérez, 2002; Wilmsmeier, Hoffmann, & Sanchez, 2006). This tendency for transport costs to increase with distance does not seem to follow a logistic pattern and is only restrained up to a certain route length by the use of alternatives to truck transport. From that point on, sea transport is the only mode that maintains a linear increase, with the rest registering exponential increases in physical distribution costs. Our research does not find any significant effects of the variable for island destination, whereas previous works report a cost reduction of almost 0.5% (e.g., Limão & Venables, 2001), although this difference is perhaps due to the small number of routes and observations related to this aspect.

At the same time, the analysis confirms that distance is not the most determining factor of transport costs. More important are the degree of competition between logistics operators on the route, the economies of scale derived from the volume of freight flow on the route and the volume of product that the company transports via the route, the configuration of the supply chain, the business strategy, and the range and quality of transport infrastructure.

It has been shown that the greatest reduction in transport costs is obtained by improving rail infrastructure (in line with the recommendation of Song & Na, 2012). A 10% improvement in its quality could contribute to reducing transport costs by 14.1% on average. The optimisation of maritime and land transport networks has positive, albeit relatively minor, effects on transport cost savings, with values of 5.6% and 4.8% for every 10% improvement. Public investment in railways thus seems to be the best option for improving the cost competitiveness of companies exporting to Europe.

The second category of factors with the greatest potential to contribute to a reduction in transport costs relates to the economies of scale achievable on a route. A 10% increase in the volume of freight transported on a route can reduce the price by 11.3%. The key role played by economies of scale in transport costs is further confirmed by the fact that if the company increased the volume of freight shipped on a route and the average size of the shipment by the same percentage (i.e., by 10% each), it could achieve cost savings of 10.8% and 11.2%, respectively. The importance of scale in determining transport costs can be observed when analysing the relationship between this variable and the size of the logistics operator. An increase in either the vehicle load capacity or the volume of freight handled helps to achieve increasing returns due to better use of the assets. For example, Sánchez et al. (2003) report that the elasticity of port efficiency is equivalent to that of distance in determining freight rates. In the case under study, the cost savings–size ratio has an elasticity of 0.802%, which is notably higher than the distance elasticity. Other studies, however, have reported elasticities greater than 0.25% (Wilmsmeier, et al., 2006).

From a perspective of transport cost savings, the results of the study suggest opting for vertical integration of the production system, a mass distribution system and a strategy focussed on price competition. In contrast, transport costs will tend to increase with the choice of a production system oriented towards outsourcing and lean production, a distribution system that prioritises just-in-time delivery in step with market demand for volume, and a strategy that prioritises service quality and high-priced products. Transport costs for an average route are 1% higher for every 10% increase in the value in euros per kilogram of the goods handled. The coefficient of this variable (0.102) is significantly higher than that obtained in some previous studies (e.g., 0.02 in Márquez et al., 2007) although others (Limão & Venables, 2001) estimate the value–weight elasticity at 0.35%. This result reflects the standard practice employed with these types of goods, whereby the preferred transport services are those that offer the best conditions with respect to quality, frequency and speed, even though the price is higher and a higher insurance premium is required.

With respect to policy interventions, the most effective measures that can be promoted to encourage a more competitive distribution towards Europe lie in improving transport infrastructures, especially rail networks. Moreover, attempts should be made to ensure that a substantial weight of exports is sent to foreign markets where demand is high, connected to the region through quality routes served by a large number of logistics operators. The growth in the volume of goods exported to a destination leads to a 10.7% reduction in transport costs for each 10% increase in the volume exported, as would be expected given the increasing returns that the exporter and the logistics operator can achieve through higher levels of traffic. The opening up of the regional market also contributes to more efficient transport. Looking at the trade imbalance in absolute terms, it can be seen that a 10% increase in trade balance reduces transport costs by 12.4%. This result is in line with previous studies, which calculate a 10% cost increase when the ratio of the negative trade balance doubles (Hoffmann, 2005). In contrast, the regulatory burden does not have a strong effect on the cost of transporting goods to Europe.

