Food and Agriculture Organization
of the United Nations

Mapping global value chain (GVC) participation, positioning and vertical specialization in agriculture and food

Background paper for
The State of Agricultural Commodity
Markets (SOCO) 2020

Mapping global value chain (GVC) participation, positioning and vertical specialization in agriculture and food

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The State of Agricultural Commodity Markets (SOCO) 2020

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Abbreviations and acronyms

BM	Borin and Mancini
DV	Domestic value-added
DVX	Indirect domestic value-added
FVA	Foreign value-added
GDP	Gross domestic product
GVCs	Global value chains
HIC	High-income country
ICIO	Inter-country input-output
IDB	Inter-American Development Bank
IDE–JETRO	Institute of Developing Economies Japan External Trade Organization
IMF	International Monetary Fund
ISIC	International Standard Industrial Classification of All Economic Activities
KWW	Koopman, Wang and Wei
MNE	Multinational enterprise
OECD	Organisation for Economic Co-operation and Development
RVA	Returned value-added
TiVA	Trade in value-added
UNCTAD	United Nations Conference on Trade and Development
VA	Value-added
VAX	Value-added exports
VS	Vertical specialization
WB	World Bank
WIOD	World input-output tables
WTO	World Trade Organization

Summary

This Final Technical Note includes:

A policy note with a short review of the literature on the state-of-art methodologies for computing indicators for global value chain (GVC) participation, positioning and vertical specialization.

A Data set, in Excel format, that includes time series of GVC indicators computed at country/industry level for the period from 1990 to 2015 for agriculture and food sectors for all countries with data in the EORA dataset.[1]

[1] Due to some inconsistencies in the Eora data, the Republic of the Sudan and the Republic of Zimbabwe are not included in the Northern Africa and Eastern Africa sub-regions, respectively.

Chapter 1

Policy note

1 Policy note

1.1 Introduction

The increasing international fragmentation of production that has occurred over the last decades has affected both trade and production: these activities have become increasingly organized around what is commonly referred to as global value chains (GVCs). GVCs can be defined as the full range of activities – dispersed across different countries – that firms and workers engage in to bring a product from its conception to its end use (see Gereffi and Fernandez-Stark, 2011).

The diffusion of GVCs has challenged the conventional wisdom on how we look at and interpret trade. Conventional measures of trade only measure the gross value of exchanges between partners. They are not able to reveal how foreign producers, upstream in the value chain, are connected to final consumers at the end of the value chain and are no longer a precise measure of how final demand in importing countries activates the exporters' production (WTO, 2019).

Furthermore, when production is organized in sequential processing stages in different countries, intermediate goods and services cross borders several times along the chain, often passing through many countries more than once. This process leads to a significant amount of "double counting" in global trade. Consequently, the country of the final producer appears to capture most of the value of goods and services traded, whereas the role of countries providing inputs upstream is overlooked.

A GVC can therefore be studied by tracing the value added along these production chains (Cattaneo *et al*., 2013; OECD–WTO, 2012).[1] New relevant questions can also be answered by applying the value-added approach such as assessing the level of country and sector participation and the country's position in the international sharing of production.

Many initiatives and efforts have been recently developed to address these issues. New datasets have been compiled by combining input–output tables with detailed bilateral trade statistics. These Inter-Country Input-Output (ICIO) tables provide a comprehensive map of international transactions of goods and services in a large dataset that combines the national input-output tables of various countries at a given point of time (see Figure 1 in Appendix D). Since the tables contain information on supply–use relations between industries and across countries, we can identify the vertical structure of international production sharing and measure cross-border value flows for a country or region (Inomata, 2017). Hence, these ICIO tables can be used in combination with long-established accounting relationships (Leontief, 1936) to pin down the links between the country-sector where the value of production originates and the market where it is absorbed in final demand (Borin and Mancini, 2016). Theoretically, we can track the value-added generation process of every product in every country at every stage of production. ICIO tables also allow us to investigate trade and production links by identifying the gross domestic product's (GDP) share of a country that is embedded in its own total exports (value added created by domestic production factors) and the foreign country's GDP share embedded in the same total exports (value-added created by foreign production factors) (see below).[2]

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[1] Value added reflects the value that is added by industries in producing goods and services. It is equivalent to the difference between industry output and the sum of its intermediate inputs.

[2] More precisely, a country's GDP is the sum of its value-added exports plus its domestic value added consumed at home, including domestic value added that is initially exported but imported back and consumed in the initial producing country (see KWW, 2014). By adding the foreign value added in a country's exports that are ultimately absorbed in the foreign

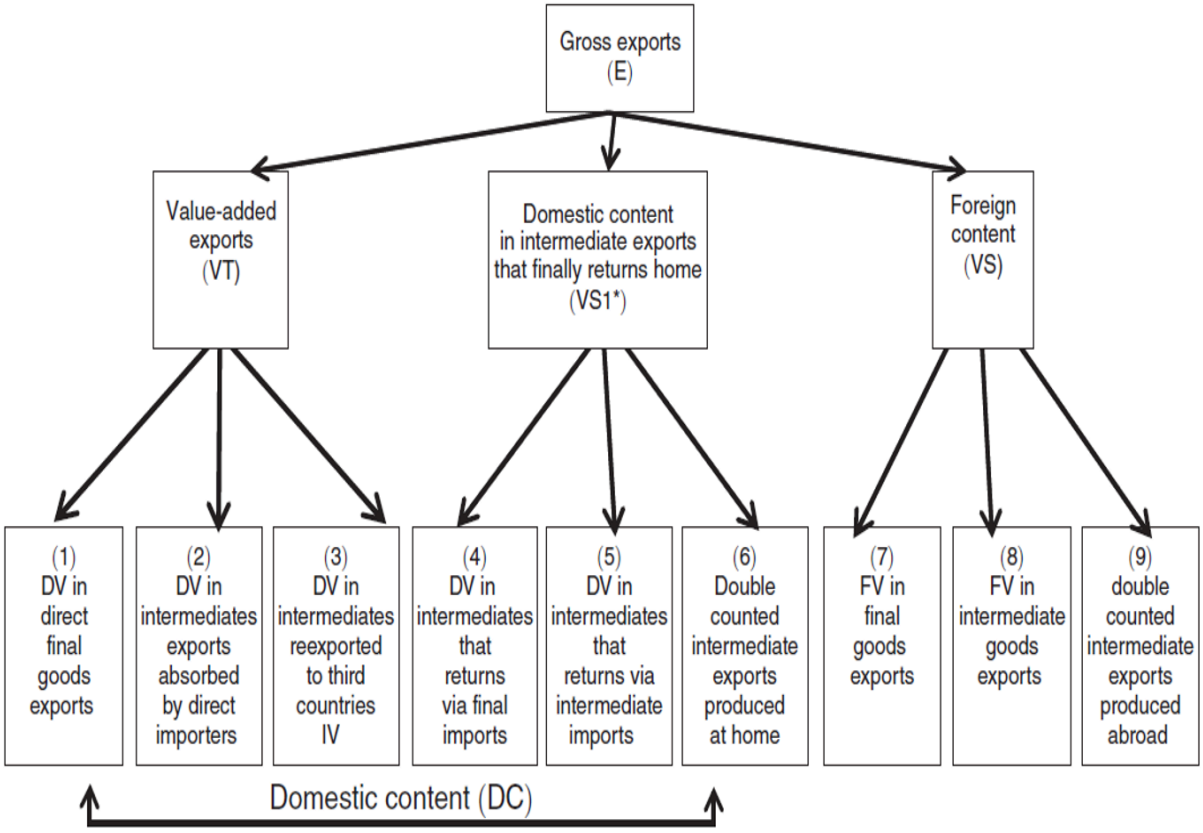
The new datasets based on ICIO tables include: the TiVA database by OECD–WTO, the World Input–Output Database (WIOD) and the EORA tables (OECD–WTO, 2012; Timmer *et al*., 2015; Lenzen *et al*., 2013).

