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BILATERAL LINER SHIPPING CONNECTIVITY SINCE 2006

POLICY ISSUES IN INTERNATIONAL TRADE AND COMMODITIES
RESEARCH STUDY SERIES No. 72

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BILATERAL LINER SHIPPING CONNECTIVITY SINCE 2006

by

Marco Fugazza
and
Jan Hoffmann

UNCTAD, Geneva

UNITED NATIONS
New York and Geneva, 2016

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Series Editor:
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DITC/UNCTAD

UNCTAD/ITCD/TAB/74

UNITED NATIONS PUBLICATION

ISSN 1607-8291

Abstract

This paper presents a unique analysis of bilateral liner shipping connectivity and its evolution during 9 years over the period from 2006 to 2014. The relevance of the analysis stems from two original contributions. First, the paper proposes a unique bilateral liner shipping connectivity index based on five components capturing the overall quality of a liner shipping connection between two countries whether a direct liner service exists or not. Second, it shows the evolution of bilateral liner shipping connectivity across time and qualifies the contribution of each component of the index. Results show that the top 50 LSBCIs are found on connections between maximum 15 countries and that the top 250 LSBCIs are found on connections between maximum 40 countries. The highest LSBCI values are obtained for intra-regional routes, notably intra-Europa and intra-Asia. Changes in the LSBCI have been predominantly driven by changes in transhipment options pointing to the crucial importance of centrality in the liner shipping network. Remote countries appear to be highly dependent on the centrality of the countries they are directly connected to and, as a consequence to be extremely vulnerable to any variation in the global set of direct connections.

Keywords: Liner shipping bilateral connectivity, container shipping networks

JEL Classification: R49

Acknowledgements

This paper is the outcome of a joint project on Maritime Connectivity between UNCTAD's Division on International Trade in Goods and Services, and Commodities and UNCTAD's Division on Trade Logistics. In that context we are particularly grateful to Anne Miroux and Guillermo Valles for their support. We are also grateful to Bismark Sitorus for helping us with the collection and treatment of raw data. Part of the results have been presented during the Trade and Development Commission, seventh session held in Geneva, 18-22 May 2015. We thank all participants for their interest and comments.

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1. INTRODUCTION

Maritime transport is at the core of international trade in merchandises. Around 80% of volume of goods exchanged in the world are transported via sea (UNCTAD, 2008). The predominance of maritime transport is explained to a large extent by an exponential intensification of containerized transport services. Over the past decades, the share of general cargo that was containerised steadily grew and is now above two-thirds of total general cargo transport. In terms of value, containerised general cargo even exceeds 90% of all general cargo. Containerization links the manufacturer or producer with the ultimate consumer or customer even if their individual trade transaction would not economically justify chartering a ship. Thanks to a network of regular container shipping services with transhipment operations in so-called hub ports, basically all countries are today connected to each other. However, despite a growing participation of developing countries in seaborne trade,[1] evidence on maritime connections suggests that, except for few of them such as China, they may have not reached their full potential.

Recent literature has emphasized the importance of transportation costs and infrastructure in explaining trade and access to international markets.[2] Another still burgeoning strand of the trade literature has attempted to assess the very impact of maritime connectivity on bilateral exports and concludes that the latter could be significantly large.[3] However, all empirical assessments related to maritime connectivity have been based either on single dimension indicators, such as the existence or not a direct maritime connection, or on bilateral indicators of connectivity constructed using unilateral measures of the later and as such lacking a true bilateral nature.

Hoffmann et al (2014) first propose a truly bilateral index of liner shipping connectivity, the Liner Shipping Bilateral Connectivity Index (LSBCI). Their LSBCI is an extension of UNCTAD's country-level Liner Shipping Connectivity Index (LSCI) computed since 2004 and based on a proper bilateralization transformation. This paper presents a revised version of the LSBCI. The index is computed for a sample of 155 costal countries during 9 years over the period from 2006 to 2014. This exercise is unique. It is the most comprehensive dealing with bilateral liner shipping connectivity over several consecutive years.

Results show that the top 50 LSBCIs are found on connections between maximum 15 countries and that the top 250 LSBCIs are found on connections between maximum 40 countries. The highest LSBCI values are obtained for intra-regional routes, notably intra-Europa and intra-Asia. Changes in the LSBCI have been predominantly driven by changes in transhipment options pointing to the crucial importance of centrality in the liner shipping network. Remote countries appear to be highly dependent on the centrality of the countries they are directly connected to and, as a consequence to be extremely vulnerable to any variation in the global set of direct connections.

Trade impact

The relevance of constructing a bilateral index of liner shipping connectivity and being able to monitor and qualify its evolution across time goes beyond strict empirical considerations. Efficient transport services do directly contribute to economic development, thus the quality of transport

[1] Between 1970 and 2010, developing countries´ share in the volume of seaborne exports rose from just 18 per cent to 56 per cent of the world´s total (UNCTAD, 2013).

[2] For instance, based on the estimation of a gravity model using US data, Anderson and van Wincoop (2003) found that transport costs correspond to an average ad valorem tax equivalent of 21%. Using a similar empirical approach, (Clark et al., 2004) estimates reveal that for most Latin American countries, transport costs are a greater barrier to U.S. markets than import tariffs.

[3] Arvis et al. (2013) results obtained for a sample 178 countries over the 1995-2010 period indicate that maritime transport connectivity and logistics performance are very important determinants of bilateral trade costs. Fugazza, (2015) using a gravity model approach based on a novel dataset on maritime connections for a sample of 178 countries collected over the 2006-2012 period finds that the absence of a direct connection is associated with a drop in exports value varying between 42 and 55 per cent.

services between markets in terms of service levels has become a crucial element for the competitiveness of regions and countries in this globalised market place. We believe the LSBCI is likely to become a useful monitoring instrument and benchmark for policy making. Unlike different “perception” indexes used for other purposes, and unlike some data that is generated by polls of experts to obtain a picture about doing business in different countries, the data on fleet deployment is hard data, which does not vary according to who is being asked, inflation rates or changing perceptions.

The rest of the paper is organized as follows. Next section discusses the components of the revised version of the LSBCI and presents some descriptive statistics. Stylized facts of the revised LSBCI are commented in Section 3. Section 4 is dedicated to the illustration of the use of revised LSBCI in assessing the liner shipping experience of a specific country. Section 5 concludes.

2. THE COMPONENTS OF THE PROPOSED LSBCI

The LSBCI is meant to reflect specifically the liner shipping connectivity between pairs of countries. In that context other aspects of connectivity such as distance are excluded from the set of components retained for the computation of the index. Distance between countries, and the level of overall connectivity of individual countries are of course also relevant for bilateral trade or trade costs. However, as regards the bilateral liner shipping connectivity as such, we aim at capturing this as a stand-alone factor.

The LSBCI includes 5 components. For any pair of countries A and B represented in our sample, the LSBCI is based on: 1) the number of transhipments required to get from country A to country B; 2) the number of direct connections common to both country A and country B; 3) the geometric mean of the number of direct connections of country A and of country B; 4) the level of competition on services that connect country A to country B; 5) the size of the largest ships on the weakest route connecting country A to country B.

All components are country-pair specific although components 4 is based on a country specific characteristic. All components are symmetric. For instance the number of transhipments necessary to move a container from A to B is exactly the same than the number of transhipments necessary to move the same container from B to A. As a consequence, the quality of liner shipping connectivity between country A and country B is identical to the quality of liner shipping connectivity between country B and country A. From a more general point of view, however, in selecting our components we aimed to attach more weight to connectivity as such (components 1, 2 and 3) than to its "intensity" (components 4 and 5). This is essentially motivated by the strong impact on freight costs of a transhipment[4] and the close relationship between the incidence of direct connections and the overall average centrality of countries in the liner shipping network.

The below sections briefly discuss the rationale for the inclusion of each component and present some stylized facts. The latter are based on a sample of 155 coastal countries (11935 country pairs) whose connectivity has been informed once a year during the period running from 2006 to 2014. The year 2007 is not reported due to the absence of observations. The underlying raw data is obtained from Lloyd’s List Intelligence, “Lloyd’s List Intelligence - Containers”.[5]

[4] For instance, Wilmsmeier and Hoffmann (2008) findings based on a sample of 189 freight rates of one company for the Caribbean show that trade routes with only indirect services (i.e. including transhipments) induce higher transport costs. Their estimates suggest that transhipment has the equivalent impact on freight rates as an increase in distance between two countries of 2,612 km.

[5] Formally Containerisation International On-line.

