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The International Economic Order and Trade Architecture

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ABSTRACT *The world has lived through an accelerated globalization process over the last 15 years. Global trade relative to world GDP has grown from 39% in 1992 to 52% in 2005. At the same time, the share of world trade of OECD countries has gone down from 73% in 1992 to 64% in 2005. These shifts have led to changes in the structure of the world trade network and, in particular, how the role and influence of emerging markets on world trade have evolved. This paper is designed to elucidate some aspects of this changing trade architecture using network analysis.*

Ordre économique international et architecture commerciale

RÉSUMÉ *Au cours des 15 dernières années, le monde a traversé une période de mondialisation accélérée. Le rapport entre le commerce mondial et le PNB du monde est passé de 39% en 1992 à 52% en 2005. Pendant la même période, la part du commerce mondial pour les pays de l'OCDE a baissé de 73% en 1992 à 64% en 2005. Ces variations ont engendré des variations dans la structure du commerce mondial, notamment dans l'évolution du rôle et de l'influence des marchés émergents sur le commerce mondial. La présente communication a pour but d'élucider certains aspects de cette architecture mondiale changeante au moyen d'une analyse des réseaux.*

El orden económico internacional y la arquitectura comercial

RESUMEN *Durante los últimos 15 años, el mundo ha atravesado un proceso acelerado de globalización. El comercio global, en relación con el PNB mundial, ha crecido de un 39% en 1992 a un 52% en 2005. Al mismo tiempo, el reparto del comercio mundial entre los países de la OECD ha descendido de un 73% en 1992 a un 64% en 2005. Estos movimientos han conducido a 20 cambios en la estructura de la red comercial mundial, y particularmente, en la forma de evolucionar de la función y la influencia de los mercados emergentes sobre el comercio mundial. Este artículo se ha destinado a aclarar ciertos aspectos de esta cambiante arquitectura comercial utilizando un análisis de redes.*

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国际经济秩序和贸易结构
摘要过去的15年间，是一个全球化加速进程的阶段。世界GDP中，国际贸易
所占比例从1992年的39%上升到了2005年的52%。与此同时，OECD成员国
中的所占比例从1992年的73%减少到了2005年的64%。这些变化引起了世界
易格局的改变，尤其是新兴市场在世界贸易中的作用和影响得到了提升和扩
。同时，本文还对世界贸易格局改变等相关问题进行了讨论和阐述。

KEYWORDS: *International economic order; economic integration; international business*

JEL CLASSIFICATION: F02; F15; F23

1. Global Trade Architecture

There is a growing perception that in the last 15 years, the world has lived through an accelerated globalisation process. From an economic perspective, this can be explained by the rapid increase in the degree of integration through international trade and investment flows. Indeed, global trade relative to world GDP has grown from 39% in 1992 to 52% in 2005. At the same time, the share of world trade of OECD countries has gone down from 73% in 1992 to 64% in 2005. This shift in the pattern of trade has led to much interest in analysing changes in the structure of the world trade network and, in particular, how the role and influence of emerging markets on world trade has evolved. At the political level, India and Brazil have assumed prominent negotiating positions in the WTO Doha Development Agenda, with other G20 leaders such as China and South Africa playing key roles in the negotiations. At the economic level, the shift has been radical and closely follows key policy developments; with China inserting itself into the trade core following its market opening in 1979, South Africa benefiting from the removal of trade sanctions in the early 1990's and India easing away from 'the licence raj' and increasingly mirroring China's rhythm of convergence with the most integrated countries in the world. At the same time, some studies have suggested that the current state of integration features a polarized international trade structure characterized by a core–periphery configuration, where countries in the periphery have been marginalized.[1] In contrast to this argument, other studies argue that current trade dynamics are leading to important changes in the structure of global trade and that some specific emerging economies are at the centre of these dynamic realignments of the world trade structure.[2]

The BRIICS economies (Brazil, Russia, India, Indonesia, China and South Africa) represent an important set of emerging economies, in part, because they each have significant trade associations with OECD economies. However, world trade patterns involve all other trading economies (non-OECD and non-BRIICS) in important ways. For example, the explosive export growth in final electronic goods from China is not as straight forward as it seems. The final assembly of electronics components (intermediate goods) happens in China; but various manufacturing processes may take place in the USA, the EU, Japan, Korea, Brazil, India, Malaysia, Indonesia, Thailand and possibly other countries. In short, the

trading patterns are so broad and interconnected that a global view is required to examine trade and business policy.

The objective of this study is to assess the changes in the structure of the world trade network over the last 10 years, and, in particular, the evolving role of the BRIICS and other emerging economies in world trade. The analysis is focused on the evolution of the degree of integration of the BRIICS countries and includes a comparison of the trade patterns observed for these economies with respect to all others. The analysis uses complex network measures for the study of disaggregated trade flows. Specifically, the trade flows are disaggregated into consumer goods, intermediate goods, raw materials, and capital goods. The ultimate objective is to provide some insights into the role that these countries, and other economies, have on the current dynamics of international merchandize trade flows.

2. The Motivation for using Complex Network Analysis with International Trade Data

Despite the growing interest in the evolution of world trade patterns, global analyses have been limited in their ability to encompass a number of phenomena that characterize modern trade patterns. Globalization processes since the Second World War have increasingly integrated flows in goods, FDI and technology transfers in complex ways (OECD, 2008). Global value chains have been sliced and diced in the manner described earlier by Vernon (1966) as product cycles. Two patterns of commercial interchange that have developed involve triangular trade as recently analysed by Athukorala (2007) using detailed statistical analysis and long supply chains tracing processes of product design, production planning, component manufacture and final assembly (OECD, 2008).

These processes and interactions, which are often administered by multinational enterprises, are difficult to measure as a whole structure, as an entity or as a pattern. At least, such patterns of trade are difficult to quantify simply; as a single or small number of trade indices. Trade performance is traditionally modelled using gravity models, revealed comparative advantage measures and constant market share analysis.[3] Typically, these approaches examine the trade performance of a country (at a time) in relation to one or all other countries. They do not usually examine all the trade interactions between all countries simultaneously. Recent advances in the study of complex networks provide indicators that can account for the presence, the structure, and the magnitude of the trade flows and therefore can be used to provide simple indicators that characterize aspects of the trade system, taken as a whole. For example, a centrality index (which will be explained below) provides a simple measure of the importance of trade between country *a* and country *b*, taking into account the importance of all countries with which country *b* trades. This index is, accordingly, beginning to encapsulate information regarding whole supply chains and/or technology sharing clubs that are, a priori, thought to be important drivers of world trade.

Sociologists and political scientists were among the first to undertake studies of trade flow interactions among countries using network analysis. Snyder & Kick (1979) used international trade data and network analysis to classify (118) countries into a core–periphery structure. Other studies that explored the core–periphery structure using aggregated trade data include Nemeth & Smith (1985) and Smith & White (1992). More recently, in the area of econophysics, a number of papers have focused on the descriptive statistics of the structure and the

evolution of the world trade network. Studies in this literature include Serrano & Boguña (2003), Garlaschelli & Loffredo (2004, 2005) and Fagiolo, *et al.* (2009). Their findings show that the world trade network is quite symmetric from an imports/exports perspective and, therefore, it can be analysed using total trade flows, exports plus imports, for the weights of the links between the countries in the network.[4] They have confirmed the presence of a core–periphery structure, and suggest the emergence of a 'rich club phenomenon' where countries that have higher trade intensities trade a lot among themselves and; surprisingly, they find that the overall network structure is fairly stationary through time. Finally, Kali & Reyes (2006, 2007) have used network analysis to derive country-specific network indicators that can explain macroeconomic dynamics such as economic growth and financial contagion.

Fagiolo, *et al.* (2009) report that the core of the trade network, based on aggregated trade flows, has changed over the past 20 years. While it included only developed countries until the mid-1990s, countries such as China and South Korea have placed themselves within the core of the network over the late 1990s and early in the first decade of the new millennium, while other more developed countries like Australia, Belgium and the Netherlands have tended to move out to the periphery (see Table 1).

The appeal of network analysis for the study of international economic integration (global trade architecture), then, is that it allows for a whole-structure appreciation of the web of trade interactions as well as the exploration of trade flows as connections, paths, and circuits. This is the objective of the current study.

3. Data, Methodology and Interpretation

This study uses bilateral trade data for 217 countries[5] to build the international trade network for 1995, 2000 and 2005. These Harmonised System data (HS, Comtrade) are used to build a matrix representation of the trade network where each entry reports the total trade flows between each possible pair of countries. In this network analysis, countries are interpreted as nodes, and total trade flows are the links between them.

The analysis is based on three key network concepts employed for exploring the structure of the world market and patterns of integration: (i) *connectivity* of the world trade network to show the evolution in the patterns of world trade;

Table 1. Countries at the core of the world trade network (aggregated trade flows)

1980	1985	1990	1995	2000	2005
USA	USA	USA	USA	USA	USA
Japan	Japan	France	Germany	Germany	China
France	France	Germany	France	France	Germany
UK	Germany[a]	Japan	Japan	Japan	France
Germany[a]	UK	UK	UK	UK	Japan
Italy	Italy	Italy	Italy	Italy	UK
Netherlands	Netherlands	Netherlands	Netherlands	China	Italy
Australia	Singapore	Belgium-Luxembourg	Singapore	Netherlands	Korea
Belgium-Luxembourg	Australia	Australia	China	Australia	Singapore

Note: [a]Up to 1989, data refer to West Germany only.
Source: Fagiolo *et al.* (2007).