This study is among the few empirical research papers that have focussed on uncovering the determinants of transport costs at firm and route level. Given the novelty of this approach, the results should be interpreted with caution as they suffer from certain limitations. First, future research should reconsider the methodology in order to address potential model specification issues, as some factors that could explain the cost of transport in the firms under study have been omitted. Second, since transport along the analysed routes is often intermodal, the study should consider the possible moderating effects arising from dependence, cooperation or conflict relationships between the mode of transport and distribution channels. Third, this analysis does not account for the ongoing improvements being made to Spanish railway infrastructure and its integration within the continental European network, which could substantially change the framework of intermodal competition. Fourth, it would have been desirable to extend the range of variables representing product demand and service quality to which firms are attached, in order to explore in more depth the impact of the competitiveness of domestic transport on the international competitiveness of industrial firms. Future lines of research should try to address these limitations.

In addition, we wish to study the impact that transport infrastructure and improvements made to that infrastructure may have on the location patterns of Spanish and foreign multinational companies. Similarly, it would be interesting to explore how transport infrastructure affects Spanish manufacturing firms' decisions to enter foreign markets. A final line of research should focus on intermodal competition and its transformation due to improvements in transport infrastructure and the institutional framework.

Notes

1. Such changes can, however, occur in the medium and long term, as the supplier companies can change the location of their production plants and logistic centres, precisely in order to achieve savings in the costs of transporting goods to the demand points.
2. This value for the coefficient of determination is significantly higher than those obtained in previous studies estimating transport cost equations (e.g., Clark, Dollar & Micco, 2004; Márquez et al., 2007), which report values below 50%.

References

Abe, K., & Wison, J. S. (2009). Weathering the storm: Investing in port infrastructure to lower trade costs in East Asia (Working Papers No. 4911). Washington, DC: World Bank Policy Research. Retrieved from https://openknowledge.worldbank.org/bitstream/handle/10986/4105/WPS4911.pdf?sequence=1.

Aggelakakis, A., Bernandino, J., Boile, M., Christidis, P., Condeco, A., Krail, M., … Schippl, J. (2015). The future of the transport industry. (Report No. EUR 27085 EN). JRC Technical Reports, Publications Office of the European Union, Luxembourg.
Albarrán, P., Carrasco, R., & Holl, A. (2013). Domestic transport infrastructure and firms´ export market participation. *Small Business Economics*, *40*, 879–898. doi:10.1007/s11187-011-9393-9
Amjadi, A., & Yeats, A. J. (1995). Have transport costs contributed to the relative decline of African exports? Some preliminary empirical evidence (Working Paper No. 1559). Washington, DC: World Bank Policy Research.
Anderson, J. (1979). A theoretical foundation for gravity equation. *American Economic Review*. *69*, 106–116.
Anderson, J. E., & van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *American Economic Review*, *93(1),* 170–192. doi:10.1257/000282803321455214
Anderson, J. E., & Wincoop, E. V. (2004). Trade costs. *Journal of Economic Literature*, *42*(3), 691–751 doi:10.1257/0022051042177649
Baier, S., & Bergstrand, J. (2001). The growth of world trade: Tariffs, transport costs, and income similarity. *Journal of International Economics*, *53*(1), 1–27. doi:10.1016/S0022-1996(00)00060-X
Baumol, W. J., & Vinod, H. D. (1970). An inventory theoretic model of freight transport demand. *Management Science*, *16*(7), 413–525. doi:10.1287/mnsc.16.7.413
Bergstrand, J. H. (1985). The gravity equation in international trade: Some microeconomic foundations and empirical evidence. *Review of Economics and* Statistics, *67*, 474–481. doi:10.2307/1925976
Bougheas, S., Demetriades, P. O., & Morgenroth, E. L. W. (1999). Infrastructure, transport costs and trade. *Journal of International Economics*, *47*, 169–189. doi:10.1016/S0022-1996(98)00008-7
Bradley, P. (1995). Buying third-party services? Beware the bells and whistles. *Traffic Management*, December, 24.
Brun, J. F., Carrère, C., Guillaumont, P., & de Melo, J. (2005). Has distance died? Evidence from a panel gravity model. *The World Bank Economic Review*, *19*(1), 99–119. doi:10.1093/wber/lhi004
Button, K. J. (1993). *Transport, the environment and economic policy*. London: Macmillan.
Caves, D. W., Christensen, L. R., & Swanson, J. A. (1981). Productivity growth, scale economies, and capacity utilisation in U.S. railroads, 1955–1974. *American Economic Review*, *71*, 994–1002.
Chang C. S. J., & Friedlaender, A.F. (1984). Output aggregation, network effects, and the measurement of trucking technology. *The Review of Economics and Statistics*, *66*(2), 267–276. doi:10.2307/1925827
Cho, H. (2014). Determinants and effects of logistics costs in container ports: The transaction cost economics perspective. *The Asian Journal of Shipping and Logistics*, *30*(2), 193–215. doi:10.1016/j.ajsl.2014.09.004
Chow, G., & Gill, V. (2011). *Transportation and logistics international competitiveness: How does Canada Fare?* (pp. 5–23). Canada: Canadian Transportation Research.
Clark, X., Dollar, D., & Micco, A. (2004). Port efficiency, maritime transport costs, and bilateral trade. *Journal of Development* Economics, *75*, 417–450. doi:10.1016/j.jdeveco.2004.06.005
Clarkson Research Studies (2004). *The tramp shipping market*. London: Clarkson Research Studies,
Coase, R. H. (1937). The nature of the firm. *Economica*, *4*, 386–405. doi:10.2307/2626876
Coca, P., Márquez, L., & Martinez, I. (2005). Infraestructuras, costos de transporte y flujos de comercio. *Revista de Análisis Económico*, *20*, 3–22
Corsi, T. M., & Grimm, C. M. (1987). Changes in owner–operator use, 1977–1985: Implication for management strategy. *Transportation Journal*, *26*(3), 4–16.

