METRO DEVELOPMENT: THE ICIO-TIVA-MODULE

A Method to Analyse Global Value Chains with METRO

Contact: MetroModel@oecd.org

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1. Introduction: Trade in value added

1. This paper documents and describes the ‘ICIO-TiVA module’, a module for Global Value Chain (GVC) analysis using the METRO model (OECD, 2015). The methodology follows Greenville et al. (2017) and has been adapted to use METRO output, in the form of base data and simulation results, to generate a pre- and post-simulation inter-country input-output (ICIO) table. The module output produces GVC indicators similar to the approach used in the OECD-WTO TiVA database. In addition to the indicators described in Greenville et al. (2017), the module contains a value added decomposition of final demand. The module output can be accessed via the METRO interface. A first application is in Greenville et al. (2018), Influencing GVCs through agro-food policy and reform, (TAD/TC/CA/WP(2017)2/REV1).

2. The METRO model base data and production relationships provide the information needed to depict the entire production process for a good (or service), and covers all trade flows and final consumption. Goods trade and consumption are distinguished by use category into intermediates and final demand (household, government and investment). With this information it is possible to trace the value chain from primary products through further processing and then to final demand. This differentiation of trade flows by use category is necessary for GVC analysis which decomposes trade into its value added elements.

3. Measuring ‘trade in value added’ (TiVA) rather than gross terms provides a different view of trade. This is illustrated in Figure 1 which shows gross trade flows and value added flows. Country A uses primary production factors, capital and labour, to produce exports of a value 100 (grey arrow) which it exports to country B. Country B further processes the good and exports value 110 to country C. In gross terms country C imports only from country B and does not have trade relations with country A. In value added terms the situation looks very different: country B adds value 10 to the good it exports, of which value 100 was created in country A. In value added terms country C imports value 10 from country B and 100 from country A. Conventional trade statistics would record a total trade flow between the 3 countries of 210 (= 100 + 110), whereas, in value added terms, total trade flows would only be 110.

4. The ICIO-TiVA module builds on the burgeoning GVC literature (for example Koopman et al., 2010, 2014; Johnson and Noguera, 2012; OECD, 2013) that has developed a set of GVC indicators as well as the decomposition of gross exports and final demand into their value added elements from METRO model results. In addition, it offers various tools to calculate indicators that describe evolving patterns of GVC integration.

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1 Document prepared by Dorothee Flaig, Jared Greenville and Kentaro Kawasaki. The document benefitted from comments and feedback provided by Javier Lopez-Gonzalez, Frank van Tongeren and Charles Cadestín.

2 Further information on the OECD-WTO TiVA database can be accessed online at: www.oecd.org/industry/ind/measuringtradeinvalue-addedanoecd-wtojointinitiative.htm.

3 Note that the module decomposes trade flows in value added components. Trade flows in the METRO model, however, are still depicted in gross terms.
5. While it is straightforward to press the button in the model’s interface and create output, the user needs to be cautious when analysing the outcome obtained: similar to all GVC analysis that derives from ICIO tables, the measures are estimates (not statistics) that rely on some well documented assumptions (for example, all firms have the same technology). Importantly, country coverage and sectoral aggregation can give a broad view only as it is ultimately firms that engage in GVCs. In addition, the measures do capture the complexity of firm ownership structures within countries. The underlying assumption in input-output (IO) tables is that firms are homogeneous and each sector producers one output. These simplifying assumptions are necessary because of the less granular data of an IO table, when compared to micro or firm level detailed statistics.

6. Furthermore and similar to other ICIO tables, such as the OECD ICIO tables, the METRO database distinguishes trade flows by use category into intermediates and final demand. In the construction of the database trade flows by use category are identified using a product-based classification of end-use (BTDIxE) which classifies goods to end uses based on their characteristics on detailed HS6 level.

7. The interpretation of the TiVA decomposition of the base data in METRO is straightforward. The TiVA decomposition of flows after a simulated policy shock reflects the structure and assumptions employed in the model (OECD, 2015) and therefore require careful interpretation. Simulated changes of derived indicators essentially result from endogenous adjustments in output, reliant on current patterns of the employment of production factors and the existing composition and size of trade flows. In addition, a typical policy shock on taxes, subsidies or tariffs will directly affect the size of value added flows, and hence different parts of value added. Thus, tax instruments directly impact on

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**Figure 1. Measuring trade in value added**

![Figure 1](image)