2.1 TRANSHIPMENTS

The first component of the proposed LSBCI is the theoretical minimum number of transhipments required to get from country A to country B. As each transhipment implies additional costs, time and risks of delays and damage, the LSBCI for a country-pair with a direct service will be higher than for a country-pair which is not connected through a direct service. As only a small part of all possible country pairs are directly connected with each other, the majority of country pairs require at least one transhipment in order to transport a container from one to the other. As can be seen form Table 1, in 2014 about 18 per cent of country pairs represented in our sample were directly connected, 64 per cent of them required at least one transhipment and 16 per cent two transhipments. Figures for 2006 were 20 per cent, 67 per cent and 12 per cent respectively. In both years there were a few country pairs that required three transhipments. No country pairs require more than 3 transhipments – at least in theory. The share of direct connections has remained relatively stable over the whole period under consideration except for a slight drop observed in 2014 but probably at work since 2012. There is clearly a spill-over effect between direct and non-direct connections as the definition of the latter depends on the former. The intensity of the effect is determined by the direct connections constituting the primary network at any point in time. In other words, depending on direct connections created or destructed across time, the repercussion of these changes could vary dramatically. For instance, the years 2006 and 2012 are characterized by a precisely identical share of direct connections. However, the share of connections that require a single transhipment and the share of connections that require two transhipments are significantly different. We also obtain that dispersion measured by standard deviation increases with the number of transhipments required to connect two countries. Both analytical elements illustrate the existence of network externalities probably ignored by any liner shipping company when the decision of removing or creating a direct connection is taken. This kind of externalities could be corroborated by country specific experiences. For instance looking at the Lithuania case we observe that despite a relatively constant group of direct connections, varying between 10 and 11 over the whole period, the relative incidence of single or double transhipments has changed dramatically from year to year. The number of connections with one transhipment has varied from 96 to 112 and that with two transhipments from 31 to 47.

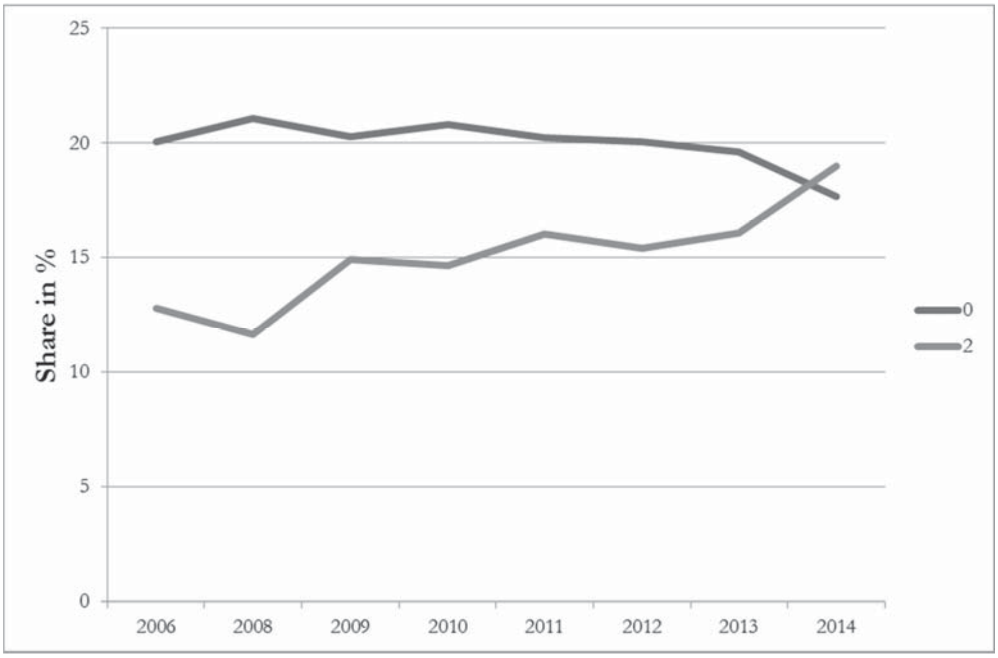
Table 1
Number of transhipments necessary to connect country pairs (shares in %)

Number of Transhipments	*2006*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*
0	20.05	21.08	20.29	20.82	20.26	20.05	19.6	17.69
1	66.98	67.25	64.2	64.43	63.65	64.49	64.23	63.2
2	12.81	11.66	14.93	14.68	16.02	15.4	16.09	18.98
3	0.16	0.01	0.58	0.06	0.07	0.06	0.07	0.13

Note: Statistics are obtained for a sample of 155 coastal countries that is 11935 country pairs.
Source: Authors calculations.

What seems to emerge from Table 1 and further illustrated in Figure 1 in terms of longer-run tendency is that the drop in direct connections has translated essentially in rising incidence of connections necessitating two transhipments. In 2006 about 13 per cent of country pairs required two transhipments to get connected. The corresponding figure in 2014 is almost 19 per cent.

Figure 1: Share of connections with zero and two transhipments

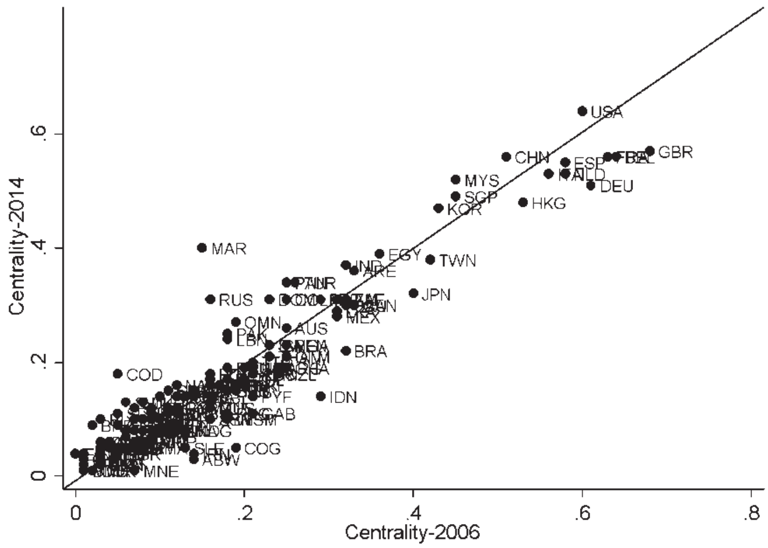


Source: Authors calculations.

The observation of more variability in terms of connectivity options whenever a direct connection service is cancelled together with the observation of an increasing incidence of two-transhipment connections may be synonymous of higher uncertainty and thus higher costs of exporting for firms.

Figure 2 shows the relationship between an indicator of centrality computed for each country in the sample in 2006 (horizontal axis) and in 2014 (vertical axis). The indicator is given by the ratio between the observed number of direct connections and the maximum observable number that is, 154. The diagonal corresponds to the 45-degree line. An observation lying above that line represents a country whose number of direct connections has increased between 2006 and 2014. The reverse is true for those observations below the 45-degree line. The best performer appears to be Morocco followed by the Russian Federation and the Democratic Republic of Congo. Amongst countries whose centrality has deteriorated we have several economically important countries such as Germany, France, Great Britain, Spain, Japan and Brazil. This may reflect a long lasting effect of the 2008 financial crisis together perhaps with a rationalization of the network of direct connections as a consequence of the crisis itself.

Figure 2: Centrality in 2006 versus centrality in 2014



Source: Authors calculations.

2.2 COMMON DIRECT CONNECTIONS

The second component is the number of common direct connections between any two countries in each country pair. It is thus the total number of countries that have a direct connection to both, the origin country A and the destination country B in the pair. This is equivalent to the theoretical number of options a shipper faces to get his goods shipped from A to B with a single transhipment. The economic rationale for this component is twofold. First, countries that lie on the same coast (e.g. Chile, Peru, Ecuador) are served by the same services and as a consequence have far more connections (services that connect them) than they would have without their common services from/to e.g. Europe, North America or Asia. Empirically, it has been shown that countries that lie on the same ocean tend to trade more with each-other. Secondly, each common connection is one more option to trade via a single transhipment. The more common connections two countries have (e.g. to get from Brazil to Ecuador via Panama, Jamaica or Bahamas), the better the two countries are connected and can trade with each-other.

Table 2 reports a series of basic descriptive statistics for the eight years under investigation. As it may have been the case for the results obtained for the previous LSBCI component, there are some indications of long lasting influence of the effects of the 2008 financial crisis and the subsequent rationalization of the liner shipping network. For instance, the maximum value has dropped dramatically in 2014 compared to 2006 and has followed a quasi-erratic path over the whole period. The P90 threshold indicating the number of common connections above which a country pair is part of the top 10 most connected pairs has moved from 22 in 2010 to 20 in 2014, which stands below the 2006 threshold.