(ii) *clustering* to gauge the importance of trading hubs, and the relationship between the core and the periphery; and (iii) *centrality* as an indicator of the overall level of influence of a given country. The Appendix presents the methodological details for the computation of the different network indicators—here we focus attention on their intuitive interpretation.

3.1. Connectivity

Connectivity is measured with the help of two different indicators: (i) node degree, i.e. the number of partners of a given country, and (ii) node strength, i.e. the trade intensities of these interactions.

Node degree is a measure of the number of trading partners a country has regardless of the size of the trade flows. If a country trades with 100 other countries, this is its node degree. The node degree indices for the BRIICS and comparator countries are given in Table 2. The indices have been expressed in percentile form, showing a country's relative position. Thus, if a country is ranked above 95, it means that its indicator score is among the top 5% of the sample. It is important, when reading these tables, to keep in mind that the indices are not affected by the growth in world trade, but rather they are affected by growth in relative trade flows among countries.

The second indicator is *node strength*. This indicator measures not only the number of trading partners that a country has but also the value of trade that passes between them (exports and imports). The node strength indicator weights the links (existence of a trade flow) that a country has by the value of this trade flow. That means that if Thailand has a similar number of trade partners as Malaysia but the

Table 2. Connectivity and number of partners

	Node degree (per cent rank analysis)							
	Raw materials		Intermediate goods		Consumer goods		Capital goods	
	1995	2005	1995	2005	1995	2005	1995	2005
Brazil	***90***	***95***	*90*	***92***	*88*	*89*	*89*	*89*
China—Hong Kong	**96**	**98**	**96**	**96**	**96**	***94***	***95***	**96**
India	***94***	**97**	**96**	**99**	***93***	**98**	*90*	**96**
Indonesia	84	***93***	83	**95**	81	**96**	83	*88*
Russian Federation	75	84	70	84	68	79	72	83
South Africa	***92***	**96**	***91***	***92***	*89*	***92***	*89*	***92***
Czech Republic	*86*	83	***92***	*86*	*89*	*86*	*89*	*87*
Mexico	82	82	83	81	*86*	84	84	84
Philippines	61	*86*	65	82	59	83	63	82
Thailand	***94***	**96**	***95***	**96**	**96**	**96**	***90***	***92***
Bangladesh	76	56	78	52	79	40	64	49
Uzbekistan	43	36	36	34	33	32	42	36

Notes: Bold numbers indicate values above 95 corresponding to countries at the core of the network, regular numbers indicate countries outside of the periphery scoring less than 85, and bold italic numbers and regular italic numbers represent countries in the inner periphery or periphery of the world trade network.

Source: Authors' calculations based on UN Comtrade database.

value of its bilateral trade tends to be much higher, the two countries would have similar *node degree* indices, but Thailand would have a higher *node strength* index.

3.2. Clustering

The third measure proposed is an index of *clustering coefficients*. Clustering is a common concept in the study of social networks. It is often referred as 'cliquishness'. For example, friendship networks typically exhibit high levels of clustering; friends of friends tend also to establish friendship links. In this study, the clustering coefficient measures whether a country is more likely to trade with its better connected partners' partners than with other unrelated countries.

The clustering coefficient used in this paper is weighted by the value of each bilateral trade flow considered. The index takes into account the strength of the links between nodes *i* and *j* but adds the strength of the links between nodes *i* and *h* and *j* and *h* to the analysis. In other words, it considers the complete triangles within the network and the intensities of trade flows that are involved. Therefore, weighted clustering allows for the assessment of the degree to which a country tends to build more (number and value) trade relationships with countries that themselves trade with each other.

3.3. Centrality

The last index included in the analysis is the *centrality* index, a measure of the relevance of a particular country to the overall trade network.

The two most common definitions of centrality in network analyses refer to (i) a local notion: a node is central if it has a large number of connections, or (ii) a global notion: a node is central if it has a position of strategic importance in the overall structure of the network. Local centrality is measured with *node degrees* and global centrality with *node strengths*.

This analysis assesses *global centrality* by estimating a Random Walk Betweenness Centrality (RWBC) index. The RWBC measures the likelihood that country *i* is involved in a randomly selected trade chain in the network. Newman (2005) offers a more intuitive explanation of this centrality measure. Let us assume that a node sends a message to a target node. The message is transmitted initially to a neighbouring node and then the message follows links from that node, chosen randomly, and continues until it reaches the target node. The probabilities assigned to outgoing links are determined by the intensity of the relationship (value of trade), so that links representing higher trade value will be chosen with higher probability. A high RWBC index for country *i* means that the likelihood of country *i* being a part of any given trade chain present within the network is high and therefore it has access to a higher proportion of shorter links to send a 'message' to any other potential country in the world trade network. Furthermore, a high proportion of messages sent by other countries to countries other than *i* will go through *i*. The RWBC thus reflects the trade connectivity (value and number of bilateral trade relationships) of a country and its partners, and its partners' partners, encompassing the whole trade chain. In other words, the RWBC captures the influence of country *i* across the whole lengths of all trade chains.

This RWBC index is used to categorize countries according to their relative importance. *Core* countries are defined as the 5% most integrated economies (at or above the 95th percentile). Countries in the *inner periphery* are defined as the 10%

most integrated (between the 90th and 95th percentile). Countries in the *periphery* are the 15% most integrated (between the 85th and 90th, percentile) and countries below the 85th percentile are said to be in or on the *outside*. Countries on the *outside* are considered to have very little influence on the world trade network in aggregate terms.

3.4. Disaggregating the World Trade Network

The main innovation in this study lies in the breakdown of world trade into four specific product types: (i) raw materials, (ii) intermediate goods, (iii) consumer goods, and (iv) capital goods. These product groupings have been chosen to differentiate the relative importance of each of the BRIICs in world markets, taking into account their revealed comparative advantages. Brazil, Russia, Indonesia and South Africa have abundant raw materials while China tends to specialize in assembling and exporting final consumer and capital goods from imported parts and components (Athukorala, 2007; OECD, 2008). Moreover, all six BRIICS countries import significant quantities of intermediate goods (components) to produce capital goods and consumer goods for export (OECD, 2008).

Previous trade network analysis (Fagiolo, *et al.,* 2009) has focused on aggregated trade flows for all commodities and has reported that the trade network presents a core–periphery structure where the 'rich club' phenomenon is present. In other words, countries with high trade values tend to trade substantially more among themselves. The analysis of the four different product types in this study allows for the comparison of the structure of the trade networks and for the analysis of the position of each country within each of the four networks. Additionally, similarities and solidus or differences between the aggregated trade flows network and the networks of the four product types can be explored.

The following sections present the results for the BRIICS countries and a set of other economies as comparators. The comparators include a small group of medium trading powers, including two OECD countries and other emerging economies, and two much smaller traders, namely Bangladesh, a least-developed country, and Uzbekistan, a transition economy. The results for all OECD countries and selected other countries are reported in the tables in the Appendix, for reference purposes. The focus of the paper is the description of the specific patterns observed in the world trade network and their evolution for the years 1995, 2000, and 2005.

4. Network Analysis

This section explores the degree of connectivity of the BRIICS by analysing their relative performance in terms of the number of trading partners and the value of their bilateral trade links in each of the four main markets given above using *node degree* and *node strength* indicators.

4.1. Partners Galore: Node Degree Analysis

Fagiolo *et al.* (2009) provide a convenient basing point for the analysis conducted here. They report that the distribution of *node degrees* in the world trade network (based on aggregate merchandize trade flows) reflects a bimodal distribution. The first mode for *node degree* lies between 50 and a 100 trading partners and the second

mode is situated around 150 trading partners (out of a sample of 159 countries). The second mode results from the fact that a significant number of countries trade with almost every country in the world. However, even though the bimodal structure has been persistent over the years, there have been realignments of countries within the distribution. As a result, the bimodality has been found to be less pronounced in 2000 than it was 20 years earlier. In other words, there has been a substantial increase recently in the number of countries that trade with almost every other country.[6] Moreover, they found that the standard deviation of the distribution of *node degrees* has remained stable, suggesting that integration has increased rather evenly. That is, less well connected countries have been increasing the number of their trade partners as much as better connected countries. This has caused the distribution curve to flatten because it is impossible for the best connected countries to significantly increase the number of their trading partners (they were already trading with virtually all other countries at the start of the period analysed).

