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BUILDING A DATASET FOR BILATERAL MARITIME CONNECTIVITY

by

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Note

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Abstract

This paper presents a unique database reporting the shortest liner shipping routes between any pair of countries for a reference sample of 178 countries over the 2006–2012 period. Computed maritime distances are retrieved using an original database containing all existing direct liner shipping connections between pairs of countries and the corresponding sea distance. The number of transhipments necessary to connect any country pair to allow for containerizable trade is also retrieved. The contribution of this database is threefold. First, it is expected to be a useful tool for a better appreciation of transport costs and access to regular container shipping services and their impact on trade. Secondly, as presented in this paper, it helps to describe and analyse the structure of the existing global network of liner shipping services for containerizable trade, i.e. most international trade in manufactured goods. Finally, our database is expected to facilitate the construction of a bilateral liner shipping connectivity index building on UNCTAD's original work.

Keywords: Maritime Transport, Sea Distance, Containerizable Trade, Trade Costs

JEL Classification: C61, F1, L91

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Any mistakes or errors remain the author's own.

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1. INTRODUCTION

Maritime transport is at the core of international trade in merchandises. Around 80 per cent of volume of goods exchanged in the world are transported via sea (UNCTAD, 2008). 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).

Containerizable transport services are key for trade in manufactured goods and global value chains. Without access to regular liner shipping services that make use of standardized sea containers, countries cannot competitively participate in globalized production. A recent empirical study confirmed the "[e]ffects of the Container Revolution on World Trade" (Bernhofen et al., 2013). As pointed out by *The Economist* (2013), "[c]ontainers have been more important for globalization than freer trade".

Recent literature has emphasized the importance of transport costs and infrastructure in explaining trade and access to international markets. Different empirical strategies have been used to produce estimates of the overall level of transport costs.

Some studies used the ratio between imports CIF and imports FOB to proxy transportation costs, the so-called CIF–FOB ratio (e.g. Baier and Bergstrand, 2001; Hummels and Lugovskyy, 2006). Estimates vary essentially with the level of product aggregation. A reasonable average estimate of such ratio computed based on total imports CIF and FOB at the country level ranges between 6 per cent and 12 per cent. At more disaggregated product levels their dispersion increases. Approximations of CIF–FOB ratios are higher for developing than for developed regions. UNCTAD estimates that in the last decade, freight costs amounted 6.4 per cent for developed countries' imports as compared to 10.6 per cent for Africa (UNCTAD, 2011).

Based on the estimation of a gravity model using United States data, Anderson and Van Wincoop (2004) found that transport costs correspond to an average ad valorem tax equivalent of 21 per cent. These 21 per cent include both directly measured freight costs and a 9 per cent tax equivalent of the time value of goods in transit. Using a similar empirical approach, Clark et al. (2004) reckon that for most Latin American countries, transport costs are a greater barrier to United States markets than import tariffs. They also find that ports efficiency is an important determinant of shipping costs.

The recent work of Arvis et al. (2013) is an extension of the contribution of Jacks et al. (2011). As such, it represents the most comprehensive country-level analysis of trade costs and their components to date. Their database includes 178 countries and covers the 1995–2010 period. Estimates of trade costs are inferred from the observed pattern of production and trade across countries. Results indicate that maritime transport connectivity and logistics performance are very important determinants of bilateral trade costs: UNCTAD's Liner Shipping Connectivity Index (LSCI) and the World Bank's Logistics Performance Index (LPI)[1] are together a more important source of variation in trade costs than geographical distance, and the effect is particularly strong for trade relations involving the South.

In order to facilitate further and more extensive analysis of container transport services, trade costs and flows, we construct a unique database reporting the shortest maritime liner shipping routes between any pair of countries for a reference sample of 178 countries over the 2006–2012 period. In non-technical terms, a "liner shipping" service can be compared to a regular bus service, with a bus "line", with fixed departure times and with many other passengers on the same bus. This is comparable

[1] The World Bank's Logistics Performance Index (LPI) and UNCTAD's Liner Shipping Connectivity Index (LSCI) both aim in different ways to provide information about countries' trade competitiveness in the area of transport and logistics. However, the scope of the activities and countries covered, as well as the measurement approach, are rather different. In spite of these differences, both indexes are statistically positively correlated, with a partial correlation coefficient of +0.71. Information concerning UNCTAD's LSCI is available in UNCTAD's *Review of Maritime Transport*. A detailed description and data of the World Bank, LPI is available via the website http://www.worldbank.org/lpi.

to the liner shipping service, where your container will be on the same ship as other containers belonging to many different owners. When we talk about liner shipping services (and the corresponding routes and distances), we look at a network of regular container shipping services. Thanks to containerization and the global liner shipping network, small and large importers and exporters of finished and intermediate containerizable goods from far away countries can trade with each other, even if their individual trade transaction would not economically justify chartering a ship to transport a few containers from A to B. Thanks to regular container shipping services and transhipment operations in so-called hub ports, basically all countries are today connected to each other. To illustrate the point, think of the Paris Metro, which is also a network of "lines", and you can calculate how many "transhipments" you may need to get from Gare Montparnasse to Rue de la Pompe, and you can calculate the "shortest route" to get from Gare Montparnasse to Rue de la Pompe, even if there is no direct metro service between the two (Hoffmann, 2012).

Shortest routes are obtained by solving for the shortest path problem in the frame of the Graph mathematical theory applying Dijkstra's algorithm. Computed maritime liner service distances are retrieved using an original database containing all existing direct liner service connections between pairs of countries and the corresponding sea distance between the two countries' respective main container ports. If a connection is considered "direct", it implies that there is no need for transhipment in a third country. Sea distance between pairs of countries represents the distance separating each coastal country's main port(s). In the cases of some large countries with several coast lines (e.g. the United States of America, Canada and others), the main port retained varies according to the trade partner considered.

Our results provide some interesting insights into the structure of the global liner shipping network. For instance, if we consider the data for 2012, about 13.3 per cent of the country pairs in our sample are connected directly, 9.6 per cent require one transhipment, 46.4 per cent, two transhipments and 21 per cent, three transhipments. This is to say that almost 70 per cent of country pairs are connected with no more than two transhipments and more than 90 per cent with no more than three transhipments.[2]

The rest of the paper is organized as follows. The next section presents our basic data and the algorithm used to compute maritime distances for connections without a direct service. Section 3 reviews some descriptive statistics and presents some stylized facts. The last section discusses immediate applications of our dataset and possible directions for further research.

2. DATA AND ALGORITHM

The resulting dataset includes 178 countries, 33 of which are landlocked. While landlocked countries have by definition no direct access to liner shipping services (their country level LSCI is not computed), they do of course also trade with overseas trading partners, making use of their neighbouring countries' seaports. In order to be able to include landlocked countries in the analysis of trade and trade costs, they are also included in the database on maritime distances, assigning the distances from/to container ports in the transit country through which the largest share of overseas trade passes.