*Source: OECD (2013).*

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5 Use shares for agricultural, mining and manufacturing sectors are obtained combining comtrade and OECD BTDIxE; for services sectors data is drawn from the OECD ICIO system. While widely used this approach also has some important caveats: first, in some cases goods become intermediates in use not in characteristics – for example tyres are final goods when bought as replacement tyres, but are intermediate goods when installed in car. Second, and deriving from the first point, there are ‘miscellaneous’ categories that cannot be attributed to intermediates or final demand categories and these can be important for some sectors (such as motor vehicles). To limit distortions the METRO database assumes proportionality to distribute those categories across end-uses.
the size of value added and the indicators derived and it is worth exploring changes within the factors that make up value added to gain a better understanding of the impacts of the policy shock explored. To facilitate this analysis, a decomposition of value added by its components (labour, capital and land, taxes and margins) is made available in the new ICIO-TiVA module. Finally, due to the structure of the ICIO trade within aggregate regions is classified as domestic flows. This needs to be kept in mind when defining the regional aggregation used in a specific study.

8. The remainder of this paper is structured as follows. The next section introduces the inter country input output table (ICIO) and how it is constructed. Section 3 derives value added exports and classic GVC indicators such as backward and forward indicator. Section 4 introduces the concept of value added in final demand and decomposes final demand into direct and indirect value added. Section 5 gives an overview of the module output, followed by concluding remarks in section 6. The Annex explains how the module is used and the output with an example.

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6 For example, regional groupings such as the European Union.
Box 1. Benefits of GVCs: Re-thinking upgrading

The debate on where countries locate in the value chain is often predicated on the idea that countries should seek a higher share of the value added of the products they produce. In fact, in terms of the domestic benefits from GVCs, it is not the share of value added that matters but rather the amount, or total value that the economic activities within the value chain generate.

A country or firm's position in the value chain will largely depend on its comparative advantage and the mix of skills and resource endowments it brings to international production. For some countries or firms, this might initially involve specialising in labour intensive segments while for others it may involve specialising in high-tech elements.

A hypothetical “smiley curve” plots, for a particular product, the stages of GVC participation against their possible value added contribution (Figure 2). At the extremities, pre- and post-production activities such as R&D and marketing tend to command a higher share of the value of a particular finished product, while manufacturing or assembly activities tend to be located at the bottom of the curve (lower value added share).

However, this “smiley curve” does not give the whole story on economic benefit of participating in value chains. It does not take into consideration that firms increasingly specialise in tasks along the value chain and therefore operate across a range of products. Hence while the firm that assembles the iPhone will retain a small share of the value of phone, that firm can specialise in assembly and can grow by assembling the smartphones of other companies. The firm can thereby reap value over a range of products and generate a much larger overall amount of domestic value added.

Ultimately, the benefits of engaging in GVCs do not depend on the position held in the value chain, but on the extent to which countries can leverage their participation to become more efficient and maximise the income and benefits from the activities they undertake now and in the future. This can be measured through changes in the domestic value added that the activity generates.
In a world of GVCs, access to cheaper and more sophisticated imported inputs is key to growing domestic value added. Assembly requires sourcing from various countries in the same way that developing the high-end specs of a smartphone requires locating elements of its production in the most cost-effective location. So in fact growth in domestic value can rely on an increasing share of foreign value added in production.

Policy-makers should therefore focus on the value that the firms are generating and not the share that is being performed domestically. In ASEAN, for example, the domestic value added share of exports fell from 71% to 67% between 1995 and 2011 but the volume of domestic value added in exports increased nearly fourfold (Figure 3). ASEAN increased the volume of its economic activity by relying on more foreign value added; that is, it is the total return that is important, not the share in any given production activity. In other words, a country may only be receiving USD 1 of value added per item, but if it is producing 500 of those items it makes a greater overall return than if it receives USD 2 per item on a product of which it can only sell 100 units competitively.

**Figure 3. Lower share, but much higher volume, ASEAN exports in 2011**

Developing domestic value added is inextricably tied to foreign value added. Recent empirical analysis shows that the use of foreign value added is one of the most important determinants of positive changes in domestic value added in exports across all types of activities (agriculture, manufacturing and services) and levels of development (for developed and emerging economies). Foreign value added is therefore a complement to, rather than a substitute for, domestic value added in exports. In a world of GVCs, more than ever, export competitiveness requires import openness.

**Source:** OECD in OECD-WTO-UNCTAD (2016)
2. The Inter-Country-Input-Output (ICIO) Table’

9. Input-Output Tables describe the sale and purchase relationships between producers and consumers within an economy. The ICIO table adds an additional layer of bilateral relationships. The heart of the ICIO is the intermediate input matrix, in which the diagonal blocks represent domestic transaction flows of intermediate goods and services across industries, while the off-diagonal blocks represent the inter-country flows of intermediates via exports and imports.