Similar patterns and changes are found in this study when the trade flows are disaggregated into the four product types. However, the bimodality is most pronounced in the cases of consumer and capital goods (see Figure 1). For these two cases, the first mode is between 40 and 60 trading partners and the second one is around 190 trading partners (out of 217). Figure 1 presents these distributions for consumer and capital goods for 1995 and 2005. For both product groups, the

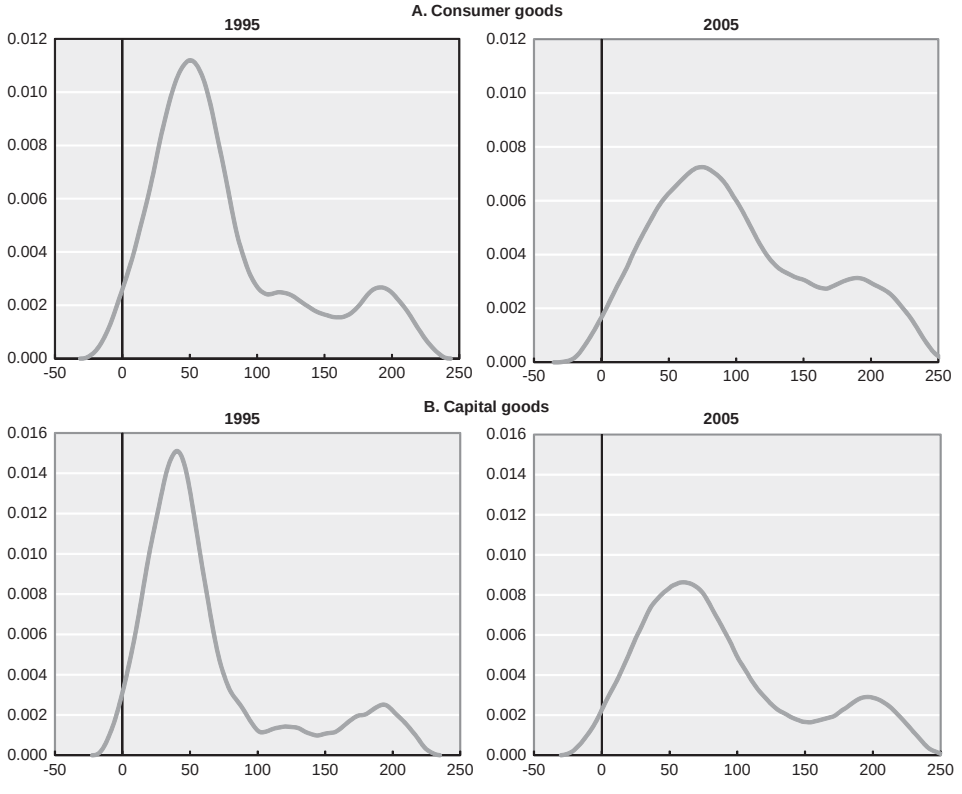

Figure 1. Node degree distribution.
Source: Authors' calculations based on UN Comtrade database.

distribution has flattened over the last 10 years. That shows that there is a smaller proportion of countries in the first mode and a larger proportion of countries beyond (to the right of) the first mode. This indicates that a higher proportion of countries are now global players. In other words, globalization is not narrowing the field of trading partners or concentrating final goods exports (both capital goods and consumer goods) in a smaller number of highly competitive product assemblers. Moreover, as with aggregated trade flows, the standard deviations of the *node degree* distributions have remained stable and there are no signs of polarization. All countries have tended to increase the number of their trading partners, and a rising number of countries are trading with almost everybody else.

Keeping in mind the characteristics of the *node degree* distribution for the trade networks for the four product types considered, it is now possible to discuss the results for specific countries and, more specifically, it is possible to identify whether or not the changes within the distribution can be traced back to the BRIICS group of countries (i.e. Brazil, China, India, Indonesia, Russia, and South Africa). Table 2 presents the results for the BRIICS countries and those for the comparator group of countries using per cent rank analysis.[7] Either the USA or Germany (not included in the table) have the maximum value of 100 for all products and years. Details on a larger group of countries are available in Table A1.

These results, regarding the bimodality of the node degree distributions, support the idea of a core–periphery structure for the trade network. The reason for this is that there are a set of countries that resemble a star-like node (i.e. a node that is connected to all the other nodes in the network), and these nodes serve as hubs to which other nodes are connected. The core–periphery structure will become more apparent when we discuss the measure of centrality introduced above (i.e. the RWBC), but a proxy measure of centrality, which focuses only on first degree connectivity, is in fact node degree. Therefore we use the same classification—core (above 95th percentile), innerperiphery (between 90th and 95th percentile), periphery (between 85th and 90th percentile), and outside (below 85th percentile)—that is used for the interpretation of the results regarding the RWBC.

Within this core—periphery structure analysis it can be seen from the results presented in Table 2 that the status of the BRIICS countries within the trade networks has evolved slightly differently for each of the product types. A constant feature over time and across product types is the dominant presence of China. China can be considered a core country in all of the sub-networks given that it has a per cent rank above 95 in the majority of cases. India is closely behind. By 2005, India was ranked within the top 95th percentile in all product types. Its performance in the global capital goods market is particularly remarkable, with its ranking improving by 6 percentile points in 10 years.

Two BRIICS cases that deserve special attention on the *node degree* measure are Indonesia and South Africa. These two countries have shown an impressive upward trend in all product types from 1995 to 2005. Indonesia was ranked below the 85th percentile in all cases in 1995, and now is ranked as a *core* country in consumer goods exports and intermediate goods, and is ranked in the 92nd percentile (*innerperiphery*) in raw materials. The only case where Indonesia is still below the 90th percentile is in capital goods, and even in this case there is a substantial increase from the position it had in 1995. South Africa is now ranked around the 92nd percentile across all product types, except in raw materials where it can be considered a *core* country.

Brazil is the country for which we see the least improvement. Brazil can now be considered a *core* country for raw materials and this is an improvement from the results reported in 1995, when the country was ranked in the 90th percentile. However, for the other three products, Brazil's position within the network has remained practically constant around the 90th percentile. In other words, it has not increased the number of countries with which it trades as much as other BRIICS countries during the last decade. This indicates a lack of incentive (or a potential failure) to establish new partner relationships and conquer new markets outside raw materials that may be related to the recent increasing demands for resources like iron ore and agricultural products in which Brazil specializes.

Finally, Russia does show an impressive increase within the *node degree* distribution of the four trade networks. The USSR was very close to being a core country prior to 1989 (see Table A4). As a separate country, Russia was below the 75th percentile in all product types in 1995, but in 2005 it is ranked around the 85th percentile across all product types. Even though these results place Russia outside the *periphery*—the only BRIICS country in that position—it is quickly moving towards it in all categories except consumer goods.

It is worth remembering that these country-specific values indicate relative performance, and do not reflect the overall increase in the number of partners discussed at the beginning of the section. The performance of the BRIICS means that other countries have lost positions in the ranking. Results for other countries are shown in Table A1. For example, Chile, the Czech Republic, Greece, and Singapore show a consistent downward trend across all the product types. Countries like Korea, Mexico, Malaysia, Portugal, and Thailand have slightly decreased or maintained their rankings, though South Korea and Thailand had high ratings to begin with. Finally, the Philippines and China Taipei show an upward trend that mirrors that of the BRIICS countries.

4.2. The Value of Bilateral Trade: Node Strength

Node strength measures the number and value (exports and imports) of trading relationships held by a given country. The results obtained for aggregate trade flows in previous studies hold true for the four different (product type) networks considered here:

- The distribution curve of *node strength* is left-skewed, indicating that the overall structure of the networks is characterized by a majority of countries holding weak (low-value) trade relationships and, in contrast to the degree distribution, there is no bimodality observed for any of the product types.
- The correlation between *node strength* and *node degree* is positive across product types and increases substantially over time, from levels around 0.6 in 1995 to 0.8 in 2005. The positive correlation between *node degree* and *node strength* suggests that, on average, countries with many trading partners tend also to have more intense trade relationships in value terms. This has become more evident in recent years, and it holds for all the product types. It is likely that this evolution is driven by countries which were already trading with almost all partners in 1995 and which have continued to increase their trade and therefore the average value of their bilateral relationships.

Based on results reported in previous studies, it is not surprising that the weighted analysis (*node strength*) leads to different conclusions from those reported for the unweighted (*node degree*) analysis.[8] The only similarity corresponds to the results observed for China, reported in Table 3. The predominant connectivity of China reported for the *node degree* distribution is mirrored within the *node strength* distribution. China is among the best-connected countries because of the very high number of trading partners and the very high value of its trade relationships (even where it's better ranked than in terms of partners).

When comparing results for *node degree* (see Table 2) and *node strength* (see Table 3), it is noticeable that the latter shows a much more homogeneous picture among BRIICS and other emerging markets, with most of them situated in the periphery of the network across the whole 1995–2005 period. Indeed, positions have been rather stable, particularly when compared with the node degree analysis, and only the Russian Federation shows significant improvement in the ranking, particularly in raw materials. The stellar performance of Russia in raw materials might be due to the development of gas and oil pipelines since the collapse of the Soviet Union. This might explain why, despite a low *node degree* ranking (84; indicating a relatively low number of trade partners), the value of the trade relationship is growing so fast that Russia is among the better connected countries in raw materials. Mexico also appears as much better connected when trade values are taken into account, most likely a reflection of the importance of its bilateral relationship with the USA. However, contrary to expectations, there are no major differences between raw materials, intermediate and consumer goods. This might be a sign that the categorization of the goods is insufficient to reflect the assembly platform role of the maquiladoras.

Brazil's scores are remarkably similar on both indicators. India and SouthAfrica, on the other hand, appear to be less well connected when trade values are taken

Table 3. Connectivity and the value of trade flows

	Node strength (per cent rank analysis)							
	Raw materials		Intermediate goods		Consumer goods		Capital goods	
	1995	2005	1995	2005	1995	2005	1995	2005
Brazil	***92***	***92***	***93***	***92***	*90*	*86*	*90*	*90*
China—Hong Kong	**96**	**99**	**97**	**99**	**98**	**99**	**96**	**99**
India	***90***	***92***	89	***93***	*86*	*90*	*87*	*86*
Indonesia	***93***	***90***	90	90	*89*	*87*	*89*	*86*
Russian Federation	*81*	**99**	77	***94***	*89*	***94***	*84*	*88*
South Africa	*89*	*86*	*86*	*86*	*82*	*83*	*86*	*85*
Czech Republic	79	80	*85*	*87*	*85*	*88*	*87*	***90***
Mexico	***94***	***93***	***91***	***93***	***94***	**95**	***94***	***95***
Philippines	77	75	*81*	80	78	*81*	*88*	*89*
Thailand	***92***	*88*	***91***	***90***	***92***	*88*	***92***	***93***
Bangladesh	72	59	76	73	76	54	67	65
Uzbekistan	44	40	37	51	46	40	59	58

Notes: Bold numbers indicate values above 95 corresponding to countries at the core of the network, regular numbers indicate countries outside of the periphery scoring less than 85, and bold italic numbers and regular italic numbers represent countries in the inner periphery or periphery of the world trade network.