New methodologies have also been developed to exploit these data. These methodologies decompose gross trade flows in different value-added components and allow new GVC indicators to be computed (see, among others, Hummels *et al*., 2001; Daudin *et al*., 2011; Johnson and Noguera, 2012; Koopman, Wang and Wei, 2014; Fally, 2012; Antràs *et al*., 2012; Antràs and Chor, 2013, 2018; Wang *et al*., 2016). By using these new indicators, the production length (more or fewer production stages between primary inputs and final goods) and the degree of participation in GVCs at country and sector levels can be identified. One of the most widely used decomposition methodologies is that proposed by Koopman, Wang and Wei (KWW), (2014) who provide a complete exposition of the key concepts needed when calculating trade in value-added terms. Specifically, they fully decompose gross exports into various sources of value-added and connect official gross statistics to value-added measures of trade. Specifically, they break gross exports down into nine different components (see Figure 1) of domestic and foreign value-added plus double counted items (that arise when intermediate goods cross borders multiple times). The result is a complete picture of the value-added generation process in which various preceding formulas for measuring value-added trade are systematically integrated into a single accounting framework. This method encompasses most of the methodologies previously proposed in the literature (for example, Hummels *et al*., 2001; Daudin *et al*., 2011; and Johnson and Noguera, 2012). KWW (2014) show that gross exports do not in general consist only of value-added that can be traced back to GDP generated either at home or abroad. Instead, they highlight that some trade flows are purely double-counted such as when intermediate inputs cross a country's borders several times in the different stages of production.

Albeit providing useful insights, the original Koopman *et al*. (2014) decomposition presents some important shortcomings and limitations (Borin and Mancini, 2019). First, they correctly measure the total domestic value-added in exports, but the breakdown by destination market is imprecise. Second, their measures of the value-added generated abroad and foreign double counted items in total exports are incorrect, since they overstate the latter component. Third, which is very important for this technical note, the KWW decomposition neglects the bilateral and sectoral dimensions of trade flows. This means, for instance, that it cannot be applied to analyse all the direct and indirect linkages between countries and sectors within the production networks. Hence, it may be inadequate for analysing a country's linkages within the GVCs, for example.

country we get part of the foreign country's GDP. The "pure double-counted" terms are not part of either country's GDP.

Figure 1 Koopman *et al.* (2014) gross exports decomposition



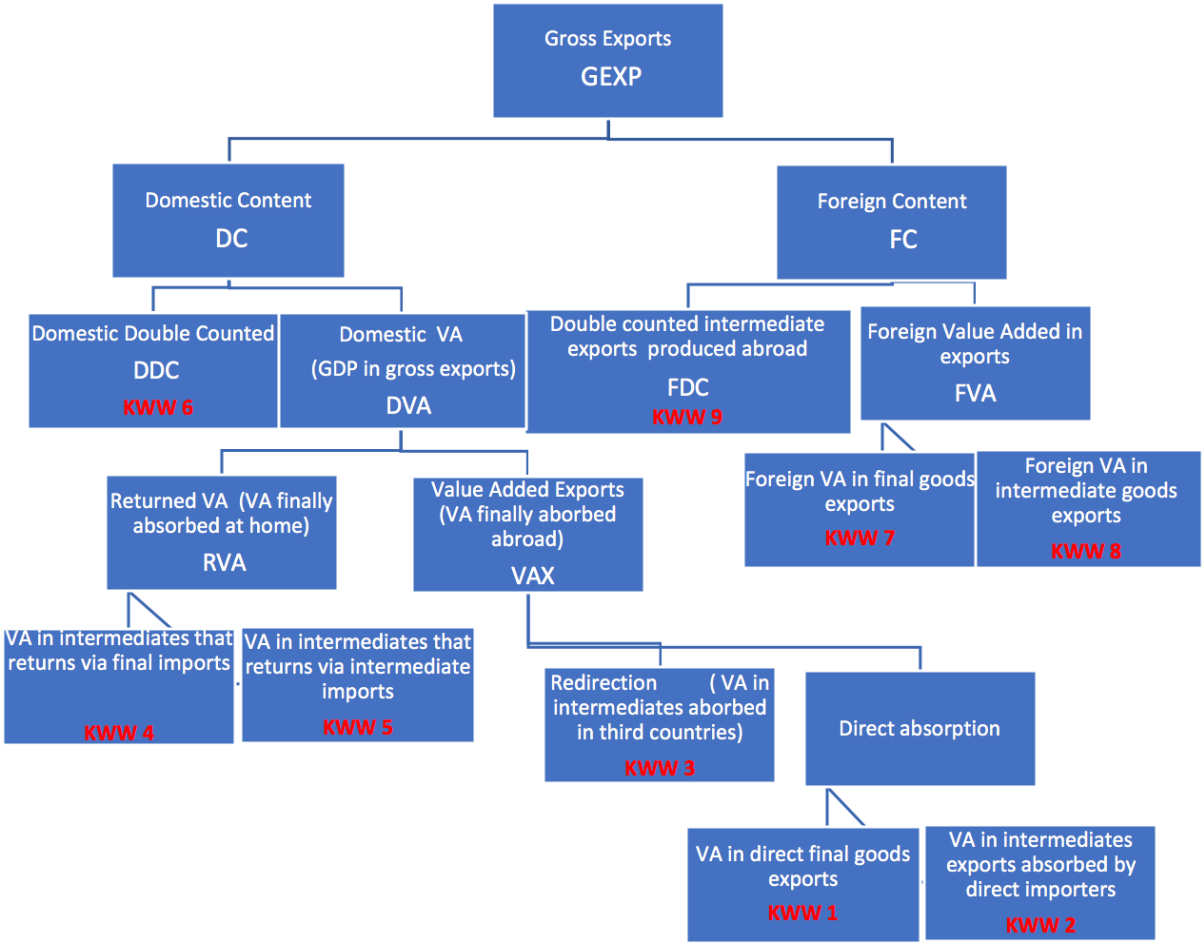
Notes: (i) Value-added exports by a country equals (1) + (2) + (3); (ii) GDP in exports equals (1) + (2 (3) + (4) + (5); (iii) Domestic content in a country's exports equals (1) + (2) + (3) + (4) + (5) + (6); (iv) (7) + (8) + (9) is labelled VS, and (3) + (4) + (5) + (6) is part of VS1 labelled by Hummels *et al.* (2001); (v) (4) is also labelled VS1* by Daudin, Rifflart, and Schweisguth (2011); (vi) (4) through (9) involve value added that crosses national borders at least twice, and are the sources of multiple counting in official trade statistics. Source: Koopman *et al.* (2014)

