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Maritime Bilateral Connectivity Analysis for Sustainable Maritime Growth: Case of Morocco

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Abstract: On the African continent, Morocco is considered among the most connected countries, according to the liner shipping connectivity index. Since optimal shipping connectivity can reduce CO_2 emissions and trade costs, through this paper we aimed to deepen the understanding of maritime connectivity based on the bilateral maritime connectivity index of Morocco and 138 of its economic partners. We first established an overview of the evolution of the bilateral maritime connectivity in Morocco and highlighted its main regional maritime partners, then defined through a statistical analysis the factors influencing the development of the bilateral maritime links of the country in order to strengthen sustainable maritime connectivity. The results of the descriptive analysis show that Morocco has developed strong maritime connections with Europe and the East of Asia and has an improved connectivity with East African countries (2006–2020). The statistical analysis of the selected factors using regression analysis combined with a gravity model shows that there has been a strong and positive impact of economic growth, logistics, linear connectivity and the maritime component, and bilateral connectivity. Moreover, economic trade and barriers have had no significant effects on bilateral connectivity.

Keywords: maritime connectivity; bilateral liner shipping; maritime hubs; statistical analysis; LCSI; determinant of maritime connections

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1. Introduction

The challenge of sustainability is an important item on the international agenda. For this reason, the African maritime sector requires improvement in order to be aligned with the objectives and principles of sustainability set out by the International Maritime Organization (IMO) [1]. African countries have an important role in the implementation of actions to minimize the impacts of the maritime sector on climate change. To this end, several actions have been agreed by the International Maritime Organization (IMO), including the renewal of actions relating to the optimization of logistics chains planning, particularly in ports [2]. The development of international maritime hubs is considered an important lever for optimizing logistics chains, particularly ports, considering their impact on commercial costs and CO_2 emissions [3].

Ports are seen as major interfaces in transport networks as they participate in the global network of large metropolises in the same way as other network nodes (airports and railway stations); these are what we call "maritime hubs", which allow the major operators to polarize their regular lines on a few strategic nodes. This hub network has developed since the advent of containerization, which led to the emergence of hubs at the crossroads of the main maritime lines [4]. Maritime connectivity is recognized as a structural factor in the economy since it allows for the optimization of commercial costs and reduces CO_2 emissions [2,5].

Connectivity is an effective measure of the ability to connect to another network; it can measure the strength of a network [5] and can explain the position of an economy in a maritime transport network. The connectivity index is calculated every year by the United

Nations Conference on Trade and Development (UNCTAD) to evaluate connectivity for each economy in the worldwide shipping network. Several earlier articles have identified an important relationship between the connectivity index and maritime costs. In 2014, Hoffmann suggested a new maritime connectivity index [6] to measure the connectivity of any two countries in order to explain the level of connectivity between countries in the worldwide shipping network [7]. Nowadays, thanks to maritime connectivity, countries are all practically connected to each other either through a regular direct maritime network or through transshipment operations via port hubs [8]. High connectivity leads to cost optimization and stimulates trade, while trade can also stimulate connectivity and further reduce costs due to positive economies of scale [9].

In effect, the causal relationships between shipping, trade, and growth are quite complex and mutually reinforcing. It would therefore be interesting to identify the relationships between connectivity, trade, and growth [5]. An analysis of the determinants of a country's strength of connectivity via the global liner network and, more specifically, the degree of bilateral connectivity between two countries, should identify areas for improvement to optimize costs, trade flows, and CO_2 emissions [6].

In Africa, the best-connected countries are those located at the extreme cardinal points (east, west, and south) of the continent, where the international maritime routes are linked to large port hubs. These countries (Morocco, South Africa, and Egypt) have confirmed their position as international hubs in the continental freight transportation network (UNCTAD). Morocco has, in fact, experienced a strong appreciation of its connectivity index, thanks to the Tanger-Med port complex. It benefits from a wide maritime frontage of 3500 km, a position on the Strait of Gibraltar at the crossroads of major global communication routes, and port connectivity that is the best in Africa, making Morocco a country open to the global economy [10,11].

Connectivity analysis can be based on the liner shipping connectivity index (LSCI) or the liner shipping bilateral connectivity index (LSBCI). The LSCI allows for a comparison between countries to evaluate their competitiveness based on the international container maritime network, while the LSCBI evaluates maritime connections based on maritime routes. The two indices are compiled by UNCTAD for 165 countries. However, these indices have been criticized because the factors on which they are based are not equally important for all countries [12].

The objective of this article is to define the key factors affecting the development of Moroccan maritime bilateral connectivity with worldwide countries. Since 90% of international trade in Morocco is carried out by sea, maritime transport and thus the increase in maritime connectivity, are major challenges for the implementation of sustainable development objectives. Our approach will be based on the shipping bilateral connectivity index (LSBCI). The choice of this measure was based on the level of granularity it brings to the analysis of connectivity in international trade. Additionally, there is no research work using this index in the Moroccan context and only a few articles have used this index in the African and Mediterranean basin context [5,13,14]. Finally, this index has mainly been used in the context of Asia, which is a world leader in bilateral connectivity. Therefore, exploring this index will teach us a lot about Morocco's interactions with its partners in order to boost Morocco's maritime connectivity with other countries and to strengthen the country's sustainable maritime connectivity.

2. Literature Review

Maritime connectivity was defined in 2006 by Wilmsmeier as access to regular and frequent transport services, combined with service opportunities provided by competition from multiple service providers [15]. It is measured by two main indicators developed by the United Nations: the first is the liner shipping connectivity index, which is an indicator of a country's position in global liner shipping networks. The second is the bilateral liner connectivity index, which reflects the connectivity of liner shipping between two countries.

2.1. Methods and Concept of Maritime Connectivity Analysis

Maritime connectivity is a key factor of where to place a territory in the global maritime network [16]. Several international organizations and researchers have analyzed this subject from different aspects, with different approaches, and based on global and continental context from America, Europe, Africa, and East Asia.

There is a strong connection between gross domestic product (GDP), international trade, and maritime transport. The evolution of shipping and international maritime trade is driven by the global macroeconomic situation [17]. According to UNCTAD, the economic gap will continue to grow in favor of the most connected countries, while the lack of maritime connectivity will continue to impact the access of small countries which are economically weak to global markets. In order to resolve this issue, it is necessary to modernize the seaports, cabotage systems, the reform of customs, and other import and export procedures in these countries [18]. In addition, the International Monetary Fund (IMF) estimates that a limited shipping capacity has a direct effect on the global economy because disruptions in shipping would have compromised the growth by 0.5 to 1 percentage point in 2021.

Many studies have confirmed that maritime connectivity is a key factor influencing trade. J Hoffman et al., applying the quasi-least likelihood method on South Africa's bilateral connectivity data, showed the strong effect of several factors on trade flows, notably, GDP, the common direct connections, the competition level of the maritime operator, the transshipments number and the direct distances negatively impact the trade flow [5]. Furthermore, it has been proved that a lack of direct connections between two pairs has a negative influence on export values ranging from 42 to 55 percent, and that any additional transshipment would have a negative impact on the export value [19]. Another study confirmed the intricate relationship linking maritime connectivity to trade and economic growth. The result of this study's analysis of the maritime connectivity's component factors revealed that none of the predictors had a positive effect on bilateral trade. Therefore, economic and trade policy should be directed toward improving maritime connectivity [20]. The findings of the study in the Maghreb region emphasized that the rise in transit flows and the integration of logistics in more recent port developments in the area are responsible for the region's increased trans-Maghreb maritime connection [21]. Fugazza and J. Hoffman have shown that transport connectivity is a key factor for bilateral exports between two economies. Empirical studies have demonstrated that a lack of direct shipping lines with a trading economy decreases export values; any additional transshipment is combined with a 40% reduced value of bilateral exports [8]. Another body of research has demonstrated, using a gravity model, the beneficial impact of liner shipping connectivity on containerized exports [15].