Source: Authors' calculations based on UN Comtrade database.

into account. More remarkably, there has been little improvement in their scores. This shows that the two countries have been more successful in diversifying their trade partners that in intensifying their existing trade relationships. Their behaviour is consistent with previous network analysis showing that node strength has remained quite stable during the period 1981–2000, suggesting that the wave of globalization has resulted in an increase in the number of connections but has not yet led to a sizeable effect on their magnitude across the network.

5. Clustering: the Diminishing Role of 'Rich Clubs'

Clustering indices are used in network analysis to examine the second-degree characteristics of the observed network. The weighted *clustering* index used here is based on the *node strength* of the country considered and the *node strengths* of the partners that are also trading with each other. In other words, the index reflects the combined *node strength* of all completed triangles within the network that include a given country. Therefore, weighted *clustering* allows for the assessment of the degree to which a country tends to build more (interms of number and intensity) relationships with countries that themselves trade with each other.

The *clustering* coefficient of each country then depends on the number of trade triangles it is involved with and the value of merchandize trade involved.

In order to interpret the economic meaning of these *clustering* indices, it is crucial to examine their correlation with *node strength* indicators. A positive correlation means that countries that trade most intensively also tend to trade with their partners' partners (revealing the existence of the 'rich club' phenomenon) where most of the trade takes place among strongly interconnected members.

Previous studies that have looked at the correlation between weighted *clustering* and *node strength* using aggregated trade flows, have reported positive correlations, with the USA, Japan and Germany holding the highest rankings for different products and years.

In this study, the correlation coefficients between *weighted clustering* and *node strength* for the four product types considered here are all positive but they show a downward trend through time. All correlation coefficients, across product types, were around 0.90 for the year 1995, while all of them decreased to levels around 0.40 for the year 2005.

The homogeneity of results among the four product types is remarkable. For example, it is surprising that the correlation is not noticeably higher for intermediate goods and consumer goods, often characterized by high levels of intra-industry trade, than for raw materials and capital goods. This might be because the categories used are too large to reveal different dynamics, or because trade patterns in the four sub-groups are less diverse than hypothesized earlier in this paper.

However, even more remarkable is the radical reduction in the correlation coefficient which has halved in 10 years. It implies that while the 'rich club' phenomenon is still present, it has weakened considerably. This is to be expected in a strong globalizing environment, particularly given that most countries have increased the number of trading partners faster than they have increased the value of their trading relationships. Nonetheless, it means that club membership has been diluted and thus there have been changes in the interpretation of country-specific rankings. In 1995, belonging to the club—holding a high ranking—was a sure sign of integration and influence in world markets. In 2005, the pattern of trade was

more multilateral, the number of actors had increased. The significance of the *clustering* index had lessened.

Interestingly, as shown in Table 4, the rankings of the BRIICS have barely increased at all. Since 1995, China has been at the top of the distribution and is continuously ranked above the 95th percentile, which means that it tends to appear in many trade triangles (complete triples) for all four products. The only country for which there is a substantial increase in the *clustering* rankings is Russia, although these increases have taken place only for raw materials and intermediate goods. Russia is ranked in the 100th and 92nd percentiles, respectively, for these products. Slight increases in clustering are indicated for India in the intermediate goods classification, where it is now ranked at the 91st percentile, and in capital goods. South Africa slightly increased its ranking in consumer goods, where it is now ranked just above the 80th percentile, but its ranking in raw materials has gone down and this is where it has a stronger comparative advantage. Interestingly, Indonesia is moving down in the *clustering* distribution across all product types. It used to be ranked around the 92nd–95th percentiles and now is below the 90th percentile in the intermediate, consumer and capital goods classifications, and just above the 90th percentile for raw materials. Finally, Brazil is characterized by a constant position across product types (close to the 90th percentile) and across time, except for consumer goods where its position has decreased. In 2005 it was ranked the 83rd percentile, down from the 87th percentile in 1995.

Among the comparator countries, the performance of Mexico is particularly noticeable. Mexico, which was already integrated into the 'rich club' in 1995, has continued to increase its *clustering* coefficient among the four product types. The Czech Republic, together with Hungary and Poland (see Table A3) has also increased its ranking across the board, most probably due to the accession process to the EU, which it joined in 2004. Other countries to have significantly improved their ranking are energy exporters such as Kazakhstan, the Russian Federation and

Table 4. Clustering coefficients

	Node clustering (per cent rank analysis)							
	Raw materials		Intermediate goods		Consumer goods		Capital goods	
	1995	2005	1995	2005	1995	2005	1995	2005
Brazil	***91***	***91***	***91***	***92***	*87*	84	*88*	*89*
China—Hong Kong	**98**	**98**	**97**	**99**	**99**	**97**	**97**	**100**
India	*88*	*90*	*88*	***91***	82	85	83	*85*
Indonesia	**97**	***91***	***94***	*88*	***91***	*88*	***91***	*87*
Russian Federation	83	**100**	79	***92***	***92***	***93***	*89*	*88*
South Africa	*87*	81	83	*85*	77	80	84	84
Czech Republic	73	80	84	*88*	83	*89*	80	*89*
Mexico	**95**	**97**	***92***	***94***	***93***	***95***	***95***	**96**
Philippines	84	75	*88*	82	*85*	81	***94***	***93***
Thailand	***90***	85	*90*	*90*	***90***	*87*	***93***	***92***
Bangladesh	74	59	74	77	74	56	65	70
Uzbekistan	40	39	39	52	47	40	64	60

Notes: Bold numbers indicate values above 95 corresponding to countries at the core of the network, regular numbers indicate countries outside of the periphery scoring less than 85, and bold italic numbers and regular italic numbers represent countries in the inner periphery or periphery of the world trade network.

Source: Authors' calculations based on UN Comtrade database.

Norway. However, Thailand, the Philippines, and Bangladesh, as well as Chinese Taipei, Sri Lanka, Malaysia and even Japan, have all experienced declines in their *clustering* ranking, showing that trade flows in South and Southeast Asia have multilateralized in the last decade.

6. Centrality within the Network: Who Matters in World Trade?

The final step in this analysis assesses the *centrality* of the BRIICS within the world trade network. As indicated in Section 2, this study uses an adaptation of the concept of Betweenness Centrality to integrate the value of trade relationships. The Random Walk Betweenness Centrality (RWBC) index was first used for the study of trade flows by Fagiolo *et al.* (2008). A high RWBC index for country *i* means that the likelihood of country *i* being a part of any given trade chain present within the network is high and therefore it has access to a higher proportion of shorter links to send a 'message' to any other potential country in the world trade network. Furthermore, a high proportion of messages sent by other countries to countries other than *i* will go through *i*. The RWBC thus reflects the trade connectivity (value and number of bilateral trade relationships) of a country and its partners, and its partners' partners, encompassing the whole trade chain. Therefore, this *centrality* measure considers the influence of a country on the whole length of each trade chain in the global network.

Previous studies (Fagiolo *et al.* 2009) report that the distribution of *centrality* indices for the trade network, based on aggregated trade flows across commodities, are left-skewed, confirming the core–periphery structure of the network. That is, there are a few countries with high *centrality* indices and many countries with a low *centrality* index. The countries that have been identified as the *core* countries in past studies (based on total merchandize trade) are those listed in Table 1. It can be seen in the table that the *centrality* core of the world trade network is extremely stable over time. By the year 2000, China and South Korea were part of this core, while countries like the Netherlands and Australia have fallen out.

The *centrality* indices for the four product types (raw materials, intermediate goods, consumer goods, and capital goods) show similar characteristics to previous studies examining total merchandize trade. (Details are available in Table A5 in the Appendix.) For all the product types, the distribution of the *centrality* indices is skewed to the left (core–periphery). Furthermore, the correlation of *centrality* with *node degree* and *node strength* is strongly positive, but there are interesting changes over time. The correlation between *centrality* and *node strength* in 1995 was around 0.90 for all product types, while in 2005 the correlation was closer to 0.50. On the other hand, the correlation between *node centrality* and *node degree* in 1995 was around 0.60 and in 2005 it was still at a similar level. These results suggest that network *centrality* in 1995 was determined mainly by the intensities of the trade relationships and that by 2005 this was no longer the case. Now, the number of trading partners is also important in the determination of a country's *centrality*. This might be interpreted as a sign that globalization has promoted multilateral integration at the expense of deepening trade relationships. This could be evidence of the past successes of the GATT/WTO system. It is of particular relevance that this trend is present in the four products considered here, including in raw materials, and is taking place at a time of proliferation of regional and bilateral trade agreements.

However, country-specific *centrality* indices are most relevant when taking all trade into account. Consequently, the remainder of this section is based on aggregated trade flows. The *centrality* index can be interpreted as an indicator of a country's level of influence on the world trade network. It takes into account the aggregated value of trade (as indicated by world trade shares), the number of trading partners and the role of these partners in the network. The index quantifies the intuitive insight that the impact on the network of a country with a trade value of 100 and four partners that mostly trade among themselves is much less than the impact of a country with the same total trade value that trades with 20 countries that each in turn trade with another 20.