To address this issue, in this technical note, we have referred to the Borin and Mancini (2015, 2019) extension of the Koopman *et al*. (2014) methodology. Borin and Mancini (2015 2019) provide exhaustive and rigorous value-added decompositions of exports at the aggregate, bilateral and sectoral levels that are consistent with the KWW framework and overcome shortcomings that affect the KWW decomposition and other previous attempts to obtain a bilateral counterpart. Following the rationale proposed by Nagengast and Stehrer (2016), Borin and Mancini (2015) propose two different ways to account for value-added in bilateral trade: the "source-based approach" that takes the perspective of the country where the value-added originates and the sink-based approach that takes the perspective of the country of final demand. In both cases, the original components in KWW can be exactly retrieved by summing up the bilateral export flows across all destinations.

In particular, BM (2015, 2019) provide proper definitions for some components that are incorrectly specified by KWW: i) the domestic value-added that is directly (and indirectly) absorbed by the final demand of the importing country; ii) the foreign value-added in exports; iii) the double counted items produced abroad. They also overcome the main problems that make imprecise and at least partially incorrect the value-added decompositions of bilateral exports previously proposed in the literature (see BM, 2015 and 2019 for technical details). Figure 2 shows the BM refinement of the KKW decomposition.

The complete bilateral decomposition is reported in Appendix A.

Figure 2 Borin and Mancini (BM) refinement of the Koopman, Wang and Wei (KKW) breakdown of aggregate exports



Source: Borin and Mancini (2016)

To address this issue, in this note we have referred to the Borin and Mancini (BM) (2015, 2019) extension of the Koopman *et al*. (2014) methodology and calculated the following value-added components of gross exports (see Appendix A for a more formal definition):

- The domestic value-added (DVA), that is value-added exported in final or intermediate goods. This is part of the Domestic Content – the part of gross exports that originated in the country – and is also a measure of GDP in gross exports (see Figure 1) or in intermediates absorbed by direct importers.
- The foreign value-added (FVA) that is value-added contained in intermediate inputs imported from abroad, exported in the form of final or intermediate goods. This is part of the Foreign Content – the part of gross exports that originated abroad (see Figure 1).
- The returned value-added (RVA) that is domestic VA in intermediates exported, re-imported and absorbed into the domestic economy. This is part of the DVA (see Figure 1).

1.2 Vertical specialization measures

One of the most important changes in the nature of international trade over the past two decades is the division of the production chain, with different stages of production located in different countries. Firms use production plants in different countries in order to exploit powerful locational advantages such as proximity to markets and access to relatively inexpensive factors of production. This international production is associated with increased trade in parts and components whereas countries are vertically linked – that is, when international production prompts countries to specialize in particular stages of a good's production. In that case, "a sequential mode of production arises in which a country imports a good from another country, uses that good as an input in the production of its own good, and then exports its good to the next country; the sequence ends when the final good reaches its final destination" (Hummels *et al.*, 1998). Scholars use the term "vertical specialization" to describe this mode of production (Hummels *et al.*, 2001).

Vertical specialization involves the increasing interconnectedness of production processes in a sequential, vertical trading chain that stretches across many countries, with each country specializing in particular stages of a good's production sequence. The production of a finished product thus involves the participation of many economies, with countries specializing in different fragments of the vertical production chain. This phenomenon has been studied quite extensively by trade economists (see, among others, Balassa, 1967; Findlay, 1978; Krugman, 1995; Feenstra and Hanson, 1996, 1997; Feenstra, 1998; Deardorff, 1998; Jones and Kierzkowski, 1997; Dixit and Grossman, 1982; and, Arndt, 1997).

More recently, several researchers have examined the issue of vertical specialization on a systematic basis and proposed different measures.

In the seminal paper of 2001, Hummels, Ishii, and Yi propose a "Vertical Specialization Index" (VS) (see VS reported as "Foreign Content" in the KWW framework, Figure 1) – a narrower concept of vertical specialization – that is the use of imported inputs to produce goods that are exported. This implies that: i) the production sequence of a good involves at least two countries; and that ii) during this sequence, the good-in-process crosses at least two international borders. This index includes both the directly and indirectly imported input content in exports. It means that imported inputs in exports are considered as a single category, without distinguishing between the part that originated abroad and the part that was originally produced by the country itself and then re-imported.

A second measure, also proposed by Hummels, Ishii, and Yi (2001) and labelled VS1, looks at vertical specialization from the export side, and measures the value of intermediate exports sent indirectly through third countries to final destinations (see the KWW framework, Figure 1).

Several more recent articles generalize the vertical specialization concept of Hummels, Ishii, and Yi (2001) and capture different dimensions of international flows of value-added.

Daudin, Rifflart, and Schweisguth (2011) reallocate the value-added contained in trade in final goods to each country that has participated in its production. They propose a measure of vertical specialization that computes the value of a country's exported goods that are used as imported inputs by the rest of the world to produce final goods which are shipped back home. Since it is a subset of VS1, they call it VS1* (see the KWW framework, Figure 1).

Finally, Johnson and Noguera (2012) suggest a measure of vertical specialization, the value-added exports (VAX), which is value-added produced in a country and absorbed abroad (see the VAX measure in the BM framework, Figure 2). They propose to use the ratio of value-added exports to gross exports – the so-called "VAX ratio" – as a summary measure of value-added content of trade.

In this note, following BM (2019), we computed the vertical specialization indicator as foreign value added and both domestic and foreign double counting on total exports (see Appendix B for a formal definition).

1.3 GVC participation measures

An important question raised in the GVC empirical literature has been to what extent individual countries and sectors are involved in international production networks.
In the past, simple indicators (such as market shares, geographical composition of imports and exports, bilateral trade balances, sectoral indices of specialization, etc.) could provide a satisfactory picture of a country's role in international markets and its evolution over time. With the increasing fragmentation of production, these indicators have become inadequate.

Some measures for GVC participation have then been developed, such as, for example, imported input shares of gross output, total inputs, or exports. However, these measures do not accurately characterize the extent of a country's involvement in such chains (see Hummels *et al*., 2001; Haltmeier, 2015). This is because they are unable to assess the extent to which imported intermediates are used in a country's exports as opposed to domestic production (Aslam *et al*., 2017).

