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FACILITATION OF TRANSPORT AND TRADE IN LATIN AMERICA AND THE CARIBBEAN

Economic impact of changes in logistics infrastructure networks: two case studies in Argentina

Introduction

Infrastructure networks play a key role in the integration of a country's economic and territorial system, enabling its logistics connectivity. Greater investment in these networks leads directly to an increase in logistics services which, together with sustainable demand and the resulting rise in connectivity, has a positive impact on the expansion of hinterlands.

This bulletin aims to shed light on the impact of infrastructure and logistics services investment on the economic development of hinterlands. It uses the ECLAC definition of logistics, that is the combination of infrastructure and the logistics services provided through this infrastructure. The purpose of this paper is to contribute to the development of proposals and the implementation of measures to improve competitiveness, sustainability and economic development.

Logistics infrastructure investment in Argentina has remained low for the past 25 years, in line with the regional average. According to data for 1990-2014 presented by ECLAC (2015), the contraction of infrastructure investment has been, on average, more persistent than that of GDP. This has led to the current shortage of infrastructure and services linked with transport, which in turn has increased the stress on existing infrastructure. In spite of this, two distinguishable dynamics are evident in Argentina, showing the relationship between infrastructure investment growth and the resulting expansion or contraction of hinterlands:

- Increased investment in ports and waterways has led to hinterland expansion, with a positive impact on grain production.
- A lack of infrastructure investment in central Argentina has led to hinterland contraction, with a negative impact on containerized cargo.

This document aims to shed light on the impact of infrastructure and logistics services investment on the economic development of hinterlands.

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This document pays homage to Martín Sgut, who helped to shape the definition of development policies, and to his wife Cristina De Lorenzo.

This issue of the *FAL Bulletin* also includes valuable comments by ECLAC staff members Azhar Jaimurzina, Gabriel Pérez Salas and Jeannette Lardé. Also acknowledged are the contributions of Roberto Liatis, Alan Harding, Rodolfo García Piñeiro, Juan Carlos del Palacio and Juan Pablo Martínez.

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In the case of hinterland expansion, research by Sánchez (2003) and Sánchez, Sánchez and Saade (2017) shows that the increased provision of port services and of waterways in the Paraná-Paraguay corridor led to the expansion of agricultural production and its industrialization, along with improvements in productivity. In the case of hinterland contraction, results are presented on the basis of previous studies[1] which analyse changes in container shippers' costs for transport from central Argentina to Asia. The study points to additional costs throughout the supply chain —owing to a lack of investment in logistics (especially infrastructure) and in the development of logistics hubs— which eventually led to hinterland contraction around Argentina's container ports.

Following this introduction, part one of the document describes the main effects of infrastructure investment on development from a theoretical standpoint. Section two provides investment data from the 1990s onward, highlighting infrastructure gaps. Part three focuses on the impact of infrastructure and logistics services investment on the economic development of hinterlands, on the basis of the dynamics mentioned above. The final section presents conclusions and reflections for future guidelines.

The topics discussed herein are part of a line of research followed by the Infrastructure Services Unit of the Natural Resources and Infrastructure Division of ECLAC since the mid-2000s, as an initiative to compile and register data on infrastructure investment from certain countries and also as a theoretical reflection on infrastructure and the problems of development (starting with the publication of Rozas and Sánchez, 2004). Several subsequent studies have analysed the obstacles to development posed by an infrastructure deficit, such as the work of Rozas, 2004; Perrotti and Sánchez, 2011; Lardé and Sánchez, 2014; and Lardé, 2016.

I. Infrastructure and development

According to Rozas and Sánchez (2004), network services in energy, transport, telecommunications, drinking water and sanitation infrastructure play a coordinating role in the economic structure of territories and their markets, and at the same time serve as concrete mechanisms that link national economies to the rest of the world. The authors point to a combination of three conditions required for infrastructure investment to have an impact on economic growth:

- Positive economic externalities: clusters of economic activity and dynamic markets.
- Investment factors: availability of funds; investment size, geographic location, impact on infrastructure networks, and timing.
- Political factors: political and institutional context.

Under these conditions, Rozas and Sánchez believe that infrastructure investments can help to reduce infrastructure network service costs and thus increase territorial connectivity and accessibility. These investments help to boost developing countries' participation in international trade, which has a similar estimated impact to that of trade barriers and tariffs, or of exchange rate distortions. Furthermore, low infrastructure service costs encourage foreign direct investment inflows, which boost investment and economic growth.