Six years are informed over the 2006–2012 period. The year 2007 is missing. Information on the number of transhipments necessary to connect any pair of countries is symmetric: if two transhipments are necessary to move containers from country C to country D, then the same number of transhipments is necessary to move containers in the opposite direction from D to C.

[2] These percentages are slightly different from earlier analysis (UNCTAD, 2013) because in this paper our database includes landlocked countries, which are connected to the global shipping network through their neighbouring transit countries.

The original dataset

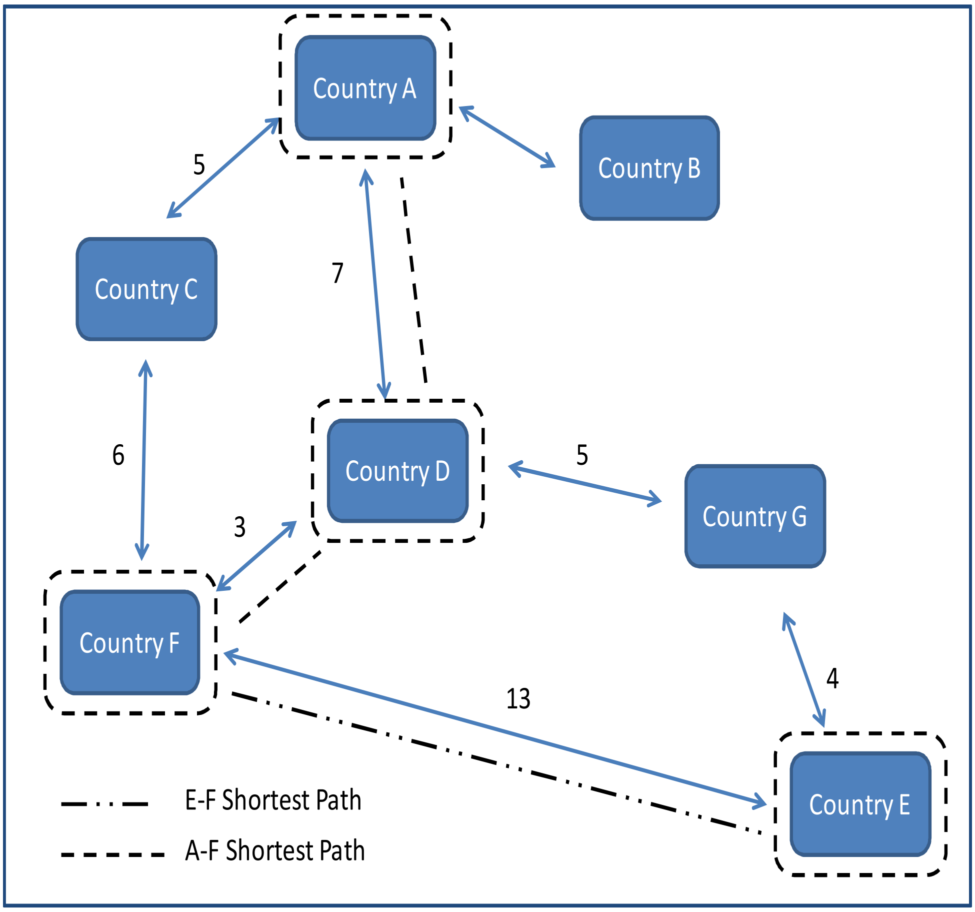
The original dataset includes two variables for each pair of country. The first variable is the maritime distance between the main container ports. The second variable is a dummy variable that assumes the value 1 if a direct service between the two countries exists, and 0 otherwise. Note that "direct" implies that there is no need for transhipment; however, the ship will usually call at other ports en route. The information on the existence or not of a direct connection is retrieved from the UNCTAD's Liner Shipping Connectivity Matrix (LSCM). The information contained in the latter database is obtained annually, in the month of May, through Lloyds List Intelligence.[3] The data covers the reported deployment of all containerships at a given point in time. This methodology allows for comparisons over time, as the sample is always complete. UNCTAD began the systematic annual gathering of data in 2004 at the country level, and in 2006 at the pair-of-country level.

The algorithm

The original dataset informs exclusively on the existence or not of a direct connection between two countries. This is already an important indication of a country's connectivity. However, this would restrict the number of assessable trade relationships to 13.3 per cent of all potential trade relationships. In order to complement the original information set we apply Dijkstra's (1959) algorithm to our original data. It is the most celebrated algorithm for the solution of the shortest path problem in graph theory. For a given source (node) in a graph such as graph 1, the algorithm finds the shortest path between that node and every other node. For example, if the nodes of the graph represent countries and edge path costs represent sea distances between pairs of countries connected directly, Dijkstra's algorithm can be used to find the shortest route between one country and any other country. In other words, Dijkstra's algorithm allows us to identify the shortest route in terms of sea distance to cover connections between any two countries. Note that the shortest route will by default be a direct connection if it exists. Consequently, the number of transhipments necessary to connect two countries is minimized. Graph 1 illustrates the solution for connecting country A to country F. The shortest path goes through country D and the total sea distance covered equals 10. The total sea distance would correspond to our measure of maritime distance. Graph 1 also illustrates the solution of the shortest path between country E and country F. Despite the fact that total sea distance between E and F going through countries G and D (i.e. 4+5+3) would be shorter that the direct distance between E and F (i.e. 13) the direct connection is retained by the algorithm. This hierarchy imposed to the algorithm reflects the fact that the cost of transhipment is likely to be much larger than the cost induced by the coverage of a longer distance but without transhipment. This constraint is in line with existing empirical findings. The analysis of Wilmsmeier and Hoffmann (2008) suggests that transhipment has the equivalent impact on freight rates as an increase in distance between two countries of 2,612 km.

[3] Detailed information and access conditions are available through the website http://www.lloydslist.com/ll/sector/containers/. Until 2011 the data was obtained annually in the month of July through Containerization International On-line, which has since been incorporated into Lloyds List Intelligence.

Graph 1: Shortest path in graph theory



3. DESCRIPTIVE STATISTICS AND STYLIZED FACTS

This section presents and briefly discusses some descriptive statistics and possible stylized facts using data on computed maritime distances and nature of connections. As mentioned before, 178 countries make our reference sample. Information is available for the year 2006, and for the years from 2008 to 2012.

3.1 CONNECTIVITY: NUMBER OF TRANSHIPMENTS

Table 1 characterizes the nature of the connection between pairs of countries across years. Figures correspond to the share of the number of transhipments necessary to connect two countries in the overall number of country–pairs connections present in the sample, that is 178,177 (= 31,506) each year.