The Hummels *et al*. (2001) measure of "vertical specialization" (the VS measure, see above), is probably one of the first and most popular measures of participation of a country in the phases of international production chains. However, as pointed out by the authors themselves, this is a partial measure of participation in global value chains since it only considers the backward linkages (that is, it measures the import content of a country's exports). They also suggest considering the exports of intermediate products that later are further processed and re-exported as the VS1 measure (see above).

Following the seminal article of Hummels *et al*. (2001), various measures of a country's integration in international production networks have been proposed.

Using some of the trade in value-added components of their decomposition, KWW (2010) propose one of the most widely used indicators of GVC participation in the field literature. They calculate GVC participation by using the FVA component and the "indirect domestic value-added" (DVX) component (that is, the domestic value-added in intermediate goods further re-exported by the partner country). More specifically, FVA is referred to as a measure of "backward participation", given that it measures imported intermediate inputs that used to generate output for export. DVX captures the contribution of the domestic sector to the exports of other countries and indicates the extent of involvement in GVC for relatively upstream industries. It can be considered as a measure of "forward GVC participation".

By expressing both measures as a percentage of exports, the formula for GVC participation is as follows:

$$GVC\ Participation = \frac{FVA + DVX}{Gross\ Exports}$$

The larger the ratio, the greater the intensity of involvement of a particular country (or sector) in GVCs.
Other studies have measured a country's forward GVC participation by identifying the export components that are later re-exported by the direct importer (see, among others, Rahman and Zhao, 2013; and Ahmed *et al*., 2017). However, these contributions rely on the KWW decomposition of gross exports. As discussed, this methodology does not properly allocate countries' exports between the share that is directly absorbed by importers and the one that is re-exported abroad. The resulting measures of GVC participation are thus imprecise.

In this work, in line with the adopted decomposition of gross exports, we follow Borin and Mancini (2019) and calculated their measure of overall GVC participation. This is given by the sum of a 'backward' component, corresponding to the VS Index, and a 'forward' component, the VS1 indicator suggested by Hummels *et al*. (2001).

The formula is as follows:

$$GVC\ overall\ Participation = \underbrace{GVCbackward}_{VS} + \underbrace{GVCforward}_{VS1}$$

Appendix B includes a formal definition of this measure.

1.4 GVC positioning measures

Recently, a strand of the international trade literature has developed measures of the positioning of countries and industries in GVCs (see Fally, 2012; Antràs *et al*., 2012; Antràs and Chor, 2013; Fally and Hillberry, 2015; Alfaro *et al*., 2019; Millerand Temurshoev, 2017; Wang *et al*., 2017).

Using the global Input-Output tables, with information on the various entries, it is now possible to compute the implied upstreamness or downstreamness of specific industries and countries.

To do this, a common approach is to consider the extent to which a country-industry pair sells its output for final use to consumers worldwide or instead sells intermediate inputs to other producing sectors in the world. A sector that sells disproportionately to final consumers would appear to be downstream in value chains whereas a sector that sells little to final consumers is more likely to be upstream in value chains.

Following this approach, in this work, we have computed 4 measures of GVC positioning. The first two measures are the most popular in the literature. The others two are simpler versions of those two measures and have been recently developed by Antràs and Chor (2018) (see Appendix C for a formal definition of these measures by equations).

The first indicator is a measure of distance or upstreamness of a production sector from final demand, which was developed by Fally (2012), Antràs *et al*. (2012) and Antràs and Chor (2013).[3] Fally's model, as well as the variation proposed by Antràs and others (2012), captures the average

[3] Though the arguments used to develop the index differ in Fally (2012) and Antràs and Chor (2013), Antràs et al. (2012) emphasize that the resulting indexes are equivalent.

number of production stages by pegging the endpoint of the sequence at final consumption, which enables us to measure the distance to final demand of a product along the production chains. More specifically, this measure (labelled U in Antràs and Chor 2018 and given the same name in our dataset) aggregates information on the extent to which "an industry in a given country produces goods that are sold directly to final consumers or that are sold to other sectors that themselves sell disproportionately to final consumers. A relatively upstream sector is thus one that sells a small share of its output to final consumers, and instead sells disproportionately to other sectors that themselves sell relatively little to final consumers" (Antràs and Chor, 2018). Building on these ideas, final goods can be considered one step away from demand, inputs directly used to produce final goods are two steps away from demand, inputs used to produce inputs are three steps away from demand, and so on. Furthermore, this count, is weighted by the share of the value of output at each production stage in total output.

The second measure, originally proposed by Fally (2012), is based on a country-industry pair's use of intermediate inputs and primary factors of production. It captures the distance or downstreamness of a given sector from the economy's primary factors of production (or sources of value-added). According to this measure (labelled D), an industry in each country is downstream if its production process embodies a larger amount of intermediate inputs relative to its use of primary factors of production. Conversely, if an industry relies disproportionately on value-added from primary factors of production, then this industry is relatively upstream.

In addition, we have also calculated simpler versions of these two measures of GVC positioning.

The first one (labelled F/GO) reduces the indicator in Antràs *et al*. (2012) to the share of a country-industry's output that is sold directly to final consumers. A lower value of this ratio is associated with a higher upstreamness from final use. The second one (called VA/GO) reduces the Fally (2012) measure of distance from value-added to the share of a country-industry's payments accounted for by payments to primary factors. Large values of this measure are associated with lower downstreamness or higher upstreamness.

We computed these indicators at the country-industry level for the "Agriculture" and "Food and Beverages" sectors (sectors 1 and 4, respectively) for all the countries in the EORA dataset for the period 1995–2015.

Appendix A Borin and Mancini (2019) bilateral decompositions of gross exports

Here we present the BM full sink-based decomposition of bilateral exports from country *s* to country *r*. The enumeration of the components recalls the original KWW (2014) components that can be simply obtained by summing the corresponding items across the different bilateral (or sectoral-bilateral) trade flows. The BM (2019) decomposition can be expressed by the accounting relationship showed in Figure 1A.

Here note that $\boldsymbol{Y_{sr}}$ indicates the demand vector of final goods produced in *s* and consumed in *r*, **B** is the global Leontief inverse matrix for the entire inter-country model, **A** is the global matrix of input coefficients, $\boldsymbol{V_s}$ incorporates the value-added shares embedded in each unit of gross output produced by country s, $\boldsymbol{E_{s\_}}$ is the vector of total exports of country s for the N sectors, and $\boldsymbol{u_N}$is the 1 x N unit row vector.

