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Assessing Systemic Trade Interconnectedness—
An Empirical Approach

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Statistics Department

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Abstract

The paper focuses on systemically important jurisdictions in the global trade network, complementing recent IMF work on systemically important financial sectors. Using the IMF's Direction of Trade Statistics (DOTS) database and network analysis, the paper develops a framework for ranking jurisdictions based on trade size and trade interconnectedness indicators using data for 2000 and 2010. The results show a near perfect overlap between the top 25 systemically important trade and financial jurisdictions, suggesting that these ought to be the focus of risk-based surveillance on cross-border spillovers and contagion. In addition, a number of extensions to the approach are developed that can provide a better understanding of trade dynamics at the bilateral, regional, and global levels.

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I. INTRODUCTION

The cross-border transmission of shocks takes place through two main channels: the financial channel and the trade channel. The global financial crisis has drawn renewed attention to the former with recent IMF Executive Board documents discussing financial sectors of "systemic importance" and their inter-linkages in the context of Fund surveillance, underscoring the relevance of financial interconnectedness.[2] Less emphasis has been placed on the trade channel, i.e., the real side of the equation. Nonetheless, understanding the impact that changes in domestic demand exert through the trade channel, especially in the case of systemically important trade sectors, is important in informing the analysis of cross-border spillovers and contagion.

Typically, considerations about the "systemic" importance of a trade sector have been based on its absolute (within jurisdiction) or relative (within the global trade system) size. Interconnectedness has, however, more recently emerged as a critical complementary consideration to gauge the systemic risk that may arise through direct or indirect inter-linkages among sectors in the global system. The idea is that the more and stronger linkages a given sector has to the global system, the higher the risk that distress in that sector may have repercussions on other jurisdictions or systemic stability.

Against this background, we develop an approach for assessing systemic trade interconnectedness by defining "systemic" trade sectors and identifying the jurisdictions hosting them.[3] The approach draws from recent IMF work on financial interconnectedness and leverages the IMF's *Direction of Trade Statistics* (DOTS) database.[4] The use of DOTS lends robustness to the analysis by providing data that are not only uniform, but also available for the entire Fund membership. Additionally, the regular updating of DOTS by the IMF's Statistics Department allows for dynamic analysis and recalibrations of the findings tracking global trade developments on a timely basis. This approach naturally complements financial interconnectedness analysis, providing a holistic view of the potential for spillovers and contagion at the bilateral, regional, and global levels.

The rest of the paper is organized in four parts. The next section introduces the analytical framework for our approach. Section III briefly describes the dataset. Section IV shows the results and elaborates on a few stylized facts so uncovered. Section V illustrates possible applications for, and extensions to, our approach. Section VI offers concluding remarks.

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[2] For example, see "*Understanding Financial Interconnectedness*" (October 2010), available at: http://www.imf.org/external/np/sec/pn/2010/pn10150.htm

[3] Our approach was introduced in the IMF's Executive Board document "*Changing Patters of Global Trade*" (June 2011), available at: http://www.imf.org/external/pp/longres.aspx?id=4578

[4] "*Integrating Stability Assessments Under the Financial Sector Assessment Program into Article IV Surveillance: Background Material*" (August 2010), available at: www.imf.org/external/np/pp/eng/2010/082710a.pdf

II. THE ANALYTICAL FRAMEWORK

Our approach is two-staged. In the first stage, jurisdictions are ranked based on trade size and interconnectedness indicators. In the second stage, the rankings of trade size and interconnectedness are combined into a composite index of systemic trade importance. Sensitivity analysis on the baseline composite index is performed to assess the robustness of the results.

A. First Stage

Size indicators

Three measures of the absolute size of a trade sector (in nominal U.S. dollars), namely: (i) total exports (X); (ii) total imports (M); and (iii) total turnover (X+M) are used to capture the importance of a jurisdiction's trade sector in the global trade system. Being based on DOTS, trade in this analysis includes goods/merchandise, but excludes services. One measure of the relative size of a trade sector, namely: total turnover relative to nominal GDP (in U.S. dollars), is used to gauge the relative importance of the trade sector within a given jurisdiction.

These four trade size indicators then are combined into a single ranking for size by ranking all jurisdictions in each of the four trade size indicators separately and taking the median rank of the four indicators for each jurisdiction as the single ranking for trade size.

Interconnectedness indicators

Similar to the approach used for financial interconnectedness, network analysis is used to infer from the pattern of cross-border linkages among trade sectors the extent to which a trade sector in a jurisdiction is "central" in the global trade system (network).

The global trade network is defined as a set of bilateral trade relationships (links), either exports or imports, of different jurisdictions (nodes). We impose a materiality threshold to ensure that the analysis focuses only on economically meaningful links, i.e., trade relationships representing less than 0.1 percent of a jurisdiction's GDP are excluded.

The network is expressed in matrix form where A_{ij} represents the value of total turnover between jurisdiction i and jurisdiction j. The matrix has dimension n equal to the number of jurisdictions. Diagonal elements are zero. Off-diagonal elements are zero for jurisdiction pairs that have no link either as exporter or importer. The indicators are based on whether a link exists, that is, they are based on the indicator $N_{ij}=1$ if $A_{ij}>0$, and 0 otherwise.

Four measures of "centrality" of a jurisdiction's trade sector within the global trade network are considered:

(i) "***In-Degree***" is the number of links that point to a node. It is given by the sum $\sum_j N_{ji}$;

(ii)   "***Closeness***" is the inverse of the average distance from node i to all other nodes. The distance between i and j, δ_{ij} equals the shortest path. The average distance from i to all other nodes is given by $\sum_j \delta_{ij}/(n\text{-}1)$. Closeness is the inverse of this measure;

(iii)   "***Betweenness***" looks at the nodes that the shortest path goes through. Let g_{jk} denote the number of shortest paths between j and k, and $g_{jk}(i)$ denote the number of such paths that go through node i. The probability that node i is on the shortest path from j to k is given by $g_{jk}(i)/g_{jk}$. "Betweenness" of node i is the sum of these probabilities over all nodes excluding i, divided by the maximum that the sum can attain: $(\sum_{j\neq i}\sum_{k\neq i}g_{ik}(i)/g_{jk})/(n\text{-}1)(n\text{-}2)$; and

(iv)   "***Prestige***" (or eigenvector centrality) considers the identity of counterparties. It is a measure of the importance of a node in the network. It assigns relative scores to all nodes in the network based on the principle that connections to high-scoring nodes contribute more to the score of the node in question than equal connections to low-scoring nodes. The "prestige" of jurisdiction i (v_i) is obtained by taking the "prestige" of its exporters, weighted by a matrix of relationships with i, that is, $v_i=\sum_j R_{ji}\,v_j$. This defines a linear system $v=R'v$ where R is the matrix of relationship. The solution to the system is the eigenvector associated with the unit eigenvalue.

Because we consider both exports and imports, the network is "undirected" and because we assign equal weights to the four measures of centrality, the network is "un-weighted" with binary values (0, 1). As with the ranking for trade size, a single ranking for trade interconnectedness is calculated from these four different indicators. All jurisdictions are ranked in each of the four interconnectedness indicators separately, taking the median of the four rankings as the single ranking for trade interconnectedness.

B. Second Stage

An overall composite index of trade systemic importance is calculated as a combination of the trade size and trade interconnectedness rankings calculated in the first stage. The rankings of size and interconnectedness are combined into a weighted average "baseline" index to allow the analysis of the relative significance of size and interconnectedness in systemic importance.

Sensitivity analysis of the composite index suggests that while weight changes affect some of the individual country rankings at the margin, they do not introduce significant changes in the listing of the jurisdictions in the upper echelons of the overall ranking. We tested for the following combinations of size and interconnectedness breakdowns: 0.8/0.2 (0.8 for size and 0.2 for interconnectedness), 0.7/0.3, 0.6/0.4, and 0.5/0.5, respectively.