Davis, H.W., & Drumm, W.H. (2002). Logistics costs and service database. Annual conference proceedings of council of logistics management, San Francisco.

De, P. (2006, April). Why trade costs matter? (Working Paper No. 7). Bangkok, Thailand: Asia–Pacific Research and Training Network on Trade.

Deardorff, A. V. (1998). Determinants of bilateral trade: Does gravity work in a neoclassical world? In Frankel, J. A. (Ed.), *The regionalization of the world economy* (pp. 7–31). Chicago: Chicago University Press

Djankov, S., Freund, C., & Pham, C.S. (2010). Trading on time. *The Review of Economics and Statistics*, *92(1)*, 166–173. doi:10.1162/rest.2009.11498

Feo, M., García, L., Martínez, I., & Pérez, E. (2003). Determinants of modal choice for freight transport: Consequences for the development of short sea shipping between Spain and Europe. In *Maritime transport II. Second International Conference on Maritime Transport and Maritime History*, *1* (pp. 667–769). Barcelona: SCI UPC,

Fernández, A., Arruñada, B., & González-Díaz, M. (2000). La cuasi-integración vertical en el transporte de paquetería por carretera. *Revista de Economía Aplicada*, *24*(8), 139–155.

Filippini, M., & Maggi, R. (1992). The cost structure of the Swiss private railways. *International Journal of Transport Economics*, *19*, 307–327. doi:10.1007/BF01065366

IMF. (2016). *World economic outlook: subdued demand: Symptoms and remedies*. Washington: International Monetary Fund.

Forkenbrock, D. J. (2001). Comparison of external costs of rail and truck freight transportation. *Transportation Research Part A: Policy and Practice*, *35*(4), 321–337. doi:10.1016/S0965-8564(99)00061-0

Francois, J., & Manchin, M. (2007). *Institutions, infrastructure, and trade*. The World Bank.