In this context, Sánchez, Cipoletta Tomassian and Perrotti (2014) took into account variables such as a country's endowment of natural resources and its economic and institutional openness as determinants of greater economic development, while focusing on its logistics performance according to the World Bank's Logistics Performance Index (LPI).[2] The outcome of the analysis indicates that in most cases the likelihood of a country becoming developed increases as its logistics performance improves. The authors note that this is not only attributable to higher LPI readings, but also to improvements in economic, social and political variables. Jaimurzina, Pérez Salas and Sánchez (2015) review the concepts linked with transport and, in line with the position of ECLAC, define logistics as the combination of infrastructure services, production, mobility, distribution of goods and regulation of services and information throughout the global supply chain.

Infrastructure networks are made up of interconnected logistics infrastructures, known as hubs. Ports, which serve as entry and exit points, and which link terrestrial, fluvial and maritime transport, are among the most important logistics hubs. In this regard, Hoffmann (2000) mentions two interdependencies between port investments and a country's location. First, ports alter trade flows by offsetting geographical disadvantages and promoting a country's foreign trade; second, they also provide income-generating opportunities through port services for a country's own foreign trade as well as that of its neighbours. The two dynamics of expansion and contraction of hinterlands presented in this document emphasize the role of ports as logistics hubs that define a region's hinterland in terms of its connection with foreign trade, which in turn has an impact on its own economic development.

[1] Reference is made to the latest research by Sánchez and Gómez Paz, a cost analysis of logistics corridors submitted as part of the presentation entitled "El desafío de la historia para la infraestructura, logística y movilidad es hoy", presented by Ricardo Sánchez at the Argentine Fluvial Transport Meeting in Rosario, Argentina, in April 2017.

[2] The Logistics Performance Index (LPI) is an indicator of supply chain performance, covering the efficiency of customs and border clearance, the quality of trade and transport in infrastructure, the ease of arranging competitively priced shipments, the competence and quality of logistics services, the ability to track and trace consignments, the frequency with which shipments reach consignees within scheduled or expected delivery times (The World Bank).

II. Historical evolution of infrastructure investment in Latin America and the Caribbean

Low growth hinders the possibility of financing infrastructure, thus generating a vicious circle that is increasingly difficult to overcome. Following this line of analysis, Lardé and Sánchez (2014) refer to the weak infrastructure investment in Latin America between the 1990s and 2013 (on average, 2.2% of GDP), in comparison with the investment requirements of 6.2% of GDP estimated by Perrotti and Sánchez (2011). This level of investment also seems insufficient compared to that of China (8.5%), Japan (5.0%) and India (4.7%). This means that the region's economies have been consistently operating with a low level of infrastructure stock, which clearly limits the possibilities of sustained growth and of closing the gaps that hinder development.

As a percentage of GDP between 2008 and 2015, average infrastructure investment in the transport sector in Latin America and the Caribbean was led by Panama (3.5%), the Plurinational State of Bolivia (3%), Honduras (2.6%), and Peru (2.5%), with Argentina lagging behind in fourteenth place (0.7%).[3] Investment levels persistently below the recommended thresholds have contributed to the growing gap between available infrastructure and that which is necessary for sustainable development (Sánchez and others, 2017).

To close this gap, infrastructure planning must incorporate the dynamics of global change. Infrastructure investment must be updated from the initial funding stages through the entire development process, with the necessary adjustments, in the framework of a comprehensive approach to national infrastructure. In other words, planning must be flexible and dynamic, consider the long term, and foresee potential risks and opportunities. With regard to adaptive planning and risk analysis, Taneja (2012) proposes the concepts of Adaptive Port Planning and Flexibility, which were implemented in the long-term planning of the port of Rotterdam.

Productivity gains, the true levers of development, require the availability of co-modal logistics routes which respond and adapt dynamically to competitiveness and sustainability criteria and can attract demand. As highlighted by Lardé (2016), infrastructure is present in the Sustainable Development Goals of the 2030 Agenda for Sustainable Development adopted by the United Nations in 2015, and is not only mentioned specifically in Goal 9 but also referred to in almost all of the Sustainable Development Goals. The Agenda outlines goals and targets for 2030 with a comprehensive development approach.

[3] Calculations on the basis of INFRALATAM, which contains information on investments in economic infrastructure in Latin America and the Caribbean for 2008-2015, with a breakdown between public and private sector investment (Sánchez and others, 2017).

