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Belt and Road
China Connectivity Index

Technical Paper

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Contents

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The modelling and results presented here are based on information provided by third parties, upon which Oxford Economics has relied in producing its report and forecasts in good faith. Any subsequent revision or update of those data will affect the assessments and projections shown.

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1. Introduction

This paper sets out the methodological underpinnings to the Belt & Road China Connectivity Index (CCI). It should be read alongside Belt & Road China Connectivity Index – Made to Measure, published by ICBC Standard Bank 4 July 2017, which sets out the findings of the inaugural dataset for CCI.

This methodology paper is split into two sections. In section 2, we define economic connectivity, identify key connectivity dimensions and pillars we quantify, and the data sources used in building up the CCI. In section 3 we discuss how raw data is transformed to construct the CCI, covering normalisation, weightings, interpolation and missing data.

Any queries about the CCI methodology should be directed to Tom Rogers, Associate Director of EMEA Macroeconomic Consulting, Oxford Economics, Email: trogers@oxfordeconomics.com.

2. Index Structure

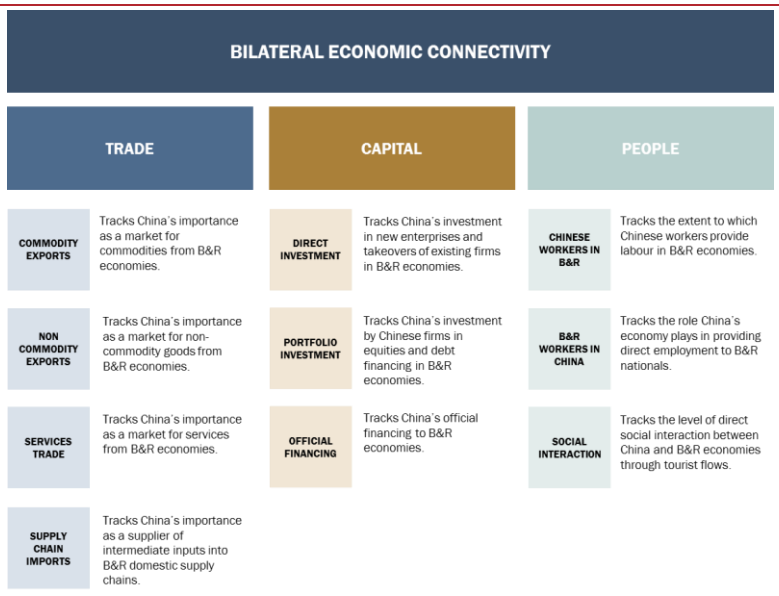
2.1 One index, three dimensions, ten pillars

Economies that are well-connected are those which have a high degree of exchange of both the inputs into economic activity, and the outputs from economic activity. For instance, in the case of the European Union (EU), by liberating barriers to movement in output, capital and people, the EU's member states have achieved an increasingly better-connected continent. Our index replicates this principle, looking at how China and Belt & Road countries are connected by flows in both output and the factors of production.

The index comprises three principle dimensions and 10 secondary pillars. 'Economic connectivity' has three principle dimensions—trade in economic output (incorporating trade in goods and services), the exchange of capital (including different types of investment flows), and the people connectivity (specifically, the exchange of workers and tourists across borders).

Each of these dimensions of economic connectivity is subsequently broken down into individual pillars, reflecting, for example, the different sources and types of capital flows between economies and how trade is made up of goods, commodity and non-commodity, and services. These channels of connectivity are measured in terms of the relative importance of Chinese connectivity, and the importance of each connectivity metric toward overall economic activity in that economy (i.e. rather than absolute nominal flows).

Figure 1 - Dimensions and pillars of economic connectivity



Source: Oxford Economics

Below we set out the indicators used for each pillar of connectivity across the three dimensions. It is important to note that while we have specified the data coverage of each source, and where composites of different data sources are required to build up a time series covering the whole 2005-2015 period, this reflects the general approach. There are countries for which there are missing data for individual years, or where data starts later than for the clear majority of countries. We have taken a pragmatic approach to filling these gaps where necessary, using approaches such as interpolation between adjoining years, or benchmarking trends from comparable countries.