10. Figure 5A depicts the interlinkages in the economy of Utopia through a traditional one-country industry by industry Input-Output Table with two sectors manufacturing and services. The ‘intermediate use’ matrix shows the row sector output that is used by the column sector.

11. Reading the table down the column (in red and bold) identifies the inputs. In this case the manufacturing sector uses 8 units from the manufacturing sector itself, 2 from the service sector, 3 imported intermediates and 30 units of domestic value added (compensation to employees, land and capital). The row identifies how the output of the row sector is used (the green dotted box). In this instance, the output (row) of the manufacturing sector in Utopia is distributed as follows; 8 units (generally these are expressed in national currency) to the manufacturing sector, 3 to the service sector, 20 for domestic consumption and 9 to exports totalling 40 units. Since the inputs that go into the production of output are all accounted for the sum of inputs must be equal to total output.

12. The single country IO table can be expanded to incorporate additional countries (Figure 5B), known as Inter-Country-Input-Output Table (ICIO). The ICIO is composed of different countries’ intermediate use and final use tables but it differentiates between domestic and imported intermediates as well as identifying the destination of the final use. Note that the import value of 13 units in Figure 5A now appears in the final use part of this ICIO as 9 units of final imports from the RoW manufacturing sector plus 4 units of service imports. Similarly the 9 units of manufacturing exports are distributed: 2 units to the RoW manufacturing sector, 1 unit to the RoW service sector and 6 units to RoW final consumers. The intermediate use panel shows domestic intermediates, which are in the diagonal and shaded in blue, and imported intermediate use matrices which are the off diagonal matrices shaded in grey.

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7 The authors are grateful to Javier Lopez-Gonzalez for the contribution of figures and their explanation in sections 3 and 4.
Figure 4. From an IO-Table to an ICIO

A) Input-Output Table, an example for Utopia.

B) The Inter-Country-Input-Output Table for Utopia and ROW.

Source: Gasiorek et al. (2015).
Figure 5. ICIO in METRO

A) Structure of the ICIO.

<table>
<thead>
<tr>
<th>R1 Sectors</th>
<th>R2 Sectors</th>
<th>Final Demand</th>
<th>Export Transport Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic intermediates</td>
<td>Domestic intermediates</td>
<td>Domestic private government consumption</td>
<td>Imported private investment goods</td>
</tr>
<tr>
<td>Imported intermediates **</td>
<td>Imported intermediates **</td>
<td>Domestic investment goods</td>
<td>Imported private government consumption</td>
</tr>
</tbody>
</table>

B) Parameters used for construction

<table>
<thead>
<tr>
<th>Regions</th>
<th>Production</th>
<th>Final Demand</th>
<th>Export Transport Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>r1</td>
<td>r2</td>
<td>r1</td>
<td>r1</td>
</tr>
<tr>
<td>Sectors</td>
<td>Sectors</td>
<td>FDP</td>
<td>FDP</td>
</tr>
<tr>
<td>Intermediate inputs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r1 sectors</td>
<td>VDFM</td>
<td>IMF2adj**</td>
<td>IMF2 (domestic)</td>
</tr>
<tr>
<td>r2 sectors</td>
<td>IMF2adj**</td>
<td>VDFM</td>
<td>IMF2 (imported)</td>
</tr>
<tr>
<td>Value added</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>factors</td>
<td>VFM</td>
<td>VFM</td>
<td>TAX ACT**</td>
</tr>
<tr>
<td>taxes</td>
<td>MARG ACT**</td>
<td>MARG ACT**</td>
<td>MARG FD</td>
</tr>
</tbody>
</table>

Note: * taxes are detailed by net factor and production taxes, tariffs, export and sales taxes. ** entries employ additional assumption to combine the bilateral with sector specific information.

Source: Authors compilation.

13. The construction of the ICIO in the METRO module follows the approach outlined in Greenville et al. (2017). Figure 6A shows the structure of the ICIO in METRO and Figure 6B details the parameters that are used to construct the ICIO. The figures show the structure of the ICIO for two regions. When more regions are employed r2 is split in row and column dimension and the cells shaded in light grey become true bilateral matrices.

METRO DEVELOPMENT: THE ICIO-TIVA-MODULE
METRO data is available in form of an IO-Table, and most entries for the construction of the ICIO can directly be derived. Some entries, however, require additional assumptions (marked with **). The ICIO is depicted in basic prices, this has some implications in the selection of prices and treatment of taxes and subsidies.