Francois, J., & Wooton, I. (2001). Trade in international transport services: The role of competition. *Review of International Economics*, *92*, 249–261. doi:10.1111/1467-9396.00277

Gagné, R. (1990). On the relevant elasticity estimates for cost structure analyses of the trucking industry. *Review of Economics and Statistics*, *72*, 160–164.

Glaeser, E. L., & Kohlhase, J. E. (2004). Cities, regions and the decline of transport costs. *Papers in Regional Science*, *83*, 197–228. doi:10.1007/s10110-003-0183-x

Golub, S., & Yeaple, S. (2002). *International Productivity Differences, Infrastructure, and Comparative Advantage*. University of Pennsylvania, Department of Economics.

Griliches, Z. (1972). Cost allocation in railroad regulation. *The bell Journal of Economics and Management Science*, *3*(1), 26–41. doi:10.2307/3003069

Hallikas, J., Virolainen, V., & Tuominen, M. (2002). Risk analysis and assessment in network environments: A dyadic case study. *International Journal of Production Economics*, *78*(1), 45–55. doi:10.1016/S0925-5273(01)00098-6

Hoffmann, J. (2005). *The determinants and fluctuations of maritime freight and charter rates*. Proceedings of the 13th Annual Congress of the International Association of Maritime Economists (IAME). Cyprus, June 23-25.

Hummels, D. (1999), *Toward a geography of trade costs*. Chicago: University of Chicago Press

Hummels, D. (2001). Have international transportation costs declined? *Journal of International Economics*, *54*(1), 75–96. doi:10.1016/S0022-1996(00)00093-3

Hummels, D. (2007). Transportation costs and international trade in the second era of globalization. *Journal of Economic Perspectives*, *21*(3), 131–154. doi:10.1257/jep.21.3.131

Jara-Díaz, S., & Cortés, C. (1996). On the calculation of scale economies from transport cost functions. *Journal of Transport Economics and Policy*, *30*, 157–170.

Jiang, X., He, X., Zhang, L., Qin, H., & Shao, F. (2017). Multimodal transportation infrastructure investment and regional economic development: A structural equation modeling empirical analysis in China from 1986 to 2011. *Transport Policy*, *54*, 43–52. doi:10.1016/j.tranpol.2016.11.004

Krugman, P. (1991a). *Geography and trade*. Cambridge MA: The MIT Press.

Krugman, P. (1991b). Increasing returns and economic geography. *Journal of Political Economy*, *99*, 483–499. doi:10.1086/261763