Because we wanted to compare our findings with those of previous IMF work on financial interconnectedness (below), we maintained the same approach of giving relatively more weight to the size than the interconnectedness dimension, which reflects historical experience. Nonetheless, this needs not be the case—and indeed may not reflect future developments. Hence, future work could usefully explore the sensitivity of the composite index with reversed breakdowns, i.e., giving relatively more weight to interconnectedness than size.

III. THE DATASET

Drawing from DOTS, we considered import and export data for 240 jurisdictions vis-à-vis each other in the years 2000 and 2010, which resulted in about 60,000 time series for each year. We then filtered out those jurisdictions for which GDP data was not available in either year, which resulted in a final sample of 169 jurisdictions representing almost 100 percent of total world trade in both years 2000 and 2010. Each of these 169 jurisdictions presented 240 possible bilateral trade relationships with the rest of the sample.

As subsequent steps, turnover (X+M) and turnover to GDP ratios were calculated for each bilateral relationship. Any relationship for which turnover was less than 0.1 percent of each jurisdiction's GDP was given a zero value and filtered out. The remaining "significant" trade relationships were given values of one and run through a specialized software for network analysis—NodeXL. This software is designed to read data in binary form (0, 1)—or "edge" and "vertex"—to calculate the four indicators of centrality described previously.

IV. THE RESULTS

The results obtained from applying our approach to the dataset are illustrated in Figure 1, which shows the global trade network based on the 2010 rankings of the top 25 systemic jurisdictions and the top 10 systemic jurisdictions, respectively.

Figure 1. The Global Trade Network, 2010
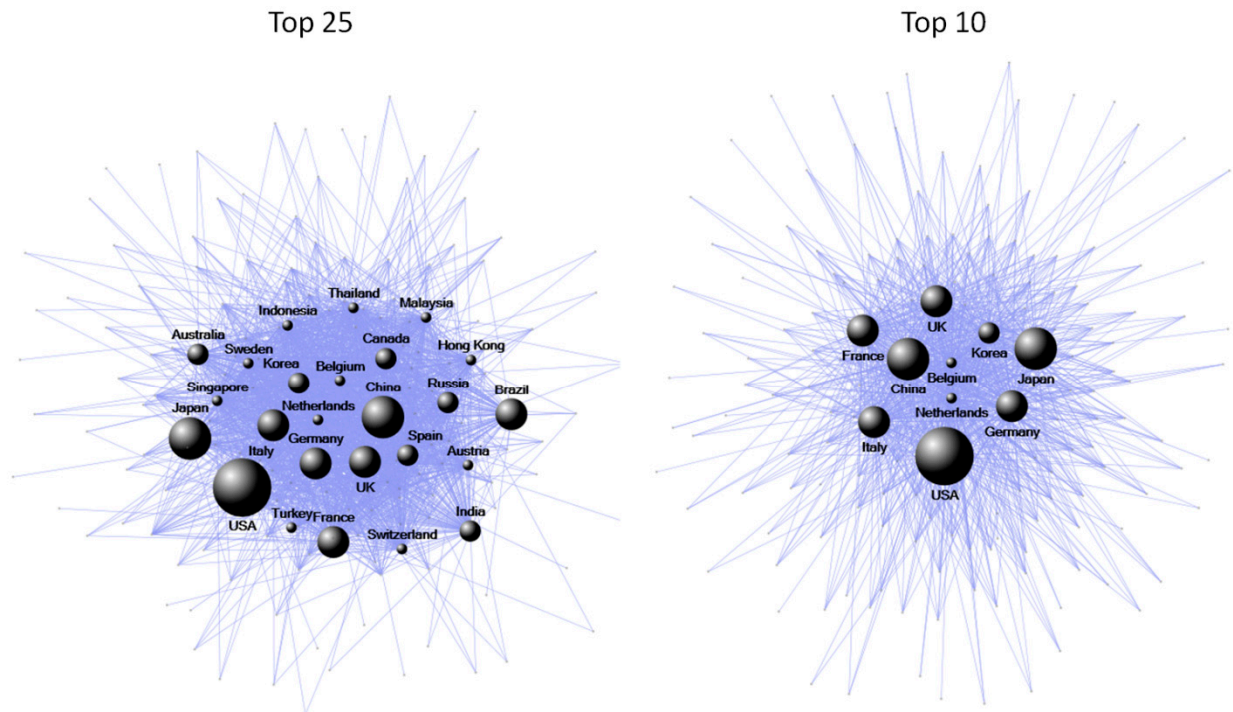
Sources: IMF DOTS Database and IMF staff estimates.

Straight lines between jurisdictions reflect the connections (links) between the trade centers of two jurisdictions (nodes). The interconnectedness of each jurisdiction is reflected by each node's distance from the center of the network and the size of each node reflects the size ranking of each jurisdiction.

The top 25 jurisdictions hosting systemically important trade sectors in the years 2000 and 2010 are summarized in Table 1. The individual overall rankings, as well as the rankings by each of the trade and interconnectedness indicators for all of the 169 sample jurisdictions in the years 2000 and 2010 are included in Appendix Tables A and B, respectively.

Table 1. Jurisdictions with Systemically Important Trade Sectors: 2000-2010

	2000				2010		
Jurisdiction	Overall Rank 1/	Size Rank	Interconnectedness Rank 2/	Jurisdiction	Overall Rank 1/	Size Rank	Interconnectedness Rank 2/
United States	1	1	8	China,P.R.: Mainland	1	2	2
France	2	4	2	Germany	2	3	6
Japan	3	3	8	Netherlands	3	6	1
Germany	4	2	11	Italy	4	7	4
United Kingdom	5	5	6	France	5	5	9
China,P.R.: Mainland	6	7	5	United States	6	1	19
Italy	7	8	3	Korea, Republic of	7	9	7
Netherlands	8	9	4	Belgium	8	11	3
Canada	9	6	14	Japan	9	4	20
Spain	10	15	1	United Kingdom	10	10	7
Korea, Republic of	11	13	7	China,P.R.:Hong Kong	11	8	17
Belgium	12	11	15	Canada	12	11	14
China,P.R.:Hong Kong	13	10	20	Spain	13	16	4
Switzerland	14	17	10	India	14	17	14
Singapore	15	14	22	Malaysia	15	17	18
Sweden	16	18	16	Switzerland	16	22	11
Malaysia	17	16	21	Thailand	17	21	14
Thailand	18	21	17	Singapore	18	13	34
Austria	19	19	22	Russian Federation	19	14	33
Ireland	20	19	26	Brazil	20	20	21
Denmark	21	25	12	Australia	21	19	25
Brazil	22	23	17	Sweden	22	27	11
Australia	23	21	22	Turkey	23	29	10
Mexico	24	12	44	Austria	24	26	24
India	25	26	12	Indonesia	25	28	22

Sources: IMF DOTS Database and IMF staff estimates.
1 Weighted average of the size and interconnectedness rankings using a 0.7/0.3 weight breakdown respectively.
2/ Excludes links representing less than 0.1% of each jurisdiction's GDP.

Our results uncover a few stylized facts:

- First, the composition of the top 25 systemic jurisdictions has remained virtually unchanged over the decade under review. With the exception of Canada and Spain, the composition of the top 10 jurisdictions in 2010 mirrored that of 2000; only three countries appear on the 2010 list that did not appear in 2000 (Indonesia, Russia and Turkey). Nonetheless, the relative rankings of individual jurisdictions have moved

markedly. This is particularly the case for the emerging Asian economies, such as China Mainland and India, which rose by five and eleven positions, respectively.

- Second, Europe and Asia have maintained their dominance at the top of the overall list. Europe has maintained its position mainly on account of its interconnectedness, whereas in Asia, size has been a more important factor. This suggests that while Asian countries are of importance to the absolute size of global trade, they are not (yet) "as central" in the global trade network as European jurisdictions.