The connectivity is linked to trade, but also to reduce the transport cost [22]. The United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) and the World Bank have explored the constraints of supply chains and connectivity to explain the higher costs and lower levels of trade integration observed in developing countries over the period of 1995–2010 [9]. In addition, maritime connectivity is a determinant of transportation costs. Researchers have investigated the relationship of connectivity and transportation costs to demonstrate through three-scenario analyses how expanding connectivity for Indonesia's Tenau Kupang port can reduce transportation costs [23]. Moreover, other studies considered that port connectivity and efficiency are closely related. In the Spanish context, research has shown, based on a sample of Spanish ports, that there is a positive link between maritime connectivity and port efficiency, i.e., relatively modest improvements in connectivity are observed following the development of port efficiency [24]. It has been demonstrated that the features of maritime networks, notably the volume of calls and connectivity, determine port efficiency [25].

Several researchers have pinpointed the factors that influence maritime connectivity. It has been attested, based on the LSCBI, that nodal strength, centrality of interdependence, centrality of degree, K-core, coefficient of clustering, quality of infrastructure port, and

the LSCI are the main factors that influence maritime connectivity [7]. Another study has used the LSCI to identify determinants of a country's maritime connectivity; the results indicate that container transit time, container transportation cost, gross domestic product, and containers per capita are determinants for a country to develop its connectivity [26]. Recently, a systemic literature review has been conducted to address the various factors that should be in place in order to promote or prevent the establishment of a direct link between countries in container shipping according to five themes: maritime network, connectivity, port selection criteria, trade, and alternative modes of transport [27].

Several international organizations have been working on the issue of maritime connectivity. The World Bank has launched the program GICA 2017, and the Global Infrastructure Connectivity Alliance's goal is to promote the growth of infrastructure connectivity. This program aims to accelerate the sharing of knowledge about the global connectivity and facilitate exchanges between experts to provide, in particular, trends, drivers, and tools in global connectivity development [28]. Additionally, the "Belt and Road Initiative" (BRI) study—which is based on data from the World Bank indicator of 32 Silk Road countries—examines the impact of port infrastructure connectivity, logistics performance, and trade on economic growth; it has demonstrated that increasing port infrastructure connectivity can improve logistics performance and economic growth [29].

Most of the research has approached the issue from the perspective of port operators hoping to improve their connectivity and, consequently, their benefits. Moreover, and by considering Shamika N. Sirimanne's statement (the Director of Unctad's Division of Technology and Logistics) that "it is important to facilitate the competition between ports to enhance efficiencies", decision makers have an important role in ensuring cross-border cooperation between ports and countries and coordinating efforts between port authorities in both countries in order to discuss prospects for developing maritime transport through the creation and strengthening of maritime links. Furthermore, the outcomes of COVID-19 have highlighted the relationship between maritime, port connectivity, and sustainable growth. In this perspective, it is important to focus on the political and economic arguments to increase resilience in global supply chains through the improvement of shipping services [30].

2.2. Variables Selections

The literature review reveals that the theory has mainly focused on the impact of connectivity on global trade; we can identify multiple studies analyzing the benefits of direct bilateral maritime connection on a country's trade, or cause and effect analyses of connectivity on trade, logistics, and the maritime network. The reciprocity that analyzes the determinant factors of bilateral maritime connectivity's growth are restricted and sophisticated. The literature has only partially addressed the determinant factors of maritime connectivity as we only found a few studies identifying the external factors affecting the maritime connectivity with other countries, particularly with the competitive pressures [11]. The articles that covered the topic were particularly focused on the network and maritime components [6,7,31].

This study seeks to expand the work already undertaken by various researchers and use this, by outlining the key factors that we believe are relevant, to build a strong bilateral connectivity between a pair of countries. Our approach combines the vision of the International Maritime Organization (IMO) to develop connectivity in a global dimension of the supply chain and the variables studied in the literature.

We were also inspired by the vision of the Word Bank regarding the definition of the connectivity in trade, where the trade connection is explained by three interconnected dimensions: the maritime networks assigned to the process before ports, port efficiency involving the logistics operations on the ports, and hinterland implicating the market and the logistics operations [17]. These three dimensions require the contribution and implication of different supply chains and economic stakeholders.

The concept of bilateral connectivity is unique, providing the maximum of granularity to understand the maritime connections between two countries, and the question of our framework is what factors contribute to enhance this connectivity in order to prepare the baseline for sustainable maritime growth.

The LSCBI evaluates the maritime connections between two pairs based on maritime routes. In the literature, there are few contributions linking the direct common connection to the LSCBI. The research of Fugazza and Hoffman has shown that the highest scores of the LSCBI are observed for intra-regional links, notably the maritimes connections between European and intra-Asian ports, where the highest number of connections is recorded [8]. Furthermore, according to worldwide data presented in this contribution, there is a significant correlation between the number of commons connections and the LSCBI. However, Fugazza et al., demonstrated that the number of direct maritime connections in developed countries is double of that in developing countries [7]. It is obvious that the direct common connection between two countries is the most important factor to consider. Previous studies have shown that a high number of connections between two pairs generates a high score of LSCBI. For this reason, our first hypothesis is:

Hypothesis 1. *The direct common connection impacts positively and significantly the LSCBI.*

Maritime connections are made by direct and indirect connections requiring transshipment; the transshipment increases the number of reachable destinations, particularly for distant economies. Wilmsmeier and Hoffmann's analysis revealed that the impact of transshipment between two nations increased the distance by 2612 km [31]. The UNCTAD confirmed that the average of the number of transshipments, which is required to transport a container between two countries, has grown over the years. In the same context, the contribution of Fugazza and Hoffman has shown that the transshipment has a negative correlation effect on the LSCBI, which means that the LSCBI score drops as the number of transshipment links between two countries increases [8]. Hence, the following is our second hypothesis:

Hypothesis 2. *The common connection with one transshipment impacts negatively and significantly the LSCBI.*

The third component is the level of competition for services connecting two countries, which is reflected in the number of maritime carriers providing a maritime connection between two countries. The competition is beneficial for shipping routes as it reduces costs and promotes innovation [32]. In addition, Wilmsmeier and Hoffman, 2006 [15], have proved in previous studies that the more links there are, the more intense is the competition [15]. Without excluding that, the competition has also a strong correlation with LSCBI according to the contribution of Fugazza and Hoffman, 2017 [8]. We thus suggest the following as our third hypothesis:

Hypothesis 3. *Competition has a positive and strong effect on the LSCBI.*

To participate in international trade, it is imperative for a country to improve its logistics infrastructure [33]; the logistics performance is measured by the logistics index (LPI). A good logistics performance increases a country's integration into the international market. The logistic was a part of the contributions of several researchers; it has been demonstrated in the Chinese context that the LPI increases bilateral connectivity [32]. Another researcher affirmed that the logistics performance index (LPI) has a strong impact on trade costs compared to the maritime distance and that the effect is important, especially for bilateral trade in the south coast [17]. In this perspective, we estimate that logistics is positively and significantly affecting the bilateral maritime connectivity. Based on the previous elements, we can state the following hypothesis:

Hypothesis 4. *Logistics affect positively and significantly liner shipping bilateral connectivity*.

The LSCI is a key index in defining the bilateral costs of international trade; it has a strong impact on trade costs compared to the maritime distance, and it has been identified as one of the most relevant factors to be introduced in the LSCBI calculations [19]. In this case, we can formulate the hypothesis below:

Hypothesis 5. *The LCSI affects positively liner shipping bilateral connectivity.*

The economic growth measured by GDP is traditionally recorded as a determinant element of maritime trade [8,17,34]. Maritime transport is linked to GDP; the impact of this historical factor of maritime connectivity can be assessed. The UNCTAD, following an expert analysis of 250 scores of the LSCBI, confirmed that the bottom country pairs essentially include small and remote and the least-developed countries [12]. Additionally, the IMF estimates that a limited shipping capacity has a direct impact on the global economy, as disruptions in shipping would have slowed growth by 0.5 to 1 percentage points in 2021. In addition, as previous studies have focused on the port level structure, our global vision requires a characteristic integration of the countries provided by GDP. In this case, [35], we can formulate the hypothesis below:

Hypothesis 6. *GDP affects positively and significantly the LSCBI.*

Trade is also a subject frequently related to maritime transport and connectivity, and the impact of connectivity and the maritime network on trade has often been evaluated [13,19,20,36]. In this research, we aim to analyze reciprocal relations using bilateral container imports and exports and their impact on bilateral maritime connectivity, which we believe to be positive and significant. Trade is represented by the importations and exportation in volume and value; thus, we formulate the two hypotheses below:

Hypothesis 7. *Importation in volume/value affects positively and significantly bilateral shipping connectivity.*

Hypothesis 8. *Exportation in volume/value affects positively and significantly bilateral shipping connectivity.*

The LSBCI is designed to focus on the connectivity of liner shipping between pairs of countries. In this context, other aspects of connectivity can be analyzed, such as the distance between countries. The nautical distance is considered, as an historical component in maritime connectivity, to be the distance between countries, and is relevant for bilateral trade or trade costs [22]. Nevertheless, only one-fifth of the variation in the cargo rate can be attributed to sea distance, meaning we can formulate the hypothesis below:

Hypothesis 9. *The nautical distance affects negatively and significantly the LSCBI.*

The barriers represented by the time on the border for administration and compliance at import and export could affect the connectivity between two partner countries. The UNCTAD affirmed that it is possible to connect two countries without being connected to the interior of the country; this situation is constraining access to the commercial market. National borders represent a major barrier to bilateral trade. For this reason, it would be relevant to integrate the component of time at the border in order to evaluate the impact of the barriers on the bilateral maritime connectivity [19]. In this case, we can formulate the two hypotheses below:

Hypothesis 10. *Time for documentary and border compliance at import affect negatively and significantly bilateral shipping connectivity.*

Hypothesis 11. *Time for documentary and border compliance at export affect negatively and significantly bilateral shipping connectivity.*

Figure 1 displays the variables and their estimated impact on bilateral liner shipping connectivity. Following an analysis of the literature review, 15 factors were identified as being present in 11 hypotheses. Table 1, in the next section, outlines the different data.

2.3. Data and Sources

Our sample is composed of the bilateral liner connectivity index (LSBCI), which measures the level of integration of Morocco with 164 economies in the international maritime network. The observations are extended over the period of 2008–2021 to trace the evolution of the country with its partners over 14 years, i.e., 164 × 4. This sample will be used to conduct a preliminary analysis in order to understand the evolution of Morocco's bilateral connectivity by region.

For the statistical analysis, we have reduced our sample to 138 countries due to data availability. All data used in this analysis were collected for the subsequent variables.

The liner connectivity index (LSCI) as well as Morocco's 138 trading partners' GDP was collected from the UNCTAD database. The data related to Morocco's exports and imports in both value and volume per country were collected from the Moroccan Office des Changes, with special consideration provided to highly containerizable products.

To analyze the logistics components, we also collected data from the World Bank on the logistics performance index. To highlight the relationship between the country, the processing times of documents, and the goods at the borders between Morocco and its partners, we have collected data from the Doing Business World Bank report of 2019 related to time, customs clearance, and administrative procedures at ports. The sea distance between two main ports was obtained from sea-distance.org.

In addition, data were collected on the components of the maritime flow, namely the common direct connections number, the carriers providing a bilateral maritime connection between country I and country J, and the number of indirect calls (with one transshipment). These data were estimated by the authors through an inventory of the existing shipping liners based on the official data of maritime connections between countries A and B available on the websites of maritime operators (Maersk, CMA CGM, and others). Table 1 outlines the definition and sources of the variables.

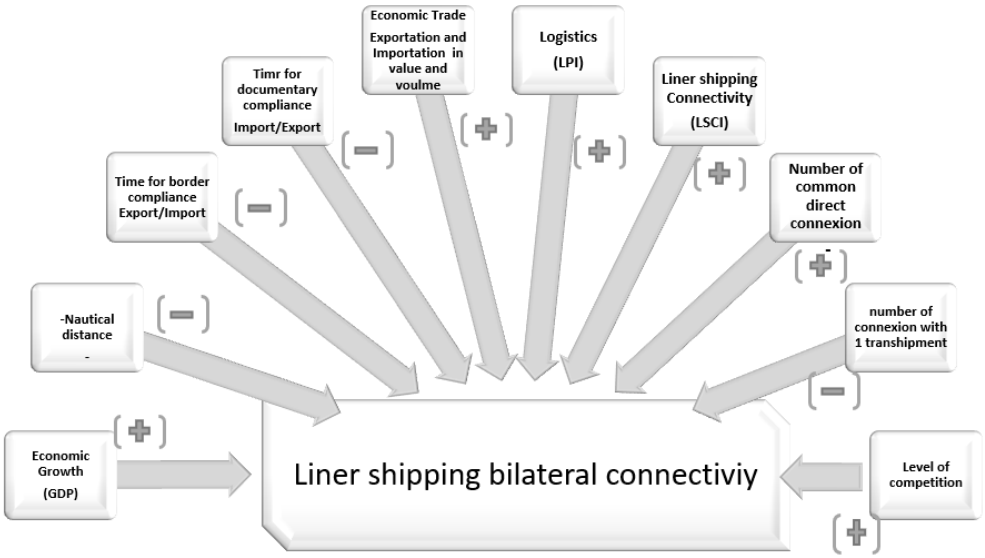

Figure 1. Research framework.

Table 1. Definition and sources of the statistics variables.

	Variable	Unit	Description	Source et Year
	LSCBI	Index	Liner shipping bilateral connectivity of (138 Countries)	2008–2021 UNCTAD [37]
1	The number of direct calls	Number	Number of direct services between two ports	Estimated by the authors based on an inventory of the existing shipping lines
2	The number of indirect calls (with 1 transshipment)	Number	Number of indirect calls requiring 1 transshipment	Estimated by the authors based on an inventory of the existing shipping lines
3	The carriers providing a bilateral maritime connection	Number	The number of carriers providing a liner (direct or indirect)	Estimated by the authors based on an inventory of the existing shipping lines
4	LPI	Index	Logistics performance index (138 countries)	World Bank 2019 [38]
5	LCSI	Index	Liner connectivity shipping index (138 countries)	UNCTAD 2019 [39]
6	GDP	Millions of USD	Gross domestic Product(138 Countries)	UNCTAD 2019 [40]
7	Sea distance	Nautical miles	Bilateral sailing distance between two main container port of countries (138 countries)	Sea Distance.org [41]
8	Value of import	USD	Imports of containerizable products	Office des changes Morocco 2019 [42]
9	Volume of import	kg	Imports of containerizable products	Office des changes Morocco 2019 [42]
10	Value of export	USD	Exports of containerizable products	Office des changes Morocco 2019 [42]
11	Volume of export	kg	Imports of containerizable products	Office des changes Morocco 2019 [42]
12	Time to import: documentary compliance (hours)	Hours	Necessary time to process the administrative customs at ports. Import	Doing Business World Bank report 2019 [43]
13	Time to import: border compliance (hours)	Hours	Necessary time to process the customs clearance at ports. Import	Doing Business World Bank report 2019 [43]
14	Time to export: documentary compliance (hours)	Hours	Necessary time to process the administrative customs at ports. Export	Doing Business World Bank report 2019 [43]
15	Time to export: border compliance (hours)	Hours	Necessary time to process the customs clearance at ports. Export	Doing Business World Bank report 2019 [43]

3. Methodology

In this research, we will combine multivariable regression analysis with the gravity equation. This equation is a model in economics that predicts the trade flow between two countries. The gravity model derived from Newton's laws of gravity, as reported by this law, the attractive forces linking two objects are comparable to their mass and inversely comparable to the distance. The application in the economy specifies that through the gravity model of international trade, we can predict bilateral trade flows based on GDP and the distance between two economies. This model is generally used in various categories of research such as estimating economic or maritime flow [5,15]. Thus, the gravity model can be formulated by the equation below:

$$\mathrm{Tij} = \mathrm{K} \cdot \frac{\mathrm{Gi} \cdot \mathrm{Gj}}{\mathrm{Dij}}$$

where:

K is a constant;
Tij corresponds to the trade flow;
D is the distance between i and j;
G is the GDP of the economy i and j.