Kumar, S., & Hoffmann, J. (2002). Globalization – the maritime nexus. In Grammenos, C. T. (Ed.), *Handbook of maritime economics and business* (pp. 35–62). London: LLP.
Lakshmanan, T. R. (2011). The broader economic consequences of transport infrastructure investments. *Journal of Transport Geography*, 19, 1–12. doi:10.1016/j.jtrangeo.2010.01.001
Laroche, F., Sys, C., Vanelslander, T., & Van de Voorde, E. (2017), Imperfect competition in a network industry: The case of the European rail freight market. *Transport Policy*, *58*, 53–61. doi:10.1016/j.tranpol.2017.04.014
Levin, R. C. (1978). Allocation in surface freight transportation: Does rate regulation matter. *The Bell Journal of Economics*, *9*(1), 18–45. doi:10.2307/3003610
Limão, N., & Venables, A.J. (2001). Infrastructure, geographical disadvantage and transport costs. *The World Bank Economic Review*, *15(3),* 451–479.
Maddison, D., Pearce, D., Johansson, O., Calthrop, E., Litman, T., & Verhoef, E. (1996). *The true costs of road transport*. London: Earthscan Publications.
Márquez, L., Martínez, I., Pérez, E.M., & Wilmsmeier, G. (2007). Determinantes de los costos de transporte marítimos. El caso de las exportaciones españolas. *Información Comercial Española ICE*, *834*, 79–93.
Martínez, I., & Hoffmann, J. (2007). Costes de transporte y conectividad en el comercio internacional entre la Unión Europea y Latinoamérica. *Información Comercial Española*, *834*, 45–59.
Martínez, I., & Suárez, C. (2005), Transport costs and trade: Empirical evidence for Latin America imports from the European Union. *Journal of International Trade and Economic Development*, *14*(3), 227–245.
Martínez-Zarzoso, I, & Suarez-Burguet, C. (2005). Transport costs and trade: Empirical evidence for Latin American imports from the European union, *The Journal of International Trade & Economic Development*, *14*(3), 353–371. doi:10.1080/09638190500212121
Martínez-Zarzoso, I., García, L., & Suárez, C. (2003). The impact of transport costs on international trade: The case of Spanish ceramic exports. *Maritime Economic and Logistics*, *5(2),* 179–198. doi:10.1057/palgrave.mel.9100069
Memedovic, O. (2008). Fuelling the global value chains: What role for logistics capabilities? *International Journal of Technological Learning, Innovation and Development*, *1*(3), 353–374. doi:10.1504/IJTLID.2008.019978
Merikas, A. C., Merikas, A. A., Polemis, D., & Triantafyllou, A. (2013). The economics of concentration in shipping: Consequences for the VLCC tanker sector. *Maritime Economics Logistics*, *16*(1), 92–110. doi:10.1057/mel.2013.19
Micco, A., & Pérez, N. (2002). Determinants of maritime transport costs *(*Working Paper No. 441). Washington: Inter-American Development Bank, Research Department.
Novy, D. (2013). Gravity redux: Measuring international trade costs with panel data (Discussion Paper No. dp1114). London: CEP, Centre for Economic Performance, London School of Economics.
Obstfeld, M., & Rogoff, K. (2000). The six major puzzles in international macroeoconomics: Is there a common cause? In B. S. Bernanke & K. Rogoff (Eds.), *MBER macroeconomics annual 2000* (pp. 339–390). Cambridge: The MIT Press.
Pellicelli, M., & Chiara, B. D. (2010). Role of intermodality in global sourcing and offshore outsourcing: Maritime transport and new rail connections between Europe and Asia. *IASK GM2010 Conference Proceedings*, 200–209.
Pesut, M. (2009). *Global supply chains, transport and competitiveness*. Europe: United Nations Economic Commission for Europe.
Porter, M. E. (1980). *Competitive strategy: Techniques for analyzing industries and competitors*. New York: Free Press
Porter, R. H. (1983). A study of cartel stability: The joint executive committee 1880–1886. *Bell Journal of Economics*, *14*, 301–314. doi:10.2307/3003634
PwC. (2016). *Shifting patterns. The future of the logistics industry*. Madrid: Pricewaterhousecoopers.

Quinet, E., & Vickerman, R. (2005). *Principles of transport economics*. Cheltenham: Edward Elgar Publishing.

Radelet, S., & Sachs, J. (1998). *Shipping costs. Manufactured exports and economic growth*. Washington: World Bank Group.

Reis, V. (2014). Analysis of mode choice variables in short-distance intermodal freight transport using an agent-based model. *Transportation Research Part A: Policy and Practice*, *61*, 100–120. doi:10.1016/j.tra.2014.01.002

Rietveld, P., & Vickerman, R. (2004). Transport in regional science: The "death of distance" is premature. *Papers in Regional Science*, *83*, 229–248. doi:10.1007/s10110-003-0184-9

Russell, D., Coyle, J. J., Ruamsook, K., & Thomchick, E. A. (2014). The real impact of high transportation costs. Supply Chain Quarterly, quarter 1. http://www.supplychainquarterly.com/archives/2014/01.

Rutten, B. J. C. M. (1995). *On medium distance intermodal rail transport. A design method for a road a rail inland terminal network and the Dutch situation of strong inland shipping and road transport modes*. Zurich: Delft Universiteitsdrukkerij.

Saeedi, H., Wiegmans, B., Behdani, B., & Zuidwijk, R. (2017). European intermodal freight transport network: Market structure analysis. *Journal of Transport Geography*, *60*, 141–154. doi:10.1016/j.jtrangeo.2017.03.002

Sánchez, R. J., Hoffmann, J., Micco, A., Pizzolitto, G. V., Sgut, M., & Wilmsmeier, G. (2003). Port efficiency and international trade: port efficiency as a determinant of maritime transport costs. *Maritime economics & logistics*, *5*(2), 199–218.