- Third, considering in particular the interconnectedness rankings included in Appendix Table B, African economies as a whole rose the most overall, however they still rank last on average. Conversely, European economies fell the most overall. In fact, the largest declines in interconnectedness are to be found in Eastern Europe, reflecting the fact that this region was hit hardest by the contraction in demand stemming from the global financial crisis.

- Fourth, over the decade under review, China has increased its prominence in the global trade network not only in terms of size, by substantially raising its share in total world exports and imports, but also in terms of interconnectedness, by increasing its significant trading partners. China is the only non-European country in the top five for interconnectedness in both years 2000 and 2010.

- Fifth, China's relation to Japan as strategic export destinations has changed considerably over the past ten years (Figure 2). The country's growing use of raw materials has enabled it to become a major destination for emerging market and developing economies' exports over the past decade.

　
Figure 2. Top Imports into China and Japan, 2000-2010
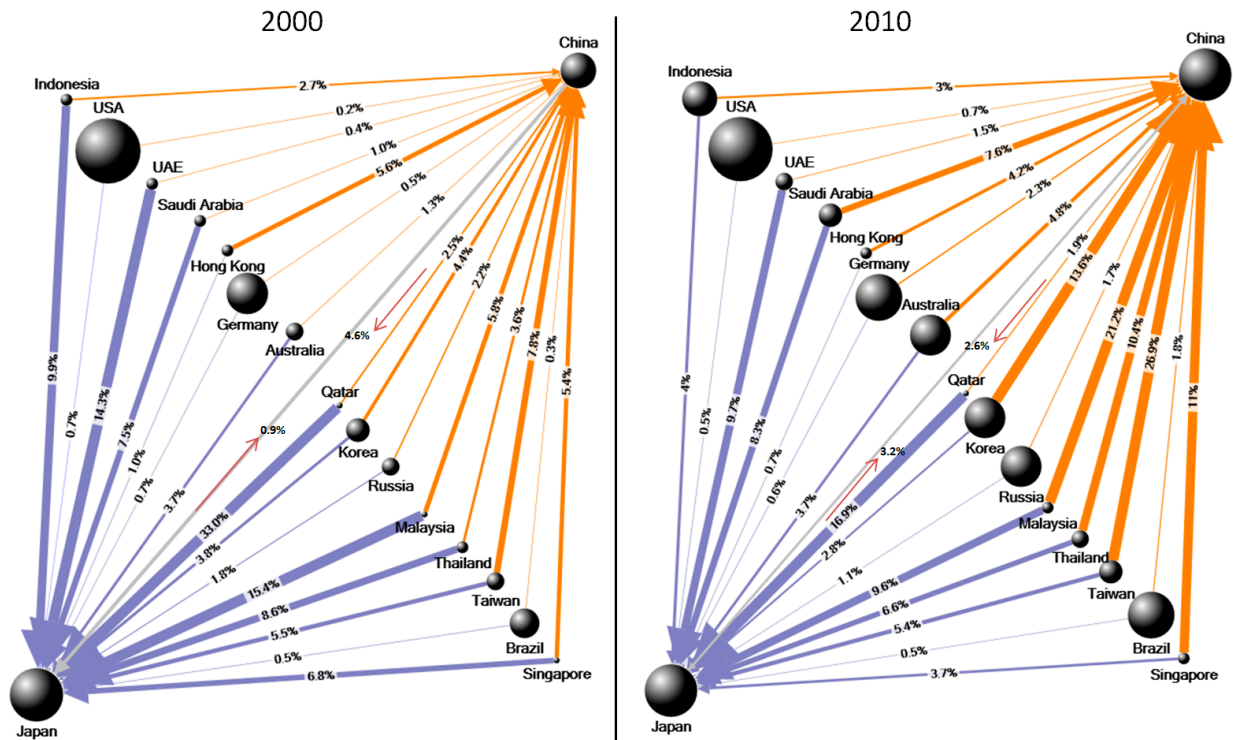
The above figure presents the top ten jurisdictions from which China and Japan imported goods in 2000 and 2010. The size of the nodes represents the relative size of each jurisdiction's nominal GDP; the width of the lines indicates the volume of exports as a percentage of the exporting jurisdiction's nominal GDP. This percentage is also indicated on the labels of each line.

Sources: IMF DOTS Database and IMF staff estimates.

Finally, the United States and Japan have fallen significantly in their centrality rankings, which was the driving force behind their decline in the overall rankings. While both countries increased their number of significant trading partners, several other countries in the top 25 added considerably more partners during the period under review.

V. APPLICATIONS AND EXTENSIONS

Our approach lends itself easily to a number of insightful exercises, including regional analyses of the data. For example, Figure 3 illustrates a possible use of the size indicators to better understand the change in regional trade dynamics over the decade under consideration. For this purpose, we have considered six systemic regions, namely: the United States, China, the United Kingdom, the GIIPS (Greece, Ireland, Italy, Portugal, and Spain), the Euro Area excluding the GIIPS (Core Euro Area), and Japan (collectively, the Systemic Regions).

Figure 3. Percent of Total Exports: 2000 vs 2010
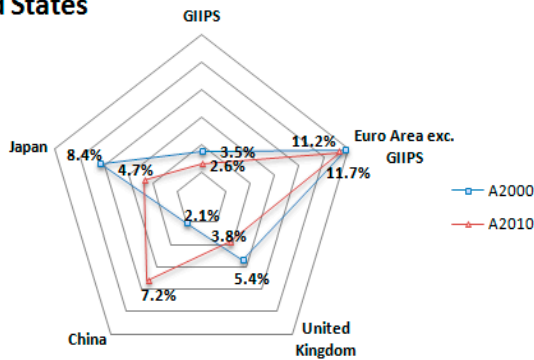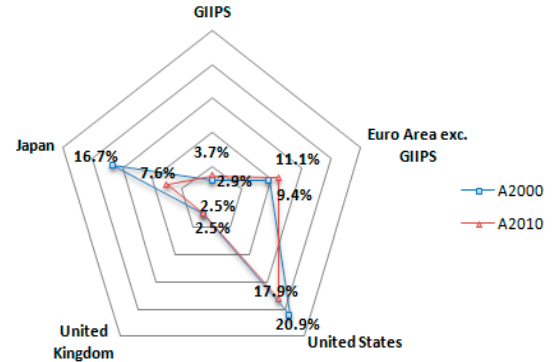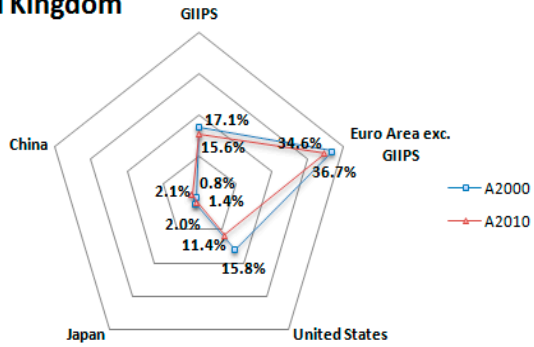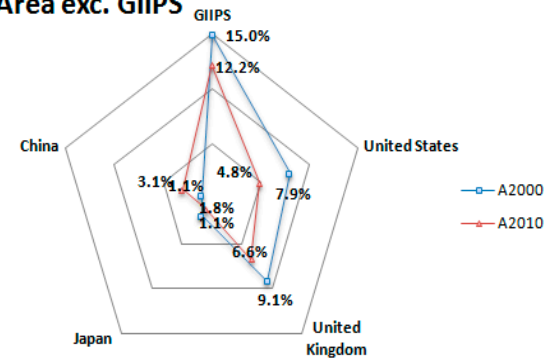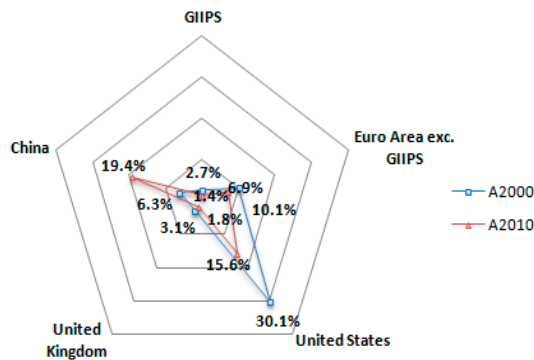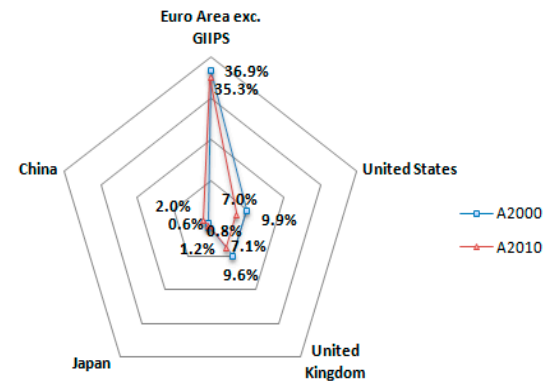
Sources: IMF DOTS Database and IMF staff estimates.