III. Analysis of hinterland expansion and contraction

The hinterland of a logistics hub —selected as a concentrator hub for the cargo— extends from the point of origin of the cargo to the boundary set by the corresponding logistics isocost curve. As regards the geography of transport, Hoffmann (2000) makes a distinction between geographic and economic distances. The first involves the physical distance between a point of origin and destination, measured in nautical miles or kilometres, while the second considers the total cost of cargo movement for the shipper.

There is also a "logistics distance", defined as the geographic and economic distance as affected by variables which reflect the efficiency and quality of logistics services and their impact on infrastructure. This helps to determine the value of a logistics leg not only in terms of costs but also reliability, efficiency and sustainability. Economic or logistics distances can be shorter or longer than geographic distances. Therefore, the hinterland of a logistics hub stretches from points of origin to destinations that offer logistics services of greater quality and efficiency, and at the same time lower costs for shippers. Also, the potential for hinterland expansion grows as these areas integrate with more competitive national and international logistics networks, thus improving conditions for economic development.

South America trades with countries on other continents through maritime routes. Increasing foreign trade requires countries to be connected via efficient logistics chains at competitive costs for all transport stakeholders —including terrestrial, fluvial and maritime modalities— to ensure internal and external connectivity. The response to the question raised by Hoffmann (2000), whether trade can be promoted through port infrastructure investment, is yes, as long as this investment translates into cost reductions and productivity gains. These improvements shorten the "economic distance"; that is, they reduce the magnitude of the geographic distance.

Two different cases are presented below, showing the impact of infrastructure development and its influence on hinterland expansion and/or contraction. These cases show general situations and offer a partial view of the complexities faced in the real world. They allow the authors to reach important conclusions which they hope will be useful in the design of future solutions based on solid conceptual grounds.

A. Hinterland expansion: agricultural production and exports

The following case describes how increased investment in port and waterway infrastructure in Argentina paved the way for hinterland expansion. The dynamics in this case study are explained on the basis of Sánchez (2003) and Sánchez, Sánchez and Saade (2017).

Sánchez (2003) analyses the development of an agricultural area, on the assumption that infrastructure investment will contribute to cost reductions and productivity gains. The central hypothesis is that transport infrastructure investment is a necessary condition for a region's productive development, especially investment linked to foreign trade, such as in ports and in waterways. This has been proven by the positive relationship between the evolution of port and waterway services (lower costs and operating times, greater reliability and new services) and the expansion of the agricultural frontier, productivity gains and the increase in agricultural production and its industrialization. Also according to the study, the provision of infrastructure at lower costs and reduced operating times, together with improved and more reliable services, depends not only on physical infrastructure but also on the market conditions created by transport policies and economic regulation, and on the characteristics of the transport market itself.

The author points to empirical evidence that the hinterland of the ports located south of the province of Santa Fe —around Rosario, San Lorenzo and San Martín— extends to areas in northern Argentina, parts of Brazil, the Plurinational State of Bolivia, Paraguay, Alto Paraná and certain mining production areas (in the Andes mountains), all of which use this port area as an exit point, together with the traditional area of influence of the ports located south of the Paraná River. The expansion of this hinterland is the result of the development of hubs which overcame previous problems —in pricing, quality and capacity— and established more efficient transport routes.

The increase in infrastructure investment was particularly evident in the expansion of port and waterway services, which have supported the development and increased productivity of this agricultural region. Soybean has been the most important driver of the region's agricultural expansion, having benefited from rising prices in international markets for a significant period.

The author establishes a relationship, from 1970 onward, between the increase in production of the region's four main grain products and some historical transport infrastructure milestones (such as changes in regulations relating to port development that fostered investment in ports and in grain storage and processing facilities), and especially several key milestones in the provision of infrastructure, with the launch of the Paraná-Paraguay-de la Plata waterway deserving special mention. These milestones contributed to two distinctive periods of production growth: between the first and second port reform (10 harvests) cumulative growth stood at 53.6%, while in the period following the second reform (5 harvests), cumulative growth stood at 13.6%. Notwithstanding that this development was accompanied by a rise in international prices, it is nonetheless significant that it coincided with infrastructure improvements through investments and better operating conditions for navigation from the ocean access to the city of Santa Fe through the Paraná-Paraguay-de la Plata waterway.