The traditional approach consists of estimating this equation taking the log model.

$$\mathrm{Ln(Tij)} = \beta 0 + \beta 1\mathrm{Ln(Gi)} + \beta 2\mathrm{Ln(Gj)} + \beta 3\mathrm{Ln(Dij)} + \varepsilon \mathrm{i}$$

The equation of gravity will be used in this article in order to explain the relation between the bilateral maritime connectivity and the previous predictors. The use of linear regression analysis can allow for examining the relationship between two or more variables.

In order to analyze the different factors influencing maritime connectivity in Morocco, five regression analyses were performed; this paper uses the multiple regression to construct the following model:

Model 1

In the first model (1), a multivariate linear regression was used to compare the Bilateral maritime connectivity index and predictive factors measuring the level of competition in terms of scheduled maritime services that serve the transport between Morocco and countries i, the direct common connections between Morocco and the number of i countries, and the common connections number between Morocco and country i requiring only one transshipment.

$$\mathrm{Yi} = \mathrm{b0} + \mathrm{b1X1i} + \mathrm{b2X2i} + \mathrm{b3X3i} \quad (1)$$

where i represents the partner countries of Morocco i = 1, 2 . . . , 138, b0 is a constant, and b1 to b5 measured the relative contribution of each factor in the model.

Yi: Bilateral liner shipping connectivity index

X1i: Level of competition in terms of scheduled maritime services that serve the transport between Morocco and i countries.

X2i: Direct common connection number between Morocco and i countries.

X3i: Common connections number between Morocco and i countries requiring a single transshipment.

Model 2

Then, the second model (2) is a multivariate linear regression with variables of Equation (1) by adding the logistics performance index (LPI) and the liner shipping connectivity index LSCI of each partner.

$$\mathrm{Yi} = \mathrm{b0} + \mathrm{b1X1i} + \mathrm{b2X2i} + \mathrm{b3X3i} + \mathrm{b4X4'i} + \mathrm{b5X5'i} \quad (2)$$

where i represents the partner countries of Morocco i = 1, 2 . . . , 138, b0 is a constant, and b1 to b5 measured the relative contribution of each factor in the model.

Yi: Bilateral liner shipping connectivity index.

X1i: Level of competition in terms of scheduled maritime services that serve the transport between Morocco and i countries.

X2i: Direct common connection number between Morocco and i countries.

X3i: Common connections number between Morocco and i countries requiring a single transshipment.

X4′i: Index of performance logistics (IPL).

X5′i: Liner shipping connectivity index.

Model 3

The third model (3), the gravity model was used to compare the bilateral liner shipping connectivity and the predictive factors measuring the available maritime components, the GDP of country i, the distance between Morocco and country i, the time required to verify documentary compliance, the time required for border compliance at the import, and also the contribution of the importation in volumes.

$$\mathrm{Yi} = \beta 0 + \beta 1\mathrm{X1i} + \beta 2\mathrm{X2i} + \beta 3\mathrm{X3i} + \beta 4\mathrm{Ln(X4i)} + \beta 5\mathrm{Ln(X5i)} + \beta 6\mathrm{Ln(X6Impi)} + \beta 7\mathrm{Ln(X7Impi)} + \beta 8\mathrm{Ln(X8i)} \quad (3)$$

i represents the partner countries of Morocco i = 1, 2 . . . , 138, β0 is a constant, and β1 to β8 measured the relative contribution of each factor in the model.

Yi: Bilateral liner shipping connectivity index.

X1i: Level of competition in terms of scheduled maritime services that serve the transport between Morocco and i countries.

X2i: Direct common connections number between Morocco and i countries.

X3i: Common connections Number between Morocco and i countries requiring a single transshipment X4i: GDP.

X5i: The nautical distance between Morocco and i countries.

X6Impi: Time required to verify documentary compliance.

X7Impi: Time required for border compliance.

X8i: Importations in volumes.

Model 4

In the fourth model (4), the gravity model was used to compare the bilateral liner shipping connectivity to the predictive factors measuring the available maritime components, the GDP of country i, the distance between Morocco and country i, the time required to verify the documentary compliance, the time required for border compliance at the import, and also the contribution of the importation in values.

$$Yi = \beta'0 + \beta'1X1i + \beta'2X2i + \beta'3X3i + \beta4Ln(X4i) + \beta'5Ln(X5i) + \beta'6Ln(X6Impi) + \beta'7Ln(X7Impi) + \beta'8Ln(X9) \quad (4)$$

where i represents the partner countries of Morocco i = 1, 2 . . . , 138, $\beta'0$ is a constant, and $\beta'1$ to $\beta'8$ measured the relative contribution of each factor in the model.

Yi: Bilateral liner shipping connectivity index.

X1i: Level of competition in terms of scheduled maritime services that serve the transport between Morocco and i countries.

X2i: Direct common connections number between Morocco and i countries.

X3i: Common connections number between Morocco and countries i requiring a single transshipment.

X4i: GDP.

X5i: The nautical distance between Morocco and i countries.

X6Impi: Time required to verify documentary compliance.

X7Impi: Time required for border compliance.

X9i: Importations in values.

Model 5

In the fifth model (5), the gravity model was used to compare bilateral liner shipping connectivity to the predictive factors measuring the available maritime components, the GDP of country i, the distance between Morocco and country i, the time required to verify documentary compliance, the time required for border compliance at the export, and also the contribution of the exportations in volumes.

$$Yi = \alpha0 + \alpha1X1i + \alpha2X2i + \alpha3\,X3i + \alpha4Ln(X4i) + \alpha5Ln(X5i) + \alpha6Ln(X6Expi) + \alpha7Ln(X7expi) + \alpha8Ln(X10i) \quad (5)$$

where i represents the partner countries of Morocco i = 1, 2 . . . , 138, $\alpha0$ is a constant and $\alpha1$ to $\alpha8$ measured the relative contribution of each factor in the model.

Yi: Bilateral liner shipping connectivity index.

X1i: Level of competition in terms of scheduled maritime services that serve the transport between Morocco and i countries.

X2i: Direct common connections number between Morocco and i countries.

X3i: Common connections number between Morocco and i countries requiring a single transshipment.

X4i: GDP.

X5i: The nautical distance between Morocco and i countries.

X6Expi: Time required to verify documentary compliance.

X7Expi: Time required for border compliance.

X10i: Exportations in volumes.

Model 6

In the sixth mode (6), the gravity model was used to compare bilateral liner shipping connectivity to the predictive factors measuring the available maritime components, the GDP of country i, the distance between Morocco and country i, the time required to verify documentary compliance, the time required for border compliance at the export, and also the contribution of the exportations in values.

$$Yi = \alpha'0 + \alpha'1X1i + \alpha'2X2i + \alpha'3\,X3i + \alpha'4Ln(X4i) + \alpha'5Ln(X5i) + \alpha'6Ln(X6Expi) + \alpha'7Ln(X7expi) + \alpha'8Ln(X11i) \quad (6)$$

Yi: Bilateral liner shipping connectivity index.

X1i: Level of competition in terms of scheduled maritime services that serve the transport between Morocco and i countries.

X2i: Direct common connections number between Morocco and i countries.

X3i: Common connections number between Morocco and i countries requiring a single transshipment.

X4i: GDP.

X5i: The nautical distance between Morocco and i countries.

X6Expi: Time required to verify documentary compliance.

X7Expi: Time required for border compliance.

X11i: Exportations in values.

Where i represents the partner countries of Morocco i = 1, 2 . . . , 138, $\alpha'0$ is a constant, and $\alpha'1$ to $\alpha'8$ measured the relative contribution of each factor in the model.

4. Analysis of the Evolution of the Maritime Connectivity Index between Morocco and Its Partners

In this section, we will analyze the LSCBI of Morocco with its 165 partners from different continents. For a better understanding of the links between Morocco and its partners, we have classified Morocco's partners into 18 geographical regions based on the UNCTAD distribution. As shown in Table 1, the maximum LSBCI is found between Morocco, Southern, and Western Europe, the maximum average is found between Morocco and Western European countries, whereas the minimum LSBCI is found between Morocco and Oceania as well as the minimum average.

As shown in Table 2, Among the 18 regions, Morocco's ports are most connected to Western Europe ports, East Asia, Southern Europe, North America, North Africa, Western Asia, and Southern Asia.