The dynamics of trade in the Systemic Regions over the past decade uncover a few points worthy of note:

- First, China's role as a strategic importer has grown substantially over the decade as exports to China as a percentage of total exports have grown in the case of the United States, Japan, and Core Euro Area.

- Second, the United Kingdom and the GIIPS have remained largely static in terms of their export profiles. In fact, the largest share of their exports throughout the decade went to each other and to the Core Euro Area. Such concentration suggests that the United Kingdom and the GIIPS are more susceptible to contagion and spillover through the trade channel from shocks emanating from the Core Euro Area than any of the other four regions.

- Third, the Core Euro Area has decreased its share of exports to the Systemic Regions, an indication that it has diversified its trading base (with the rest of the world). This point is supported by Figure 4, which shows that the Core Euro Area has overtaken the United States as the region with the most diversified export structure.

Figure 4. Share of Total Exports to the Systemic Regions
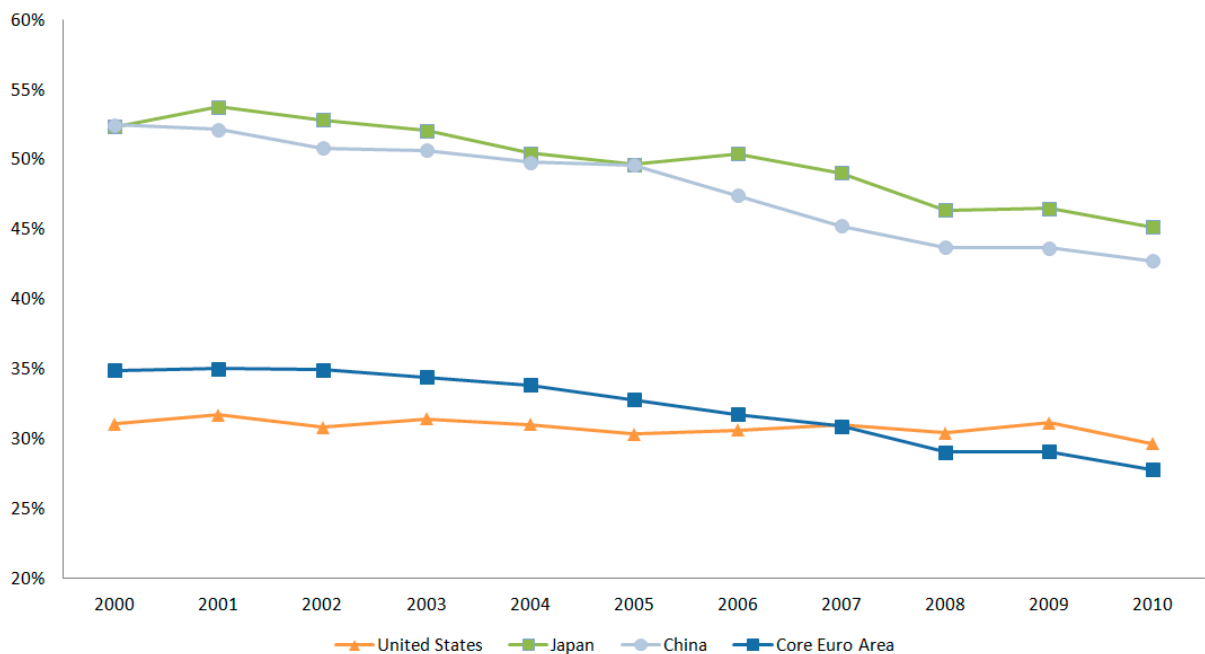
Sources: IMF DOTS Database and IMF staff estimates.

- Fourth, Figure 4 also shows that, while the United States and the Core Euro Area have more diversified export profiles, Japan and especially China have increased markedly their diversification towards the rest of the world over the decade under consideration.

Additional insights may be gained from comparing our findings on systemic trade interconnectedness with earlier findings on systemic financial interconnectedness. To this end, we have calculated the overall ranks of the jurisdictions with systemically important trade sectors shown in Table 1 using a weighted average of the size and interconnectedness rankings with a 0.7/0.3 weight breakdown (0.7 for size and 0.3 for interconnectedness). This is the same size and interconnectedness weight breakdown that had been used for determining the overall ranks of the jurisdictions hosting systemic financial centers.

As Table 2 and Figure 5 show, there is a very strong overlap between jurisdictions hosting trade and financial sectors of systemic importance. In fact, there is an almost perfect overlap between the top 25 jurisdictions with systemic financial sectors and the top 25 jurisdictions with systemic trade sectors in 2010. [5]

Table 2. Composite Index Ranking: the Top 25 Systemic Jurisdictions, 2010

Systemic Trade Sector Rank	Jurisdiction	Systemic Financial Sector Rank 1/	Jurisdiction
1	China , P.R. Mainland	1	United Kingdom
2	Germany	2	Germany
3	Netherlands	3	United States
4	Italy	4	France
5	France	5	Japan
6	United States	6	Italy
7	Korea, Republic of	7	Netherlands
8	Belgium	8	Spain
9	Japan	9	Canada
10	United Kingdom	10	Switzerland
11	China , P.R. Hong Kong	11	China , P.R. Mainland
12	Canada	12	Belgium
13	Spain	13	Australia
14	India	14	India
15	Malaysia	15	Ireland
16	Switzerland	16	China , P.R. Hong Kong
17	Thailand	17	Brazil
18	Singapore	18	Russian Federation
19	Russian Federation	19	Korea, Republic of
20	Brazil	20	Austria
21	Australia	21	Luxembourg
22	Sweden	22	Sweden
23	Turkey	23	Singapore
24	Austria	24	Turkey
25	Indonesia	25	Mexico

Sources: IMF DOTS Database and IMF staff estimates.