BRIICS *centrality* indices are shown for aggregate trade flows in Figure 2 and Table 5. It is worth highlighting that, with the exception of Indonesia, all the BRIICS countries were situated in the *inner periphery* or inside the *core* of the network by 2005. Furthermore, the *centrality* index has been steadily increasing for most BRIICS countries. Countries in Table 5 and 6 are listed according their 2005 ranking. The last column indicates their ranking (among the same countries) according to their share of world trade in 2005. Some of the differences are striking. Among the countries listed, India has the seventh highest trade share but the fourth highest *centrality* index. All the BRIICS, with the exception of Indonesia, have higher scores of *centrality* than their share of world trade warrants. That might partly explain their increasing role in multilateral negotiations at the expense of countries with higher shares of world trade.

The *centrality* indices are surprisingly sensitive to major policy changes, including trade policy changes. For example, Figure 2 shows with startling clarity the impact of the international sanctions against the South African apartheid regime and the quick recovery of the country once negotiations for the end of apartheid started in 1990; with the liberalization of Nelson Mandela.

Equally remarkable is the performance of China after the 1979 launch of the *'Reforms and Openness'* programme by Deng Xiaoping which included the opening

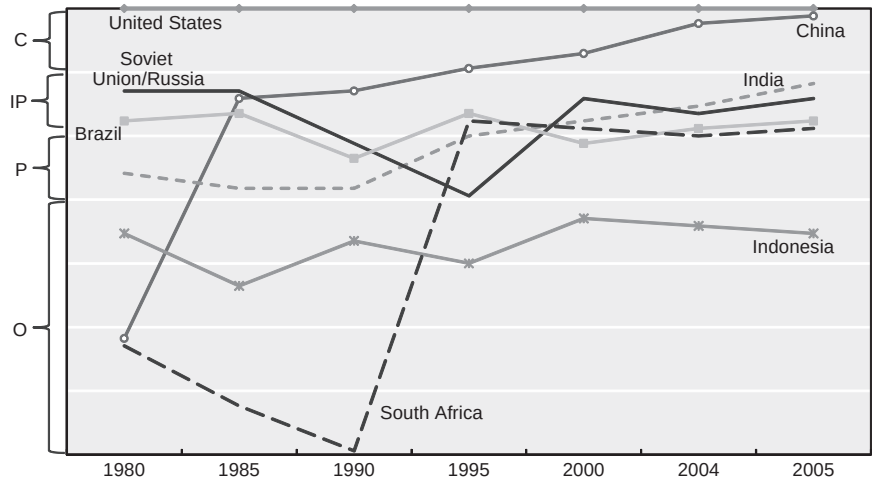

Figure 2. Striding towards the core of the network. Evolution of BRIICS centrality indices (1980–2005).
Source: Authors' calculations based on UN Comtrade database.

Table 5. Centrality of BRIICS countries

Ranked according to 2005 results	1980	1985	1990	1995	2000	2004	2005	Ranked according to share of world trade amongst countries shown
USA	**100**	**100**	**100**	**100**	**100**	**100**	**100**	1
China	74	***93***	***94***	***95***	***96***	***99***	***99***	3
Germany	**98**	**98**	**99**	**99**	**99**	**99**	**99**	2
India	*87*	*86*	*86*	***90***	***91***	***92***	***94***	7
Spain	***93***	***94***	***94***	***94***	***94***	***95***	***94***	4
Soviet Union/Russia	***94***	***94***	*89*	*85*	***93***	***92***	***93***	6
Brazil	***91***	***92***	*88*	***92***	*89*	***91***	***91***	9
South Africa	74	69	65	***91***	***91***	***90***	***91***	11
Thailand	78	*85*	*89*	***92***	***90***	*89*	***90***	8
Mexico	81	81	84	***85***	*86*	84	84	5
Indonesia	82	78	82	80	84	83	82	10
USA	**C**	**C**	**C**	**C**	**C**	**C**	**C**	1
China	O	***I-P***	***I-P***	***I-P***	**C**	**C**	**C**	3
Germany	**C**	**C**	**C**	**C**	**C**	**C**	**C**	2
India	*P*	*P*	*P*	***I-P***	***I-P***	***I-P***	***I-P***	7
Spain	***I-P***	***I-P***	***I-P***	***I-P***	***I-P***	***I-P***	***I-P***	4
Soviet Union/Russia	***I-P***	***I-P***	*P*	*P*	***I-P***	***I-P***	***I-P***	6
Brazil	***I-P***	***I-P***	*P*	***I-P***	*P*	***I-P***	***I-P***	9
South Africa	O	O	O	***I-P***	***I-P***	***I-P***	***I-P***	11
Thailand	O	*P*	*P*	***1-P***	***I-P***	*P*	***I-P***	8
Mexico	O	O	O	***I-P***	*P*	O	O	5
Indonesia	O	O	O	O	O	O	O	10

Notes: For this data set the countries of the former Soviet Union and Russia were grouped as one in order to avoid the change in the number of nodes present in the network after the collapse of the Soviet Union.
C = core and contains countries that are above the 95th percentile of the distribution;
I-P = inner periphery and contains countries that are above the 90th percentile of the distribution and below the 95th percentile;
P = secondary periphery and contains countries that are above the 85th percentile of the distribution and below the 90th percentile, and;
O = out of the periphery and contains countries that are below the 85th percentile of the distribution.
Source: Authors' calculations based on UN Comtrade database.

of foreign trade. India's trade policy reforms in the early 1990s had a dramatic impact on its rate of convergence towards the core of the world trade network. Following that rise it has paralleled China's progression.

Russia, as expected, recovered much of its *centrality* position in the late 1990s. However, the more recent boom in raw material prices has not increased its convergence rate, probably because Russia continues to trade with a relatively small number of countries compared with other BRIICS and *core* countries. Brazil and Indonesia have experienced more stable paths and have not converged towards the *core* group. Interestingly, the two countries seem to move systematically in opposite directions but there is no obvious reason why this should be the case.

The results for the BRIICS countries are particularly interesting when their performance is compared to other countries. Among developing economies, only Korea, Singapore and China can be considered *core* countries in 2005. Outside the BRIICS, Thailand is the only other developing country in the *inner periphery*.

At the same time, the BRIICS performance is very heterogeneous. Russia, China and India are three of the top four performers among countries listed in Table A4. Indonesia has improved its rankings by two percentile points, but both Brazil and South Africa have slightly reduced their *centrality* index and have joined other countries such as Mexico, Singapore, Japan or France, which are struggling to maintain their positions in relation to China and India. However, other countries have experienced a more severe drop in their *centrality* position within the network. This includes, for example, Denmark, Hong Kong China and Australia. Canada, the only G7 country outside the core group, has dropped outside the *inner periphery* since 1990. Further details can be seen in Tables A4 and A5. Table A4 lists *centrality* indices for aggregated trade flows, and Table A5 details *centrality* results for the four product types (raw materials, intermediate goods, consumer goods, and capital goods).

The analysis has revealed very few differences across these four product types. Nonetheless, the nuances revealed by the disaggregation of merchandize trade are consistent with previous studies. Athukorala & Yamashita (2006) analyse patterns of international production fragmentation and its implications for trade patterns. Their findings suggest a realignment of supply–demand (export–import) chains. China's imports of parts and components have grown and this has led to a rapid expansion of manufacturing exports to North America and the EU. To some extent these findings are consistent with those of Rodrik (2006) and Lall & Albaladejo (2004). The general perception is that some countries, like China and India, have increased their presence in the assembly and trade in final products (consumption and capital goods), while others like Brazil, Indonesia, Mexico, and Russia have become relatively more concentrated in the supply of raw materials and intermediate goods (components). Based on the *centrality* results reported in Table A5, it can be argued that countries such as China, India, and Singapore are increasing their degree of influence across all product types but are relatively more central in the networks for consumer goods and capital goods. In contrast, countries such as Argentina, Brazil, Mexico and, to some extent, Russia are (relatively) more central countries (i.e. more influential) in the trade networks for raw materials and intermediate goods. However, the differences are small and both country-specific performances and network characteristics tend to be relatively homogeneous across the four products, indicating that the world trade network is highly unified at least across merchandize trade. In order to pick up specialization effects, further sectoral disaggregation would be required. Future analysis might also consider repeating this study using only export flows. This would produce results that could be directly related to comparative advantages.

7. International Economic Order

The results from the network analysis confirm some interesting factors about the evolution of the world trade network and possible implications for the governance of international institutions. In particular, it is worth highlighting that:

- There have been only three new entrants to the *core* of the world trade network over the last 25 years (Singapore, Korea, and China) and only China has become an established member. However, India is knocking at the door. India and perhaps Russia are likely to displace some of the lowest ranked countries such as Singapore, Korea or perhaps Italy. Australia and

Belgium are at risk of leaving the innerperiphery and being replaced by countries such as Malaysia.

- The inner periphery group is much less stable, with a 50% turnover in the last 10 years. This reflects countries such as Singapore which fluctuate between core and inner periphery, and countries such as Thailand which struggled to maintain rankings above 90%.
- Many more countries have become middle powers, driven by an increase in the number of their bilateral relationships. That means that the increased trade flows of the last decade are driven more by the creation of new bilateral relationships than by the intensification of existing trade flows. This is consistent with the higher than average growth rates for South–South trade reported in previous studies.[9]

In short, globalization has not led to the polarization and marginalization of less well connected countries. On the contrary, the world trade network has become more multilateral, a result that might deserve further probing given the proliferation of bilateral and regional trade agreements in the last decade. It would be particularly interesting to use network analysis to assess whether globalization can be expected to lead to a compression of all integration indicators across countries and particularly of centrality indicators, indicating an erosion in the core–periphery structure of world trade.