Over the whole period, on average about 13 per cent of country pairs are connected directly, about 10 per cent need one transhipment, about 49 per cent, two transhipments and about 21 per cent, three transhipments. This is to say that about 72 per cent of country pairs are connected with no more than two transhipments and around 93 per cent ,with no more than three transhipments.

Table 1: Number of transhipments
(Share in total number of bilateral relationships)

	2006	*2008*	*2009*	*2010*	*2011*	*2012*
0	13.3	13.8	13.2	13.6	13.3	13.3
1	9.5	9.9	9.7	10.3	9.7	9.6
2	49.0	49.6	49.5	50.0	49.0	46.4
3	21.2	22.0	21.6	20.2	20.8	21.0
4	5.7	4.4	5.2	5.2	6.5	6.9
5	1.0	0.3	0.6	0.6	0.8	1.9
6	0.3	0.0	0.2	0.1	0.0	0.6
7	0.1	0.0	0.0	0.0	0.0	0.3
8	0.0	0.0	0.0	0.0	0.0	0.1
Total	100.0	100.0	100.0	100.0	100.0	100.0

Looking at the average number of connections at the country level over the whole period of time as reported in Table 2 (left quadrant) we observe that this characteristic is actually common to several large advanced economies. Indeed, the United Kingdom of Great Britain and Northern Ireland is the country with the smallest average number of transhipments, followed by France, Belgium, Germany and three other countries of the European Union. This ranking could be the result of a strong intra-European Union trade effect. Nevertheless even when trade relationships with other members of the Union are not included, those European countries stay among the top 10 country list. The other top 15 countries are the United States and seven East Asian countries. There is again a clear intraregional effect within the latter group of countries.

The right quadrant of Table 2 contains the corresponding bottom 15 countries. The geographical composition is more heterogeneous and all continents are represented. The bottom list is not only made of landlocked countries and small island States.

Table 2: Top and bottom 15 countries: Average number of transhipments

Top 15	*Mean*	*Bottom 15*	*Mean*
GBR	0.73	RWA	3.15
FRA	0.79	MWI	3.15
BEL	0.84	ZMB	3.15
DEU	0.87	BOL	3.16
NLD	0.88	ISL	3.16
ITA	0.92	TKM	3.20
ESP	0.93	NER	3.20
CHN, HKG SAR	0.95	BLZ	3.23
CHN	0.97	SVK	3.31
USA	0.98	HUN	3.31
KOR	1.07	BLR	3.32
MYS	1.11	NRU	3.42
SGP	1.13	MLI	3.53
CHN, TWN Province of	1.19	MDA	3.62
JPN	1.29	ARM	4.10

Note: Names of countries, territories or areas of geographical interest and their subdivisions are listed here according to the country alpha-3-codes established by the International Organization for Standardization (ISO).

Figure 1: Number of transhipments by country/country groups

Note: Names of countries, territories or areas of geographical interest and their subdivisions are listed here according to ISO country alpha-3-codes.

Table 3 and Table 4 report the top and bottom 10 countries respectively in terms of number of direct connections. As far as the top countries are concerned figures do confirm what was shown in the previous table. Great Britain enjoys the largest number of direct connections in all four years reported despite the fact that between 2006 and 2012 it has lost 10 per cent of them. No general trend pops up. Some countries have seen the number of direct connections increasing others have seen it decreasing (e.g. Great Britain). The group composition has only marginally changed over the period with the exit of Italy on one hand and the entry of Malaysia on the other end. This is somehow in contrast with the bottom 10 country group. Only five countries stayed in the latter group over the whole period.

Table 3: Top 10 connected countries: Number of direct connections (selected years)

2006		*2008*		*2010*		*2012*	
GBR	105	GBR	108	GBR	99	GBR	93
BEL	98	FRA	99	FRA	96	FRA	92
FRA	96	BEL	97	BEL	92	USA	91
DEU	93	DEU	96	CHN, HKG SAR	89	NLD	88
USA	90	ESP	91	CHN	88	BEL	88
ESP	89	ITA	90	USA	86	CHN	86
NLD	89	USA	89	NLD	86	CHN, HKG SAR	85
ITA	84	NLD	87	DEU	85	ESP	83
CHN, HKG SAR	82	CHN	81	ITA	79	MYS	82
CHN	77	CHN, HKG SAR	81	ESP	79	DEU	81

Note: Names of countries, territories or areas of geographical interest and their subdivisions are listed here according to ISO country alpha-3-codes.

Table 4: Bottom 10 connected countries: Number of direct connections (selected years)

2006		*2008*		*2010*		*2012*	
NRU	1	NRU	1	ALB	1	ALB	1
ALB	1	IRQ	2	MMR	2	QAT	2
MMR	2	QAT	2	IRQ	3	MMR	2
BHR	3	PLW	3	QAT	3	IRQ	3
IRQ	4	SOM	3	NRU	3	BRN	3
QAT	4	BHR	3	MDV	4	NRU	3
PLW	4	ALB	3	BGD	5	BGD	4
BLZ	4	KWT	4	PLW	5	MDV	4
BRN	4	SYC	4	SOM	6	PLW	5
KWT	4	BGD	4	BRN	6	SOM	6

Note: Names of countries, territories or areas of geographical interest and their subdivisions are listed here according to ISO country alpha-3-codes.

A noticeable fact is the significant decrease after 2008 in the number of direct connections enjoyed by the group of the top 10. This could be clearly seen as a consequence of the collapse of world demand in the aftermath of the financial crisis started at the end of the year 2007. Counting the number of connections with a maximum of two transhipments generates slightly different results at both the top and the bottom of the country ranking. As shown in table 5, economies such as Singapore, Brazil, Egypt, Taiwan Province of China and Portugal, appear at least once among the list of the top 10. The composition of the worst performer country group varies quite significantly over the period, as shown in Table 6. In addition, many of these countries were not in the bottom group when considering the number of direct connections. The maximum number of connexions is observed for the United Kingdom in 2006 and equals 177. The lowest number of connections is observed for Nauru in 2010 and equals 29.

In general, allowing for two transhipments considerably increases the number of reachable destinations especially for the most remote economies such as Albania and Nauru. In the former case, this is explained by the proximity of an extremely well-connected country such as Italy, which acts as a transit export platform. Nauru, despite an exponential increase of potential connections, remains the most remote economy.