2.2 Trade dimension

Non-commodity goods exports: China's economic growth has propelled it from being the world's 10th-largest importer of non-commodity goods in 2000 to the 2nd-largest in 2016. China is a key export market for Belt & Road manufacturers. This pillar uses UN COMTRADE data to track the importance of China as an export market for Belt & Road economies for non-commodity goods.

Non-commodity goods exports to China are defined as total goods exports to China less commodity exports to China (see below). Nominal US dollar values are used. This dataset has data for the full range of the CCI, from 2005-2015. For the denominator, we use two metrics – firstly total non-commodity exports (again using COMTRADE data), and GDP, using data sourced from national statistics agencies via Haver Analytics.

Commodity exports: Thanks to rapid economic growth and investment in recent decades, China accounted for almost half of global consumption of all major base metals in 2015. This pillar tracks how important commodity trade with China has become for Belt & Road economies, again using UN COMTRADE data for relevant product codes. Within UN COMTRADE a variety of industrial classification typologies are available. We use the UN's Broad Industrial Classification (BEC) codes to define commodities. Specifically, the group includes BEC codes:

- 11 (Food and beverages, primary),
- 21 (Industrial supplies not elsewhere specified, primary), and
- 31 (Fuels and lubricants, primary).

Nominal US dollar values are used. This dataset has data for the full range of the CCI, from 2005-2015. For the denominator, we use total commodity exports from the Belt & Road economies using the same source, and secondly GDP in the respective economy, using national data sources via Haver Analytics.

Services trade: No bilateral data source comparable to UN COMTRADE exists at a global level for services trade, pillar 2 of the trade dimension. Moreover, we were unable to identify an official Chinese source for this data. However, according to the Chinese Statistical Yearbook, travel and tourism spending accounts for 56% of total Chinese service imports from around the world. Of the remaining 44% of Chinese services imports, 20% of service imports are accounted for by transport services, much of which seems likely to be concentrated in key trade centres such as Hong Kong, Singapore and hubs in other regions, rather than being spread across Belt & Road economies. A further 11% is accounted for by intellectual property payments and a range of professional and financial services, which are key comparative advantages of major advanced economies (compared to the primarily emerging markets comprising Belt & Road).

As such, we are confident that for most Belt & Road economies, tourism and travel forms the bulk of total services exports to China. Oxford Economics' Global Tourism Decision Metrics (TDM) databank provides the data source for this pillar.

TDM incorporates data from the United Nations World Tourism Organisation (bilateral arrivals), national tourism agencies (inbound and outbound aggregate and bilateral Travel & Tourism spending) and national statistics/central bank balance of payments data from across the world to estimate bilateral spending for inbound and outbound tourists to and from 185 economies. This allows us to track Chinese tourist spending across the globe, including in the Belt & Road economies.

Again, we choose to track Chinese tourism spending across Belt & Road in nominal dollar terms, and benchmark this against total tourism spending in the Belt & Road economy concerned, as well as benchmarking against GDP, using data from national statistics agencies sourced via Haver Analytics. For the denominator, we use firstly total tourism spending in the respective Belt & Road economy (again using TDM data), and secondly, GDP data sourced from national statistics agencies via Haver Analytics.

Supply chain: China's makes an ever-increasing contribution to the manufacturing and service sector supply chain in other economies. This pillar therefore tracks intermediate and capital goods imports from China to Belt & Road economies, again using UN COMTRADE data for relevant product codes. The product codes for supply chain connectivity, from the BEC industry breakdown on UN COMTRADE, are as follows;

- 41, Capital Goods (excluding transport equipment),
- 521 (Transport equipment, industrial),
- 111 (Food and beverages, primary, mainly for industry),
- 121 (Food and beverages, processed, mainly for industry),
- 21 (Industrial supplies, not elsewhere specified, primary),
- 22 (Industrial supplies, not elsewhere specified, processed),
- 31 (Fuels and lubricants, primary),
- 322 (Fuels and lubricants, processed),
- 42 (Parts and accessories of capital goods except transport equipment),
- 53 (Parts and accessories of transport equipment).

Our unit of measurement is again current price US dollars, and for the denominators for this metric we use firstly total goods imports in these categories for the Belt & Road economies using the same source, and secondly GDP in the respective economy, using national data sources via Haver Analytics.