Figure 1A BM (2019) decomposition of bilateral exports

$$
\begin{aligned}
\mathrm{u}_N\mathrm{E}_{sr} = {} & \overset{1}{\mathrm{V}_s\mathrm{B}_{ss}\mathrm{Y}_{sr}} \\
& + \mathrm{V}_s\mathrm{B}_{ss}\mathrm{A}_{sr}(\mathrm{I}-\mathrm{A}_{rr})^{-1}\left[\overset{2a}{\mathrm{Y}_{rr}} + \overset{2b}{\sum_{j\neq r}^{G}\mathrm{A}_{rj}\mathrm{B}^{\natural}_{jr}\mathrm{Y}_{rr}} + \sum_{j\neq r}^{G}\mathrm{A}_{rj}\overset{2c}{\sum_{k\neq s,r}^{G}\mathrm{B}^{\natural}_{jk}\mathrm{Y}_{kk}}\right] \\
& + \mathrm{V}_s\mathrm{B}_{ss}\mathrm{A}_{sr}(\mathrm{I}-\mathrm{A}_{rr})^{-1}\left[\overset{3a}{\sum_{j\neq r,s}^{G}\mathrm{Y}_{rj}} + \sum_{j\neq r}^{G}\mathrm{A}_{rj}\overset{3b}{\sum_{l\neq s,r}^{G}\mathrm{B}^{\natural}_{jr}\mathrm{Y}_{rl}}\right. \\
& \qquad \left. + \sum_{j\neq r}^{G}\mathrm{A}_{rj}\overset{3c}{\sum_{k\neq s,r}^{G}\mathrm{B}^{\natural}_{jk}\mathrm{Y}_{kr}} + \sum_{j\neq r}^{G}\mathrm{A}_{rj}\overset{3d}{\sum_{k\neq s,r,l}^{G}\sum_{l\neq s,r}^{G}\mathrm{B}^{\natural}_{jk}\mathrm{Y}_{kl}}\right] \\
& + \mathrm{V}_s\mathrm{B}_{ss}\mathrm{A}_{sr}(\mathrm{I}-\mathrm{A}_{rr})^{-1}\left[\overset{4a}{\mathrm{Y}_{rs}} + \overset{4b}{\sum_{j\neq r}^{G}\mathrm{A}_{rj}\mathrm{B}^{\natural}_{jr}\mathrm{Y}_{rs}} + \sum_{j\neq r}^{G}\mathrm{A}_{rj}\overset{4c}{\sum_{k\neq s,r}^{G}\mathrm{B}^{\natural}_{jk}\mathrm{Y}_{ks}}\right] \\
& + \mathrm{V}_s\mathrm{B}_{ss}\mathrm{A}_{sr}(\mathrm{I}-\mathrm{A}_{rr})^{-1}\overset{5}{\sum_{j\neq r}^{G}\mathrm{A}_{rj}\mathrm{B}^{\natural}_{js}\mathrm{Y}_{ss}} \\
& + \mathrm{V}_s\mathrm{B}_{ss}\mathrm{A}_{sr}(\mathrm{I}-\mathrm{A}_{rr})^{-1}\overset{6}{\sum_{j\neq r}^{G}\mathrm{A}_{rj}\mathrm{B}^{\natural}_{js}\mathrm{E}_{s*}} \\
& + \overset{7}{\sum_{t\neq s}^{G}\mathrm{V}_t\mathrm{B}_{ts}\mathrm{Y}_{sr}} + \overset{8}{\sum_{t\neq s}^{G}\mathrm{V}_t\mathrm{B}_{ts}\mathrm{A}_{sr}(\mathrm{I}-\mathrm{A}_{rr})^{-1}\mathrm{Y}_{rr}} \\
& + \mathrm{V}_r\mathrm{B}_{rs}\mathrm{A}_{sr}(\mathrm{I}-\mathrm{A}_{rr})^{-1}\left[\overset{9a}{\sum_{j\neq r}^{G}\mathrm{Y}_{rj}} + \overset{9b}{\sum_{j\neq r}^{G}\mathrm{A}_{rj}(\mathrm{I}-\mathrm{A}_{jj})^{-1}\mathrm{Y}_{jj}}\right] \\
& + \overset{9c}{\sum_{t\neq s,r}^{G}\mathrm{V}_t\mathrm{B}_{ts}\mathrm{A}_{sr}(\mathrm{I}-\mathrm{A}_{rr})^{-1}\mathrm{E}_{r*}} \\
& + \mathrm{V}_r\mathrm{B}_{rs}\mathrm{A}_{sr}(\mathrm{I}-\mathrm{A}_{rr})^{-1}\overset{9d}{\sum_{j\neq r}^{G}\mathrm{A}_{rj}(\mathrm{I}-\mathrm{A}_{jj})^{-1}\mathrm{E}_{j*}}
\end{aligned}
$$

Source: BM (2019), pp. 57–58

Where $B^s \equiv (I - A^s)^{-1}$ is the Leontief inverse matrix derived from the input coefficient matrix A^s which excludes the input requirement of other economies from country s (see BM, 2019, for further details).

The following terms form the BM (2019) bilateral decomposition of gross exports:

1 domestic value-added (VA) in direct final good exports;

2a domestic VA in intermediate exports absorbed by direct importers as local final goods;

2b domestic VA in intermediate exports absorbed by direct importers as local final goods only after additional processing stages abroad;

2c domestic VA in intermediate exports absorbed by third countries as local final goods;

3a domestic VA in intermediate exports absorbed by third countries as final goods from direct bilateral importers;

3b domestic VA in intermediate exports absorbed by third countries as final goods from direct bilateral importers only after further processing stages abroad;

3c domestic VA in intermediate exports absorbed by direct importers as final goods from third countries;

3d domestic VA in intermediate exports absorbed by third countries as final goods from other third countries;

4a domestic VA in intermediate exports absorbed at home as final goods of bilateral importers;

4b domestic VA in intermediate exports absorbed at home as final goods of bilateral importers after additional processing stages abroad;

4c domestic VA in intermediate exports absorbed at home as final goods of a third country;

5 domestic VA in intermediate exports absorbed at home as domestic final goods;

6 double-counted intermediate exports originally produced at home;

7 foreign VA in exports of final goods;

8 foreign VA in exports of intermediate goods directly absorbed by the importing country *r*;

9a and 9b foreign VA in exports of intermediate goods re-exported by *r* directly to the country of final absorption;

9c and 9d double-counted intermediate exports originally produced abroad.

Using this decomposition, we computed the following terms:

- The domestic value-added, $\mathbf{DVA_{sr}}$, as the sum of the components from 1 to 5;
- The foreign value-added, $\mathbf{FVA_{sr}}$, as the sum of the components from 7 to 9b;

The returned value-added, $\mathbf{RVA_{sr}}$ as the sum of all the components from 4 to 5.