Table 5: Top 10 connected countries: Number of connections with a maximum of two transhipments (selected years)

2006		*2008*		*2010*		*2012*	
GBR	177	ESP	176	ESP	176	GBR	174
ESP	176	GBR	176	GBR	176	NLD	174
NLD	176	NLD	176	NLD	176	CHN, TWN Province of	173
ITA	174	BEL	175	BEL	175	MYS	171
BEL	173	FRA	174	PRT	174	KOR	171
FRA	173	ITA	173	FRA	174	FRA	171
CHN, TWN Province of	172	DEU	171	BRA	174	ESP	171
DEU	171	CHN, TWN Province of	170	KOR	173	CHN, HKG SAR	171
CHN, HKG SAR	169	PRT	170	CHN, HKG SAR	173	BEL	169
SGP	168	CHN, HKG SAR	170	EGY	173	DEU	168

Note: Names of countries, territories or areas of geographical interest and their subdivisions are listed here according to ISO country alpha-3-codes.

Table 6: Bottom 10 connected countries: Number of connections with a maximum of two transhipments (selected years)

2006		*2008*		*2010*		*2012*	
BLZ	34	NRU	41	NRU	29	NRU	30
NRU	36	BLZ	41	ARM	34	LTU	32
COD	38	ISL	41	IRQ	39	ISL	33
LVA	49	IRQ	44	GEO	42	EST	33
ISL	49	LVA	45	LTU	45	LVA	36
SUR	50	SUR	49	LVA	46	SLV	36
SOM	51	GUY	49	EST	47	ARM	36
ARM	54	SYC	52	ISL	47	NIC	38
MDV	57	SOM	54	PLW	48	ABW	39
GUY	59	HTI	56	BLZ	51	PLW	42

Note: Names of countries, territories or areas of geographical interest and their subdivisions are listed here according to ISO country alpha-3-codes.

3.2 SEA AND MARITIME DISTANCES

Maritime distance is an estimated sea distance. It is obtained by summing sea distances on all sea transport sections between two countries. When the connection is direct, maritime and sea distances perfectly coincide.

Table 7 and Table 8 contain some basic statistics qualifying estimated maritime distances for several countries or geographical groups of countries. Not surprisingly, countries in the Pacific region are characterized by the largest mean and median values of maritime distance. Together with the fact that countries in the region, including Australia and New Zealand, do not rank very well in terms of average number of transhipments per connection, it makes the Pacific region the most remote one. On the other extreme of the distribution are the United States, Canada and European countries. This corroborates previous results on the average number of transhipments per connection. As a consequence, the latter countries appear to be at the core of maritime connections. The Africa group statistics are comparable to those of the European Union, although African countries do not present any comparable performance in terms of number of transhipments per connection.

Changes over the 2006–2012 period have not been dramatic in most cases. The largest ones are observed for countries in the Pacific region and for Asian countries.

Table 7: Maritime distance (estimated): 2006

	Mean	Median	SD	CV	Max	Min
AUS	16 464	16 709	6 089	0.37	26 973	1 985
Africa	10 822	10 060	5 678	0.52	30 843	141
America	12 526	12 203	6 220	0.50	31 636	117
Asia	12 302	12 114	5 989	0.49	29 228	143
Canada	9 778	9 834	4 141	0.42	25 148	1 141
CHN	14 575	15 668	5 361	0.37	22 243	896
EUR	10 455	9 643	6 107	0.58	32 332	85
Europe	10 004	9 877	5 685	0.57	28 313	256
IND	10 899	11 119	5 712	0.52	24 746	941
JPN	15 017	15 972	5 801	0.39	24 007	1 241
NZL	16 899	17 074	6 010	0.36	28 423	2 280
Pacific	17 551	18 614	6 817	0.39	33 054	152
USA	9 685	9 688	4 692	0.48	26 197	165
Total	11 926	11 303	6 276	0.53	33 054	85

Note: Names of countries, territories or areas of geographical interest and their subdivisions are listed here according to ISO country alpha-3-codes.

Table 8: Maritime distance (estimated): 2012

	Mean	Median	SD	CV	Max	Min
AUS	16 232	16 281	5 950	0.37	27 254	1 985
Africa	10 974	10 358	5 673	0.52	31 178	141
America	12 588	12 523	6 144	0.49	30 262	117
Asia	11 796	11 497	5 863	0.50	30 017	143
Canada	9 883	10 127	4 117	0.42	21 152	1 141
CHN	14 441	15 709	5 365	0.37	22 031	896
EUR	10 315	9 505	6 134	0.59	32 493	85
Europe	9 883	9 584	5 663	0.57	32 232	256
IND	10 965	11 025	5 873	0.54	24 461	941
JPN	15 288	15 907	6 158	0.40	25 374	1 241
NZL	17 531	17 438	6 611	0.38	29 515	2 280
Pacific	16 275	16 900	6 267	0.39	29 921	152
USA	9 451	9 173	4 487	0.47	21 630	165
Total	11 761	11 219	6 132	0.52	32 493	85

Note: Names of countries, territories or areas of geographical interest and their subdivisions are listed here according to ISO country alpha-3-codes.

Average maritime distance for the Pacific region has fallen by more than 7 per cent and median maritime distance by about 9 per cent. Average and median maritime distance for the Asian countries group fell by about 5 per cent.

Overall, this trend can be considered positive. Although the number of direct connections has decreased for many countries, a geographically wider distribution of major transhipment ports has improved the options to connect trading partners with transhipments implying a lower distance to be travelled by the traded container – albeit also requiring a larger number of transhipments.

Despite its exceptional impact on overall aggregate demand and trade, the financial crisis of 2008 does not seem to have deeply affected maritime distances. This may come as a surprise considering the figures on the average number of transhipments reviewed previously. A clear exception is New Zealand, whose mean and median maritime distance increased by more than 8 per cent between 2008 and 2010 and have only marginally decreased since then.

Table 9: Variations in estimated maritime distances and number of transhipments

	Variation	*Maritime distance (per cent)*	*Number of transhipments (%)*
2006–2012	>0	15	12.2
	<0	16	10.2
2006–2008	>0	13.5	8
	<0	14.4	12.3
2008–2010	>0	14	11.3
	<0	17	9.5
2010–2012	>0	13	13
	<0	12.6	7