Based on the maritime connectivity index, the top five most connected economies are in East Asia and Southeast Asia, specifically, China, Singapore, Korea, Hong Kong (China), and Malaysia, which have a powerful bilateral maritime connection with Morocco. This highlights Morocco's position as a maritime transport hub in Africa thanks to the Tanger-Med transshipment hub according to UNCTAD.

The maritime connectivity between Morocco and its trading partners has evolved well since 2008, as depicted in Figures 2–5:

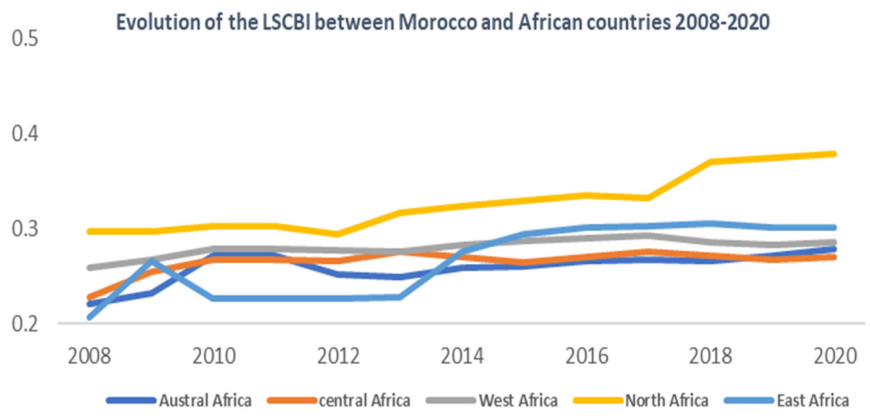

Figure 2. Evolution of the LSCBI between Morocco and African countries 2008–2020.

Table 2. Descriptive statistics of the data LSCBI 2019.

Continent	Region	LSCBI 2019				
		Average	Max	Min	Deviation	Var
Africa	Southern Africa	0.239	0.272	0.205	0.047	0..002
	Central Africa	0.223	0.268	0.172	0.040	0.002
	West Africa	0.249	0.284	0.168	0.034	0.001
	North Africa	0.266	0.374	0.223	0.072	0.005
	East Africa	0.204	0.301	0.161	0.045	0.002
America	Central America	0.222	0.286	0.175	0.047	0.002
	South America	0.246	0.324	0.171	0.060	0.004
	Caribbean	0.190	0.269	0.156	0.038	0.001
	North America	0.268	0.367	0.157	0.106	0.011
Asia	South Asia	0.262	0.369	0.176	0.086	0.007
	Western Asia	0.265	0.395	0.172	0.074	0.005
	East Asia	0.356	0.427	0.242	0.073	0.005
	South East Asia	0.247	0.408	0.158	0.090	0.008
Europe	Southern Europe	0.289	0.440	0.164	0.093	0.009
	Western Europe	0.433	0.440	0.429	0.005	0.000
	Eastern Europe	0.259	0.294	0.227	0.025	0.001
	Northern Europe	0.231	0.435	0.167	0.084	0.007
Oceania	Oceania	0.176	0.246	0.102	0.031	0.001

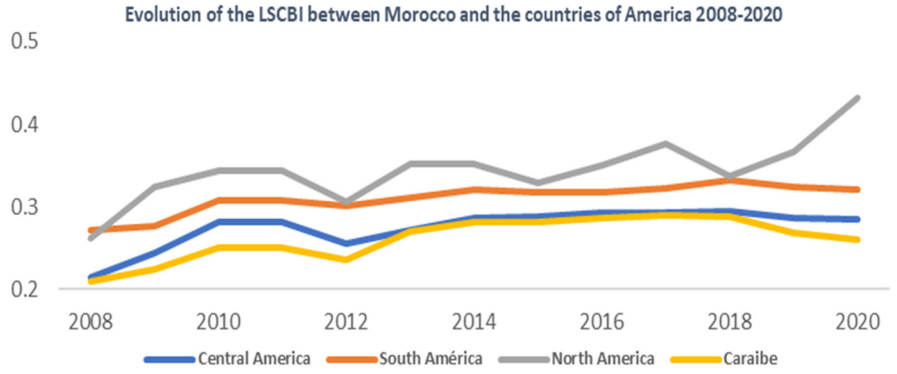

Figure 3. Evolution of the LSCBI between Morocco and American countries 2008–2020.

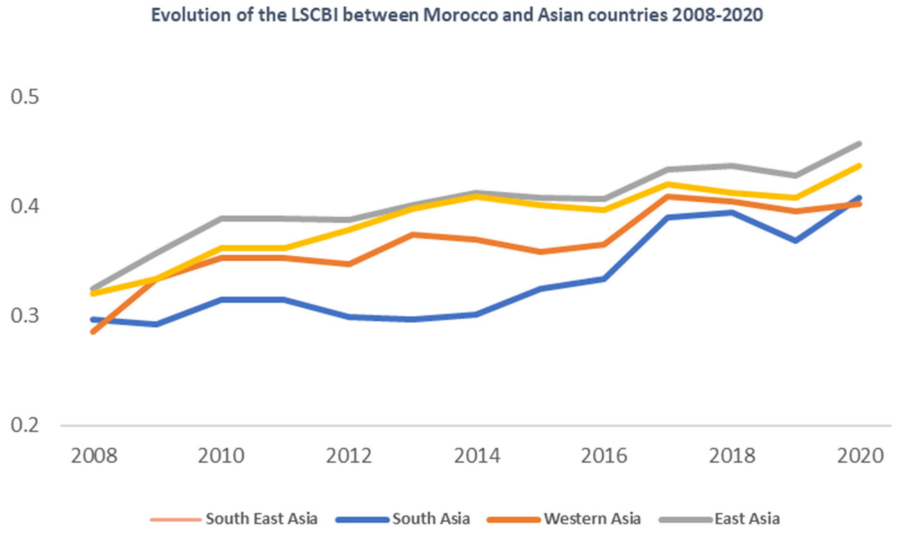

Figure 4. Evolution of the LSCBI between Morocco and Asian countries 2008–2020.

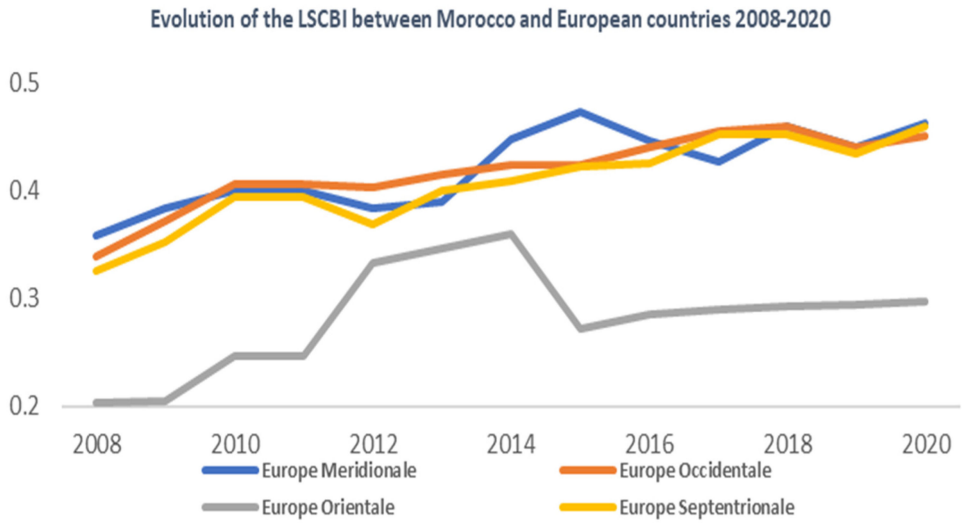

Figure 5. Evolution of the LSCBI between Morocco and European countries 2008–2020.

Between 2008 and 2020, the maritime connection in Africa changed, especially between North African and East African countries; the best evolution was recorded between Morocco and East Africa with 30% in the same period.

In Asia, maritime connectivity evolved between 2008 and 2020, particularly with East Asian countries.

In America, connectivity has also improved, particularly with North America with 40% of evolution, which is the best performance registered during this period.