1/ As identified in "Integrating Stability Assessments Under the Financial Sector Assessment Progran into Article IV Surveillance: Background Material"

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[5] The top 25 jurisdictions with systemic financial sectors as identified in "*Integrating Stability Assessments Under the Financial Sector Assessment Program into Article IV Surveillance: Background Material*" (August 2010), available at: www.imf.org/external/np/pp/eng/2010/082710a.pdf

Figure 5. Jurisdictions with Systemic Trade and Financial Sectors

Source: IMF staff estimates.
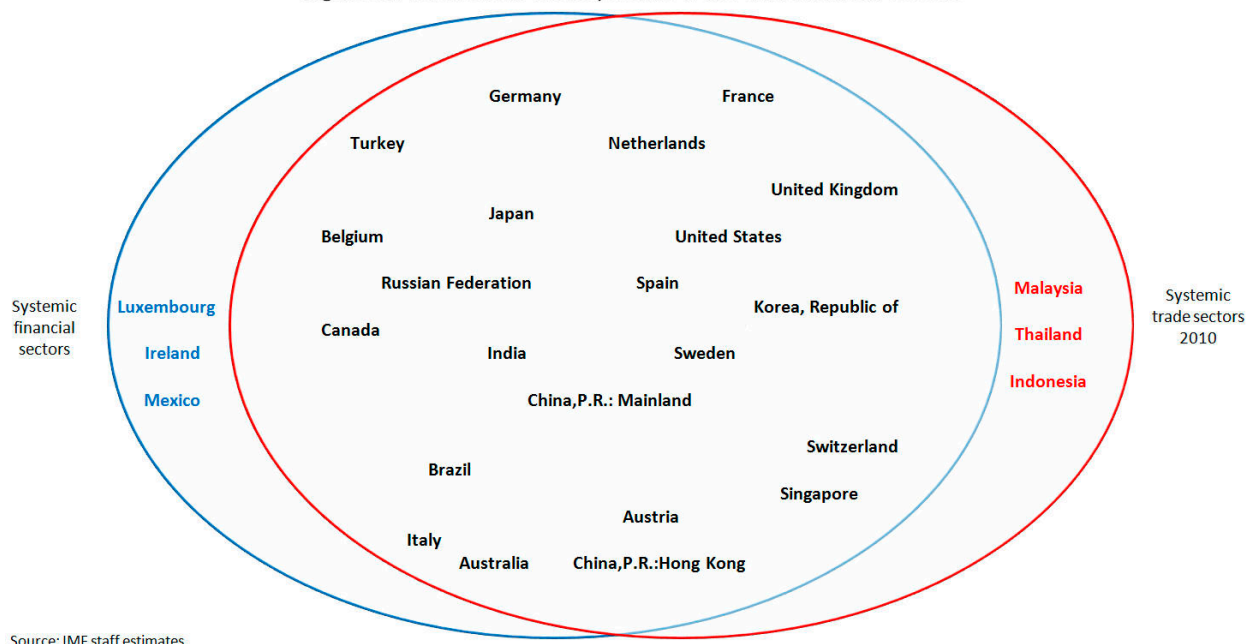
The only exceptions are: Luxembourg, Ireland, and Mexico whose systemic importance is limited to the financial sector; and Indonesia, Malaysia, and Thailand whose systemic importance is limited to the trade sector.

Finally, our approach may be extended by relaxing either one or both of the assumptions imposed on the network, namely that it be "undirected" and "un-weighted." For example, the analysis could focus on exports or imports only and/or give more weight to the eigenvector centrality relative to the other three interconnectedness indicators, or any combinations thereof. Additionally, future work could explore the sensitivity of the composite index with reversed breakdown, i.e., giving relatively more weight to the interconnectedness than the size dimension.

VI. CONCLUDING REMARKS

The paper has laid out our approach for assessing systemic trade interconnectedness using network analysis and the IMF's DOTS database. Our results uncover several stylized facts offering additional insights into the changing patterns of global trade over the decade 2000-2010. We also have shown possible applications of our approach to gain a better understanding of trade dynamics across world regions and the overlapping of trade and financial sectors of systemic importance in the top 25 jurisdictions. Our approach lends itself easily to a wide range of analytical exercises addressing specific global trade issues, as well as global (trade and financial) interconnectedness issues.

The use of DOTS has lent robustness to our analysis by providing uniform data for 169 jurisdictions representing almost 100 percent of total world trade in both the year 2000 and the year 2010. Additionally, the quarterly updating of DOTS makes it possible to recalibrate our findings to track global trade developments on a timely basis.

From a policy perspective, jurisdictions hosting both systemic trade and financial sectors would seem to be the natural focus of risk-based surveillance on cross-border spillovers and contagion. The analysis underscores that these jurisdictions display the strongest inter-sectoral interconnectedness to the global economy. As such, they have the highest potential for transmitting disturbances to other jurisdictions or to systemic stability via either the trade or financial channel or indeed both channels simultaneously. These jurisdictions would thus seem to warrant particular attention and further analysis on the risks associated with their activities, especially when carried out through systemically important financial institutions and non-financial corporations.

Appendix I: Trade and Interconnectedness Rankings for 169 Jurisdictions, 2000 and 2010

The Appendix includes details on the individual rankings of all the 169 jurisdictions in our dataset that are summarized in two tables, Appendix Table A and Appendix Table B.

Appendix Table A focuses on the four trade size indicators: (i) exports; (ii) imports; (iii) turnover; and (iv) the turnover to GDP ratio. It shows the overall rank, as well as the rankings for each of the four trade size indicators, for each jurisdiction in the year 2000 and the year 2010.

Appendix Table B focuses on the four trade interconnectedness indicators: (i) in-degree; (ii) closeness; (iii) betweenness; and (iv) prestige. It shows the overall rank, as well as the rankings for each of the four trade interconnectedness indicators, for each jurisdiction in the year 2000 and the year 2010.

Table A. Size Rankings

Jurisdiction	2000					2010				
	Rank	Exports	Imports	Turnover	Turnover/GDP	Rank	Exports	Imports	Turnover	Turnover/GDP
Albania	135	139	120	128	137	129	127	119	128	124
Algeria	50	44	57	46	93	50	48	53	49	97
Angola	71	64	99	74	17	64	51	75	58	69
Argentina	40	42	41	41	166	42	41	49	41	152
Armenia	126	137	123	131	79	131	135	127	131	114
Aruba	135	146	124	141	105	154	158	152	153	125
Australia	21	24	18	20	140	19	20	18	19	151
Austria	19	23	20	19	56	26	28	26	26	62
Azerbaijan, Rep. of	106	97	117	110	97	83	64	93	75	92
Bahamas, The	86	110	78	91	33	84	118	77	91	6
Bahrain, Kingdom of	66	61	80	71	10	66	59	86	71	10
Bangladesh	69	70	58	66	145	73	74	61	69	135
Barbados	122	138	118	124	114	145	143	141	146	104
Belarus	61	63	59	61	8	55	62	56	62	33
Belgium	11	11	12	11	7	11	10	12	12	11
Belize	145	145	145	146	49	148	146	153	151	45
Benin	144	143	138	144	144	112	142	102	118	30
Bolivia	106	101	103	104	128	112	98	113	107	116
Bosnia and Herzegovina	100	121	93	106	86	104	109	103	105	98
Brazil	23	26	22	24	164	20	21	19	20	167
Brunei Darussalam	88	81	111	95	46	96	86	133	101	55
Bulgaria	71	74	66	72	34	65	68	63	66	44
Burkina Faso	147	148	142	145	157	145	141	140	143	157
Burundi	164	161	160	165	152	163	163	159	162	148
Cambodia	111	107	112	112	58	98	102	92	97	23
Cameroon	109	95	108	107	143	118	105	115	112	143
Canada	6	6	6	6	54	11	12	10	11	113