2.3 Capital dimension

Direct investment: China's early growth phase typically consisted of inbound direct investment as major global corporations sought to take advantage of China's competitive advantage by either establishing new production facilities in China (i.e. "Greenfield investment") or through taking majority stakes in, or control of, existing Chinese firms. But China's role as an outbound investor has become increasingly important, and indications are that Chinese outbound investment surpassed inbound investment for the first year in 2016.

This pillar tracks the stock of direct investment (both greenfield and in majority stakes or takeovers of existing firms) from China into Belt & Road economies using the IMF's Coordinated Direct Investment Survey (CDIS) and UNCTAD. We use a combination of sources here since the most up-to-data data source is IMF CDIS, but there is a shorter historical time series. We therefore extrapolate back from

2009 using growth in the stock of direct investment as reported by the UNCTAD data series.

This pillar gauges the importance of direct investment from China into Belt & Road economies by taking nominal dollar values for the stock of inward investment from China and benchmarking against 1) the total stock of inbound investment, and 2) GDP. in the Belt & Road economy. For the first metric, we again use data from CDIS/UNCTAD for the total stock of inbound direct investment, and for the second we use national accounts data as sourced from Haver Analytics.

Portfolio investment: China's portfolio assets overseas have risen from US $92 billion in 2004 to over US $260 billion in 2015. This pillar tracks the importance of portfolio flows from China to Belt & Road economies.

Unfortunately, an internationally-comparable data source mapping portfolio investment from China into Belt & Road economies is not available, so a composite approach is necessary. For the country detail, we use the IMF's Coordinated Portfolio Investment Survey (CPIS), which has nominal dollar values for portfolio investment between a matrix of over 200 countries. The CPIS has a long time series of data, but the first year for which China is reported is 2015.

As such, we use data from the Chinese State Administration for Foreign Exchange for the aggregate stock of Chinese portfolio investment overseas, to constrain the total across Belt and Road economies from 2014 back to 2005. Within this constrained total, we then use growth in the stock of direct investment to "backcast" stocks of portfolio investment.

Again, we benchmark this nominal dollar stock of Chinese investment in each Belt & Road economy against first the total stock of inbound portfolio investment (using CPIS data, which has a long time-series for most Belt & Road economies) and against nominal GDP, using data from national statistics agencies via Haver Analytics.

Note that this approach implicitly assumes the share of Belt & Road in total outbound Chinese portfolio investment is broadly stable over history. This aligns well with the actual path of the share of Belt & Road in total Chinese outbound direct investment, which is analysed in the main paper. Looking ahead, we will review potential new data sources for this pillar in order to strengthen the robustness of the historical data (i.e. from 2005-2014).

Official investment: China's overseas aid finance has grown from close to zero in 2000 to US $9 billion in 2016, with the promise of a US $20 billion package for Africa in the coming three years. However, historical data is not available from official sources on an internationally comparable basis. As such, this pillar tracks these flows using data from AidData.org.

AidData.org was founded in 2009 in a partnership between Brigham Young University, the College of William and Mary, and Development Gateway. AidData has a searchable portal of one million past and present development finance activities from over 90 funding agencies, including over 10,000 individual official finance flows from China to other economies around the world. The database encompasses the entire period for the CCI, from 2005-2015.

This pillar uses nominal dollar values from AidData.org for flows from China to Belt & Road economies, benchmarking these against GDP in the respective economy, as well as total government spending in the economy. The denominators for these calculations are sourced from national statistics agencies via Haver Analytics.

2.4 People dimension

Chinese workers in Belt & Road: Chinese workers form a key part of the workforce in several Belt & Road economies. This pillar tracks which countries rely most heavily on Chinese workers to support growth, using data from the UN's database on Migrants by Destination and Origin. The UN's database is available for five-year intervals (i.e. 1990, 1995...2015), and we interpolate for years between 2005 to 2010, and 2010 to 2015, to estimate a time series for each Belt & Road economy for the ten years of CCI. For years outside this five-year cycle we will need to use additional sources to track Chinese workers in Belt & Road. We propose to use data from the Chinese Statistical Yearbook on nationals employed overseas to grow the UN series, for intervening years, but will also investigate other methodologies and data sources in the months ahead. For the denominator in this pillar, we use total employment in the respective Belt & Road economy, using data sourced from national statistical agencies via Haver Analytics.