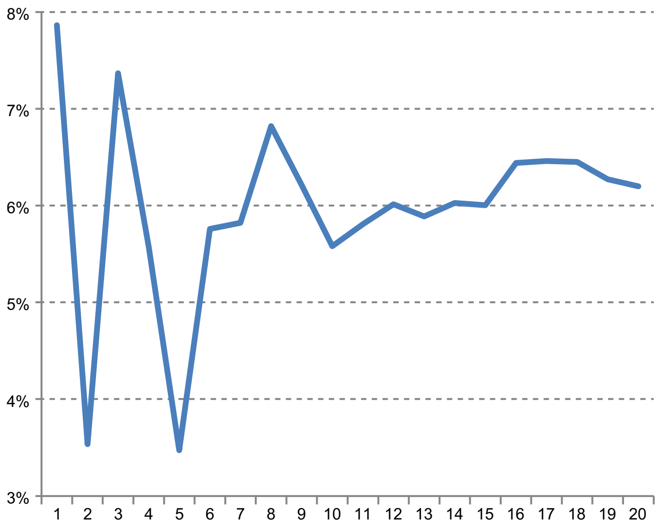
Sánchez, Sánchez and Saade (2017) analyse the impact of infrastructure improvements on economic development and obtain an objective indicator of the impact of infrastructure improvements on agricultural production expansion (measured as an additional foot of waterway depth). The study builds an agricultural production model for Argentina based on maize, wheat and soybean output —80% of total national production— to measure the impact of an additional foot of waterway depth on total production. The model employs ordinary least squares (OLS) estimates and a vector autoregressive (VAR) model for the 1969-2016 period.

"Agricultural production" is the dependent variable in the main equation of the initial model, while "prices of commodities", "climate" (measured by rainfall intensity) and others —all of which are typically used in agricultural models— are the explanatory variables. The "depth" of the waterway is added as the variable representing infrastructure. The OLS estimate confirms that all the explanatory variables are significant, with the "depth" coefficient rated as the highest at 1.81.

After estimating vector autoregression, Sánchez, Sánchez and Saade (2017) carry out an impulse response (IR) analysis in order to measure the impact of the change in infrastructure on production. The change in infrastructure is represented by the additional foot of depth (34 feet in the deepest part) and the impact on agricultural production is subsequently estimated for the next 20 years. The analysis shows that the additional foot in depth has its greatest impact on agricultural production during the first year (7.9%), with the impact receding in the second and fourth years, although from year 10 onward the curve stabilizes at around 6% year-on-year growth (figure 1). For the 20-year period modelled, agricultural production grew at an annual average rate of 6%.

Figure 1

Impulse response of infrastructure improvement in relation to agricultural production (Impact of an additional foot in depth over 20 years)



Source: Sánchez, Sánchez and Saade (2017).

In short, a quantitative analysis based on historical information from 1969 to 2016 relating to the variables that explain the evolution of maize, wheat and soybean production in Argentina concluded that an additional foot in waterway depth generates an annual increase of 6% in agricultural production, with all other economic variables remaining equal.

B. Hinterland contraction: the container market

In contrast with the dynamics described above, the following case refers to the lack of infrastructure investment in the central region of Argentina, which has resulted in hinterland contraction. The impact is analysed on the basis of changes in transport costs for containerized cargo shipped from central Argentina to Asia.

A shipment of containerized cargo could be exported through a port on the Atlantic or one on the Pacific. Hoffmann (2000) argues that trade flows and international transport services share a reciprocal influence, and that both are in part the result of countries' geographic location and the distance to the principal markets. The main determinants of transport decisions are costs and efficiency. A product needs to reach its destination as soon as possible, at the lowest cost and with minimum risk.

Changes in recent years, brought about by a lack of infrastructure investment in logistics hubs and inland legs, signal a shift in the relationship between the hinterlands of ports on the west coast, such as San Antonio on the Pacific, and those on the east coast, such as the port of Buenos Aires on the Atlantic. These changes have resulted in ports on the west coast capturing a greater volume of cargo.

This analysis was carried out on the basis of a sample of cargoes shipped from central Argentina to China, and aimed to determine the hinterland boundary at a point between the areas of influence of both oceans. This boundary is an isocost curve which delimits the point of origin of cargo for which both alternatives are interchangeable (in other words, they both involve the same costs and logistics efficiency, so the shipper could select one or the other with the same result). The position of the isocost is determined by the costs and efficiency of hubs and logistics legs, which result from the combination of three key components: (1) land transport, (2) modal interchange points and (3) maritime transport.