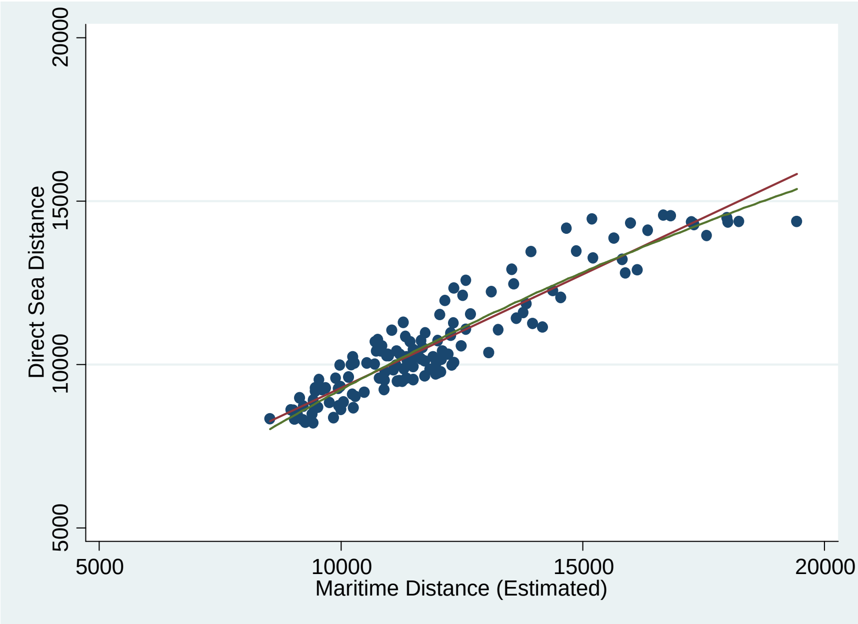
A study of the variations in maritime distances and transhipments as reported in Table 9, however, reveals features consistent to a large extent with the series' average behaviour. Over the whole period under investigation, 30 per cent of connections have varied in terms of maritime distance. Among these 30 per cent, half of them lengthened and half of them shortened. Surprisingly enough, the biennium following the financial crisis has been marked by a large share of shortened connections. With regard to the number of transhipments, about 22 per cent of connections have varied over the 2006–2012 period. The number of transhipments necessary to connect two countries has increased for 12 per cent of connections and has decreased for about 10 per cent of them. The post-financial crisis period has been characterized by an increasing share of connections necessitating a larger number of transhipments.

The direct sea distance and the shortest connection distance with transhipment are by nature strongly correlated. The maritime distance with transhipments, however, tends to increase with respect to sea distance as the latter increases. The farther away two countries are from each other, the more likely it is that they need more transhipments to trade with each other, and each transhipment implies some deviation from the shortest (direct) route. Figure 2 reproduces this relationship for a selection of years (left quadrant) and regions (right quadrant), which include the whole set of composing countries. The relationship appears to be relatively stable during the period under observation. The pre-crisis period is characterized to some extent by larger maximum maritime distances than the post-crisis period.

There are some salient facts about regional relationships. Sample means are indicated by vertical and horizontal dashed lines and the red curve connect fitted values based on a quadratic approximation. Pacific countries were found to be characterized by relatively large maritime distances. As shown in figure 2, this is a consequence of essentially larger sea distances from most trade partners. As far as American countries are concerned, the quadratic fit is almost a linear fit. This is to a large extent the reflection of a large number of direct connections to the United States, the geographical configuration of the continent and the existence of the Panama Canal.

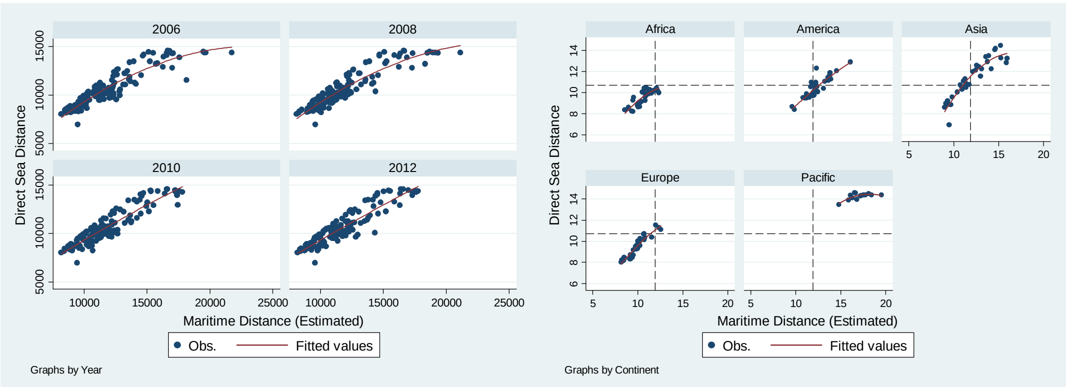
The whole set of relationships between direct sea distance and maritime distances with transhipments presented above remain similar whether or not we include those country pairs with a direct maritime connection. In the latter case, as mentioned previously, the two distances by definition coincide.

Figure 2: Direct sea distance and maritime distance (estimated) with transhipments



Note: The red line represents the linear fit of the relationship, the green line, its quadratic fit.

Figure 3: Direct sea distance and maritime distance (estimated)

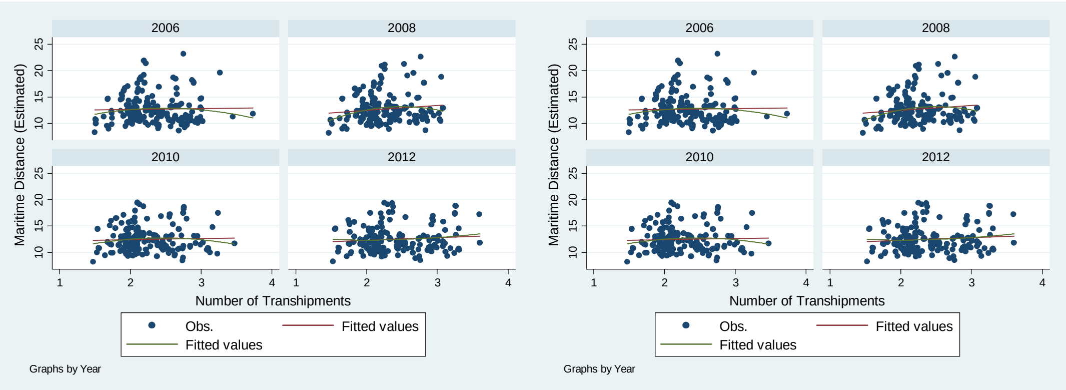


Note: The red line represents the quadratic fit of the relationship.

The question of whether maritime distances with transhipment and the associated number of transhipments are correlated does not have an obvious answer. The linear and quadratic fit lines reported in Figure 4 both suggest that the two measures are only weakly correlated. The right quadrant reports similar fits when all direct connections are excluded. Even with that subsample, the two distance measures remain only weakly correlated.

This result suggests that distance as such may not fully reflect the incidence of transport costs, and it may have to be considered together with the number of transhipments in assessing the impact of transport costs on bilateral exchanges.

Figure 4: Maritime distance (estimated) and number of transhipments (country averages)



Note: The red line represents the linear fit of the relationship, the green line, its quadratic fit.