Belt & Road workers in China: Several other economies have a large expatriate workforce in China, with remittances growing ten-fold between 2000 and 2015. This pillar tracks which countries have the highest concentration of workers in China, relative to employment in their own economy. Again, we use data from the UN's Migration database, and interpolate for years in between 2005-2010, and 2010-2015. for years outside this cycle we will again need to use additional data sources to track Belt & Road workers in China. Again, Chinese national data sources can help in this respect, and we will investigate other data sources and methodologies in the months ahead. For the denominator, we use total employment in the respective Belt & Road economy, using data sourced from national statistical agencies via Haver Analytics. In future analysis, we may explore whether bilateral remittances data from the same source can add further depth to CCI.

Social connectivity: Around 68 million overseas citizens visited China in 2016. While not directly a driver of economic prospects in Belt & Road countries, we include the importance of China as a tourist destination given the potential lon ger-term spill over benefits from trade and investment that are linked to tourism.

For this pillar, we track the volume of visitors from Belt & Road economies visiting China, relative to the size of that economy's population. For visitor numbers, we use the UN's World Tourism Organisation databank. To benchmark against population, we use data from Oxford Economics' internal models, sourced from Haver Analytics. The ultimate source data is typically United Nations, or in the case of European economies, Eurostat.

Figure 2 – Data used in the China Connectivity Index

Dimension	Pillar	Indicator	Source	Data periodicity	Approximate historical time-series
Trade Connectivity (60% weighting)	Commodity Exports	Non-commodity goods exports to China % GDP	UN COMTRADE, Haver Analytics	Annual	1962–2016
		Non-commodity goods exports to China % total non-commodity exports	UN COMTRADE, Haver Analytics	Annual	1962–2016
	Non-Commodity Exports	Commodity exports to China % GDP	UN COMTRADE, Haver Analytics	Annual	1962–2016
		Commodity exports to China % total commodity exports	UN COMTRADE, Haver Analytics	Annual	1962–2016
	Services Trade	Tourism spending from China % GDP	Oxford Economics Tourism Decision Metrics	Annual	1995–2015
		Tourism spending from China % total inbound tourism spend	Oxford Economics Tourism Decision Metrics	Annual	1995–2015
	Supply Chain Imports	Supply chain imports from China % GDP	UN COMTRADE, Haver Analytics	Annual	1962–2016
		Supply chain imports from China % total supply chain imports	UN COMTRADE, Haver Analytics	Annual	1962–2016

Capital Connectivity (30% weighting)	Direct Investment	Inward direct investment from China % GDP	IMF, UNCTAD, Haver Analytics	Annual	2003–2015
		Inward direct investment from China % total inward FDI	IMF, UNCTAD, Haver Analytics	Annual	2003–2015
	Portfolio Investment	Total portfolio investment from China % GDP	IMF, SAFE, Have Analytics	Annual	2015–2016
		Total portfolio investment from China % total inward portfolio investment	IMF, SAFE, Have Analytics	Annual	2015–2016
	Official Financing	Official financing from China % GDP	AidData.org, Haver Analytics	Bespoke	1962–2016
		Official financing from China % total government expenditure	AidData.org, Haver Analytics	Bespoke	1962–2016
People Connectivity (10% weighting)	Chinese workers in B&R	Migrants from China % national employment	UN, Haver Analytics	5 yearly interval, annual observations	1990–2015
	B&R workers in China	Migrants to China % national employment	UN, Haver Analytics	5 yearly interval, annual observations	1990–2015
	Social interaction	Visitors to China & national population	UN World Tourism Organisation	Annual	1995–2015
		Visitors to China % total outbound tourists	UN World Tourism Organisation	Annual	1995–2015

Source: Oxford Economics

3. Computing the Index

This section discusses how the data is transformed into an index that tracks and compares bilateral connectivity over time and across B&R economies. There are two parts to this section.

- Firstly, how to transform metrics showing the relative importance of a channel of connectivity with China such that readings/scores are comparable across countries and different pillars ("Normalising" the data).
- Secondly, how the normalised metrics are weighted to provide an overall reading/score for each dimension, and ultimately for the overall index of bilateral connectivity.