In Europe, maritime connectivity has also increased, particularly with Southern, Western, and Northern Europe, and has decreased with Eastern Europe.

Based on the preliminary analysis through the visualization of graphs of the bilateral maritime connectivity evolution between Morocco and its partners, it is clear that Morocco's maritime connectivity is closely linked to East Asian countries and Southern, Western, and Northern Europe. However, the connections within Africa, despite their evolution, still remains rather weak.

It should also be noted that Morocco has a strong relationship or polarization with a hub in each region that plays the role of the hub, which highlights the hub position of well-known ports of Morocco to captivate the flows, especially the supply of West African countries.

5. Data Description

Table 3 shows the descriptive statistics of the variables applied in this analysis in order to estimate the factors affecting the liner shipping bilateral connectivity, using regression analysis and the gravity model:

Table 3. Descriptive statistics table (Morocco).

Variable	N	Mean	ErT Mean	EcTyp	Minimum	Q1	Median	Q3	Maximum
LSCBI	138	0.25404	0.00670	0.07872	0.15888	0.18456	0.24403	0.28616	0.46054
PIB in millions (USD)	138	612,425	193,678	2,275,203	249	13,026	61,739	364,940	21,477,497
Nautical distance (ND)	138	4264	225	2643	32	2026	3632	5268	10,860
The carriers providing a bilateral maritime connection	138	2.804	0.202	2.367	0.000	1.000	2.000	4.000	12.000
Number of direct calls (NDC)	138	2.435	0.444	5.214	0.000	0.000	0.000	3.000	46.000
Number of common connections (1 transshipment)	138	2.413	0.376	4.414	0.000	0.000	1.000	3.000	28.000
IPL	133	2.8874	0.0495	0.5709	1.7100	2.4250	2.7300	3.2750	4.2000
LCSI 2019	137	30.63	2.38	27.87	2.63	8.62	19.23	45.22	155.97

Table 3. *Cont.*

Variable	N	Mean	ErT Mean	EcTyp	Minimum	Q1	Median	Q3	Maximum
Volume importations	138	175,828,458	44,395,954	521,534,377	0	56,270	6,166,117	40,164,966	3,723,769,015
value of importations	138	313,347,424	93,787,430	1,101,752,842	0	123,114	8,080,020	106,575,154	8,272,332,596
Volume exportations	138	54,339,478	15,244,870	179,086,670	0	166,828	4,859,928	33,944,130	1,400,378,513
value of exportations	138	243,848,752	105,187,162	1,235,669,371	0	433,629	9,403,583	76,173,809	10,560,760,401
Time to import: documentary com	138	61.50	9.05	106.29	0.50	4.00	34.38	79.29	1090.00
Time to import: border compliance	138	76.20	6.63	77.94	0.00	24.00	56.00	97.43	402.00
Time to export: documentary com	138	48.86	6.29	73.93	0.50	4.75	24.70	60.00	528.00
Time to export: border compliance	138	61.06	4.88	57.28	0.00	24.00	49.52	83.34	296.00

6. Results and Findings

As explained previously, the empirical analysis is based on a sample of 138 countries which are Moroccan partners and have a bilateral connectivity with Morocco. The Multivariate linear regression approach is based on the gravity equation to analyze the effect of independent variables on the liner connectivity bilateral shipping index.

The correlation test of Pearson provided in Table 4 shows that there is no obvious linear relationship between foreign trade (importation and exportations) of Morocco's container ports flow and the bilateral liner shipping connectivity index, so these variables are eliminated in the linear regressions. Due to this, the establishment of the regression model needs to be combined with the gravity model to better explain the content of the project under study.

The maritime network is viewed as a very complex network constituted of a direct and indirect maritime connection between a couple of countries. Even though the liner shipping network provides a regular set of services, with a regular frequency on specific routes, there are still many countries without a direct connection to each other. According to the United Nations, only 17% of countries are directly connected to each other. On the other hand, for Morocco, 35% of countries are directly connected to it. The measure of connectivity has been described as the economic distance linking a pair of countries [14]. To this end, the aim is to find statistically the factors influencing this bilateral connectivity in the Moroccan context in order to identify bilateral forces in order to strengthen Morocco's connectivity, its structure, and enhance its integration in the global maritime transport network to join a sustainable maritime network. The literature has allowed us to select 13 variants that could represent these factors. As mentioned previously, these factors are formulated with 11 hypotheses and 6 models. The results of the six models are showed in Tables 5–7 below.

Table 5 represents the results of the regression of model 1 and model 2 represented by Equations (1) and (2). The results of model 1 show that the level of competition, the direct connection, and the connection with one transshipment are statistically significant in model 1 (p-values less than 0.01). The results in model 2, Equation (2), indicate that the level of competition, direct maritime links, the logistics performance index (LPI), and the liner shipping of the connectivity index (LSCI) are statistically significant in model 2 (p-values less than 0.01). However, the connection with one transshipment is no more significant in Equation (2) (p-values more than 0.01).

Table 4. Correlation test of Pearson of independent variables.

	LSCBI	PIB in Millions (USD)	Nautical Distance (ND)	Number of Shipping Liner Assura	Number of Direct Calls (NDC)	Number of Common Connections	IPL	LCSI 2019	Time to Export: Documentary Compliance	Time to Export: Border Compliance	Time to Import: Documentary Compliance	Time to Import: Border Compliance
GDP in millions $	0.339											
Nautical distance (ND)	−0.157	0.201										
Number of shipping liner Assura	**0.822**	0.389	−0.164									
Number of direct calls (NDC)	**0.674**	0.257	−0.251	0.774								
Number of common connections (with on transshipment)	**0.581**	0.335	0.208	0.424	0.212							
IPL	**0.599**	0.254	−0.175	0.506	0.360	0.376						
LCSI 2019	**0.871**	0.521	0.121	0.720	0.540	0.675	0.555					
Time to export: documentary com	−0.257	−0.128	0.024	−0.242	−0.163	−0.183	−0.134	−0.273				
Time to export: border compliance	−0.258	−0.169	−0.021	−0.243	−0.192	−0.209	−0.194	−0.344	0.646			
Time to import: documentary com	−0.143	−0.099	−0.022	−0.150	−0.104	−0.152	−0.078	−0.191	0.769	0.596		
Time to import: border compliance	−0.191	−0.147	0.006	−0.171	−0.146	−0.158	−0.176	−0.250	0.532	0.719	0.559	
Volume importations	0.507	0.433	−0.102	0.541	**0.691**	0.101	0.279	0.472	−0.151	−0.223	−0.068	−0.185
value of importations	0.531	0.457	−0.139	0.600	**0.773**	0.158	0.283	0.510	−0.160	−0.231	−0.125	−0.207
Volume exportations	0.465	0.176	−0.290	0.538	**0.774**	0.066	0.240	0.323	−0.119	−0.159	−0.096	−0.164
Value of exportations	0.411	0.142	−0.220	0.480	**0.759**	0.068	0.207	0.302	−0.111	−0.171	−0.097	−0.163

Table 5. Regression results of model 1 and model 2.

Variables	Model 1	Model 2
Constant	**0.00575** *** 0.000	**0.16208** *** 0.000
Number of shipping liner (competition)	**0.00248** *** 0.000	**0.00872** *** 0.000
Direct connection number	**0.00104** *** 0.008	**0.002128** ** 0.012
Common connections number (requiring a single transshipment)	**0.000861** *** 0.000	**0.000981** 0.248
IPL	-	**0.00677** ** 0.016
LCSI	-	**0.001436** *** 0.000
Significance levels = 0.05 **. 0.01 ***	R^2 **(adjust)** 75.42%	R^2 **(adjust)** 84.59%

Table 6. Results of regression using gravity models (reported to importation in values and volumes)—models 3 and 4.