Appendix B GVC participation and Vertical Specialization indicators

GVC participation indicators reported in the dataset are computed following Borin and Mancini (2019, p.20). Specifically, the overall bilateral GVC participation from country s to country r is that it can be decomposed into a 'backward' component, corresponding to the VS Index and a 'forward' component, corresponding to the VS1 indicator suggested by Hummels *et al*. (2001). The overall bilateral GVC participation indicator can be thus defined as follows:

$$GVC\ overall\ Participation_{sr} = GVCbackward_{sr} + GVCforward_{sr} = VS_{sr} + VS1_{sr}$$

Where

$$GVC\ backward_{sr} = VS_{sr} = \frac{V_s(I - A_{ss})^{-1} \sum_{j \neq s}^{G} A_{sj} B_{js} E_{sr} + \sum_{t \neq s}^{G} V_t B_{ts} E_{sr}}{u_N E_{sr}}$$

And

$$ward_{sr} = VS1_{sr} = \frac{V_s(I - A_{ss})^{-1} A_{sr} (I - A_{rr})^{-1} (\sum_{j \neq r}^{G} Y_{rj} + \sum_{j \neq r}^{G} A_{rj} \sum_{k}^{G} \sum_{l \neq s}^{G}}{u_N E_{sr}}$$

Appendix C GVC positioning indicators

The downstreamness and upstreamness measures are computed following Antràs and Chor (2018) using data from Eora 26. Eora provides three different matrices: the intermediate use matrix (Z), the final demand matrix (FD) and the value-added matrix (VA).

Eora considers a world economy with 189 (J) countries (plus a 190th 'Rest of the World' country) and 26 (S) sectors. The intermediate use matrix is a $J*S+1$ by $J*S+1$ matrix that contains, in each Z_{ij}^{rs} entry, information on intermediate purchases by industry $\boldsymbol{S}$ in country $\boldsymbol{j}$ from sector $\boldsymbol{r}$ in country $\boldsymbol{i}$ (country RoW has a unique residual sector). The final use matrix is $J*S+1$ by $J+1$ matrix containing, in each entry FD_{ij}^{r}, final consumption of sector $\boldsymbol{r}$ from country $\boldsymbol{i}$ by country j (final consumption is obtained as the sum of household final consumption, non-profit institutions serving households, government final consumption, gross fixed capital formation and acquisitions less disposals of valuables). The value-added matrix is a 1 by $J*S+1$ matrix where each entry VA_j^s represents the country j's value-added employed in the production of industry $\boldsymbol{S}$ (obtained as the sum of compensation of employees, taxes on production, subsidies on production, net operating surplus, net mixed income and consumption of fixed capital).[4]

Following Antràs *et al.* (2012) and Antràs and Chor (2018), we have computed our GVC measures after first performing a "net inventory" correction. This correction consists of imputing N_i^r changes in inventories to each Z_{ij}^{rs} and FD_{ij}^{r} entry by applying a multiplicative factor equal to $Y_i^r/(Y_i^r-N_i^r)$ where $Y_i^r=\sum_{s=1}^{S}\sum_{j=1}^{J}Z_{ij}^{rs}+\sum_{j=1}^{J}FD_{ij}^{r}=\sum_{s=1}^{S}\sum_{j=1}^{J}Z_{ij}^{rs}+FD_i^r$ is the gross output in sector r in country i.

In order to measure sectoral upstreamness, we adopt two methods. The first is the measure F/GO: computed as FD_i^r/Y_i^r, it simply represents the share of gross output in sector $\boldsymbol{r}$ in country $\boldsymbol{i}$ that is sold to final consumers. The second is the U_i^r index by Antràs and Chor (2013). Since $Y_i^r=\sum_{s=1}^{S}\sum_{j=1}^{J}Z_{ij}^{rs}+\sum_{j=1}^{J}FD_{ij}^{r}=\sum_{s=1}^{S}\sum_{j=1}^{J}a_{ij}^{rs}Y_j^s+FD_i^r$ where $a_{ij}^{rs}=Z_{ij}^{rs}/Y_j^s$ is the dollar amount of sectors $\boldsymbol{r}$'s output from country $\boldsymbol{i}$ needed to produce one dollar worth of industry $\boldsymbol{S}$'s output in country j, and $Y_i^r=FD_i^r+\sum_{s=1}^{S}\sum_{j=1}^{J}a_{ij}^{rs}FD_j^s+\sum_{s=1}^{S}\sum_{j=1}^{J}\sum_{t=1}^{S}\sum_{k=1}^{J}a_{ij}^{rs}a_{jk}^{st}FD_k^t+\cdots$, we obtain

$$U_i^r=1*\frac{FD_i^r}{Y_i^r}+2*\frac{\sum_{s=1}^{S}\sum_{j=1}^{J}FD_j^r}{Y_i^r}+3*\frac{\sum_{s=1}^{S}\sum_{j=1}^{J}\sum_{t=1}^{S}\sum_{k=1}^{J}a_{ij}^{rs}a_{jk}^{st}FD_k^t}{Y_i^r}+\cdots$$

Computing an infinite power series is not required since it is sufficient to compute the vector of $J*S$ by 1 upstreamness values:

$$U=[I-A]^{-2}FD_i^r \oslash [I-A]^{-1}FD_i^r$$

Where A is the matrix composed by a_{ij}^{rs}s whereas $\oslash$ refers to an elementwise division.

Two measures are adopted for downstreamness. The first is the VA/GO measure computed as VA_j^s/Y_j^s that gives a measure of the weight of value-added on the total sum of inputs. The

[4] Contrarily to WIOD, neither Full Eora nor Eora26 are perfectly balanced, despite the authors' attempt to find an optimal balanced Multi-Regional Input-Output that best satisfies conflicting data (see https://worldmrio.com/documentation/faq.jsp). Such a lack of balance gives row totals (Gross Output) that do not coincide with column totals (Total Inputs) and value-added matrices provided by Eora that differ from the 'indirect' value-added obtained residually from column totals. In our computations we have adopted the VA matrices provided by Eora in order to compute VA/GO and downstreamness indices whereas for the VA/GO and FU/GO indices, we have considered, as a denominator, column and row totals respectively.

second is the D_j^s. Since $Y_i^r = \sum_{r=1}^{S}\sum_{i=1}^{J} Z_{ij}^{rs} + VA_j^s = \sum_{r=1}^{S}\sum_{i=1}^{J} b_{ij}^{rs} Y_i^r + VA_j^s$ where $b = Z_{ij}^{rs}/Y_i^r$ is the share of sectors r's output in country i that is used in industry S in country j, and $Y_j^s = VA_j^s + \sum_{r=1}^{S}\sum_{i=1}^{J} b_{ij}^{rs} VA_i^r + \sum_{r=1}^{J}\sum_{i=1}^{J}\sum_{t=1}^{S}\sum_{k=1}^{J} b_{ki}^{tr} a_{ij}^{rs} VA_k^t + \cdots$, we find that

$$D_j^s = 1 * \frac{VA_j^s}{Y_j^s} + 2 * \frac{\sum_{r=1}^{S}\sum_{i=1}^{J} VA_i^s}{Y_j^s} + 3 * \frac{\sum_{r=1}^{S}\sum_{i=1}^{J}\sum_{t=1}^{S}\sum_{k=1}^{J} b_{ki}^{tr} b_{ij}^{rs} VA_k^t}{Y_j^s} + \cdots$$

Computing an infinite power series is not required since it is sufficient to compute the vector of $J * S$ by 1 downstreamness values:

$$D = [I - B]^{-2} VA_j^s \oslash [I - B]^{-1} VA_j^s$$

Where B is the matrix composed by b_{ij}^{rs}s whereas $\oslash$ refers to an elementwise division.