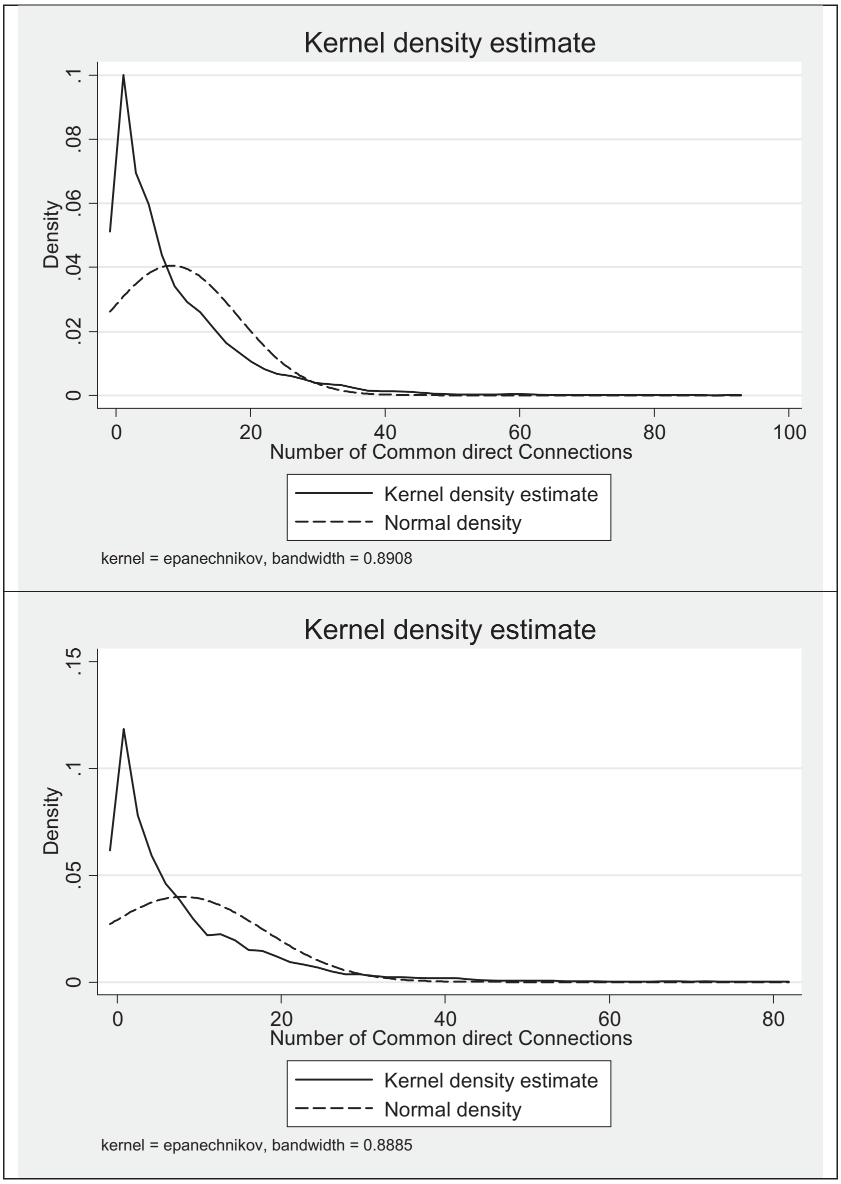
Figure 3 illustrates the kernel density function of this component for the years 2006 and 2014. The shape of this non-parameterized distribution suggests that most country pairs are characterized by a relatively small number (less than 10) of common direct connections. Comparing the two panels of Figure 3 indicates that the distribution has somewhat shifted to the right. A larger share of bilateral relationships is characterized by a relatively larger number of common direct connections. At the same time, however, we notice that the share of country pairs with a relatively large number of common direct connections has fallen. All these elements are equivalent of saying that the core of the liner shipping network has become more concentrated in 2014 compared to what is was in 2006. In other words more countries are connected to fewer hubs. This would be consistent with the previous observations of a larger number of country pairs connected via 2 transhipments.

Table 2
Number of common direct connections

	Mean	*Median*	*Standard Deviation*	*Maximum*	*p10*	*p90*
2006	8.33	5.00	9.83	92.00	0.00	21.00
2008	8.85	5.00	10.49	95.00	0.00	22.00
2009	8.07	5.00	9.94	87.00	0.00	21.00
2010	8.57	5.00	10.33	90.00	0.00	22.00
2011	8.23	5.00	10.14	80.00	0.00	21.00
2012	8.30	5.00	10.20	87.00	0.00	21.00
2013	7.95	4.00	9.95	85.00	0.00	20.00
2014	7.92	4.00	9.99	81.00	0.00	20.00

Note: Statistics are obtained for a sample of 155 coastal countries that is 11935 country pairs.
Source: Authors calculations.

Figure 3: Kernel density Common direct Connections in 2006 (upper graph) and 2013 (lower graph)



Source: Authors computations.

2.3 THE GEOMETRIC MEAN OF THE NUMBER OF DIRECT CONNECTIONS

We opted for the inclusion of a measure able to reflect the degree centrality of the country pair based on that of each composing country. The reason is twofold. First, the country pairs ranking obtained with the component proposed in Hoffman and al. (2014) appeared to be at odd with other components rankings. Second, despite the fact that this component is not bilateral in essence, the centrality of a country pair in the network of liner shipping connections is expected to be significantly affected by the centrality in that network of each country taken separately. Moreover, we see this component as an indicator of the access to the network provided by each possible trade partner. In that context we can see the measure as truly bilateral. Taking the geometric mean provides a balanced measure of this bilateral access to the rest of the world.

Basic descriptive statistics are reported in Table 3. There is clearly a strong link with component 1 statistics. Both mean and median values have been falling in most recent years. This is most probably a consequence of the fall in the share of directly connected country pairs.

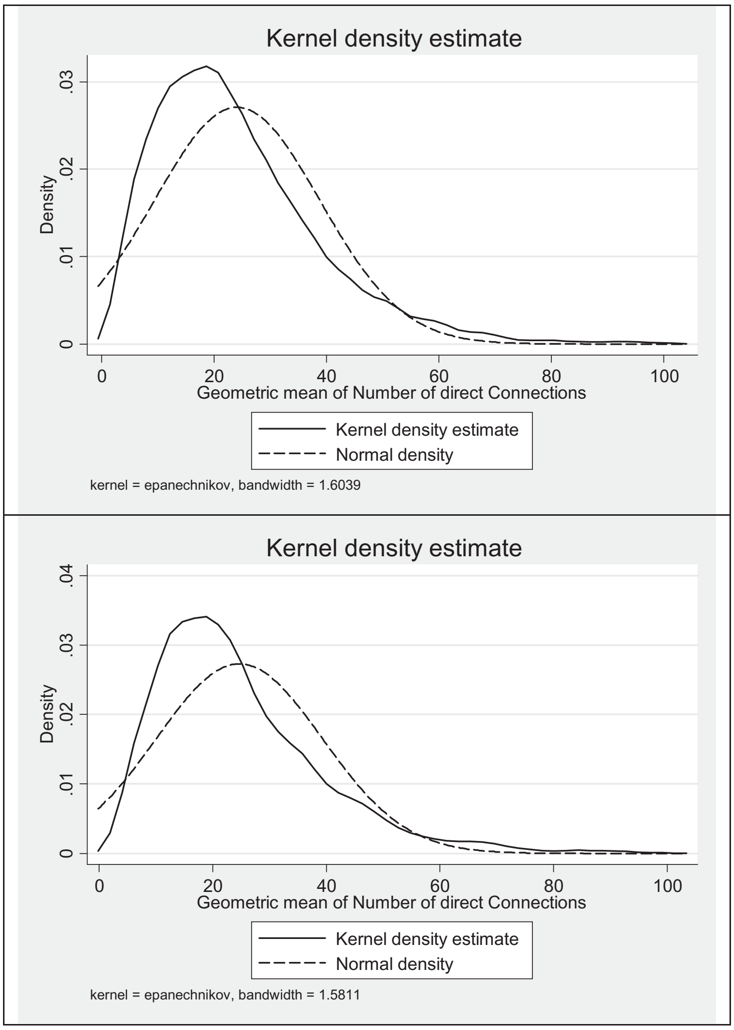
Table 3
Number of direct connections: Geometric mean

	Mean	*Median*	*Standard Deviation*	*Maximum*	*p10*	*p90*
2006	24.12	21.35	14.73	102	8.06	43.59
2008	24.79	21.91	15.35	105	8.00	45.37
2009	23.89	21.07	14.57	98	7.94	43.27
2010	24.87	21.82	14.80	99	9.06	44.72
2011	25.08	22.25	14.82	96	9.00	44.59
2012	25.30	22.45	15.00	101	9.00	45.17
2013	24.54	21.45	14.59	100	9.17	44.00
2014	24.69	21.56	14.62	101	9.17	44.19

Note: Statistics are obtained for a sample of 155 coastal countries that is 11935 country pairs.
Source: Authors calculations.

The kernel density functions of the component for the year 2006 and 2013 are shown in Figure 4. No dramatic change can be identified. However, we can easily distinguish the appearance of a small bump just below 40. This is consistence with the overall tendency to move towards a network more concentrated on fewer destinations.

Figure 4: Kernel density Direct Connections Geom. Mean in 2006 (upper graph) and 2014 (lower graph)



Source: Authors computations.