Scherer, F. M., & Ross, D. (1990). *Industrial market structure and economic performance* (3rd ed.). Boston: Houghton Mifflin.

Schmalensee, R., & Willig, R. D. (1989). *Handbook of industrial organization*. Amsterdam: Elsevier.

Smith, R., Miller, C., & Parhizkar, O. (2008). *Improving the international competitiveness of the forest products industry through proved transportation methods*. Virginia: USDA.

Song, J.Y., & Na, H.S. (2012). A study of the intercontinental transportation competitiveness enhancement plan between Northwest Asia and Europe using the TranSiberian railway. *International Journal of Engineering and Technology*, *4*(2), 208–212. doi:10.7763/IJET.2012.V4.350

Stepien, M., Legowik-Swiacik, S., Skibinska, W., & Turek, I. (2016). Identification and measurement of logistic cost parameters in the company. *Transportation Research Procedia*, *16*, 490–497. doi:10.1016/j.trpro.2016.11.046

Stock, G.N., Noel, P.G., & Kasarda, J.D. (2000). Enterprise logistics and supply chain structure: the role of fit. *Journal of Operations Management*, *18*(5), 531–547. doi:10.1016/S0272-6963(00)00035-8

Sys, C. (2009). Is the container liner shipping industry an oligopoly? *Transportation Policy*, *16*(5), 259–270. doi:10.1016/j.tranpol.2009.08.003

Toyli, J. (2008). Logistics and financial performance: An analysis of 424 Finnish small and medium-sized enterprises. *International Journal of Physical Distribution & Logistics Management*, *38*(1), 57–80.

UNCTAD (2015). *Informe sobre el transporte marítimo 2015*. Geneva: Publicación de Naciones Unidas.

Williamson, O. E. (1979). Transaction-cost economics: The governance of contractual relations. *Journal of Law and Economics*, *22*(2), 233–261. doi:10.1086/466942

Williamson, O. E. (1985). *The economic institutions of capitalism. Firms, markets, relational contracting*. New York: The Free Press.

Williamson, O. E. (1986), *Economic organization. Firms, markets and policy control*. New York: New York University Press.

Williamson, O. E. (1991). Strategizing, economizing, and economic organization. *Strategic Management Journal*, *12*(Winter special issue), 75–94. doi:10.1002/smj.4250121007

Wilmsmeier, G., Hoffmann, J., & Sánchez, R. J. (2006). The impact of port characteristics on international maritime transport costs. *Research in transportation economics*, *16*(1), 117–140. doi:10.1016/S0739-8859(06)16006-0
Wilmsmeier, G., & Martínez-Zarzoso, I. (2010). Determinants of maritime transport costs: A panel data analysis for Latin American trade. *Transportation Planning and Technology*, *33*(1), 105–121. doi:10.1080/03081060903429447
Wilmsmeier, G., & Pérez, G. (2005). Maritime transport costs and connectivity on maritime routes to South America. 13th Annual Congress on the International Association of Maritime Economists IAME, Cyprus, June 23–25.
World Trade Organization. (2013). *Annual report 2013*. Ginebra: World Trade Organization.
Xu, H. (2016). Domestic railroad infrastructure and exports: Evidence from the silk route. *China Economic Review*, *41*, 129–147. doi:10.1016/j.chieco.2016.09.005
Yoko, K., Mun, S., Yoshihiko, N., & Sung, J. (2012). Determinants of transport costs for inter-regional trade (Discussion Paper No. 12-E-016). Tokyo: ROETI, The Research Institute of Economy, Trade and Industry.
Zamora, A., & Pedraza, O. H. (2013). El transporte internacional como factor de competitividad en el comercio exterior. *Journal of Economics, Finance and Administrative* Science, *18*, 108–118.