Cape Verde	159	168	156	157	116	156	165	155	155	100
Central African Republic	149	141	164	154	136	160	156	158	159	155
Chad	164	154	161	160	167	132	113	148	139	121
Chile	43	45	44	44	110	41	42	46	40	88
China,P.R.: Mainland	7	7	8	7	134	2	1	2	2	117
China,P.R.:Hong Kong	10	10	10	10	2	8	11	9	10	2
China,P.R.:Macao	90	86	98	92	47	132	138	109	122	165
Colombia	51	49	53	53	156	52	55	54	55	159
Comoros	167	167	167	167	126	166	166	166	166	129
Congo, Democratic Republic of	123	106	133	118	125	105	100	120	111	77
Congo, Republic of	102	91	143	111	38	92	80	132	98	31
Costa Rica	66	67	65	69	44	71	63	80	74	36
Côte d'Ivoire	77	77	92	81	73	79	77	96	87	57
Croatia	73	75	62	68	90	75	76	72	76	112
Cyprus	102	109	79	93	112	120	128	97	106	139
Czech Republic	32	37	30	36	18	29	29	29	30	19
Denmark	25	28	27	26	82	34	35	34	33	101
Djibouti	143	147	137	143	11	141	144	136	140	4
Dominica	161	159	159	164	55	157	154	157	158	7
Dominican Republic	63	69	55	60	63	85	93	74	79	132
Ecuador	80	72	83	77	109	74	70	71	73	82
Egypt	57	66	42	49	149	53	61	42	50	137
El Salvador	81	83	75	78	83	102	101	98	99	90
Equatorial Guinea	118	108	152	126	19	95	83	139	102	68
Estonia	76	78	71	76	5	77	78	85	81	29
Ethiopia	124	130	116	119	160	115	121	95	103	150
Fiji	121	119	127	122	36	139	129	143	142	47
Finland	30	29	32	32	68	37	40	39	38	103
France	4	4	5	4	113	5	6	5	5	136
Gabon	83	80	113	87	25	103	91	137	109	70
Gambia, The	153	162	149	152	77	155	162	154	154	46
Georgia	142	135	130	138	141	117	120	107	119	86
Germany	2	2	2	2	98	3	3	3	3	76
Ghana	95	99	90	97	81	101	104	82	90	107
Greece	46	54	39	43	147	58	66	43	53	161
Grenada	157	156	155	156	48	165	164	162	165	65
Guatemala	82	85	72	79	130	81	84	81	80	109
Guinea	139	123	141	134	138	121	119	122	123	20
Guinea-Bissau	158	151	165	161	84	160	150	165	164	84
Guyana	126	124	135	130	20	141	131	146	145	32
Haiti	139	136	128	136	154	130	140	123	132	73
Honduras	96	102	91	99	85	93	95	88	93	40
Hungary	36	38	35	38	13	31	34	33	32	16
Iceland	96	93	94	96	106	109	103	124	114	80
India	26	30	25	28	163	17	19	13	16	154

Indonesia	27	25	34	27	89	28	24	28	29	140
Iran, Islamic Republic of	42	41	46	42	124	35	33	38	34	123
Ireland	19	20	24	23	12	38	32	48	35	59
Israel	34	34	29	34	99	43	46	47	46	110
Italy	8	8	7	8	123	7	8	8	7	131
Jamaica	98	104	85	94	107	125	136	108	121	122
Japan	3	3	3	3	165	4	4	4	4	163
Jordan	79	105	76	83	59	77	94	76	83	64
Kazakhstan	61	57	73	63	39	51	50	55	52	93
Kenya	92	96	86	89	129	89	97	78	86	91
Korea, Republic of	13	12	13	13	76	9	7	11	9	54
Kuwait	54	46	63	51	61	62	45	70	54	89
Kyrgyz Republic	134	127	140	137	43	107	130	101	113	8
Lao People's Democratic Republic	133	132	131	135	67	121	115	130	126	49
Latvia	88	94	88	88	71	81	81	84	84	53
Lebanon	98	118	67	80	131	87	106	73	77	96
Libya	69	51	77	59	121	53	54	69	57	51
Lithuania	74	79	69	75	40	68	67	66	68	26
Luxembourg	52	60	52	55	27	67	69	65	67	63
Macedonia, FYR	105	103	101	105	30	106	107	106	110	42
Madagascar	124	112	129	120	135	137	132	135	136	120
Malawi	139	133	139	142	100	144	133	145	144	115
Malaysia	16	17	17	16	3	17	17	20	18	9
Maldives	148	157	146	148	52	147	159	147	149	87
Mali	119	140	114	121	91	141	151	128	138	138
Malta	84	88	84	84	9	126	124	121	127	74
Mauritania	129	126	134	132	21	128	117	138	133	24
Mauritius	101	100	100	103	45	121	123	118	124	95
Mexico	12	13	11	12	78	15	15	16	15	105
Moldova	126	129	125	129	26	121	126	116	125	41
Mongolia	129	125	136	133	23	119	112	126	120	35
Morocco	60	62	51	57	108	69	71	57	65	108
Mozambique	132	134	121	125	142	114	111	110	116	60
Myanmar	91	92	89	90	94	94	92	90	92	146
Nepal	114	117	106	114	132	140	139	129	134	160
Netherlands	9	9	9	9	15	6	5	7	6	17
New Zealand	48	50	49	50	111	55	57	58	60	134
Nicaragua	110	122	104	113	80	115	110	114	117	25
Niger	137	142	126	140	88	152	153	142	147	153
Nigeria	49	40	68	45	57	43	37	50	43	102
Norway	31	27	36	29	101	32	30	35	31	118
Oman	58	55	74	62	41	59	56	68	64	43
Pakistan	55	58	54	56	153	62	65	52	59	149
Panama	108	113	82	101	139	45	90	40	56	5
Papua New Guinea	94	84	115	102	16	87	79	112	94	13

Paraguay	111	111	97	108	120	96	99	91	96	56
Peru	64	65	61	64	151	59	58	59	61	145
Philippines	29	32	31	33	29	40	47	36	39	71
Poland	32	35	26	31	115	24	26	25	25	81
Portugal	39	43	28	37	103	45	52	37	44	111
Qatar	59	53	87	65	37	55	43	67	51	78
Romania	53	56	50	54	74	49	53	45	48	79
Russian Federation	24	16	33	21	102	14	9	17	13	133
Rwanda	154	153	154	153	162	148	147	149	148	164
Samoa	155	158	153	155	6	162	155	161	161	34
São Tomé and Príncipe	167	166	168	168	51	168	168	168	168	106
Saudi Arabia	28	21	37	25	95	25	18	30	23	67
Senegal	117	120	109	116	117	111	116	104	115	83
Seychelles	150	150	148	149	50	150	148	151	150	15
Sierra Leone	152	149	151	150	62	151	149	150	152	75
Singapore	14	14	15	14	1	13	14	15	14	3
Slovak Republic	47	52	47	52	14	38	44	41	42	14
Slovenia	55	59	56	58	31	59	60	60	63	22
Solomon Islands	156	152	162	158	87	153	145	163	156	28
South Africa	38	36	38	39	118	36	38	32	37	128
Spain	15	15	14	15	122	16	16	14	17	144
Sri Lanka	68	71	64	70	53	79	85	79	78	126
St. Kitts and Nevis	160	164	157	159	60	163	161	160	163	39
St. Lucia	151	163	147	151	96	135	160	125	137	1
St. Vincent & Grens.	161	160	158	162	75	159	157	156	157	18
Sudan	111	98	110	109	155	89	82	89	88	162
Suriname	138	128	144	139	24	136	125	144	141	58
Sweden	18	18	19	18	70	27	27	27	28	85
Switzerland	17	19	16	17	69	22	23	23	22	72
Syrian Arab Republic	75	73	70	73	168	72	72	62	70	168
Tajikistan	120	114	132	123	4	127	137	117	129	48
Tanzania	114	116	107	115	158	110	114	99	104	127
Thailand	21	22	21	22	22	21	22	22	21	27
Togo	146	144	150	147	133	138	134	134	135	21
Tonga	166	165	166	166	104	167	167	167	167	94
Trinidad and Tobago	84	82	95	86	66	76	75	100	82	37
Tunisia	65	68	60	67	64	69	73	64	72	50
Turkey	35	39	23	30	148	29	31	21	27	141
Turkmenistan	92	87	105	98	35	108	108	105	108	130
Uganda	129	131	122	127	159	134	122	131	130	158
Ukraine	45	47	48	48	32	45	49	44	47	61
United Arab Emirates	37	31	40	35	72	23	25	24	24	38
United Kingdom	5	5	4	5	127	10	13	6	8	142
United States	1	1	1	1	161	1	2	1	1	166
Uruguay	87	89	81	85	150	85	87	83	85	119

Uzbekistan	102	90	102	100	146	100	96	94	95	147
Vanuatu	161	155	163	163	42	158	152	164	160	52
Venezuela, Rep. Bol.	40	33	43	40	119	45	36	51	45	156
Vietnam	44	48	45	47	28	33	39	31	36	12
Yemen, Republic of	77	76	96	82	65	89	88	87	89	99
Zambia	116	115	119	117	92	98	89	111	100	66

Sources: IMF DOTS Database and IMF staff estimates.