3.3 TRADE, MARITIME DISTANCE AND TRANSHIPMENTS

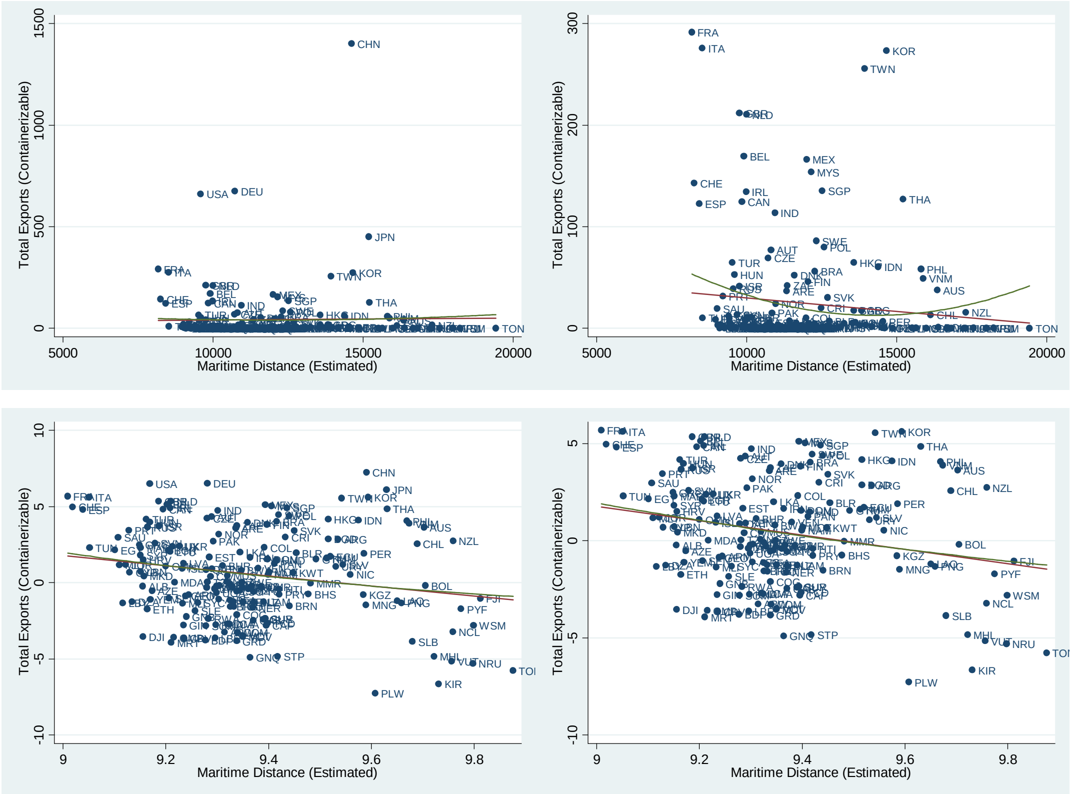
In the absence of extensive estimates of transport costs, distance has been used to proxy the latter. However, previous results revealed that additional information on maritime transport costs may be contained in the counting of transhipments necessary to move containers between any pair of countries.

The intensive margin of trade

Figure 5 shows a scatter between total containerizable exports (period average) and the estimated average maritime distance. The left quadrant refers to the whole sample while the right quadrant refers to a sample without China, the United States, Japan and Germany. In the former case the unconditional relationship between exports and maritime distance appears to be positive although close to zero. When excluding the largest exporting countries, the unconditional relationship turns to be negative, as expected.

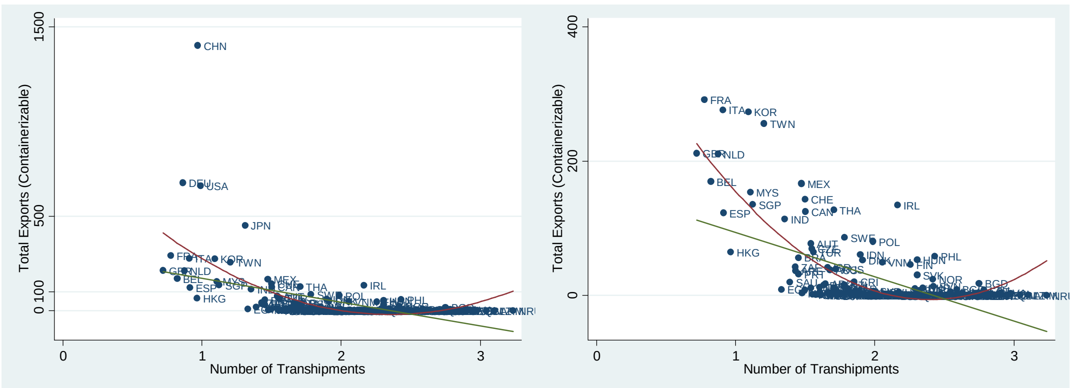
Figure 6 illustrates the relationship between total containerizable exports and the number of transhipments. Whether we include (left quadrant) or not (right quadrant) the largest exporters, the unconditional relationship is clearly negative. In other words, bilateral trade tends to decrease with the number of transhipments. Or, put differently, the direct connections tend to increase if demand (trade in containerizable goods) so requires.

Figure 5: Containerizable exports and maritime distance (estimated) for liner shipping connections



Note: Values in upper quadrants are in levels, and values in lower quadrants are in natural logs. The red line represents the linear fit of the relationship, the green line, its quadratic fit.

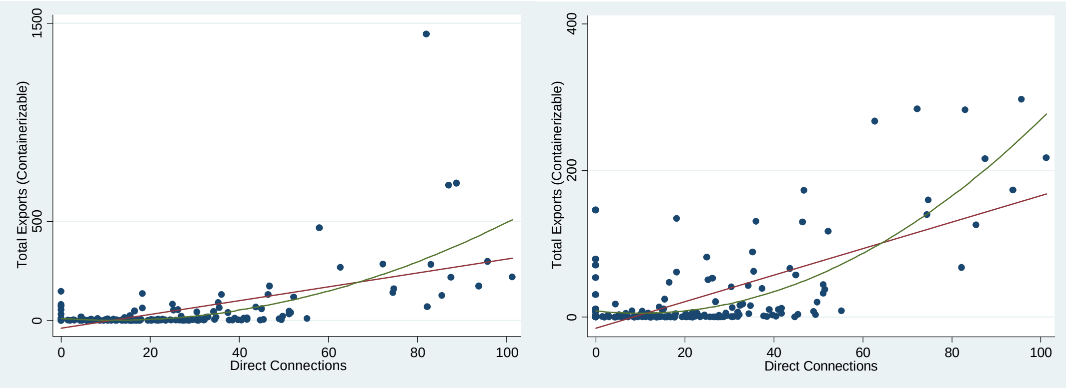
Figure 6: Containerizable exports and number of transhipments



Note: The red line represents the linear fit of the relationship, the green line, its quadratic fit.