The *centrality* index (see Table 5) is the indicator that best summarizes the status of a country within the world trade network. These results suggest that the BRIICS countries, with the exception of Indonesia, are either highly integrated into world trade networks or are currently increasing their degree of integration to such an extent that some of them are now part of the *core*. The analyses of *node degree, node strength,* and *clustering* indices suggest that this is probably the result of a number of influences—the establishment of new trading partnerships, involvement in trading clubs, and/or the intensification of existing trading relationships.

The changing patterns of integration shown here provide evidence that some BRIICS economies could play increasingly valuable roles in international trade organizations such as WTO. The *centrality* index indicates that China, India, and Russia are at the same the level of importance as the highest-income OECD countries. Brazil and South Africa are close behind. Indonesia is an outlier in this group and has yet to break into the periphery.

Unsurprisingly, the analysis confirms the establishment of China as top trading power. If the analysis used aggregated figures for the EU, it is likely that China would be placed third and not second in the overall centrality ranking. However, China has clearly displaced Japan.

The results for India and Russia are particularly interesting. The analysis is based on merchandize trade, and it is likely that if the same analysis could be done to include trade in services, then India would belong to the *core* group. Moreover, India's performance is very much driven by its score in *node degrees;* that is, by the number of new bilateral relationships established since 1991. Russia has followed the opposite path. Its recovery since the collapse of communism has materialized through increasing its *node strength* and *clustering;* that is, by increasing the value of its bilateral trade with its better connected partners. This probably reflects the fact that most new Russian trade has been created with EU members, the USA and probably China, rather than with other emerging countries or the former Soviet Union Republics.

The future of Brazil and South Africa's *centrality* is unclear. The two countries could be inching towards exiting the *inner periphery*. However, their performance in 2005 showed some improvement. Both countries have probably been assisted by the recent boom in commodity prices, but, according to this analysis, establishing new trading relationships, particularly with other emerging middle powers, could be instrumental in maintaining their *inner periphery* status.

Notes

1. See Ottaviano *et al.* (2002); Garlaschelli & Loffredo (2004, 2005); Fagiolo *et al.* (2009).
2. See Athukorala & Yamashita (2006); De Gregorio & Lee (2004); Fagiolo *et al.* (2009).
3. For a review of gravity model approaches see Harrigan (2002).
4. Fagiolo *et al.* (2009) provide statistical evidence for the symmetry of the network and justify the use of total trade as the weights for the links between countries.
5. After excluding countries with zero trade entries for all product classes, unspecified countries and the like.
6. Fagiolo *et al.* (2009) used trade flows for the 1981–2000 period for their analysis.
7. Per cent rank analysis uses the distribution of results for the overall network and assigns a rank for each country in the data set as a proportion of the maximum value (which is always a G8 country and usually the USA).
8. Fagiolo *et al.* (2008).
9. Kowalski & Shepherd (2006).
10. Fagiolo *et al.* (2009) have shown that the network indicators and the network characteristics of the World Trade Network are very robust to different weighting procedures. For example, one can use the actual trade flow as the weight for each link or a weighted trade measure like total trade to GDP ratios.

References

Athukorala, P.-C. (2007) *The Rise of China and East Asian Export Performance: Is Crowding-out Fear Warranted?*, Working Paper 2007/10, Division of Economics, Australian National University, Canberra.

Athukorala, P. & Yamashita, N. (2006) Production fragmentation and trade integration: East Asia in a global context, *North American Journal of Economics and Finance*, 17(3), 233–256.

De Gregorio, J. & Lee, J. (2004) Growth and adjustment in East Asia and Latin America, *Economia*, 5(1), 69–134.

Fagiolo, G., Reyes, J. & Schiavo, S. (2008) On the topological properties of the world trade web: a weighted network analysis, *Physica A*, 387(15), 3868–3873.

Fagiolo, G., Reyes, J. & Schiavo, S. (2009) The world-trade web: topological properties, dynamics and evolution, *Physical Review E*, forthcoming.

Fisher, E. & Vega-Redondo, F. (2006) *The Linchpins of a Modern Economy*, Working paper, Cal Poly.

Garlaschelli, D. & Loffredo, M. (2004) Patterns of link reciprocity in directed networks, *Physical Review Letters*, 93(26), Pt 1: 268701.

Garlaschelli, D. & Loffredo, M. (2005) Structure and evolution of the world trade network, *Physica A*, 355(1), 138–144.

Harrigan, J. (2002) Specialization and the volume of trade: do the data obey the laws?, in: K. Choi & J. Harrigan (eds) *Handbook of International Trade*, London, Basil Blackwell.

Kali, R. & Reyes, J. (2006) The architecture of globalisation: a network approach to international economic integration, *Journal of International Business Studies*, 38, 595–620.

Kali, R. & Reyes, J. (2007) *Financial Contagion on the International Trade Network*, Mimeo, University of Arkansas.

Kowalski, P. & Shepherd, B. (2006) *South–South Trade in Goods*, OECD Trade Policy Working Paper No. 40, OECD, Paris.

Lall, S. & Albaladejo, M. (2004) China's competitive performance: a threat to East Asian manufactured exports?, *World Development*, 32(9), 1441–1466.

Nemeth, R. & Smith, D. (1985) International trade and world-system structure: a multiple network analysis, *Review: A Journal of the Fernand Braudel Center*, 8(4), 517–560.

Newman, M. (2005) A measure of betweenness centrality based on random walks, *Social Networks*, 27, 39–54.

OECD (2008) *Globalisation and Emerging Economies: Selected Policy Issues*, R. Safadi & R. Lattimore (eds) , Paris, OECD.

Onnela, J., Saramaki, J., Kertesz, J. & Kaski, K. (2005) Intensity and coherence of motifs in weighted complex networks, *Physical Review E*, 71, 065103.

Ottaviano, G., Tabuchi, T. & Thisse, J.-F. (2002) Agglomeration and trade revisited, *International Economic Review*, 43(2), 409–436.

Rodrik, D. (2006) *What's So Special about China's Exports?*, NBER Working Paper No. 11947.

Serrano, A. & Boguña, M. (2003) Topology of the world trade web, *Physical Review E*, 68, 015101(R.

Smith, D. & White, D. (1992) Structure and dynamics of the global economy: network analysis of international trade, 1965–1980, *Social Forces*, 70, 857–893.

Snyder, D. & Kick, E. (1979) Structural position in the world system and economic growth 1955–70: a multiple network analysis of transnational interactions, *American Journal of Sociology*, 84, 1096–1126.

Vernon, R. (1966) International investment and international trade in the product cycle, *Quarterly Journal of Economics*, 80(2), 190–207.

Appendix

Let A and W be the binary adjacency matrix and the weighted adjacency matrices described in the text, where the generic entry in A, $a_{ij} = a_{ji}$ is set equal to one if and only the total trade between country i and country j is greater than zero i.e exports of i to j plus imports of i from $j > 0$). Regarding the weighted matrix, W, we simply use the actual total trade values (i.e. $e_{ij} = e_{ji} =$ total trade between country i and j).[10]

In order to avoid biases in the analysis and also to ensure that each entry of the weighed matrix, w_{ij}, is inside the interval [0, 1] for all (i, j) we let the generic entry in W be equal to $w^*_{ij} = 1/2\,(e_{ij} + e_{ji})$. Then the node degree, d_i, and node strength, s_i, for node (country) i are computed as follows:

$$d_i = \sum_j a_{ij} \tag{A1}$$

$$s_i = \sum_j w_{ij}. \tag{A2}$$

For the computation of the (weighted) clustering coefficient, Onella *et al.* (2005) suggest that the clustering coefficient c_i, for node (country) i is computed as follows:

$$c_i = \frac{\frac{1}{2}\sum_{j \neq i}\sum_{h \neq (i,j)} w_{ij}^{\frac{1}{3}} w_{ih}^{\frac{1}{3}} w_{jh}^{\frac{1}{3}}}{\frac{1}{2} d_j (d_i - 1)}. \tag{A3}$$

The clustering coefficient ranges between 0 and 1 and reduces to the clustering coefficient of a binary matrix when the weights become binary. This coefficient takes into consideration all of the edges in a complete triple, while ignoring weighted links not participating in any triangle, and in is invariant to weight permutation for a given triple.