Variables	Model 3	Model 4
Constant	**0.1664** *** 0.000	**0.1663** *** 0.000
Number of shipping liner (competition)	**0.01400** *** 0.000	**0.01397** *** 0.000
Number of direct connections	**0.00200** * 0.089	**0.00201** * 0.084
Common connections number (requiring a single transshipment)	**0.005329** *** 0.000	**0.005327** *** 0.000
GDP	**0.01719** *** 0.001	**0.01694** *** 0.001
Nautical distance	**−0.0167** 0.214	**−0.0165** 0.207
Time required to verify documentary compliance	**0.00828** 0.152	**0.00833** 0.148
Time required for border compliance	**−0.00289** 0.210	**−0.00290** 0.209
Importations in volumes	**0.00017** 0.210	-
Importations in values	-	**0.000279** 0.771
Significance levels = 0.1 *, 0.01 ***	R^2 **(adjust)**: 77.55%	R^2 **(adjust)**: 77.56%

The statistical results show that the level of competition and the direct maritime links have an affirmative and compiling effect on the bilateral liner shipping connectivity index even with the addition of the logistics performance index (LPI) and the LSCI (liner shipping of connectivity index). The LCSI and LPI have also a positive and important impact on the connectivity of the liner shipping bilateral index. Among the five factors representing the hypotheses (1 to 5), the level of competition and the LSCI have the greatest effect; the direct common connection and the logistics performance index also impact positively on bilateral liner shipping, while the number of common connections per country pair requiring a single transshipment loses its relevance with the addition of the LCSI and LPI compared to the other factors.

Table 6 represents the results of the regression combined with gravity models 3 and 4 of the importations in both value and volume. The results of models 3 and 4 with the volume and value of the importations show the same statistical significance: the level of competition, the direct connection, the connection with one transshipment, and the GDP have a positive effect and are statistically significant (p-values less than 0.01), while the time required to verify documentary compliance and the time required for border compliance at import, nautical distance, and the values and volumes of importations are statistically insignificant (p-values more than 0.01).

Table 7. Results of regression using gravity models (reported to exportations in volume and values)—models 5 and 6.

Variables	Model 5	Model 6
Constant	**0.1457** *** 0.003	**0.1480** *** 0.002
Number of shipping liner (competition)	**0.01383** *** 0.000	**0.01393** *** 0.000
Number of direct connections	**0.00225** * 0.060	**0.00217** * 0.069
Common connections number (requiring a single transshipment)	**0.005129** *** 0.000	**0.005147** *** 0.000
GDP	**0.01423** *** 0.005	**0.01511** *** 0.002
Nautical distance	**−0.0075** 0.604	**−0.0093** 0.517
Time required to verify documentary compliance at export	**0.00675** 0.254	**0.00728** 0.216
Time required for border compliance at export	**−0.00309** 0.107	**−0.00305** 0.113
Exportations in volumes	**0.001184** 0.222	
Exportations in volumes		**0.000940** 0.326
Significance levels = 0.1 *, 0.01 ***	R^2 **(adjust)**: 77.99%	R^2 **(adjust)**: 77.80%

Table 7 represents the results of the regression combined with gravity models 5 and 6 of the exportations in terms of both value and volume. The results of models 5 and 6 with the volume and value of the exportations show that the level of competition, the direct connection, the connection with one transshipment, and the GDP have a positive effect and are statistically significant (p-values less than 0.01), while the time required to verify documentary compliance and the time required for border compliance at export, nautical distance, and the values and volumes of exportations are statistically insignificant (p-values more than 0.01). The statistical results indicate for both the value and volume of the imports and exports that the level of competition and direct maritime links has an affirmative and compiling effect on the bilateral liner shipping connectivity index, either estimated with or without the trade exportation components. Otherwise, the number of common connections per country pair requiring a single transshipment become significant in the model, including the volume and value of exports. Hence, the container trade has a positive impact on bilateral shipping connectivity, but the impact is not significant compared to the other predictors either estimated in value and volume. This means that there is no representative impact of the trade in value and volume in the bilateral liner shipping connectivity index. In addition, the outcomes indicate that the improvement of maritime connectivity between two countries is largely driven by the partner market factor represented by GDP. The nautical distance and time to compliance for documentary has a negative effect on the bilateral connectivity, but it is not very significant for both value and volume models since it loses its relevance in comparison with other predictors.

7. The Analysis of Regression Results

The results presented by the linear regression and by the gravity models in Tables 5–7 provide evidence for hypothesis 1. Our study confirms that the number of direct connections positively affects the country's connectivity; this result supports the conclusion of a previous piece of research demonstrating that the available regular maritime container services is crucial to define the component of bilateral maritime connectivity [20].

The frequency of the services is very significant for the bilateral connectivity between two countries. The performance of a container hub port to handle cargo is highly dependent on the level of frequency of globalized maritime services [22].

In addition, the development of the connectivity in Morocco is also a good example as the score of Morocco's connectivity has greatly improved over the past decade, rising from 110th place in 2006 to 30th place over the past 5 years through a significant increase in the number of connections with direct services.

As opposed to what was formulated in hypothesis 2 based the contribution of Fugazza and Hoffman, we confirmed that the transshipment has a negative correlation effect on the LSCBI. The results of our study approve those common connections per country pair requiring a single transshipment to be affirmative, but there was an insignificant effect on model 2, which became significant in other models, including the nautical distance, and trade in volume and value [44].

The option of connecting with only one transshipment has been considered by previous researchers as a commercial opportunity and a future direct connection project [45]. This result is in line with our results since direct connections are always the best choice. However, the presence of a connection with one transshipment can be a good option to ensure the bilateral connectivity remains between two countries, with a potential for developing direct connections in the future in case of the presence of trade potential. Thus, transshipment is a real opportunity for Morocco to connect, remote, and enforce direct destinations.

The results presented by the linear regression and by the gravity models have also provided evidence for hypothesis 3. Our study confirms that the level of competition impacts positively on the country's connectivity. This result supports the conclusion of a previous piece of research which demonstrated that competition has also a strong positive correlation with the LSCBI [22].

The development of competition between operators is a key point to develop bilateral connectivity between two countries. In theory, the presence of competition in a particular route motivates shipping companies to reduce their costs and margins and consequently strengthen routes and connectivity and promote innovation, especially in terms of sustainability [46]. In addition, if the container's traffic has been governed by maritime alliances, the competition has become regional and even continental [32]. This trend is favorable to the local and national economy, as well as to international trade, and acts as an instrument for innovation, achieving a flexible multi-service organizational structure, which is a key factor in the case of an international seaport [22].

Regarding the level of competition on services linking Morocco and its partner, it can be seen from the six models that it has the most obvious ability to explain the bilateral liner shipping connectivity and it shows a strong positive correlation, indicating that the deeper the level of competition, the greater the bilateral liner shipping connectivity index. A greater openness in the maritime field will allow for increased participation in the maritime transport market, the improvement of the maritime sector in Morocco, and thus the improvement of the bilateral connectivity of Morocco and its partners.

China has the highest scores of the LSCBI in the world, with the pair of China and Hong Kong heading the raking of bilateral liner shipping connectivity since 2006. If we compare the maximum number of carriers providing a liner shipping between point a and point b, we find that in Morocco, it is around 15, while the number of carriers in China is around 60 [31]. If we explore the carriers operating between Morocco and its partners, we observe that there is no Moroccan maritime fleet. For the international operator, we find a very limited number of shipping companies, such as CMA CGM, MSC, and Maersk, who concentrate more than 80% of the market. This situation is not beneficial for competition [47]. In this case, the Moroccan ports should strengthen their cooperation with worldwide ports to remain in the African and international competition.

The results presented by the linear regression in Table 4 have also provided evidence for the hypothesis 4. Our study confirms that the level of competition impacts positively on a country's connectivity.

The LPI represents the competitiveness of logistics in the country; ports are an important node of the global supply chain. In the Chinese context, a study has demonstrated that a favorable LPI has positive impacts on port selection and connectivity [31]. The

World Bank has approved this hypothesis in the context of a study on the Mediterranean basin. Indeed, the role of logistics development for the countries of the southern shore is essential for their integration into international trade. The development of infrastructures and logistics services will, therefore, help to capture a part of the transit flows that cross the Mediterranean Sea (30% of world container traffic) [17]. The importance of logistics can also be seen through the current trend of shippers who have promoted a vertical integration by investment in logistics services to reinforce their position in the market.

Our findings support these previous theories as the logistics connectivity index is also significant and has a positive impact on maritime connectivity. This result recommends that Morocco should concentrate on developing maritime links with countries with developed logistics in order to achieve a higher level of connectivity an enhance sustainability.