2.4 THE LEVEL OF COMPETITION ON SHIPPING SERVICES

The fourth component is the level of competition on services that connect country pairs. This is indicated with the constraining number of carriers that operate along the route between the country pair. The higher this number is, presumably the higher is the competition. If the competition on a shipping route is increased, the shipping lines have an incentive to reduce their transportation costs and margins on these routes (Hummels et al., 2009, Asturias and Petty, 2013) leading in turn to a decrease in transportation costs for shippers using that particular route. In theory, there are often hundreds of theoretical options to connect two countries. For the generation of this component, we have computed the Max-Min of the number of companies on the “best” connection between two countries in terms of the number of companies. For example, if I can get from A to B via C with 5 companies competing on the route A-C and 8 companies competing on the route C-B, then the competition on the thinnest route for this option is 5. If there is another option to get from A to B via D, with 6 companies competing on the route A-D and 7 companies competing on the route D-B, then the competition on the thinnest route for this option is 6. Comparing these two options, the Max-Min (i.e. the highest number on the leg with the lowest number) is 6, and “6” will be the value incorporated for the LSBCI for this component.

Descriptive statistics are reported in Table 4. On average, the number of carriers operating on maritime routes has increased. They were less than 4 in 2006 and almost 5 in 2014. The median in 2014 is twice the median in 2006. Fifty per cent of maritime routes are served by at least 4 carriers. At the same time the maximum number of carriers operating on a single route has diminished by one fourth between 2006 (82 carriers) and 2014 (63 carriers). In 2006 and 2008 the country pair showing the maximum value of 82 was Great Britain-The Netherlands. In 2009 a dramatic drop to a maximum of 58 carriers was observed for the country pair. It remained nonetheless at the top of the list together with the Belgium-The Netherlands country pair. Since 2010, the maximum number of carriers operating is found on Eastern Asian routes. The Malaysia-Singapore country pair dominated in the years 2010 and 2011 with 58 servicing. Since 2012, the China-South-Korea country pair has occupied the first rank. However, while 72 carriers operated in 2012 they were only 63 in 2014.

The relatively high variability in this statistic is likely to be the reflection of highly fluctuating trade flows strictly related to fluctuating demand conditions in the aftermath of the 2008 financial crisis.

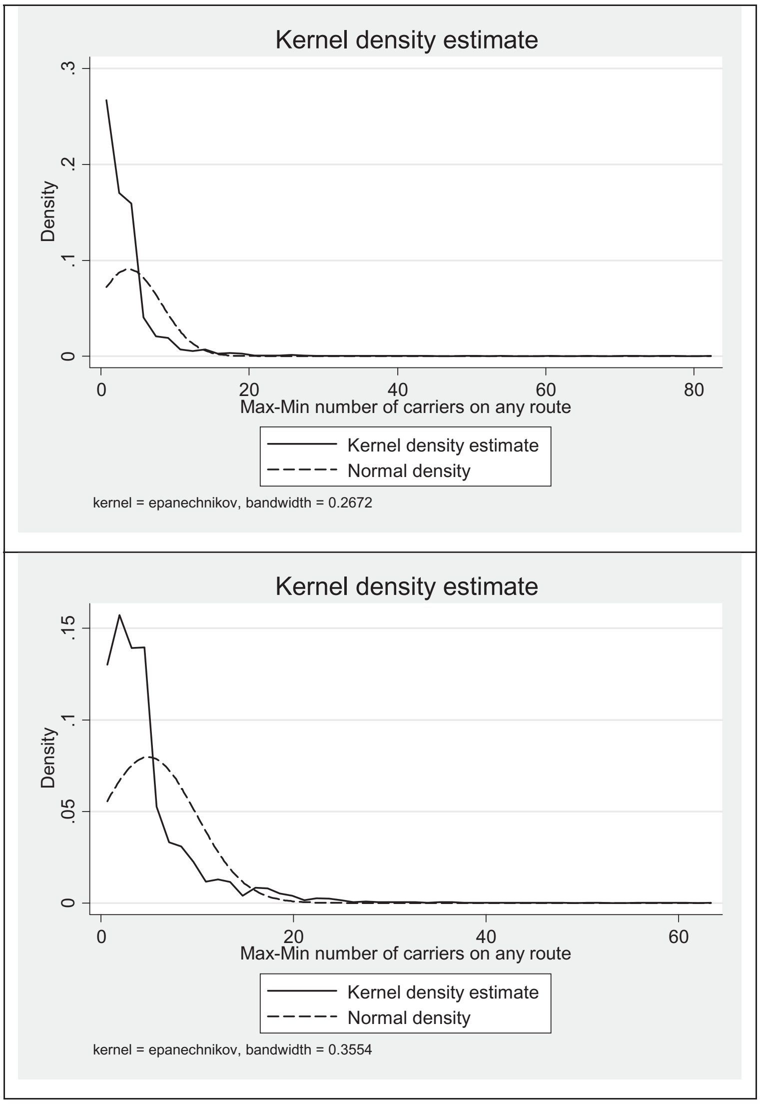
Table 4
Largest number of carriers operating on the least competitive leg

	Mean	*Median*	*Standard Deviation*	*Maximum*	*p10*	*p90*
2006	3.73	2.00	4.40	82.00	1.00	7.00
2008	3.70	2.00	4.26	82.00	1.00	8.00
2009	3.37	2.00	3.73	58.00	1.00	7.00
2010	3.35	2.00	3.82	58.00	1.00	7.00
2011	3.43	2.00	3.84	57.00	1.00	7.00
2012	4.82	3.00	5.09	72.00	1.00	10.00
2013	4.86	4.00	4.97	67.00	1.00	10.00
2014	4.90	4.00	5.00	63.00	1.00	10.00

Note: Statistics are obtained for a sample of 155 coastal countries that is 11935 country pairs.
Source: Authors calculations.

The kernel density function of this component is illustrated in Figure 5. Changes in its shape corroborate previous remarks. Due to the collapse of the maximum value observed in 2014, the distribution has inflated towards the lowest values and as a consequence has become much less dispersed than it was in 2006. The effects are similar to a redeployment of carriers away from historical destinations often associated with strong demand for containerized goods. In accordance with our interpretation of the component, overall competition amongst liner shipping companies may have increased. However, if no redeployment really occurred, our results would just suggest that fewer ship companies have been focusing on fewer routes. This would not necessarily be synonymous of an intensified competition.

Figure 5: Kernel density Number of carriers operating on least competitive leg in 2006 (upper graph) and 2014 (lower graph)



Source: Authors computations.

2.5 SHIPS SIZE

The fifth component is the size (expressed in twenty-foot equivalent unit, TEU) of the largest ship on the thinnest route. Calculations are based on the same approach used for the fourth component. The maximum ship size can be considered to be an indication of the level of infrastructure in the trading countries as well as the countries in which the transhipment occurs. The vessel size is also an indicator for economies of scale on the sea-leg. On several connections where there is a direct link the ship deployed on the direct link is not the option with the largest ships. For example, direct services from the west coast of South America to Europe may deploy smaller ships than those deployed on services to Panama, and from Panama to Europe; put differently, for the LSBCI we will include a larger vessel size than the one from the direct service. Descriptive statistics are reported in Table 5. The average size has increased significantly and steadily during the 2006-2014 period. This is also the case for the maximum size. The latter may have driven the former as suggested by the inspection of Figure 6 which shows the kernel density of the component.

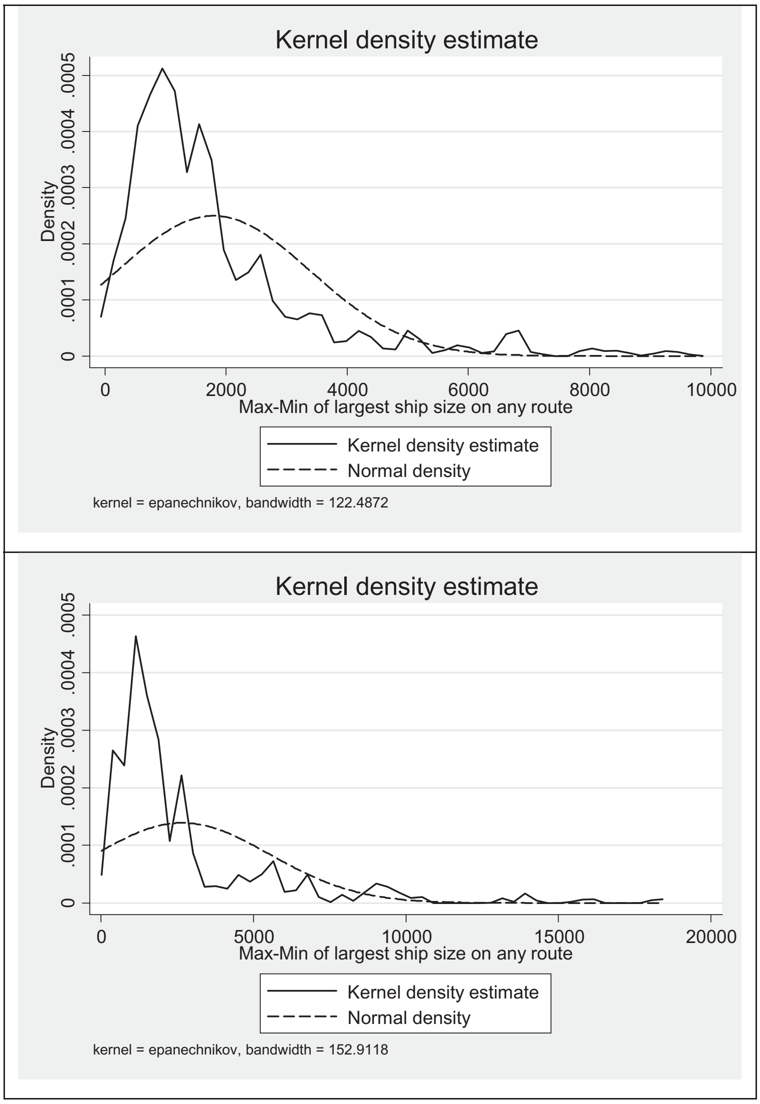
Table 5
Size in TEU of the largest ship operating on the weakest leg