Table B. Interconnectedness Rankings

	2000					2010				
Jurisdiction	Rank	Degree	Betweenness	Closeness	Prestige	Rank	Degree	Betweenness	Closeness	Prestige
Afghanistan, Islamic Republic of	178	178	169	177	178	170	170	164	169	170
Albania	151	148	167	154	145	133	133	130	132	131
Algeria	76	76	96	77	75	64	63	77	64	63
American Samoa	190	188	187	191	190	192	189	187	192	192
Angola	130	130	150	128	125	126	126	151	125	122
Antigua and Barbuda	176	176	165	176	179	178	177	175	179	178
Argentina	36	36	49	36	36	29	27	42	30	26
Armenia, Republic of	143	140	164	141	141	120	120	138	119	118
Aruba	125	125	114	124	135	144	141	131	144	146
Australia	22	21	25	21	25	25	25	35	25	27
Austria	22	23	33	23	22	24	24	32	23	24
Azerbaijan, Republic of	100	100	103	99	96	95	94	114	92	97
Bahamas, The	95	93	101	91	97	109	106	106	110	113
Bahrain, Kingdom of	78	78	79	75	77	84	84	87	82	79
Bangladesh	60	61	13	60	69	51	55	40	49	60
Barbados	89	91	44	89	105	99	94	84	104	112
Belarus	51	48	60	51	51	48	46	48	46	48
Belgium	15	12	10	15	15	3	2	4	2	5
Belize	128	128	115	127	137	99	91	100	97	102
Benin	105	102	117	106	100	98	94	113	97	98
Bermuda	177	176	168	177	177	181	180	171	180	180
Bhutan	195	194	187	195	195	191	191	187	190	190
Bolivia	138	135	151	137	133	145	142	160	144	139
Bosnia and Herzegovina	165	158	183	166	150	176	175	183	175	174
Botswana	185	185	187	184	185	182	182	181	181	181
Brazil	17	17	28	17	17	21	21	28	21	20
Brunei Darussalam	170	169	180	169	164	166	166	177	164	163
Bulgaria	49	49	65	51	49	42	42	45	42	42
Burkina Faso	160	158	171	161	159	137	135	158	136	129
Burundi	168	169	162	166	169	150	149	149	149	148
Cambodia	158	158	166	156	153	127	126	110	132	126
Cameroon	90	90	83	91	94	75	75	86	75	76

Canada	14	12	24	12	13	14	14	23	14	14
Cape Verde	154	153	154	160	151	145	146	125	144	142
Central African Republic	140	138	127	141	136	149	149	147	151	148
Chad	147	144	158	147	142	153	154	167	152	150
Chile	50	49	52	49	52	45	45	55	45	47
China, P.R.: Hong Kong	20	20	21	20	20	17	17	22	17	15
China, P.R.: Macao	133	135	153	132	127	158	159	162	152	154
China, P.R.: Mainland	5	4	16	4	5	2	2	9	2	2
Colombia	62	59	68	59	65	60	58	75	59	62
Comoros	162	162	173	161	158	151	152	169	149	145
Congo, Democratic Republic of	133	133	147	134	132	131	131	124	127	133
Congo, Republic of	109	108	89	113	114	108	106	121	105	95
Costa Rica	84	83	93	84	83	79	77	105	79	78
Côte d'Ivoire	54	53	63	54	55	49	49	52	49	51
Croatia	63	61	64	64	63	101	91	111	92	109
Cuba	148	144	129	149	163	157	149	137	162	164
Cyprus	63	64	84	63	61	66	66	65	65	65
Czech Republic	39	39	50	39	38	39	39	51	39	39
Denmark	12	12	3	12	14	13	13	10	13	13
Djibouti	115	119	107	113	116	118	122	118	119	117
Dominica	132	130	116	134	145	88	90	88	89	96
Dominican Republic	88	86	88	87	99	81	82	72	79	91
Ecuador	74	72	87	74	76	73	71	102	73	72
Egypt	48	49	69	48	48	36	36	12	36	38
El Salvador	121	119	144	121	121	123	120	142	123	123
Equatorial Guinea	170	168	177	170	165	165	164	176	164	161
Eritrea	189	188	187	192	189	189	186	187	191	187
Estonia	58	58	61	58	58	161	159	153	160	162
Ethiopia	142	140	157	141	134	134	133	148	134	127
Falkland Islands	192	194	187	189	193	194	194	187	189	194
Faroe Islands	188	188	187	188	188	187	185	187	186	185
Fiji	145	147	6	141	156	141	142	1	139	155
Finland	29	28	32	29	28	23	23	36	24	23
France	2	1	4	1	2	9	9	15	9	8
French Territories: French Polynesia	184	184	179	183	184	183	182	170	181	183
French Territories: New Caledonia	179	180	178	179	180	179	179	179	176	177
Gabon	115	111	126	117	112	115	113	128	115	114
Gambia, The	107	105	119	107	101	93	94	116	92	92
Georgia	108	108	137	108	110	92	91	117	91	89
Germany	11	10	15	10	11	6	4	14	4	6
Ghana	72	72	94	71	72	71	71	97	71	70
Gibraltar	179	179	181	180	176	173	173	173	171	172
Greece	30	30	35	30	30	38	38	44	38	37
Greenland	187	186	187	187	187	190	189	187	188	189
Grenada	173	173	152	172	173	138	138	129	137	141

Guam	186	186	187	185	186	188	186	187	184	186
Guatemala	79	78	90	77	80	86	86	98	86	85
Guinea	109	108	133	113	107	93	94	123	92	86
Guinea-Bissau	159	158	159	163	157	155	154	154	152	153
Guyana	98	97	82	98	103	97	94	94	97	108
Haiti	137	133	118	137	143	118	118	141	118	120
Honduras	115	111	124	108	118	103	94	126	105	101
Hungary	46	46	66	46	43	52	52	74	53	49
Iceland	91	93	59	91	91	91	94	57	92	88
India	12	12	23	12	12	14	14	7	14	16
Indonesia	19	19	29	19	18	22	22	33	22	22
Iran, Islamic Republic of	56	57	72	54	54	61	61	80	62	61
Iraq	157	153	174	156	152	158	157	168	152	156
Ireland	26	26	36	26	21	26	27	41	26	25
Israel	43	43	56	42	45	44	44	47	43	45
Italy	3	3	11	3	1	4	4	17	4	3
Jamaica	94	91	100	91	98	87	88	71	86	100
Japan	8	8	20	8	8	20	20	25	20	18
Jordan	65	66	45	65	66	65	66	43	65	64
Kazakhstan	71	71	92	71	70	82	81	64	82	84
Kenya	73	74	43	71	79	52	52	39	53	57
Kiribati	194	191	184	194	194	196	194	187	195	195
Korea, Republic of	7	7	5	7	10	7	7	3	7	12
Kuwait	97	97	132	97	89	77	79	81	77	77
Kyrgyz Republic	123	119	135	125	117	125	124	89	125	132
Lao People's Democratic Republic	151	151	176	151	144	164	163	172	163	158
Latvia	75	78	37	77	74	147	147	144	148	157
Lebanon	60	61	76	60	60	49	50	61	49	50
Lesotho	196	194	187	196	196	186	186	184	184	188
Liberia	175	175	175	175	175	172	171	166	170	171
Libya	127	125	146	128	123	111	111	135	109	103
Lithuania	79	76	109	82	73	139	138	136	141	144
Luxembourg	67	68	81	65	64	75	75	104	76	75
Macedonia, FYR	101	100	139	104	87	177	176	180	177	176
Madagascar	114	117	108	113	113	110	109	68	110	110
Malawi	101	104	102	91	102	103	109	96	97	111
Malaysia	21	21	31	21	23	18	18	20	18	17
Maldives	166	164	185	163	155	142	142	163	141	138
Mali	118	115	148	117	111	124	125	156	123	121
Malta	69	69	74	69	68	74	74	29	73	74
Mauritania	96	93	125	99	90	95	94	122	97	87
Mauritius	82	83	14	81	82	63	64	46	60	66
Mexico	44	44	58	45	43	61	61	85	62	58
Moldova	93	93	106	89	92	83	82	82	82	82
Mongolia	136	135	141	134	130	185	184	185	183	184