Land transport costs correspond to operating costs, and the associated increases or decreases are closely linked to return cargo opportunities, which translate into productivity gains and reduced costs for carriers. Costs associated with modal interchange points refer to costs of modal interchange services, stopovers and checks, as well as costs directly linked with infrastructure investment to provide efficient services. Finally, maritime transport costs cannot be estimated simply on the basis of the cost for a shipping company to operate a vessel between the point of origin and the final destination of cargo. Indeed, Sánchez and Wilmsmeier (2017) shed light on several premises related to maritime transport, which is characterized by a strong concentration of operators, a variety of cost constraints (in addition to the relationship between supply and fleet capacity), and by the management of multiple cargoes with different levels of demand.

Economies of scale and the concentration of transport operators are the main conceptual differences between the cost of maritime transport and that of land transport. Maritime transport takes greater advantage of economies of scale than land transport; the link between the costs of maritime transport and operating costs, distances covered or the state of inland infrastructure is weaker, and the infrastructure costs associated with modal interchange tend to be linked to hub infrastructure conditions. Maritime transport is also characterized by a far greater concentration of operators than land transport, which often makes it difficult to establish a relationship between the cost of a logistics leg for a maritime operator and the price that is actually offered to a shipper.

In order to define the cost isocost of cargo shipped from Argentina to China under different scenarios, the analysis is based on the costs borne by the shipper from the cargo's point of origin to its final destination, taking into account land transport, modal interchange points and maritime transport. It also takes qualitative variables into consideration, such as transit time, security and services offered. The result is an isocost point, at which the cost of a logistics leg to one place or another is the same for a shipper, as defined under different scenarios.

The following parameters for estimating a shipper's transportation costs are predefined:

- Transported cargo: dry cargo in a 40-foot container
- Point of origin of cargo: central inland Argentina
- Cargo destination: Shanghai, China
- Inland leg: by truck
- Loading ports: Buenos Aires, Argentina[4] or San Antonio, Chile,[5] (both seen as competitive hub ports, as neither are feeder ports)
- Maritime leg: by established maritime operators (with several port calls)

Cost and efficiency of land transport

Land transport costs for a shipper depend directly on variable costs (fuel, lubricant and tyre inputs), fixed costs (staff, amortization of rolling stock, insurance and administrative costs) and taxes and profits of the carrier for a return trip between a point of origin and a destination. These depend on:

- Driving distance between the point of origin and the destination (km) — short, medium or long.
- Number of monthly trips between the point of origin and the destination, which depends on distance, road condition, geographic accidents and other variables that may have an impact on the possibility of carrying out monthly trips.
- Probability of a round trip, which depends on the ability to seize return cargo opportunities.

Distances (whether short, medium or long) determine the impact of fixed costs on total costs, as the former are higher for short distances and lower for long distances. Currently, high fuel prices mean that inputs have a large impact, but relative weight can change depending on the social, economic and political context.

The number of monthly trips is equivalent to the number of completed return trips between a point of origin and a destination, and has a direct impact on fixed costs. If carriers are unable to shorten idle time, fixed costs rise. Idle time is observed in short legs, typically owing to waiting times at points of origin or destinations, scheduling problems on arrival or exit, delays at border crossings, sanitary barriers, geographic accidents, lower speeds due to bad road conditions, and weather, among other factors. Seasonal cargo is another variable that can affect the number of monthly trips.

The probability of securing return cargo is directly related to the cost paid by the shipper, as carriers who are unable to secure return cargo will charge the one-way leg at a rate equivalent to the total cost of a return trip, resulting in a significant increase in the costs borne by the shipper. Whenever there is a marked imbalance between cargoes at the points of origin and of destination, the possibility of securing return cargo is slim. If the shipper manages to secure return cargo, the cost will nonetheless be that of opportunistic freight; hence, profitability tends to be lower in logistics legs with cargo imbalances. Additionally, containers tend to return empty, meaning the opportunity to secure return cargoes is usually lost. Accordingly, in container transport logistics, the cost of picking up empty containers must also be added, as it is not generally added directly to transport costs. Inland logistics platforms offer greater cargo concentration opportunities and therefore greater return cargo probabilities, hence increasing a carrier's hold utilization and overall profitability.