	Mean	*Median*	*Standard Deviation*	*Maximum*	*p10*	*p90*
2006	1794.73	1344.00	1596.83	9742.00	485.00	3584.00
2008	1953.18	1438.00	1744.26	12508.00	519.00	4250.00
2009	2252.72	1606.00	2095.82	14770.00	519.00	5050.00
2010	2252.75	1604.00	2165.17	14770.00	518.00	4990.00
2011	2293.93	1454.00	2261.95	15550.00	518.00	5100.00
2012	2484.09	1510.00	2597.19	15550.00	500.00	5762.00
2013	2551.77	1604.00	2647.04	16020.00	600.00	6350.00
2014	2664.75	1638.00	2867.98	18270.00	418.00	6539.00

Note: Statistics are obtained for a sample of 155 coastal countries that is 11935 country pairs.
Source: Authors calculations.

The Kernel density further reveals an intensified use of ships of size between 5000 TEU and 10000 TEU in 2014 compared to 2006. Over the period under investigation we observe an intensification of the use of super-sized ships. In 2006, the largest existing ship could sail on one route only. In 2012 and 2013 the number of routes jumped to 55 and the size of the ship has been doubled with respect to it was in 2006. Over the last three years, the size of the largest ship moved from 15550 TEU to 18270 TEU. This change may explain why the largest ships could only sail down 45 routes in 2014 as port infrastructures certainly need time to adjust to new size requirements.

Figure 6: Kernel density of the size of the largest ship operating on the leg with smallest ships in 2006 (upper graph) and 2013 (lower graph)



Source: Authors calculations.

3. THE LSBCI

This section discusses the computation of our synthetic bilateral index. Some stylized facts are also presented.

3.1 COMPONENTS NORMALIZATION AND AGGREGATION

In order to establish a unit free index all components are normalized using the standard formula: Normalized_Value=(Raw-Min(Raw))/(Max(Raw)-Min(Raw)). We opted for this formula rather than the (Raw/Max(Raw)) formula essentially because of the existence of minimum values which differ from zero. If all minimum values for all components were zero both formulas would be equivalent and would generate identical normalized values.

The LSBCI is computed by taking the simple average of the five normalized components. As a consequence, the LSBCI can only take values between 0 and 1. As to the first component, we simply take its complement to unity that is 1-Normalized_Value to respect the correspondence between higher values and stronger connectivity.

3.2 INTER-TEMPORAL COMPARISON

In order to make index values comparable across time, maximum and minimum values for each component correspond to the maximum and minimum observed over the whole time period under consideration. The use of identical maximum and minimum values across years allows for a direct comparison across time and across countries. It is then possible to keep track of the evolution of a specific country score across time but also in comparison with the evolution of other countries' scores. Table 6 reports some standards descriptive statistics characterizing the whole sample. Mean and median values show very little variation across time. Dispersion as measured by the standard deviation has increased only slightly.

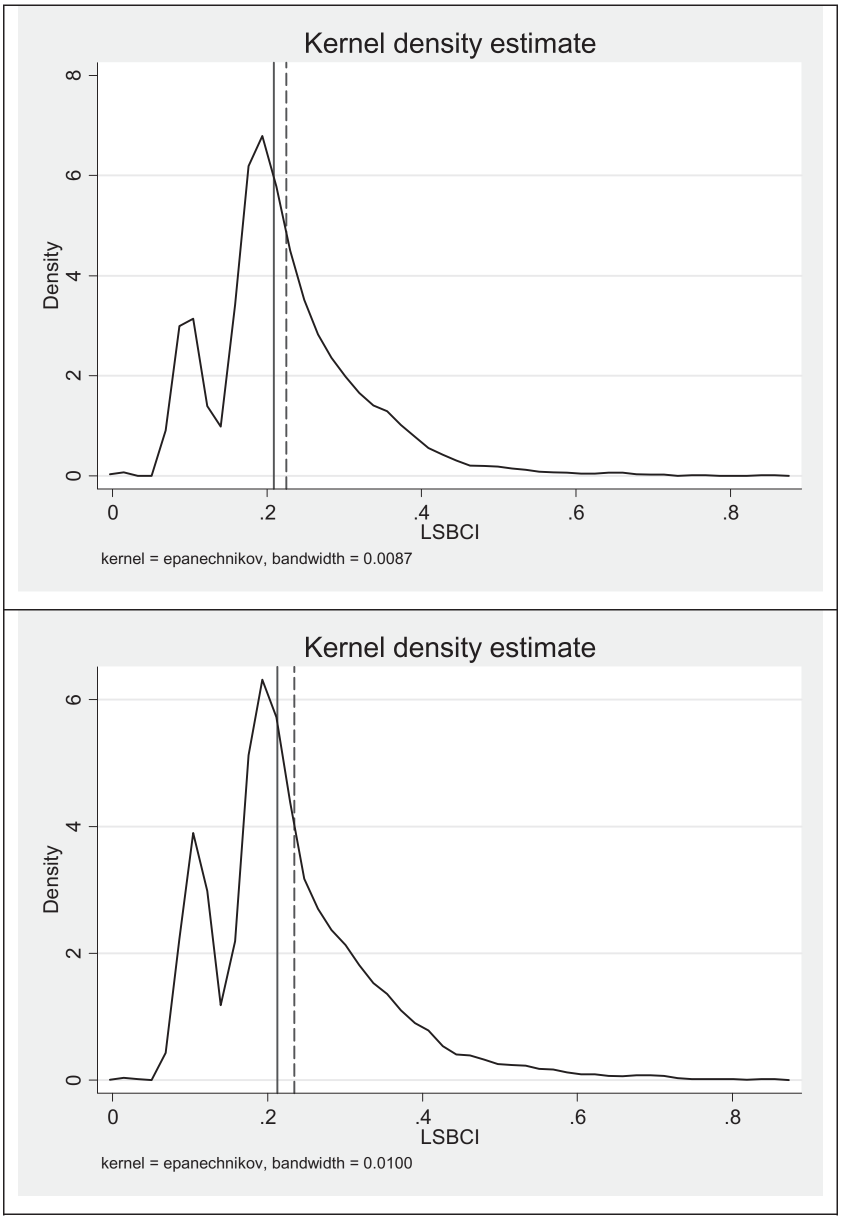
Table 6
LSBCI: selected descriptive statistics

	Mean	*Median*	*Standard Deviation*	*Maximum*	*p10*	*p90*
2006	0.225	0.209	0.097	0.867	0.103	0.350
2008	0.230	0.212	0.100	0.875	0.102	0.359
2009	0.226	0.209	0.102	0.860	0.103	0.358
2010	0.230	0.211	0.104	0.845	0.105	0.362
2011	0.230	0.210	0.104	0.847	0.104	0.362
2012	0.236	0.214	0.108	0.866	0.110	0.375
2013	0.234	0.211	0.108	0.877	0.108	0.372
2014	0.235	0.213	0.110	0.863	0.109	0.374

Note: Statistics are obtained for a sample of 155 coastal countries that is 11935 country pairs.
Source: Authors calculations

The latter fact is reflected in the changes of the kernel probability density function shape observed between 2006 and 2014. The two functions are reported in the upper and lower panel of Figure 7 respectively.

Figure 7: LSBCI distribution (Kernel density estimation) in 2006 (upper panel) and 2014 (lower panel)

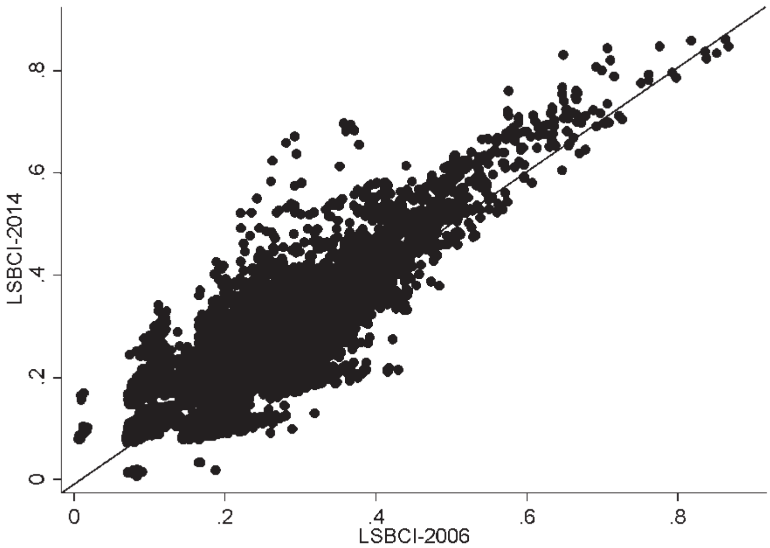


Note: The dashed vertical segment indicates the mean value, the plain segment the median

Source: Authors calculations.