As shown in Table 5, the LSCI also has the greatest effect on bilateral liner shipping in our results, which confirms hypothesis 5.

In theory, several authors have integrated this index in their studies to explain that the position from the main international liner shipping networks has a greater effect on maritime cost. This means that the further a country from the main maritime routes, the higher the transport cost and maritime trade [25]. In addition, another study has confirmed that the LCSI can act as the principal component to compute the LSCBI [8]. However, the results of the research were quite contradictory, as the UNCTAD has highlighted that this variable should be taken with great caution, since a low LSCI does not usually mean that a country is isolated, and a low connected economy can have a strong connection with its partners, as in the case of several African countries.

In addition, Morocco recorded a major evolution in Africa, with an increase of 661% in the period between 2004 and 2018 [37].

If Morocco increased its LPI and LCSI, increasing the LPI and LCSI of its partners seems to be relevant for developing connectivity. That is why launching a program similar to Chinese Silk Road countries in the Moroccan context can be a great challenge to improve both the liner shipping and the logistics performance to all members of the program.

Our findings confirm, as shown in Tables 6 and 7, that economic growth affects positively bilateral shipping connectivity; indeed, the GDP of Morocco's partners has an affirmative and significant effect on the Moroccan bilateral liner shipping connectivity index either estimated with the flow of imports or exports within the four models. This result confirms that the bilateral liner connectivity is linked to the size of the economy, attesting that the more important the partner's economy, the more developed the bilateral connectivity becomes.

Generally, the maritime transportation increases the size of a country's economy, and maritime container transportation has a positive and strong effect on GDP [48]. In line with our hypothesis, several studies have shown that, obviously, economic size has something to contribute to a country's degree of connectivity, but it is not enough to generalize this phenomenon. A statistic contribution estimated that the correlation between GDP and maritime connectivity is around 75%; it also confirmed that GDP has a substantial effect on the relationship and connectivity with a country's neighbors. This study statistically confirmed that for high-GDP countries, the impact of distance on trade has been almost fully absorbed, but for poorer countries, it remains important [49]. Additionally, UNCTAD, following an expert analysis of 250 scores of the LSCBI, confirmed that the bottom country pairs essentially include small and remote and the least-developed countries. In addition, Fugazza et al., demonstrated that the number of direct maritime connections for developed countries is twice as much as that for developing countries.

Indeed, several theories notably addressed by Hoffman and Fugazza have analyzed bilateral maritime trade. The frequency of connections increases the commercial potential between two partners [6]. This potential has been quantified by a 5% increase in the value of exports for each additional direct connection [8], as well as by an increase of 2.8% in exports and 2.4% in imports for each additional connection [13].

If the theory confirms an obvious impact of connectivity on trade, through several works of Fugazza and Hoffmann, who showed that improving connectivity is an important element to facilitate trade [5,8], verifying the relationship of reciprocity is the objective of the models (from models 3 to 6).

The results show that there is no significant impact of the importation in value and volume in the bilateral liner shipping connectivity index. In other words, the increase in the volume or value of imports between Morocco and another partner does not justify a strong bilateral connection, even if there is a significant correlation between the importation and exportation in volume and value with the number of the direct call.

Additionally, for exports in terms of their value and volume, there is no correlation between these two variables and the bilateral connectivity index. In other words, the increase in export flows in their value or volume does not affect the bilateral connectivity between Morocco and its partner, even if it is correlated with the number of direct calls, since the connectivity is also reinforced by links with transshipment. The existence of a significant exports and imports flow does not increase connectivity.

The result seems logical since the port of Tanger-Med, which receives the largest share of annual calls, handles 80% of transshipment flows. The result justifies the non-correlation between the LSCBI and international trade. As an example, to support this statement, the score of the LSCBI between Morocco and Spain is among the best in world; this score is supported by a traffic inter-hub connection between Algeciras and Tanger-Med and not by high maritime trade [50].

Various barriers, notably the nautical distance, the time required for verifying documents, and the time required for border compliance at import and export, represent a significant obstacle to the physical delivery of goods and connectivity.

Traditionally, nautical distance is considered one of the main determinants of freight rates and thus of the commercial competitiveness of countries. This hypothesis has been changed with containerization; the introduction of containers has reduced the constraints imposed by distance. The container can connect distant and less developed countries to the central nodes of the global economy [51,52]. Our findings show that the introduction of the nautical distance in four models (3, 4, 5, and 6) has a negative effect on the bilateral connectivity, but it is not very significant compared to other variables for both imports and exports in terms of their value and volume.

Furthermore, the time required for verifying documents and the time required for border compliance at import and export had no significant effect on the bilateral connectivity index, at either import or export, compared into the other variants. So, our hypothesis regarding time at the borders has not been verified.

Nevertheless, according to the UNCTAD, the digitalization of the exchange of information at the border improves the efficiency and competitive position of maritime communities as the time the goods spend at the border has a negative impact on connectivity. In addition, the Belt and Road Initiative (BRI), which is a program dedicated to enhancing connectivity in Southeast Asia, dedicates important capital, diplomatic, and political resources to reduce the barriers to and enhance connectivity [44]. Enhanced cooperation in cross-border practices is important to strengthen maritime transport and connectivity.

8. Conclusions

The objective of this analysis was to define the key factors affecting the development of Moroccan maritime connectivity with countries worldwide. Since 90% of the international trade in Morocco is carried out by sea, maritime transport and the increase in maritime connectivity is a particular target for the implementation of sustainable development objectives.

In this research, we first used a descriptive analysis of the LSCBI database to understand the most connected region with Morocco. The results show that Morocco has a strong bilateral connectivity with Western, Southern, and Northern Europe and East Asia. In Africa, Morocco is mostly connected to the north and east of Africa. Then, we employed a

literature review to identify the factors that we believe to be relevant to develop a strong bilateral connectivity. The analysis of the literature review identified 15 factors structured under 6 topics, namely: economic growth, economic trade, barriers, logistics, connectivity, and the maritime component.

The statistical analysis using the regression combined with the gravity model of the 15 factors showed that there is a strong and positive impact of economic growth, logistics, and the maritime component on bilateral connectivity, economic trade have a positive but not a very significant impact, and barriers have a negative but not a very significant impact.

The main factors impacting the bilateral connectivity are part of a global vision for a supply chain through developing the number of shipping companies, encouraging the competitively of carriers, developing connectivity in the global maritime network, and developing logistics in the port by enhancing the port's performance and hinterland for both the country and its partners. These factors are the baseline to developing future hub ports and they can also allow for enhancing and promoting corporation between ports in sustainable maritime practices. The factors identified constitute a prerequisite for the development of sustainable maritime connectivity.

Moreover, it would be relevant for future research to estimate the impact of the adoption of the practice of maritime factors defined in terms of their environmental, economic, and social effect, such as the example of the piece of research expressing the impact of artificial intelligence on economic and social environment gain [53]. However, this kind of study is quite complex as it requires an accurate estimation of the ratios that allow for calculating the impact of each factor on the territory.

In addition, the outcomes of COVID-19 have highlighted the relationship between maritime transport, port connectivity, and sustainable growth. From this perspective, it is important to focus on political and economic arguments to increase resilience in global supply chains through the improvement of global shipping services [30].

In fact, the configuration of the future shipping network is becoming increasingly defined by sustainable characteristics [27]. Morocco has a successful track record in terms of the development of connectivity as the country has developed in terms of a direct connection by rising from 110th place in 2006 to 30th place over the past 5 years through a significant increase in the number of connections with direct services. However, other factors must be taken into consideration, especially in terms of improving competitiveness and integration into a global vision for a supply chain, as recommended by the International Maritime Organization guidelines, to improve the logistics and liner shipping connectivity of partners, as also recommended by the outcomes of our study. More concretely, the "Belt and Road Initiative" (BRI) is a good example reflecting this logic as this program was designed to strengthen the connectivity between China and different regions of the world; it combines port infrastructure, connectivity, logistics performance, and trade on the economic growth of 32 countries in a worldwide vision [54]. This program is an excellent model to benchmark in order to develop a similar program in Morocco.

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