The centrality measure used in this study is actually the Random Walk Betweenness Centrality (RWBC) measure proposed by Fisher & Vega-Redondo (2006), which is an expansion of the binary indicator proposed by Newman (2005). The intuition behind the indicator, and its computation, is as follows. Consider an impulse generated from node h that works its way through the network in order to get to node k. Let $f\,(h, k)$ be the source vector $(N \times 1)$, such that $f_i(h, k) = 1$ if $i = h$,

$f_i(h, k) \neq 1$ if $i = k$, and 0 otherwise. Newman (2005) shows that Kirchoff's law of current conservation implies that:

$$v(h, k) = [D - W]^{-1} f(h, k). \tag{A4}$$

where $v(h, k)$ denotes the $N \times 1$ of nodes voltages, $D = \text{diag(s)}$ and $[D - W]^{-1}$ is computed using the Moore–Penrose pseudo-inverse. Then, this implies that the intensity of the interaction flowing through node i originated from node h and that getting to target node k is determined by:

$$I_i(h, k) = W \cdot |v(h, k) - 1v_i(h, k)| \tag{A5}$$

where $I_h(h, k) = I_k(h, k) = 1$, and therefore the RWBC of node i can be computed as follows:

$$RWBC_i = \frac{\sum_h \sum_{k \neq h} I_i(h, k)}{N(N - 1)}. \tag{A6}$$

The intuitive explanation for betweenness centrality is discussed by Newman (2005) in which he assumes that that a source node sends a message to a target node. The message is transmitted initially to a neighbouring node and then the message follows an outgoing link from that node, chosen randomly, and continues in a similar fashion until it reaches the target node. In the original measure presented by Newman (2005) the probabilities assigned to outgoing edges are all equal but in Fisher & Vega-Redondo (2006) these probabilities are determined by the magnitude of the outgoing trading relationships. Hence links that represent greater magnitude for a trading relationship will be chosen with higher probability. In other words, this centrality measure exploits (randomly) the whole length of the trade chains present in the network for country i and, therefore, is the highest degree measure considered in the analysis since it goes beyond the analysis of trading partners that have one or two degrees of separation from country i and considers the intensities of the trade linkages.

Table A1. Node degree results

	Node degree (Percent rank analysis).											
	Raw materials			Intermediate goods			Consumer goods			Capital goods		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Austria	88	87	81	92	92	90	91	89	91	93	92	91
Belgium-Luxembourg	97	97	94	97	96	97	97	95	92	98	95	93
Denmark	96	96	94	95	94	94	95	93	96	96	97	99
Finland	81	81	74	88	88	87	88	87	86	92	93	90
France	98	98	99	97	96	98	98	93	98	97	96	98
Germany	99	100	100	99	99	100	100	99	100	99	100	100
Greece	91	92	86	86	87	82	90	91	85	88	88	86
Hungary	87	86	74	86	86	78	87	82	81	83	83	85
Iceland	63	60	59	65	58	59	63	55	62	68	61	66
Ireland	91	89	84	91	90	88	91	89	88	93	89	89
Italy	97	96	96	98	98	97	98	96	97	98	96	97
Netherlands	99	98	98	99	97	98	98	98	99	97	98	98
New Zealand	93	91	92	84	85	85	85	83	84	87	86	90
Norway	88	89	86	89	88	88	90	87	85	91	91	90
Portugal	89	88	88	90	89	87	92	92	90	88	89	86
Slovak Republic	72	69	70	85	81	80	82	83	81	84	81	81
Spain	95	95	93	94	93	93	94	94	94	94	92	93
Sweden	89	87	82	94	93	90	95	94	91	96	95	95
Switzerland	93	93	91	95	94	93	94	96	94	95	98	96
Turkey	89	89	89	87	87	89	87	88	88	86	86	87
UK	100	99	98	100	99	99	100	98	100	100	99	99
Argentina	86	85	91	82	81	84	84	83	84	82	79	80
Australia	97	98	95	89	90	89	89	90	89	92	96	92
Canada	95	94	97	93	91	94	92	89	94	94	91	93
Chile	82	85	79	79	78	71	79	78	75	75	69	69
Czech Republic	86	81	83	92	86	86	89	86	86	89	87	87
Japan	95	93	92	97	95	94	97	96	93	99	99	97
Korea, Rep.	89	89	90	93	95	95	93	96	93	95	97	93

Table A1 (*Continued*)

	Node degree (Percent rank analysis).											
	Raw materials			Intermediate goods			Consumer goods			Capital goods		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Malaysia	87	88	81	89	89	90	93	91	93	90	88	88
Mexico	82	82	82	83	83	81	86	85	84	84	84	84
Philippines	61	84	86	65	83	82	59	85	83	63	85	82
Poland	83	85	86	84	82	88	81	79	87	85	82	88
Singapore	91	92	85	88	91	80	85	96	77	87	93	82
Taiwan, China	76	89	90	72	93	92	69	90	90	72	94	93
Thailand	94	94	96	95	98	96	96	98	96	90	94	92
USA	100	100	100	100	100	100	99	100	98	100	100	98
Brazil	90	91	95	90	89	92	88	88	89	89	86	89
China—Hong Kong	96	96	98	96	97	96	96	95	94	95	93	96
India	94	95	97	96	95	99	93	93	98	90	90	96
Indonesia	84	95	93	83	99	95	81	100	96	83	89	88
Russian Federation	75	86	84	70	85	84	68	85	79	72	85	83
South Africa	92	93	96	91	92	92	89	92	92	89	90	92
Bangladesh	76	69	56	78	72	52	79	78	40	64	58	49
Haiti	37	36	29	48	37	38	53	32	37	37	42	40
Tajikistan	13	22	20	28	25	28	24	20	24	23	25	21
Uzbekistan	43	31	36	36	34	34	33	32	32	42	50	36
Sri Lanka	56	52	86	58	59	79	47	49	85	53	52	73
Paraguay	66	55	65	62	44	45	62	40	51	53	37	35
Kazakhstan	41	67	61	42	72	64	37	52	53	42	64	61
Senegal	51	67	74	57	67	72	58	61	68	59	70	73

Source: Authors' calculations based on UN Comtrade database.

Table A2. Node strength results

	Node strength (percent rank analysis)											
	Raw materials			Intermediate goods			Consumer goods			Capital goods		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Austria	82	80	82	93	91	91	93	92	93	91	91	92
Belgium-Luxembourg	97	94	94	97	96	98	96	96	97	95	93	93
Denmark	91	89	89	89	86	85	92	91	89	89	89	87
Finland	81	81	82	89	89	88	86	85	85	89	90	88
France	98	97	96	99	98	99	99	99	99	99	98	98
Germany	99	98	97	100	100	100	100	100	100	99	99	100
Greece	82	80	78	83	82	80	85	85	84	82	82	80
Hungary	79	77	79	82	83	83	84	85	85	82	89	91
Iceland	71	63	64	60	62	63	59	56	59	56	61	61
Ireland	83	81	81	88	92	91	89	90	91	91	93	91
Italy	96	95	95	98	97	97	97	97	98	97	95	96
Netherlands	98	97	96	96	96	97	97	96	96	95	95	96
New Zealand	86	82	81	83	81	77	80	79	80	80	79	78
Norway	95	96	95	88	85	84	88	87	88	88	85	84
Portugal	83	81	80	85	85	84	91	89	86	86	85	84
Slovak Republic	74	73	75	80	80	81	79	81	82	78	81	84
Spain	95	93	93	95	95	95	95	96	96	94	94	94
Sweden	87	85	87	94	93	92	93	93	92	93	93	92
Switzerland	88	84	86	95	94	94	95	94	95	93	92	92
Turkey	84	82	85	86	87	89	87	89	90	84	87	87
UK	99	99	97	98	97	96	98	98	98	98	99	98
Argentina	89	88	84	84	87	84	82	81	80	83	84	82
Australia	94	93	94	90	89	88	90	91	91	90	89	88
Canada	97	98	96	96	98	96	96	97	96	97	97	96
Chile	88	86	89	84	84	85	80	79	79	81	80	78
Czech Republic	79	76	80	85	85	87	85	86	88	87	88	90
Japan	100	100	98	99	99	98	99	98	97	100	100	99
Korea, Rep.	93	92	91	95	96	96	95	95	94	96	96	97

Table A2 (*Continued*)

	Node strength (percent rank analysis)											
	Raw materials			Intermediate goods			Consumer goods			Capital goods		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Malaysia	90	87	88	92	89	88	91	92	89	95	94	94
Mexico	94	94	93	91	94	93	94	95	95	94	96	95
Philippines	77	78	75	81	83	80	78	84	81	88	92	89
Poland	84	85	88	87	88	89	88	88	92	85	88	89
Singapore	87	83	83	94	92	92	94	93	93	98	97	97
Taiwan, China	89	96	100	92	95	95	87	94	92	92	96	95
Thailand	92	88	88	91	90	90	92	89	88	92	91	93
USA	100	100	100	100	100	100	100	100	100	100	100	100
Brazil	92	91	92	93	93	92	90	88	86	90	90	90
China—Hong Kong	96	96	99	97	99	99	98	99	99	96	98	99
India	90	90	92	89	91	93	86	87	90	87	85	86
Indonesia	93	90	90	90	90	90	89	90	87	89	86	86
Russian Federation	81	95	99	77	93	94	89	93	94	84	86	88
South Africa	89	84	86	86	86	86	82	82	83	86	84	85
Bangladesh	72	65	59	76	76	73	76	77	54	67	67	65
Haiti	29	30	32	43	39	35	44	41	38	37	32	24
Tajikistan	17	26	28	23	37	38	14	20	32	23	23	26
Uzbekistan	44	37	40	37	48	51	46	37	40	59	59	58
Sri Lanka	64	55	62	73	72	71	55	55	72	64	68	62
Paraguay	69	59	63	60	57	54	72	60	49	69	56	57
Kazakhstan	27	83	90	36	75	76	51	67	74	49	70	75
Senegal	42	60	55	50	56	53	47	51	55	47	50	52

Source: Authors' calculations based on UN Comtrade database.