On the contrary, direct connections are likely to be positively associated with exports. Figure 7 reports the relationship between direct connections and containerizable exports. Unsurprisingly, the association is clearly positive. Once again, the relationship does not seem to be driven by outliers. It remains clearly positive even after outliers such as the largest exporters are excluded from the sample (right quadrant).

Figure 7: Containerizable exports and direct connections

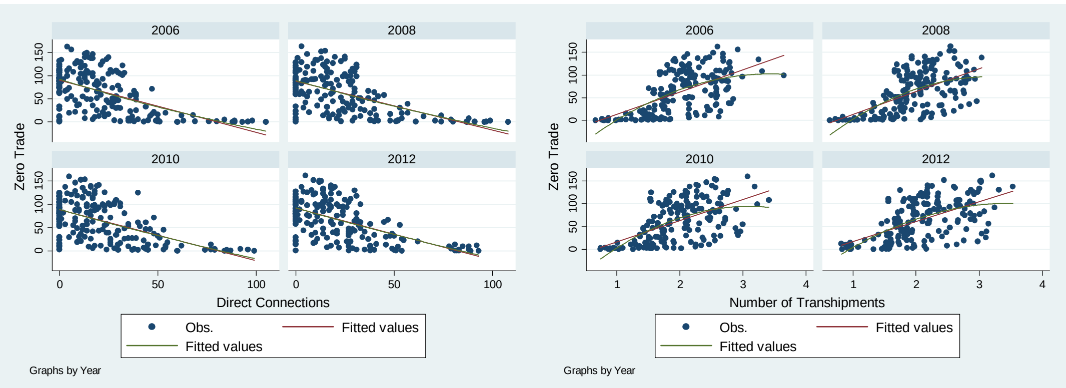


Note: The red line represents the linear fit of the relationship, the green line, its quadratic fit.

The extensive margin of trade

Previous graphs were focused on active trade relationships. However, about one third of containerizable trade flows among countries in our sample are zero. Transports costs and their connectivity component may be good predictors of trade patterns at its extensive margin. This is visible in Figure 8. The number of direct connections affects the incidence of zero trade (left quadrant). Countries characterized by a larger number of direct connections show a smaller number of zero trade flows. The right quadrant of Figure 8 reveals that as the average number of transhipments necessary to connect to any country increases, the incidence of zero trade flows also increases. Without talking about causality, the creation of direct connections could help remote economies promote their exports.

Figure 8: Zero trade and maritime connectivity



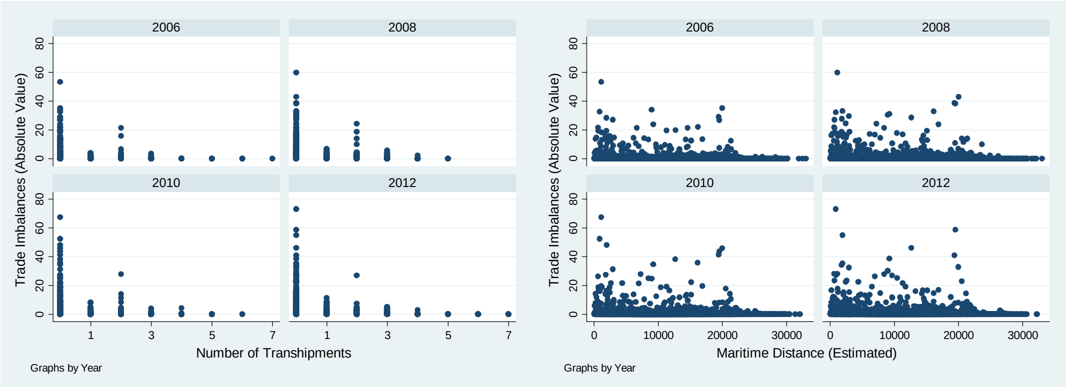
Note: The red line represents the linear fit of the relationship, the green line, its quadratic fit.

Trade imbalances

About 20 per cent of trade relationships are unilateral. This means that for about 20 per cent of the country pairs represented in the data, a zero containerizable trade flow in one direction is associated with a positive trade flow in the opposite direction. This is an extreme illustration of asymmetric trade flows. However, all bilateral trade flows are asymmetric to some extent.

Figure 9 reports for a selection of years the relationship between a measure of country pair trade unbalance, the number of transhipments to connect the country pair and the corresponding maritime distance, respectively. Trade imbalances are measures by the absolute value of the difference (absolute) between the two trade flows. Nothing really significant comes out of a basic graphical analysis. If at all related, the relationship could be only slightly negative. Trade imbalances would tend to diminish as the number of transhipments and the maritime distance increase.

Figure 9: Trade imbalances and connectivity



4. APPLICATIONS AND FUTURE RESEARCH

Despite the importance of trade costs as drivers of the geographical pattern of economic activity, global value chains, and of exchanges of merchandise goods between countries, most contributions to their understanding remain piecemeal.

Traditionally sea distance is assumed to be among the main determinants of freight rates and thus also of the trade competitiveness of countries. Findings by Wilmsmeier and Hoffmann (2008) based on a sample of 189 freight rates of one company for the Caribbean confirm to some extent the general positive correlation between distance and freight rates. However, sea distance explains only one fifth of the variance of the freight rate. Other possible determinants of trade competitiveness are transport connectivity, defined as the access to regular and frequent transport services and the level of competition in the service supply. The basic set of variables to account for transport costs are sea (maritime) distance, various aspects of liner shipping connectivity, trade balance of containerizable goods, various aspects of port infrastructure endowment and the countries' general level of development. As mentioned previously, Wilmsmeier and Hoffmann (2008) also show that trade routes with only indirect services (i.e. including transhipments) induce higher transport costs. Unconditional correlations between our two measures and trade of containerizable goods presented in the previous section appear to be supportive of such conclusions.

In this context, the definition of the number of transhipments necessary to connect any country pair and the computation of the corresponding effective maritime distance for a sample of 178 countries during a six-year period is a clear contribution to the empirics of trade. Our two variables could be of immediate use in the analysis of transport costs and their implications for bilateral trade. However, a clear causal relationship may be difficult to identify, as there are most probably serious endogeneity issues related to either reverse causality or variables or both. Further research is necessary and will be forthcoming in a companion paper.