Table 1. Conventions and notations for indexing in equations

<table>
<thead>
<tr>
<th>Set</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>c</td>
<td>Commodity</td>
</tr>
<tr>
<td>a</td>
<td>Activity/sector</td>
</tr>
<tr>
<td>u</td>
<td>Use category</td>
</tr>
<tr>
<td>- uint(u)</td>
<td>Intermediate use (member of u)</td>
</tr>
<tr>
<td>r</td>
<td>Region</td>
</tr>
<tr>
<td>w</td>
<td>Partner region</td>
</tr>
</tbody>
</table>

14. The Production columns depict intermediate inputs by sector, both domestic and imported (by region). Domestic use of intermediate inputs (VDFM) is directly obtained from model output multiplying price (PDA) and quantity (QDA) of intermediate input use (c, “uint”) by activity (a) in world currency (and adjusted for the exchange rate ER):

\[
VDFM_{c,a,r} = QDA_{c,\text{uint},a,r} \times PDA_{c,\text{uint},a,r} / ER_r
\] (1)

15. Imports are detailed by (importing) region (r), commodity (c), (exporting) partner (w) and use category (u; intermediate imports, imports for household and government consumption, and investment). To construct an ICIO with its full bilateral representation of flows bilateral intermediate imports need to be allocated over producing activities (a). This is done by assuming proportionality, hence it is assumed that sectors, while varying in the amount of imports used, use these in the same bilateral proportions:

\[
IFM2adj_{w,c,a,r} = \text{Imports}_{\text{pbasic}}_{c,\text{uint},w,a,r} \times \frac{QMA_{c,\text{uint},a,r} \times PMA_{c,\text{uint},a,r}}{\sum_a (QMA_{c,\text{uint},a,r} \times PMA_{c,\text{uint},a,r})}
\] (2)

16. Where QMA is the quantity and PMA the price of imports of commodity c used as input in production activity a. Bilateral imports are thus multiplied by the share sector a uses of the imported input. ‘Imports_{pbasic}’ are imports at basic prices which are specified for all use categories:

8 To be precise the METRO database is stored as Social Accounting Matrix (SAM) which means that it also has more detail in the institutional accounts as compared to an IO-table.

9 The basic price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any tax payable, and plus any subsidy receivable, on that unit as a consequence of its production or sale; it excludes any transport charges invoiced separately by the producer. (SNA 2008)

10 Refer to the model documentation (OECD, 2015) or user guide (Flaig and Arriola, 2018) for a detailed explanation of prices in the METRO model.

11 This assumption is also employed in the construction of the OECD ICIO, see for example Ahmad et al. (2017). Aggregate (sum over source regions) import shares are sourced from GTAP and vary by activity for countries where this information is available. Where this information is not available, and similar to the treatment in OECD ICIO, intermediate imports are distributed over activities assuming proportionality.

12 The ICIO is specified in basic prices, therefore trade flows need to be expressed net of all taxes and tariffs. In order to net out export taxes the partner’s export prices (PER_{c,u,w1,r2}) are used to
17. Domestic and imported final demand use categories IPM2, IGM2 and IIM2 are directly derived from METRO variables, where the imported matrices are based on Imports_pbasic.13

18. Each region exports transport services (VST), which in METRO are specified as exports to the so-called Globe region:

\[ VST_{c,r} = QER_{c, uint, wglor} \times PWE_{c, uint, wglor} \]  \( (4) \)

19. The Value Added part of the ICIO includes factor demand, net taxes (tax minus subsidy) and margins. Factor demand (VFM) contains values, quantity (FD) times factor payments per unit wages/rents (WF*WFDIST) detailed by labour categories, capital, land and natural resources (f) and producing activity (a).

\[ VFM_{f, a, r} = FD_{f, a, r} \times WF_{f, r} \times WFDIST_{f, a, r} / ER_r \]  \( (5) \)

20. Taxes on intermediates (TAX_ACT) and final demand (TAX_FD) include factor and production taxes, tariffs, export and sales taxes.

- Taxes on factor use (TF) and production (TX), and sales taxes (TSA) are by activity and are directly derived from METRO variables for all use categories.
- Tariffs and specific tariffs are allocated over producing activities assuming proportionality.
- Export taxes are treated differently. Export taxes increase the cost of imports and thus constitute a cost for the firm which uses the good in its production process. Export taxes are thus allocated to the importer.14

21. Finally, trade and transport margins for final demand are directly obtained from METRO variables. Margins on intermediate demand are allocated over producing activities assuming proportionality, similar to intermediate imports.