Figure 8 scatters the LSBCI of each country pair in 2014 against the value of their LSBCI in 2006. Points above the 45-degree line represent country pairs whose LSBCI has increased between 2006 and 2014. Points below the 45-degree line represent country pairs whose LSBCI has decreased. between 2006 and 2014. A majority of country pairs, namely 67 per cent, moved up in terms of LSBCI performance.

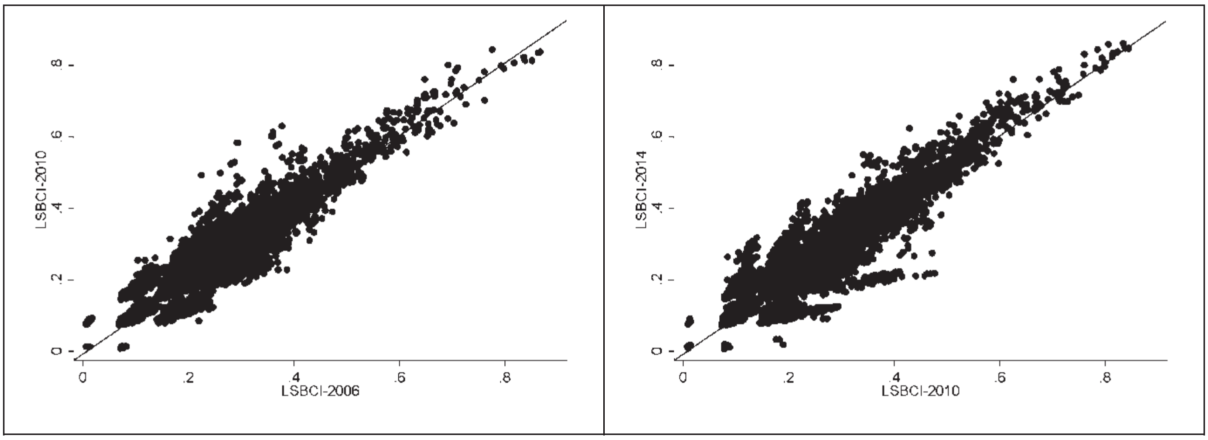
Figure 8: LSBCI variation between 2006 and 2014



Source: Authors calculations.

A decomposition of the variation observed between 2006 and 2014 represented in figure 9 suggest that most of the improvement has occurred since 2010. A more precise analysis indicates that indeed the LSBCI has stagnated for a large majority of country pairs in the immediate aftermath of the 2008 world crisis for taking off only after 2010.

Figure 9: LSBCI variation between 2006 and 2010 and, between 2010 and 2014



Source: Authors calculations.

3.3 RANKINGS

The following tables report the top (Table 7) and bottom (Table 8) twenty country pairs according to the value of their LSBCI. Rankings are again based on our sample of 155 costal countries corresponding to 11935 country pairs.

Table 7 reveals that besides developed countries and essentially European countries only Eastern Asian countries are part of the top 20 country pairs. However, their presence is clearly more marked in 2014 and 2010 that it was in 2006. Seven of the top twenty country pairs are constituted by

Eastern Asian countries and one country pair involves China. Moreover the China-Hon Kong (Province of China) pair was at the top of the list in 2010. It moved down to the fourth rank in 2014 but still with a small progression in its LSBCI value.

Table 7

Top 20 country pairs in 2006, 2010 and 2014

year	exporter	importer	LSBCI	year	exporter	importer	LSBCI	year	exporter	importer	LSBCI
2014	NLD	GBR	0.86	**2010**	*HKG*	*CHN*	0.84	**2006**	GBR	BEL	0.87
	NLD	DEU	0.86		GBR	BEL	0.84		NLD	GBR	0.86
	GBR	BEL	0.85		NLD	GBR	0.83		DEU	BEL	0.85
	HKG	*CHN*	0.85		NLD	BEL	0.82		GBR	DEU	0.84
	KOR	*CHN*	0.85		DEU	BEL	0.81		NLD	BEL	0.84
	NLD	BEL	0.84		GBR	DEU	0.81		NLD	DEU	0.82
	DEU	BEL	0.83		NLD	DEU	0.81		FRA	BEL	0.80
	MYS	*CHN*	0.83		*SGP*	*CHN*	0.80		GBR	FRA	0.79
	GBR	DEU	0.82		GBR	FRA	0.80		*HKG*	*CHN*	0.78
	SGP	*MYS*	0.82		*SGP*	*MYS*	0.79		FRA	ESP	0.76
	SGP	*CHN*	0.81		FRA	BEL	0.79		NLD	FRA	0.76
	KOR	*HKG*	0.80		*KOR*	*CHN*	0.79		FRA	DEU	0.75
	GBR	FRA	0.80		NLD	FRA	0.78		ITA	FRA	0.73
	NLD	FRA	0.79		*KOR*	*HKG*	0.76		GBR	ESP	0.72
	ITA	ESP	0.79		*MYS*	*CHN*	0.76		ITA	ESP	0.72
	FRA	BEL	0.79		FRA	DEU	0.76		*SGP*	*MYS*	0.71
	FRA	ESP	0.78		*SGP*	*HKG*	0.75		ESP	BEL	0.71
	FRA	DEU	0.78		GBR	ESP	0.74		NLD	ESP	0.71
	MYS	*HKG*	0.77		ESP	BEL	0.73		*KOR*	*CHN*	0.71
	USA	*CHN*	0.76		GBR	*CHN*	0.73		ITA	GBR	0.70

Source: Authors Calculations

Deeper analysis reveals that in 2006 the top 50 connections are on 15 countries, 9 developed (Belgium, France, Germany, Great Britain, The Netherlands, Spain, Italy, Japan and the USA) and 6 Asian (China, Taiwan (Province of China), Hong Kong (Province of China), Malaysia, South Korea and Singapore). The top 100 connections are on 17 countries (the previous 15 plus Canada and Egypt) and the top 250 connections are on 36 countries. The latter group includes amongst others two Latin American countries (Argentina and Mexico) and two Caribbean countries (the Dominican Republic and Jamaica) and one Sub Saharan African country, namely South-Africa. In 2010 the group making the top 50 connections is the same than in 2006. The top 100 connections are on 21 countries (the previous 15 plus Egypt, Morocco, Panama, Portugal, Saudi Arabia and the United Arab Emirates). The top 250 connection are on 33 countries. Amongst others one additional Latin American country (Mexico), one Caribbean (Jamaica) and South Africa are present in the latter group.

In 2014, Japan exits the top 50 group and the 100 group is made of 18 countries only. The top 250 group expands to include 39 countries.

Bottom 20 country pairs are composed by essentially small and remote islands (e.g. Cook Islands Montserrat, Nauru) or poor developing countries with a very weak centrality index. The presence of Latvia and Albania amongst this list reflects essentially the fact that their centrality in the network is also weak but not because of their remote geographical situation. Their poor performance in terms of centrality comes from their close link to an important hub such as Italy for Albania or Germany for Latvia.

Table 8
Bottom 20 in 2006, 2010 and 2014

year	exporter	importer	LSBCI	year	exporter	importer	LSBCI	year	exporter	importer	LSBCI
2014	NRU	MMR	0.07	**2010**	MDV	COK	0.08	**2006**	MSR	MHL	0.02
	NRU	MNE	0.07		MDV	BMU	0.08		YEM	MSR	0.02
	MNE	BMU	0.07		COK	BMU	0.08		COK	COD	0.01
	NRU	BMU	0.07		NRU	MMR	0.07		SYC	MSR	0.01
	GEO	COG	0.03		NRU	COK	0.07		SVN	MSR	0.01
	COG	BGR	0.03		NRU	ALB	0.07		SOM	MSR	0.01
	COM	COK	0.02		NRU	BMU	0.07		MSR	COD	0.01
	MNE	COG	0.02		SYC	COK	0.01		SDN	MSR	0.01
	SLE	COK	0.02		COK	BGR	0.01		MSR	KHM	0.01
	COK	BGR	0.02		SYC	NRU	0.01		PLW	MSR	0.01
	GEO	COK	0.02		COK	COD	0.01		MSR	BGD	0.01
	LVA	COK	0.02		NRU	COD	0.01		MSR	MDV	0.01
	IRN	COK	0.02		GEO	COK	0.01		MSR	BRN	0.01
	COK	COG	0.02		COK	BHR	0.01		MSR	KWT	0.01
	IRQ	COK	0.02		IRQ	COK	0.01		MSR	IRQ	0.01
	COK	ALB	0.01		SOM	COK	0.01		MSR	BHR	0.01
	SOM	COK	0.01		ERI	COK	0.01		MSR	COK	0.01
	NRU	COG	0.01		QAT	COK	0.01		MSR	MMR	0.01
	ERI	COK	0.01		NRU	IRQ	0.01		NRU	COD	0.01
	MNE	COK	0.01		COK	ALB	0.01		NRU	MSR	0.01

Source: Authors Calculations.