CHAPTER 2

Dataset with trade in value-added components, indicators of global value chain (GVC) participation, GVC positioning and specialization computed for agriculture and food sectors

2 Dataset with trade in value-added components, indicators of global value chain (GVC) participation, GVC positioning and specialization computed for agriculture and food sectors

The Excel files attached to this Technical Note include time series of GVC indicators computed at country/industry level for the period from 1995 to 2015.

Specifically, the GVC indicators are computed for agriculture and food sectors for as many countries as the data in the EORA dataset.

The computed indicators are the following:

- Trade in value-added components, namely: domestic value-added (DVA), returned value-added (RVA), and foreign value-added (FVA);
- Indicators of GVC participation;
- Vertical specialization measures;
- Indicators of GVC positioning.

These indicators are computed following selected methodologies explained in Section 1 above.

To compute these indicators, we have used the Eora Multi-Region Input-Output (MRIO) database (see Lenzen *et al.*, 2012, and Lenzen *et al.*, 2013). This database provides a set of both national and global input-output tables, covering 190 countries for complete time series from 1990 to 2015.

Eora is available in several formats. "Eora26" is a simplified model where all countries have been aggregated to a common 26-sector classification, according to the International Standard Industrial Classification of Economic Activities (ISIC Rev.3) that is consistent across all countries covered (see Table 11). In addition, for countries where more detailed classifications are available, more detailed input-output tables are also available (see the "Full Eora" version). Given the need to compare across countries, we focus on the "Eora26" version.

The benefit of Eora is that it has greater country and time coverage than other sources. However, this comes at a (certain) cost of data reliability given the method by which the input-output tables have been constructed for countries where no official supply-use tables are available. Consequently, some data errors are possible, mainly due to balancing issues. Specifically, as underlined by the data provider, the current Eora tables have been constructed with an emphasis on fulfilling balancing conditions for large countries, but less for small countries (see https://worldmrio.com/documentation/faq.jsp).

Table 1 Eora sector classification

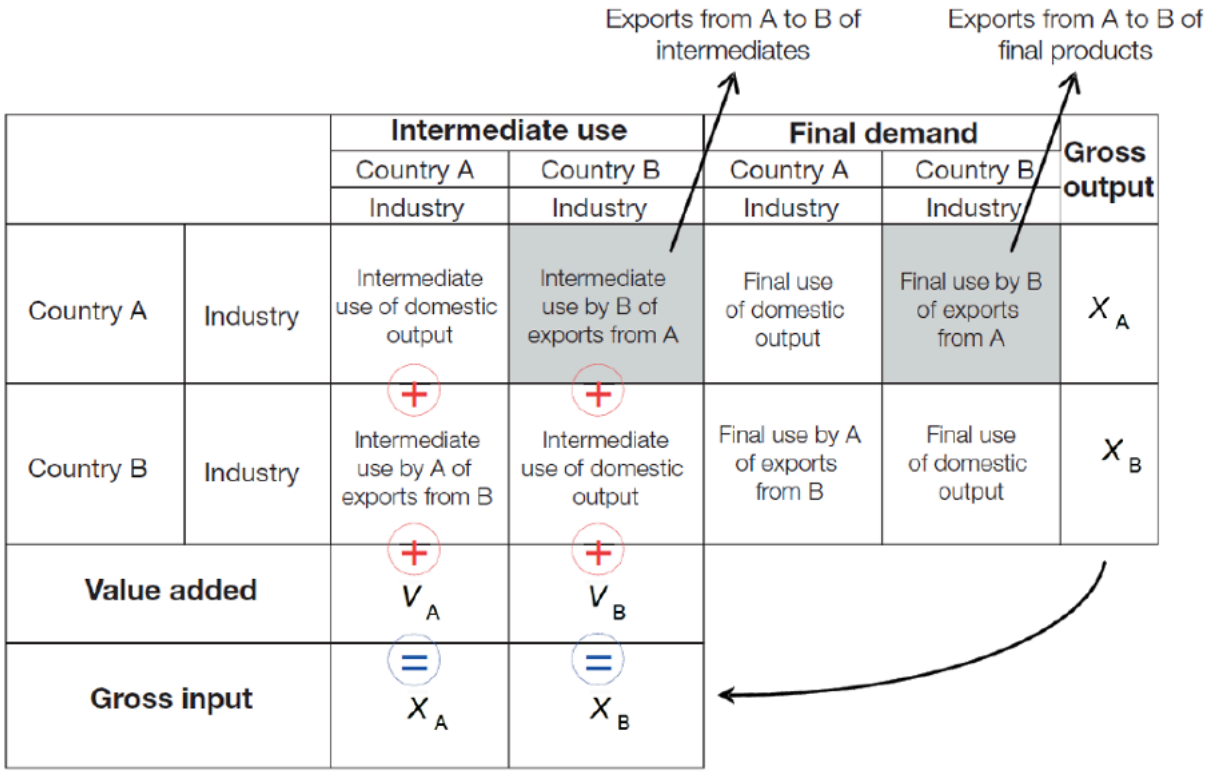
Industry Code	Sector Description
1	Agriculture
2	Fishing
3	Mining and Quarrying
4	Food and Beverages
5	Textiles and Wearing Apparel
6	Wood and Paper
7	Petroleum, Chemical and Non-Metallic Mineral Products
8	Metal Products
9	Electrical and Machinery
10	Transport Equipment
11	Other Manufacturing
12	Recycling
13	Electricity, Gas and Water
14	Construction
15	Maintenance and Repair
16	Wholesale Trade
17	Retail Trade
18	Hotels and Restaurants
19	Transport
20	Post and Telecommunications
21	Financial Intermediation and Business Activities
22	Public Administration
23	Education, Health and Other Services
24	Private Households
25	Others
26	Re-export and Re-import

Table 2 Eora "Agriculture" and "Food and Beverages"' industries - ISIC correspondence and disaggregation