Connectivity has become an increasingly popular research topic. However, a clearly established bilateral connectivity index for shipping is still lacking. Our two variables can contribute to the establishment of such an index. The latter could be based on the combination of our two constructed variables and of some liner shipping connectivity aspects. This procedure is in line with a recent tentative index building on UNCTAD's country-level Liner Shipping Connectivity Index (LSCI) and would be called LSBCI (Liner Shipping Bilateral Connectivity Index). Generally speaking, four sets of components should be considered for the development of a bilateral index. First, the number of companies providing direct services between two countries should be represented. A simple version of this component would be a dummy variable which assumes the value 1 if a direct service exists at all, and 0 if not. A more sophisticated version would include the number of transhipments necessary to connect any pair of countries, as computed in this paper. Second, the number of common connections between any country A and any country B should also be included. A simple version of this component would be a dummy variable, which assumes the value 1 if exists an option to connect the two countries with one transhipment, and 0 if not. By the same token, the number of second-level connections could be generated, i.e. how many options there are to get from country A to country B with two transhipments. Third, combinations of both countries' LSCI, such as the product, or the geometric average of both countries' index should be considered. The Index already includes five components, notably the number of ships, their TEU capacity, the size of the largest ship, the number of companies and the number of services. Finally, data on vessel deployment with transhipment options included should be used. Even for pairs of countries without a direct connection, it is possible to generate what are the best connections between them under specific criteria, such as the number of companies in the market or the largest ships deployed on the different legs of a connection with one or more transhipments. This represents an immediate application of the algorithm developed previously with an additional cost reference. Instead of solely considering the sea distance, we would also consider the number of companies or the largest vessel size deployed in identifying the shortest path. The development of the country-level Liner Shipping Connectivity Index (LSCI) has shown to be useful for policymakers and researchers. It can help to illustrate trends in a country's connectivity to the global liner shipping network. The development a similar type of index for pairs of countries would certainly enlarge the scope of the country-level LSCI.

ANNEX: LIST OF COUNTRY ALPHA-3-CODES

Country code	*Country name*	*Country code*	*Country name*
ABW	Aruba	GHA	Ghana
AFG	Afghanistan	GIN	Guinea
AGO	Angola	GMB	Gambia
ALB	Albania	GNB	Guinea-Bissau
ARE	United Arab Emirates	GNQ	Equatorial Guinea
ARG	Argentina	GRC	Greece
ARM	Armenia	GRD	Grenada
ASM	American Samoa	GTM	Guatemala
ATG	Antigua and Barbuda	GUM	Guam
AUS	Australia	GUY	Guyana
AUT	Austria	HKG	China, Hong Kong Special Administrative Region
AZE	Azerbaijan	HND	Honduras
BDI	Burundi	HRV	Croatia
BEL	Belgium	HTI	Haiti
BEN	Benin	HUN	Hungary
BFA	Burkina Faso	IDN	Indonesia
BGD	Bangladesh	IND	India
BGR	Bulgaria	IRL	Ireland
BHR	Bahrain	IRN	Iran (Islamic Republic of)
BHS	Bahamas	IRQ	Iraq
BLR	Belarus	ISL	Iceland
BLZ	Belize	ISR	Israel
BMU	Bermuda	ITA	Italy
BOL	Bolivia (Plurinational State of)	JAM	Jamaica
BRA	Brazil	JOR	Jordan
BRB	Barbados	JPN	Japan
BRN	Brunei Darussalam	KAZ	Kazakhstan
BTN	Bhutan	KEN	Kenya
BWA	Botswana	KGZ	Kyrgyzstan
CAF	Central African Republic	KHM	Cambodia
CAN	Canada	KIR	Kiribati
CHE	Switzerland	KNA	Saint Kitts and Nevis
CHL	Chile	KOR	Republic of Korea
CHN	China	KWT	Kuwait
CIV	Côte d'Ivoire	LAO	Lao People's Democratic Republic
CMR	Cameroon	LBN	Lebanon
COD	Democratic Republic of the Congo	LBR	Liberia
COG	Congo	LBY	Libya
COK	Cook Islands	LCA	Saint Lucia
COL	Colombia	LKA	Sri Lanka
COM	Comoros	LSO	Lesotho
CPV	Cabo Verde	LTU	Lithuania
CRI	Costa Rica	LUX	Luxembourg
CUB	Cuba	LVA	Latvia
CYM	Cayman Islands	MAR	Morocco
CYP	Cyprus	MDA	Republic of Moldova
CZE	Czech Republic	MDG	Madagascar
DEU	Germany	MDV	Maldives
DJI	Djibouti	MEX	Mexico
DMA	Dominica	MHL	Marshall Islands
DNK	Denmark	MKD	The former Yugoslav Republic of Macedonia
DOM	Dominican Republic	MLI	Mali
DZA	Algeria	MLT	Malta
ECU	Ecuador	MMR	Myanmar
EGY	Egypt	MNG	Mongolia
ERI	Eritrea	MOZ	Mozambique
ESP	Spain	MRT	Mauritania
EST	Estonia	MSR	Montserrat
ETH	Ethiopia	MUS	Mauritius
FIN	Finland	MWI	Malawi
FJI	Fiji	MYS	Malaysia
FRA	France	NAM	Namibia
GAB	Gabon	NCL	New Caledonia
GBR	United Kingdom of Great Britain and Northern Ireland	NER	Niger
GEO	Georgia	NGA	Nigeria

…/…

Country code	*Country name*
NIC	Nicaragua
NLD	Netherlands
NOR	Norway
NPL	Nepal
NRU	Nauru
NZL	New Zealand
OMN	Oman
PAK	Pakistan
PAN	Panama
PER	Peru
PHL	Philippines
PLW	Palau
PNG	Papua New Guinea
POL	Poland
PRT	Portugal
PRY	Paraguay
PYF	French Polynesia
QAT	Qatar
ROU	Romania
RUS	Russian Federation
RWA	Rwanda
SAU	Saudi Arabia
SDN	Sudan
SEN	Senegal
SGP	Singapore
SLB	Solomon Islands
SLE	Sierra Leone
SLV	El Salvador
SOM	Somalia
STP	Sao Tome and Principe
SUR	Suriname
SVK	Slovakia
SVN	Slovenia
SWE	Sweden
SWZ	Swaziland
SYC	Seychelles
SYR	Syrian Arab Republic
TCD	Chad
TGO	Togo
THA	Thailand
TJK	Tajikistan
TKM	Turkmenistan
TON	Tonga
TTO	Trinidad and Tobago
TUN	Tunisia
TUR	Turkey
TZA	United Republic of Tanzania
UGA	Uganda
UKR	Ukraine
URY	Uruguay
USA	United States of America
UZB	Uzbekistan
VCT	Saint Vincent and the Grenadines
VEN	Venezuela (Bolivarian Republic of)
VNM	Viet Nam
VUT	Vanuatu
WSM	Samoa
YEM	Yemen
ZAF	South Africa
ZMB	Zambia
ZWE	Zimbabwe

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