3.4 THE LSBCI AND ITS COMPONENTS

Table 9 reports some standard coefficients of pairwise correlation between the LSBCI and its components taken in their raw form for the year 2014. All coefficients are significant at 1 per cent. Results obtained for previous years are similar. The negative sign on the first component is due to the fact that we consider the number of transhipments, meaning that more implies weaker connectivity. The strongest correlation is found for component 2, the number of direct common connections two countries share. The weakest, in absolute value, is found for component 4 reflecting the level of competition on services on the weakest leg of a maritime route linking two countries.

Table 9
The LSBCI and its components (raw): pairwise correlations in 2014

Component	LSBCI
1	-0.7913
2	0.9398
3	0.9126
4	0.6361
5	0.7992

Source: Authors Calculations

Table 10 reports the relative contribution to the LSBCI value, expressed as a share, of each component. It corresponds to the ratio between the normalized component's value and the index value.

The predominance of the first component that is the number of transhipments necessary to connect two countries is a consequence of the distribution of the underlying variable. As the latter can only take three values a change of one unit in the raw variable translates into a change in the normalized value of 0.33. Moreover, as they are only few country pairs whose normalized value is 0 (3 transhipments), the de facto minimum value is 0.33.

Table 10
Components (normalized)' shares in LSBCI

Year	*1*	*2*	*3*	*4*	*5*
2006	0.635	0.059	0.184	0.039	0.082
2008	0.628	0.061	0.184	0.039	0.087
2009	0.620	0.056	0.185	0.037	0.103
2010	0.617	0.059	0.189	0.035	0.100
2011	0.615	0.056	0.192	0.036	0.101
2012	0.604	0.055	0.188	0.049	0.104
2013	0.604	0.053	0.184	0.051	0.108
2014	0.602	0.052	0.185	0.051	0.110

Source: Authors Calculations.

Table 11 shed some light on the contribution of each component, and more precisely their average absolute change, to the average absolute change in LSBCI observed during the period 2006-2014. We consider positive and negative variations of the LSBCI separately in order to assess more precisely the contribution of each component.

Table 11
Decomposition of changes in LSBCI: positive versus negative variation 2006-2014

	Number of Transhipments	***Common Direct***	***Geo. Direct***	***Carriers Constraint***	***Ship Size Constraint***	***LSBCI***
Negative	-0.101	-0.029	-0.0295	0.0068	-0.0045	-0.157
Positive	0.093	0.0176	0.042	0.0193	0.068	0.2403

Source: Authors Calculations.

As expected, the number of transhipments component plays a crucial role particularly in cases where the LSBCI variation is negative. The other two components reflecting the centrality of the country pair in the liner shipping network (Common Direct and Geo. Direct) play also a major role in cases where the LSBCI variation is negative. However, the contribution of both the carriers and the ship size components is close to zero. In cases where the LSBCI increases, all components do participate in shaping that variation. The strongest influence is from the Number of Transhipments component and the Ship size component. In brief, keeping the centrality of the country pair in the liner network is clearly the most important factor of preservation of the LSBCI level. The relaxation of the carriers and ship size constraints can only have a second order effect.

Table 12 report the average of relative changes in the components and their respective standard deviation. Statistics are computed for the whole sample and for positive and negative changes in LSBCI separately. Overall the average number of transhipments necessary to connect any country pair has remained almost constant. However, it has increased by 27 per cent in cases of a decrease in the LSBCI and has decreased by 13 per cent in cases of an increase. As to the number of common direct connections, it has increased by 7 per cent overall, 50 per cent in cases of a positive variation in the LSBCI and has decreased by 50 per cent in cases of a negative variation. A similar contrast is observed for the geometric mean of direct connections. On average, the number of carriers and the maximum ship size operating on any maritime itinerary have increased. Interestingly, this is true for both positive and negative variations of the LSBCI. Moreover changes are sizeable. On average the number of carriers has increased by almost 80 per cent and the maximum ship size has almost doubled. It must be noticed however, that variability is not negligible as reflected in standard deviation values relative to average ones.

Table 12
Relative changes in components' raw values

	LSBCI variation	Mean	Standard Deviation
Number of Transhipments	negative	0.269	0.457
	positive	-0.130	0.294
	all	0.015	0.409
Common Direct	negative	-0.498	0.432
	positive	0.494	1.158
	all	0.072	1.044
Geo. Direct	negative	-0.136	0.223
	positive	0.275	0.431
	all	0.120	0.417
Carriers Constraint	negative	0.754	1.907
	positive	0.807	1.667
	all	0.787	1.761
Ship Size Constraint	negative	0.301	1.884
	positive	1.371	3.150
	all	0.968	2.791

Source: Authors Calculations

Results presented in Table 11 are consistent with results presented in Table 12. The LSBCI is highly sensitive to changes in centrality indicators such as its first three components. Freight costs indicators such as carriers and maximum size components play an important role in driving LSBCI variations especially when positive but their impact remains of second order.

3.5 TRANSHIPMENTS AND THE LSBCI

As discussed previously, the choice of the LSBCI components has been "biased" more in favor of the extensivity (captured by components 1 to 3) of connectivity than its intensity (captured by components 4 and 5). Previously presented figures reveal a crucial role played by the number of transhipments component, that is component 1. Table 13 shows how this component has varied between 2006 and 2014. For almost 78 per cent of country pairs, the number of transhipment to connect them has remained constant. For about 13 per cent of them that number has increased (deterioration) and for about 10 per cent it has decreased (improvement).

Table 13
Variation in the number of transhpiments 2006-20014

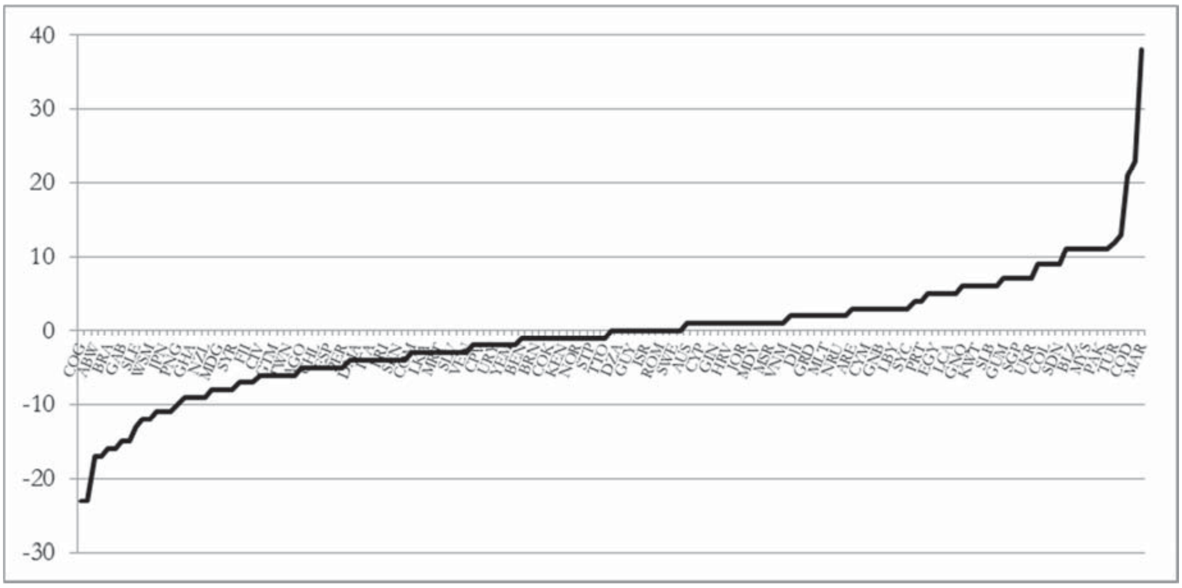
Variation	Country-pairs	Share in Total (%)
-2	5	0.04
-1	1,142	9.69
0	9,134	77.53
1	1,491	12.66
2	9	0.08

Source: Authors Calculations.

The list of countries which have been able to improve their connectivity in terms of transhipping in at least 30 destinations (out of 154) includes Bahrain, Belize, the democratic Republic of Congo, Jordan, Kuwait, Morocco, Qatar, The Russian Federation, and Slovenia. At the other extreme, the list of countries whose connectivity in terms of transhipping has deteriorated in at least 30 destinations includes Aruba, Bulgaria, Congo, Fiji, Georgia, Haiti, Indonesia, Iran, Iraq, Latvia, Saint Kitts and Nevis, Madagascar, Montenegro, Mauritania, Papua New Guinea, Sierra Leone, Tonga and Vanuatu. In this latter group many countries are characterized by a very small number of direct connections. As a consequence their dependency on the centrality index of those destinations they are directly connected to is extremely high.