EORA Industry Code	*EORA Sector Description*	*ISIC Rev.3 correspondence*	*ISIC Section/Division - Group - Class - Description*
1	Agriculture	1	**Division 01 - Agriculture, hunting and related service activities** 011 Growing of crops; market gardening; horticulture 0111 Growing of cereals and other crops n.e.c. 0112 Growing of vegetables, horticultural specialties and nursery products 0113 Growing of fruit, nuts, beverage and spice crops 012 Farming of animals 0121 Farming of cattle, sheep, goats, horses, asses, mules and hinnies; dairy farming 0122 Other animal farming; production of animal products n.e.c. 013 0130 Growing of crops combined with farming of animals (mixed farming) 014 0140 Agricultural and animal husbandry service activities, except veterinary activities 015 0150 Hunting, trapping and game propagation including related service activities
		2	**Division 02 - Forestry, logging and related service activities** 020 0200 Forestry, logging and related service activities
4	Food & Beverages	15	**Division 15 Manufacture of food products and beverages** 151 Production, processing and preservation of meat, fish, fruit, vegetables, oils and fats 1511 Production, processing and preserving of meat and meat products 1512 Processing and preserving of fish and fish products 1513 Processing and preserving of fruit and vegetables 1514 Manufacture of vegetable and animal oils and fats 152 1520 Manufacture of dairy products 153 Manufacture of grain mill products, starches and starch products, and prepared animal feeds 1531 Manufacture of grain mill products 1532 Manufacture of starches and starch products 1533 Manufacture of prepared animal feeds 154 Manufacture of other food products 1541 Manufacture of bakery products 1542 Manufacture of sugar 1543 Manufacture of cocoa, chocolate and sugar confectionery 1544 Manufacture of macaroni, noodles, couscous and similar farinaceous products 1549 Manufacture of other food products n.e.c. 155 Manufacture of beverages 1551 Distilling, rectifying and blending of spirits; ethyl alcohol production from fermented materials 1552 Manufacture of wines 1553 Manufacture of malt liquors and malt 1554 Manufacture of soft drinks; production of mineral waters
		16	**Division 16 Manufacture of tobacco products** 160 1600 Manufacture of tobacco products

Appendix D

Figure 1 Example of Basic Input-Output Table



Source: UNCTAD (2013)

Table 1 List of countries by regional areas

Oceania	
1	AUS - Australia
2	FJI - Fiji
3	NCL - New Caledonia
4	NZL - New Zealand
5	PNG - Papua New Guinea
6	PYF - French Polynesia
7	VUT -Vanuatu
8	WSM - Samoa

Africa					
	Western Africa	Northern Africa	Middle Africa	Eastern Africa	Southern Africa
1	BEN - Benin	DZA - Algeria	AGO - Angola	BDI - Burundi	BWA - Botswana
2	BFA -Burkina Faso	EGY - Egypt	CAF- Central African Republic	DJI - Djibouti	LSO - Lesotho
3	CIV - Cote d'Ivoire	LBY - Libya	CMR -Cameroon	ERI - Eritrea	NAM - Namibia
4	CPV - Cape Verde	MAR - Morocco	COD - Democratic Republic of the Congo	ETH - Ethiopia	ZAF - South Africa
5	GHA -Ghana	TUN - Tunisia	COG - Congo-	KEN - Kenya	SWZ - Swaziland
6	GIN - Guinea		GAB - Gabon	MDG - Madagascar	
7	GMB - Gambia		STP - Sao Tome and Principe	MWI - Malawi	
8	LBR - Liberia		TCD - Chad	MUS - Mauritius	
9	MLI - Mali			MOZ -Mozambique	
10	MRT - Mauritania			RWA - Rwanda	
11	NER - Niger			SYC -Seychelles	
12	NGA -Nigeria			SOM - Somalia	
13	SEN - Senegal			TZA - United Republic of Tanzania	
14	SLE - Sierra Leone			UGA - Uganda	
15	TGO - Togo			ZMB - Zambia	

Asia					
	Central Asia	Western Asia	South Asia	South -Eastern Asia	Eastern Asia
1	KAZ - Kazakhstan	ARM - Armenia	AFG - Afghanistan	BRN - Brunei Darussalam	CHN - China
2	KGZ - Kyrgyzstan	AZE - Azerbaijan	BGD - Bangladesh	KHM - Cambodia	HKG - Hong Kong SAR, China
3	TJK - Tajikistan	BHR - Bahrain	BTN - Bhutan	IDN - Indonesia	JPN - Japan
4	TKM -Turkmenistan	CYP - Cyprus	IND - India	LAO - Lao People's Democratic Republic	PRK -Democratic People's Republic of Korea
5	UZB - Uzbekistan	GEO - Georgia	IRN -Iran, (Islamic Republic of)	MYS - Malaysia	KOR - Republic of Korea
6		IRQ - Iraq	MDV - Maldives	MMR - Myanmar	MAC - Macao SAR, China
7		ISR - Israel	NPL - Nepal	PHL - Philippines	MBG - Mongolia
8		JOR - Jordan	PAK - Pakistan	SGP - Singapore	TWN - Taiwan Province of China
9		KWT - Kuwait	LKA - Sri Lanka	Thailand	
10		LBN - Lebanon		VNM – Viet Nam	
11		OMN - Oman			
12		PSE - Palestine			
13		QTA - Qatar			
14		SAU - Saudi Arabia			
15		SYR - Syrian Arab Republic			
16		TUR - Turkey			
17		ARE - United Arab Emirates			
18		YEM -Yemen			

North America				
	North America	Central America	Caribbean	South America
1	BMU - Bermuda	BLZ - Belize	ATG - Antigua and Barbuda	ARG - Argentina
2	CAN - Canada	CRI - Costa Rica	ANT - Antilles	BOL - Bolivia
3	GRL - Greenland	SLV - El Salvador	ABW - Aruba	BRA - Brazil
4	USA - United States of America	GTM - Guatemala	BHS - Bahamas	CHL - Chile
5		HND - Honduras	BRB - Barbados	COL - Colombia
6		MEX - Mexico	VGB - British Virgin Islands	ECU - Ecuador
7		NIC - Nicaragua	CYM - Cayman Islands	GUY - Guyana
8		PAN - Panama	CUB - Cuba	PRY - Paraguay
9			DOM - Dominican Republic	PER - Peru
10			HTI - Haiti	SUR - Suriname
11			JAM - Jamaica	URY - Uruguay
12			TTO - Trinidad and Tobago	VEN - Venezuela (Bolivarian Republic of)

Europe				
	Northern Europe	Eastern Europe	Southern Europe	Western Europe
1	DNK - Denmark	BLR - Belarus	ALB - Albania	AUT - Austria
2	EST - Estonia	BGR - Bulgaria	AND - Andorra	BEL - Belgium
3	FIN - Finland	CZE - Czechia	BIH - Bosnia and Herzegovina	FRA - France
4	ISL - Iceland	HUN - Hungary	HRV - Croatia	GER - Germany
5	IRL - Ireland	MDA - Republic of Moldova	GRC - Greece	LIE - Liechtenstein
6	LVA - Latvia	POL - Poland	ITA - Italy	LUX - Luxembourg
7	LTU - Lithuania	ROU - Romania	MKD - North Macedonia	MCO - Monaco
8	NOR - Norway	RUS - Russian Federation	MLT - Malta	NDL - Netherlands
9	SWE - Sweden	SVK - Slovakia	MNE - Montenegro	CHE - Switzerland
10	GBR - United Kingdom of Great Britain and Northern Ireland	UKR - Ukraine	PRT - Portugal	
11			SMR - San Marino	
12			SRB - Serbia	
13			SVN - Slovenia	
14			ESP -Spain	

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