The methodology used to estimate carrier costs follows that of transport models which take into account the overall business case for carriers, including their profits. This analysis employs the model developed by Roberto Liatis, which is based on cost structure information reported by the relevant business chambers. Another reference is the information included in the publication on freight rates for cereals and oilseeds ("Tarifas de transporte de cereales y oleaginosas") by the Argentine Federation of Freight Transport Enterprises (FADEEAC), which considers these rates as costs for the shipper. In Spain, the road freight transport cost observatory of the Ministry of Transport developed ACOTRAM, a tool which estimates the cost of road freight transport. Sgut and others (2006) proposed a methodology to define costs and identify logistics cost overruns. This tool is used to measure the latter's impact on Paraguay's international trade competitiveness.

The analysis only looks at land transport by truck. However, transporting goods over a regional transport network with logistics hubs linked to railways and waterways could offer cost-cutting opportunities, following the co-modality rationale described in the waterway case study described above.

Costs expressed in US$/km following the Liatis transport model for a one-way leg covering an average distance are presented below. Differences between the cost per km on the east coast and on the west coast are recorded to include or exclude the Andes mountains, and the impact of other scenarios is also considered. Estimated values serve as references and are subject to change as the transport market is part of a dynamic economy.

4 Port of Buenos Aires – Argentina (34.57938S 58.37362O).
5 Port of San Antonio – Chile (33.59215S 71.61697O).

Table 1
Land transport costs for the carrier + profit

Land transport	West coast US$/km	East coast US$/km
Base case scenario	1.68	1.40
Cost reduction scenario, east coast	1.68	1.19
Return cargo probability scenario	1.68	0.94
Cost reduction scenario, west coast	1.43	1.40
Return cargo probability scenario, west coast	1.13	1.40
Scenario excluding impact of Andes mountains	1.40	1.40
Base case scenario with cost reduction and return cargo probability, east coast	1.68	0.80
Base case scenario with cost reduction and return cargo probability, excl. Andes, west coast	0.80	1.40

Source: Results on the basis of the model by Roberto Liatis, April 2017.
Note: The values for these variables are directly linked to costs and opportunities for trips, and to profit margins, which differ depending on the size of the transport company. Variable sensitivity in the next five years: the variable can change as a result of reduction in variable costs, construction of new routes or inland logistics infrastructure. It is considered a low clearance rail tunnel that is under planning, but this infraestructure will not be available in the short term.

A low clearance rail tunnel which is under planning is considered, but this infrastructure will not be available in the short term.

Aside from the factors mentioned above, the selection of a logistics corridor also depends on the timeliness and security it offers. Trip times, checks and delays have an impact on a carrier's productivity, reducing the number of possible monthly trips and increasing the impact of fixed costs as a result of higher transport costs to cover additional expenses due to idle times. Logistics chains can improve their productivity through initiatives to increase security, such as the Business Alliance for Secure Commerce (BASC) or the Customs Trade Partnership Against Terrorism (C-TPAT), which facilitate door-to-door transport (Sgut, 2006).

Costs and efficiency at the modal interchange point

Costs for shippers at the modal interchange point refer to documentation expenses and inspection processes.

Costs and efficiency of port use and ocean freight rates

When transporting containers by sea, shippers face costs charged by the freight forwarder and the port. In some countries shippers pay all charges to the freight forwarder (which is the most common practice), while in others part of the payment is made to the freight forwarder and the rest to the port terminal operator, depending on the services provided. These different systems are under review, as each modality has its advantages and disadvantages from a regulatory standpoint. As a result of these differences and of the need to compare costs among countries, the cost of port use and maritime freight is considered as a single unit, which includes the following charges:

- Terminal handling charges (THC)
- Other charges: for example storage, cargo movements and inspections
- Ocean freight rates: basic freight rate plus other charges, such as, bunker adjustment factor (BAF), currency adjustment factor (CAF), war risk premiums, piracy surcharges, container seal fees, electronic release of cargo fees, documentation fee and late arrival fees are commonly charged.

Port charges, terminal handling charges and other costs do not vary substantially from one port to another, while the fees that terminal operators charge their clients are directly related to investments and operating costs, and increase owing to infrastructure obsolescence and operating deficiencies.

Ocean freight rates, which include basic freight rates plus other charges, depend on factors that bear little relationship to sea distances between ports. Containers are transported by ship, with a slot reserved for each one, just as a seat is reserved for each passenger on an airplane. Certain aspects, such as stops, distances or destinations, are not conditioned by costs. Therefore, ocean freight rates