3.1 Normalising the data

Once the raw data (i.e. in nominal dollars or numbers of persons) are transformed from their raw format to a metric that shows the relative importance to the economy (e.g. by benchmarking them against total trade, GDP or other appropriate denominator), these series are then normalised, so that they can be assessed over time and across economies in a consistent manner. Our approach follows a standard "z-score" normalisation process. This takes the cross-country average for each indicator in the relevant year and assesses the extent to which a country is above or below this average. The formula for the z-score is set out in Equation 1 below.

Specifically, we calculate median connectivity on each metric for 2015 based on data for the 64 OBOR countries, and then map each economy against this average both in 2015 and then over time back to 2005. A score of 0 denotes the cross-country median for each pillar in 2015. Countries that have more bilateral connectivity on this metric have scores that are above 0, and countries with less connectivity are scored below 0. Subsequently, the pillars are measured against this median score from 2015. This enables connectivity for each pillar to be compared across country, and over time. Finally, scores are capped at a given minimum or maximum value, to prevent outlying (but accurate) observations from skewing results. After analysing the data, Oxford Economics decided to cap z-scores at values of +3 and -3, with any z-scores falling within this range remaining unchanged.

Equation 1 - Z score formula

Standard score, $z = \frac{X-\mu}{\sigma}$

In the equation z refers to the standardised score for the country concerned in the specified year, X refers to the metric (e.g. the country's commodity exports to China as a percent of GDP), μ refers to the median value of that metric across all countries in 2015, and σ is the standard deviation of the metric across all countries in 2015. Standard practice is to compute z-scores using the mean value across all countries. However, given the inherent volatility of the data used in this index, Oxford Economics decided to use the median values when standardising the raw data.

Based on the values of the capped z-scores as discussed above, Oxford Economics then computed distance to frontier (DTF) scores for each indicator within the index to enhance the interpretability of the indicator scores. That is, distance to frontier scores capture the gap between a given economy's performance on a particular indicator and performance of the most connected

country. Calculating the distance to frontier score for each indicator involves rescaling the capped z-scores using the following linear transformation:

Equation 2 – Distance to Frontier formula

DTF = ((X – lowest connectivity score) / (highest connectivity score – lowest connectivity score)) *100

In this equation, 'X' refers to a given economy's capped z-score on a given indicator in a given year, while 'highest score' and 'lowest score' refer to the highest and lowest capped z-scores across all B&R economies on that indicator in 2015. The effect of this transformation is to allocate the highest performing economy on each indicator a score of 100, and the lowest performing a score of 0 in 2015, with DTF scores between 2005 and 2014 all computed relative to best (and worst) practice in 2015. This transformation to a DTF scoring methodology ensures consistency with the approach taken in the Economic Health Index, which accompanies and complements CCI.

3.2 Weighting the data

The computation of the index is based on successive aggregations of scores from indicator level, to dimension level and finally to the overall connectivity score. As such, weightings must be allocated to each indicator and to each dimension to be able to compute the overall connectivity scores. To determine the indicator weights to be used in the index, Oxford Economics analysed and compared the relative importance of each indicator to the B&R economies in aggregate i.e. across all Belt & Road economies. This resulted in the computation of the 'average' indicator weights for the median Belt & Road economy, as outlined in **Error! Reference source not found.**.

Then, to reflect the specific characteristics of the different B&R economies and adjust indicator weightings per country, country specific adjustment factors were computed based on each country's score on each indicator relative to the all countries' median score, with adjustment factors capped at specific maximum and minimum values as computed by Oxford Economics. For example, within the trade dimension of the index, the computation of country specific adjustment factors facilitates the reflection of the relative importance of different exporting industries to the different B&R economies.

For instance, tourism is by far the most important export sector of the Maldives economy, with commodity trade contributing comparatively little to export revenues. In the absence of country specific adjustment factors that scale up the weighting applied to the tourism trade indicators and scale down the weighing applied to the commodity trade indicators for the Maldives, it would then be 'penalised' in terms of its overall connectivity score due to its comparative lack of natural resources, while the importance of its tourism links to China would be underrepresented within the index. Therefore, by creating country specific weighting adjustment factors based on its score on each indicator relative to the all countries' median score, the Maldives gets the largest upward adjustment of all B&R economies on the tourism indicators, and amongst the largest downward on the commodity trade indicators. This effectively customises the composition of the trade dimension to better reflect the structure of the Maldives economy.