Morocco	47	47	62	47	47	46	47	58	46	46
Mozambique	149	148	104	146	149	113	113	79	110	114
Myanmar	135	138	120	137	131	153	154	157	152	152
Namibia	181	182	170	181	183	175	173	165	174	173
Nauru	191	191	187	190	191	196	194	187	195	195
Nepal	151	151	172	151	147	156	157	178	152	147
Netherlands	4	4	18	4	4	1	1	11	1	1
Netherlands Antilles	168	164	143	171	172	168	165	146	168	168
New Zealand	40	40	2	40	40	31	32	6	31	34
Nicaragua	172	169	155	172	171	117	116	134	116	119
Niger	119	119	145	119	119	128	126	115	127	130
Nigeria	53	54	51	54	57	52	52	53	53	52
North Korea	146	148	98	141	170	152	152	108	152	166
Norway	31	31	12	30	31	35	35	27	35	33
Oman	81	81	78	77	81	57	57	60	58	55
Pakistan	33	32	38	32	35	31	32	26	31	32
Panama	70	69	86	69	71	72	71	91	71	73
Papua New Guinea	138	140	128	132	140	147	148	90	147	151
Paraguay	141	140	140	147	138	106	104	101	105	107
Peru	68	65	75	68	67	68	64	73	68	66
Philippines	54	54	55	53	56	56	55	63	49	54
Poland	33	33	41	34	33	36	36	49	36	36
Portugal	28	28	26	28	29	26	25	24	29	28
Qatar	106	105	122	99	104	122	122	145	119	116
Romania	42	42	54	43	41	55	50	66	53	53
Russian Federation	35	33	42	34	34	33	31	34	33	31
Rwanda	154	153	160	151	154	142	142	132	141	143
Saint Helena	193	191	186	193	192	195	191	186	194	193
Samoa	162	167	70	156	167	163	161	150	160	159
São Tomé and Príncipe	162	162	161	163	160	161	41	37	40	41
Saudi Arabia	41	41	48	41	42	40	66	69	68	68
Senegal	92	86	99	91	93	69	113	133	110	105
Seychelles	150	153	134	149	148	113	104	119	102	99
Sierra Leone	119	117	130	121	115	103	34	13	33	35
Singapore	22	23	8	23	27	34	88	112	89	90
Slovak Republic	56	54	71	57	53	88	86	107	86	93
Slovenia	65	66	97	65	62	88	168	152	166	167
Solomon Islands	167	172	149	166	168	168	181	182	186	181
Somalia	183	182	182	185	181	183	27	30	26	29
South Africa	32	33	46	33	32	28	4	2	4	4
Spain	1	1	1	1	3	4	58	70	57	56
Sri Lanka	51	52	67	50	50	57	135	127	137	135
St. Kitts and Nevis	156	153	138	155	161	136	126	99	127	137
St. Lucia	113	114	85	111	124	128	118	109	122	128
St. Vincent and the Grenadines	124	123	121	123	128	121	131	155	127	125

Sudan	111	111	142	111	108	131	116	103	116	124
Suriname	104	102	95	104	109	116	178	161	178	179
Swaziland	181	181	163	182	182	179	11	5	11	11
Sweden	16	16	27	16	16	11	11	19	11	9
Switzerland	10	10	17	10	9	11	103	140	102	94
Syrian Arab Republic	87	86	123	88	84	102	27	38	26	30
Taiwan Province of China	25	23	30	23	26	29	138	139	140	140
Tajikistan	129	128	131	128	129	140	66	31	65	71
Tanzania	85	85	34	84	88	67	14	8	14	21
Thailand	17	17	9	17	19	14	84	83	85	81
Togo	99	97	113	99	95	85	167	76	166	165
Tonga	174	174	80	174	174	167	77	59	79	83
Trinidad and Tobago	82	81	73	82	86	77	47	62	46	44
Tunisia	59	59	77	60	59	46	9	18	9	10
Turkey	27	27	39	27	24	10	126	92	127	134
Turkmenistan	130	130	105	128	139	128	194	187	195	195
Tuvalu	198	194	187	197	197	196	111	143	110	104
Uganda	122	123	136	119	120	112	40	54	41	40
Ukraine	37	37	47	37	37	40	43	50	44	42
United Arab Emirates	45	44	53	43	46	43	7	16	7	7
United Kingdom	6	4	7	4	6	7	18	21	18	19
United States	8	8	22	8	7	19	70	67	70	69
Uruguay	86	86	111	86	85	70	169	174	171	169
Uzbekistan	126	125	156	125	122	171	161	120	159	160
Vanuatu	160	164	110	156	166	160	79	95	77	80
Venezuela, República Bolivariana de	77	74	91	76	78	80	60	78	60	59
Vietnam	38	38	40	37	39	59	191	187	193	191
Yemen, Republic of	101	105	57	99	106	107	106	56	105	105
Zambia	112	115	19	108	126	135	135	93	134	136
Zimbabwe	144	144	112	140	162	173	172	159	173	175

Sources: IMF DOTS Database and IMF staff estimates.

References

Ahuja, R.K., T.L. Magnanti, and J.B. Orlin, 1993, *Network Flows: Theory, Algorithms, and Applications*, Prentice Hall, Upper Saddle River, N.J.

Clauset, A., M.E.J. Newman, and C. Moore, 2004, "Finding community structure in very large networks," *Physical Review* E 70, 066111.

Freeman, L.C., 1977, "A set of measures of centrality based upon betweenness," *Sociometry* 40, 35-41.

International Monetary Fund, 2010, *Direction of Trade Statistics* (Washington: International Monetary Fund)

_____, 2010, "*Integrating Stability Assessments Under the Financial Sector Assessment Program into Article IV Surveillance: Background Material*" (August) available at: www.imf.org/external/np/pp/eng/2010/082710a.pdf

_____, 2010, "*Understanding Financial Interconnectedness*" (October), available at: http://www.imf.org/external/np/sec/pn/2010/pn10150.htm

_____, 2011, "*Changing Patters of Global Trade*" (June), available at: http://www.imf.org/external/pp/longres.aspx?id=4578

Newman, M.E.J., 2004, "Analysis of weighted networks," *Physical Review* E 70, 056131.

_____, 2005, "A measure of betweenness centrality based on random walks," *Networks* 27, 39-54.

_____, 2008, "Mathematics of networks," in L.E. Blume and S.N. Durlauf, eds., *The New Palgrave Encyclopedia of Economics*, 2nd Edition, Palgrave Macmillan, Basingstoke.