Figure 10 plots the progression in terms of net creation of direct connections between 2006 and 2014 at the country level. Countries are ordered in terms of their performance in terms of net creation. The top five performers are Morocco, the Russian Federation, the Democratic Republic of Congo, Panama and Turkey. Net creation amounted to 12 for Turkey and to 38 for Morocco. The bottom five performers are the Congo, Aruba, Indonesia, Great Britain and Brazil. Net creation amounted to -23 for both the Congo and Indonesia and, to -16 for Brazil. The presence of Brazil and especially Great Britain amongst the bottom five performers might be surprising. However, it is probably the reflection of a rationalization of the liner shipping network implied by the 2008 crisis and its severe impact on global demand.

Figure 10: Direct Connections: Net creation 2008-2014



Source: Authors Calculations.

3.6 THE LSBCI AND MARITIME DISTANCE

As discussed above, the LSBCI components reflect specifically the liner shipping connectivity between pairs of countries. Maritime distance has not been included in the set of components as it represents a more generic indicator of connectivity or more precisely of connectability. Moreover, except for direct connections, maritime distance is affected directly by the maritime route characteristic and may vary across time if the latter vary. We computed an effective measure of maritime distance corresponding to the shortest route between any pair of countries. Once again, when connections are direct, the effective maritime distance we compute coincides with the sea distance. The correlation between the two measures is always extremely high, close to 0.95 each year. Table 14 shows pairwise correlation coefficients between our measure of effective maritime distance, the LSBCI and its components. Results are reported for the years 2006, 2010 and 2014. Variations across time of these different coefficients are not excessive. The strongest correlations are found with the number of transhipments component and the number of common direct connections component. Both are relatively high but not still reasonable to consider the impact of these components not to be completely dictated by that of maritime distance.

Table 14
Maritime distance and the LSBCI: pairwise correlations

	Number of Transhipments	Common Direct	Geo. Direct	Carriers Constraint	Ship Size Constraint	LSBCI
2006	0.3859	-0.3053	-0.1376	-0.1373	-0.1213	-0.2849
2010	0.3993	-0.2911	-0.137	-0.144	-0.1326	-0.2983
2014	0.401	-0.2984	-0.1404	-0.1299	-0.1138	-0.2951

Source: Authors Calculations.

The conclusion holds for the LSBCI. In other words, the LSBCI does represent an authentic liner shipping connectivity index which is not exclusively driven by maritime distance.

4. DISCUSSION

This paper presents a revised version of the Liner Shipping Bilateral Connectivity Index computed for a set of 155 coastal countries observed 9 years during the period from 2006 to 2014. Some unique statistics and trends are discussed in detail in order to shed light on the evolution of bilateral connectivity since 2006. This original set of information is an important complement to UNCTAD's country-level Liner Shipping Connectivity Index (LSCI), which however could only support unilateral analysis. The definition and construction of the LSBCI based on reliable data on fleet deployment is clearly of empirical interest. The index and its components are expected to reflect to a large extent freight costs. As such they can be added to the set of determinants of bilateral trade in containerizable goods. In a companion paper, Fugazza and Hoffman (2015) present the first assessment of the impact of the LSBCI on bilateral exports of containerizable goods using a comprehensive set of country pairs observed for 8 years over the 2006-2013 period. All results point to a significant impact of the index and its components on the intensive margin of trade in containerizable goods.

The definition and construction of the LSBCI however, goes beyond the attempt to identify how bilateral connectivity affects bilateral exchanges. Its inter-temporal dimension and the possibility to monitor changes in the index and its components over time could be extremely helpful in framing practical policy orientations. The LSBCI framework offers a unique globalized view of the liner shipping network and hence offers the possibility to appreciate the position in that network of a specific country within several dimensions.

Table 15 reports the decomposition of the LSBCI value for the top 10 destinations of some country for the year 2006 (upper panel) and the year 2014 (lower panel).

The information displayed in Table 15 can be used in several ways. For instance, it could help in drawing some stylized facts about the top 10 connections in each year. We have that the composition changes to some extent not only at the country level itself but also in terms of geographical composition with an increased presence of Latin American countries to the detriment of Asian and European ones. If we look at the number of transhipments necessary to connect our country to its top ten destinations, for instance, we see that we have only direct connections. Within the Top 10 group some countries appear in both years. In that case, we would be able to identify precisely the causes of the progression or regression of a specific country. If we look at the case of Belgium (BEL), it was in second position in 2006 but slipped to the fourth rank in 2014. Nothing really negative can be identified expect for the loss of one common direct destination. The "downgrading" of the destination is due to a progression which has been slower than that of other countries such as Colombia and China. All this set of information would allow policy makers to elect a direction to dig deeper in order to come eventually to some possible policy orientation conclusions. Obviously Table 14 shows only an extract of our country's liner shipping relationships. The analysis could be extended to the full set of destinations that is 154, and we could easily reproduce the above approach.

A last consideration has to do with land-locked countries. Maritime connectivity is clearly an issue for land locked countries as they are fully relying on the maritime connectivity of their transit countries. A clear and precise appreciation of the issue requires a dedicated and possibly systematic analysis which goes beyond simply assigning the LSBCI of their transit countries to land locked countries.

Table 15
LSBCI and its components: a country's top 10 destinations

2006	Sea_Dist	Trans	DIRECT	DIR_Mea	Ship	carriers	I_Trans	I_DIRECT	I_DIR_M	I_carriers	I_Ship	LSBCI
USA	5902.32	0.00	28.00	52.21	2775.00	9.00	1.00	0.29	0.49	0.11	0.15	0.409
BEL	10460.10	0.00	27.00	53.58	2202.00	5.00	1.00	0.28	0.50	0.06	0.12	0.393
HKG	17540.29	0.00	24.00	49.06	3091.00	6.00	1.00	0.25	0.46	0.07	0.17	0.391
FRA	10102.66	0.00	27.00	53.31	2202.00	4.00	1.00	0.28	0.50	0.05	0.12	0.390
CHN	16382.79	0.00	25.00	47.86	3091.00	6.00	1.00	0.26	0.45	0.07	0.17	0.390
DEU	10943.47	0.00	26.00	52.49	2202.00	4.00	1.00	0.27	0.49	0.05	0.12	0.387
COL	1079.72	0.00	27.00	34.06	2556.00	15.00	1.00	0.28	0.32	0.18	0.14	0.384
PER	1303.81	0.00	27.00	30.46	3091.00	15.00	1.00	0.28	0.28	0.18	0.17	0.383
KOR	15499.39	0.00	25.00	44.08	3091.00	6.00	1.00	0.26	0.41	0.07	0.17	0.383
GBR	10328.60	0.00	26.00	55.44	1740.00	2.00	1.00	0.27	0.52	0.02	0.10	0.382

2014	Sea_Dist	Trans	DIRECT	DIR_Mea	Ship	carriers	I_Trans	I_DIRECT	I_DIR_M	I_carriers	I_Ship	LSBCI
USA	5902.32	0.00	28.00	56.92	4256.00	10.00	1.00	0.29	0.54	0.12	0.23	0.437
COL	1079.72	0.00	28.00	39.12	5652.00	15.00	1.00	0.29	0.37	0.18	0.31	0.430
CHN	16382.79	0.00	26.00	51.67	5652.00	4.00	1.00	0.27	0.49	0.05	0.31	0.423
BEL	10460.10	0.00	26.00	51.38	4256.00	8.00	1.00	0.27	0.48	0.10	0.23	0.417
NLD	10465.65	0.00	25.00	51.38	4256.00	8.00	1.00	0.26	0.48	0.10	0.23	0.415
FRA	10102.66	0.00	25.00	52.82	4256.00	6.00	1.00	0.26	0.50	0.07	0.23	0.413
PAN	1581.61	0.00	29.00	40.62	4256.00	12.00	1.00	0.31	0.38	0.15	0.23	0.412
HKG	17540.29	0.00	24.00	47.75	5652.00	4.00	1.00	0.25	0.45	0.05	0.31	0.411
PER	1303.81	0.00	24.00	28.46	5652.00	19.00	1.00	0.25	0.26	0.23	0.31	0.411
MEX	3718.82	0.00	25.00	35.92	5652.00	12.00	1.00	0.26	0.33	0.15	0.31	0.410

Source: Authors calculations.

Notes: The first column reports the top 10 destinations in 2006 and 2014 respectively. The second column shows the sea distance to these destinations. Columns 3 to 7 report raw values of each LSBCI component. Columns 8 to 12 report the normalized value of each LSBCI component. The last column reports the LSBCI for each of the top 10 destinations.

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Printed at United Nations, Geneva
1600069 **(E)** – February 2016 – 246

UNCTAD/ITCD/TAB/74

United Nations publication
ISSN 1607-8291