To arrive at the final indicator weights for each country, the 'average' indicator weights were multiplied by the country specific adjustment factors for each country and the resulting weights were then re-scaled to ensure that weightings summed to 100% within each dimension. A summary of the minimum, median, and maximum weights applied within each dimension and across countries is set out

in Figure 3[1]. Note that these will only sum to 100% in the case of the median weights, since the minimum and maximum columns will reflect different countries across different indicators. An illustration of how the weights differ in the Trade dimension of connectivity for two very different economies is set out in Figure 4.

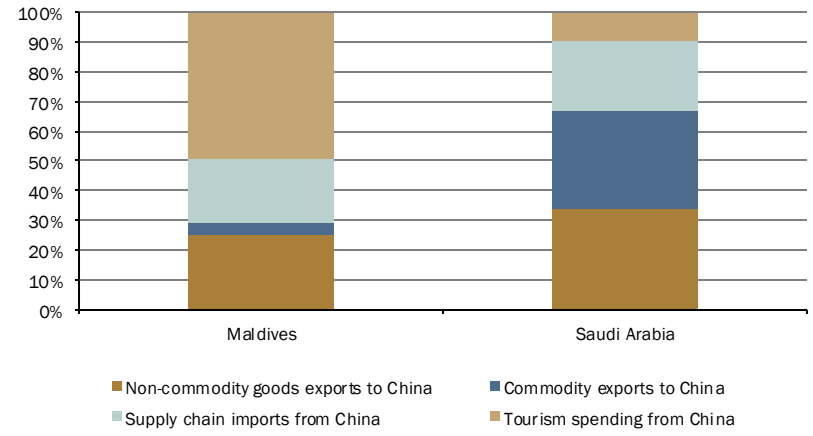
Finally, and based on the analysis of the relative importance and quality of data available on trade, capital and people connectivity, weights of 60%, 30% and 10% were applied to each dimension respectively when computing the overall connectivity scores for each country. These dimension weights reflect a range of considerations, including the generally-greater importance of trade to GDP than capital investment for Belt & Road economies, and the numbers of indicators felt to be of relevance within each dimension.

Figure 3 – Weights used in the China Connectivity Index

		Weight within dimension		
Dimension	**Indicator**	**Min**	**Median**	**Max**
Trade Connectivity (60% weighting)	Non-commodity goods exports to China as % GDP	12.40%	18.75%	75.00%
	Non-commodity goods exports to China as % total non-commodity exports	0%	18.75%	34.20%
	Commodity exports to China as % GDP	0%	6.25%	21.30%
	Commodity exports to China as % total commodity exports	0%	6.25%	21.30%
	Tourism spending from China as % GDP	0%	18.75%	24.80%
	Tourism spending from China as % total inbound tourism spend	0%	18.75%	24.80%
	Supply chain imports from China as % GDP	0%	6.25%	46.10%
	Supply chain imports from China as % total supply chain imports	0%	6.25%	25.90%
Capital Connectivity (30% weighting)	Inward direct investment from China as % GDP	10.60%	25.00%	33.30%
	Inward direct investment from China as % total inward FDI	10.60%	25.00%	33.30%
	Total portfolio investment from China as % GDP	9.30%	15.00%	28.10%
	Total portfolio investment from China as % total inward portfolio investment	9.30%	15.00%	28.10%
	Official financing from China as % GDP	5.30%	10.00%	22.90%
	Official financing from China as % total government expenditure	5.30%	10.00%	22.90%
People Connectivity (10% weighting)	Migrants from China as % national employment	0%	17.50%	25.90%
	Migrants to China as % national employment	0%	17.50%	25.90%
	Visitors to China as % national population	24.10%	32.50%	50.00%
	Visitors to China as % total outbound tourists	24.10%	32.50%	50.00%

Source: Oxford Economics

Figure 4 -Trade dimension weights by type of trade, Maldives and Saudi Arabia



Source: Oxford Economics

[1] Since the minima apply to more than one economy for many pillars we do not specify which countries are the minima and maxima. However, as noted, these reflect the characteristics of the respective economy, e.g. the weighing for tourism in the trade dimension is highest for Maldives, at 25%, and the weighting for commodity trade is highest for Iraq, at 21%.

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