Table A3. Clustering index

	Node clustering (percent rank analysis)											
	Raw materials			Intermediate goods			Consumer goods			Capital goods		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Austria	82	76	83	93	92	92	93	93	94	90	90	91
Belgium-Luxembourg	94	93	94	99	98	98	97	96	99	93	93	93
Denmark	88	85	87	86	83	83	90	88	88	87	85	85
Finland	80	78	84	91	88	87	82	82	83	86	87	86
France	97	95	95	100	99	98	98	98	100	97	97	96
Germany	98	94	96	100	100	100	100	99	100	99	99	99
Greece	79	73	77	83	80	79	84	83	84	76	79	77
Hungary	75	71	82	82	82	85	81	85	85	79	89	90
Iceland	77	70	68	64	66	66	60	59	60	53	61	59
Ireland	81	82	84	87	93	93	88	91	92	89	92	92
Italy	94	92	94	98	97	97	98	97	98	95	94	94
Netherlands	96	96	96	97	96	97	96	96	97	94	95	96
New Zealand	86	81	79	78	80	76	75	75	76	75	75	72
Norway	95	98	99	86	84	84	85	87	91	79	82	81
Portugal	80	79	76	85	85	83	89	89	88	83	84	84
Slovak Republic	63	70	77	75	76	80	71	80	83	69	78	83
Spain	93	91	92	94	94	95	95	95	96	92	93	94
Sweden	84	84	88	93	92	91	91	92	92	91	91	90
Switzerland	84	79	82	95	95	94	95	94	96	92	92	92
Turkey	85	78	86	85	87	86	86	89	90	85	86	87
UK	96	97	97	96	96	96	97	98	98	98	98	97
Argentina	86	86	84	84	86	82	78	78	73	82	85	79
Australia	93	92	95	89	89	87	88	91	90	90	89	88
Canada	99	99	98	96	97	96	96	97	95	96	96	95
Chile	89	88	90	87	87	89	79	81	79	84	84	81
Czech Republic	73	72	80	84	86	88	83	86	89	80	85	89
Japan	100	99	99	98	99	99	99	99	96	100	100	99
Korea, Rep.	95	93	93	95	96	96	95	95	94	96	96	98

Table A3 (*Continued*)

	Node clustering (percent rank analysis)											
	Raw materials			Intermediate goods			Consumer goods			Capital goods		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Malaysia	89	85	88	90	90	88	89	90	86	95	95	95
Mexico	95	97	97	92	94	94	93	96	95	95	96	96
Philippines	84	81	75	88	85	82	85	86	81	94	94	93
Poland	83	85	89	89	90	90	89	92	92	84	88	88
Singapore	81	76	79	92	91	93	94	93	93	99	97	98
Taiwan, China	92	96	92	95	95	95	94	94	91	98	98	97
Thailand	90	87	85	90	88	90	90	90	87	93	93	92
USA	100	100	100	99	100	100	100	100	99	100	100	100
Brazil	91	89	91	91	93	92	87	85	84	88	91	89
China—Hong Kong	98	95	98	97	98	99	99	100	97	97	99	100
India	88	88	90	88	89	91	82	84	85	83	83	85
Indonesia	97	90	91	94	89	88	91	89	88	91	87	87
Russian Federation	83	91	100	79	91	92	92	93	93	89	81	88
South Africa	87	83	81	83	83	85	77	77	80	84	82	84
Bangladesh	74	65	59	74	77	77	74	77	56	65	70	70
Haiti	33	44	43	48	46	43	50	51	42	49	41	29
Tajikistan	14	16	29	26	32	32	17	16	32	21	8	27
Uzbekistan	40	31	39	39	45	52	47	39	40	64	61	60
Sri Lanka	68	56	53	74	75	68	57	53	68	66	71	56
Paraguay	66	58	54	57	57	53	73	62	46	74	62	64
Kazakhstan	19	84	93	30	74	78	53	64	77	53	67	74
Senegal	49	58	48	50	51	44	47	45	48	49	44	44

Source: Authors' calculations based on UN Comtrade database.

Table A4. Centrality index (aggregated trade flows). Per cent rank Random Walk Betweenness Centrality (RWBC)

	1980	1985	1990	1995	2000	2004	2005
Australia	95	95	95	94	95	94	92
Belgium-Luxembourg	95	95	96	95	94	93	92
Brazil	91	92	88	92	89	91	91
Canada	92	92	91	88	88	88	88
China	74	93	94	95	96	99	99
Denmark	88	88	92	89	86	85	84
France	99	99	99	99	99	98	98
Germany	98	98	99	99	99	99	99
China—Hong Kong	85	86	88	86	85	84	83
India	87	86	86	90	91	92	94
Indonesia	82	78	82	80	84	83	82
Italy	97	97	97	97	97	96	96
Japan	99	99	98	98	98	98	98
Korea, Rep.	84	91	93	93	92	94	96
Malaysia	77	82	84	88	88	89	89
Mexico	81	81	84	85	86	84	84
Netherlands	96	96	96	96	96	96	95
New Zealand	89	91	87	87	83	88	88
Portugal	85	84	86	86	89	87	85
Singapore	94	96	95	96	95	95	95
South Africa	74	69	65	91	91	90	91
Soviet Union	94	94	89	85	93	92	93
Spain	93	94	94	94	94	95	94
Sweden	90	90	90	84	85	86	86
Switzerland	91	88	91	89	87	86	87
Taiwan, China	72	71	92	91	92	91	89
Thailand	78	85	89	92	90	89	90
Trinidad and Tobago	92	89	80	79	82	82	86
Turkey	64	78	79	82	79	85	85
UK	98	98	98	98	98	97	97
USA	100	100	100	100	100	100	100

Source: Authors' calculations based on UN Comtrade database.

Table A5. Centrality index per product type

	Node centrality (percent rank analysis)											
	Raw materials			Intermediate goods			Consumer goods			Capital goods		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Austria	81	78	78	86	85	85	86	85	86	93	89	89
Belgium-Luxembourg	97	96	94	97	96	96	95	94	94	95	93	95
Denmark	93	87	88	89	88	87	91	89	88	94	92	91
Finland	79	78	77	87	85	83	84	81	80	90	92	90
France	99	98	98	99	99	99	99	99	99	99	99	99
Germany	98	98	96	100	99	99	100	100	99	100	100	100
Greece	87	84	82	80	82	82	87	87	84	84	87	84
Hungary	84	79	76	78	77	75	81	79	79	81	83	86
Iceland	63	50	52	60	50	51	42	33	43	75	68	71
Ireland	86	76	73	84	86	84	83	82	81	85	90	86
Italy	96	96	96	97	97	98	97	97	97	98	98	97
Netherlands	97	96	97	96	95	96	96	95	96	96	96	96
New Zealand	95	92	93	94	90	92	91	88	92	89	88	93
Norway	91	91	92	84	84	80	82	82	83	89	86	85
Portugal	84	81	82	88	88	86	89	91	87	89	89	88
Slovak Republic	67	63	65	77	70	72	71	67	70	80	78	80
Spain	95	94	95	94	93	93	95	96	96	95	95	95
Sweden	83	83	84	89	90	88	89	89	88	94	94	93
Switzerland	88	88	87	92	92	92	92	90	90	91	89	88
Turkey	86	85	87	90	89	91	90	88	91	88	88	88
UK	100	99	97	99	98	98	99	98	98	98	98	98
Argentina	89	86	91	88	86	88	83	83	84	83	82	82
Australia	98	97	99	95	93	95	97	96	96	97	96	96
Canada	95	92	95	92	91	93	88	86	89	92	91	89
Chile	82	82	86	81	81	80	79	78	78	78	75	76
Czech Republic	80	73	72	84	78	79	84	80	81	87	83	85
Japan	99	100	98	98	98	97	98	98	98	99	99	98
Korea, Rep.	89	89	90	96	97	96	94	93	94	95	97	97

Table A5 (*Continued*)

	Node centrality (percent rank analysis)											
	Raw materials			Intermediate goods			Consumer goods			Capital goods		
	1995	2000	2005	1995	2000	2005	1995	2000	2005	1995	2000	2005
Malaysia	90	89	88	89	89	89	93	91	90	92	91	90
Mexico	89	85	90	91	87	87	85	89	87	86	85	87
Philippines	66	86	75	73	87	77	66	86	76	79	87	83
Poland	87	83	83	81	83	86	84	85	85	85	85	87
Singapore	88	88	83	95	92	90	96	97	97	96	96	96
Taiwan, China	85	90	92	87	96	94	79	90	91	84	93	92
Thailand	92	93	89	91	93	91	95	94	93	90	93	92
USA	100	100	100	100	100	100	100	100	100	100	100	100
Brazil	94	93	96	93	91	92	93	92	92	91	90	91
China—Hong Kong	96	97	100	98	100	100	98	99	100	97	97	99
India	92	94	94	93	96	97	92	93	95	88	86	92
Indonesia	91	90	89	90	94	89	87	93	89	87	84	83
Russian Federation	83	99	99	79	95	95	88	96	95	86	94	94
South Africa	93	93	92	95	94	94	94	95	93	93	95	94
Bangladesh	76	67	53	68	63	58	74	68	39	55	63	51
Haiti	26	26	34	30	30	29	26	31	26	21	21	20
Tajikistan	25	16	22	38	44	41	17	23	30	27	31	27
Uzbekistan	48	34	39	63	52	36	59	33	28	70	74	54
Sri Lanka	52	48	61	71	68	68	40	36	64	52	54	56
Paraguay	64	72	81	48	39	48	60	45	39	57	36	40
Kazakhstan	44	91	91	63	75	76	56	62	76	60	78	76
Senegal	34	80	51	45	74	76	45	74	80	41	70	75

Source: Authors' calculations based on UN Comtrade database.