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13 The domestic demand component of final demand is calculated similar to intermediate demand multiplying the domestic price \( PD_{c,a,r} \) with the quantity demanded \( QD_{c,a,r} \) expressed in world currency.

14 This might be important when analysing GVC effects from changes in export taxes/subsidies.
3. Value Added Exports (VAE)

3.1. The Value Added Exports Matrix

22. The VAE-Matrix (Koopman et al., 2010) is the most widely used measure of GVC activity and serves as base for the calculation of GVC indicators. It identifies the origin of the value added that is embodied in exported products. More specifically the VAE matrix (Figure 7) shows how the value added that is embodied in exports decomposes across different origins and destinations. As in traditional IO analysis each entry identifies a transaction from the row account to the column account.

23. The first entry in this VAE matrix shows that in order to produce exports, the manufacturing sector in Utopia uses 7.7 units of value added from its own domestic sector. Further down in the column the second entry shows that the Utopian manufacturing sector uses 0.5 units of Utopian services value added to produce exports. Adding these domestic inputs to the imported ones (in the RoW matrix below, i.e. 0.5 units from RoW manufacturing sector and 0.3 unit from RoW service sector) results in the total value of exports of the Utopian manufacturing sector. Here the 9 units of gross manufacturing exports are ultimately incorporating 9 units of value added.

Figure 6. VAE matrix

*Note:* This matrix is derived from Figure 5. Rows show source region and sector of value added, columns show exporting region and sector.

24. Notice that the input (column sum) and the output VAE (row sum) values differ. Utopian manufacturing exports are 9 units but Utopian manufacturing VAE represent only 8.7 units. The manufacturing value added in exports is smaller than the exports of the manufacturing sector. The reason is that the input (column) VAE includes value added from all other sectors, including imported value added from other countries, used to produce manufacturing exports whereas the output (row) VAE exclusively captures the value added of the Utopian manufacturing sector. For services output VAE is bigger than
the input VAE reflecting the fact that services are less exported but constitute an important input into exported goods.

Box 2. Calculating VAE and VAY matrices

Let \( N \) and \( K \) be the number of countries and sectors respectively. The variable \( V \) is defined as a \( NK \times NK \) diagonal matrix where each diagonal element shows the share of value added in total output \( \frac{v_i}{x_i} \) where \( v_i \) is the direct value added (the sum of labour wage, capital rental, land rent, and net factor subsidy) and \( x_i \) total output value of sector \( i \) in country \( r \), respectively. Let \( A \) be the technological coefficient where each entry represents the necessary amount of intermediate inputs to increase one unit of output.

Output \( X \) is composed of intermediate (AX) and final demand (Y): \( X = AX + Y \). Then the following relationship can be derived: \( X - AX = Y \), hence \( IX - AX = Y \) and \( (I - A)X = Y \). Thus, output is \( X = (I - A)^{-1}Y \), where \( I \) is an identity matrix.

Using this relationship, it is possible to decompose exports into value added by source. For example, let \( E \) be a \( NK \times NK \) diagonal matrix where each diagonal element shows column sector’s export. Then a matrix \( V[I - A]^{-1}E \) identifies the source of value added for column sector’s export. Using similar algebra, it is also possible to identify the source of value added for final demand. Let \( Y \) be a \( NK \times N \) matrix where each column entry shows a country’s final demand. Then a \( NK \times N \) matrix \( V[I - A]^{-1}Y \) shows source of value added for a country’s total final demand. If interested in a specific product, it is possible replace the matrix \( Y \) with zero except for that product. For example, let \( YA \) be a final demand matrix where non-agricultural/food sectors are replaced as zero. Then \( V[I - A]^{-1}YA \) shows source of value added for column country’s agricultural/food consumption.

Source: adapted from Greenville et al. (2017).

25. The VAE-matrix in METRO is derived from the ICIO following the methodology as described in Greenville et al. (2017).

26. First, the matrix of input coefficients (A) is derived from the ICIO dividing the intermediate input matrix by total output (the column sum).

\[
a_{w,c,r,a} = \frac{ICIO_{w,c,r,a}}{\sum_{w,c} ICIO_{w,c,r,a}} \quad (6)
\]

where \( w = \) partner region, \( c = \) commodity, \( r = \) (importing) region and \( a = \) producing activity

This matrix is used to calculate the Leontief inverse \( I - AF^{-1} \).

The vector of Value Added coefficients (\( v \)) is defined as share of value added in total output and contains factor use, taxes\(^{15}\), and trade and transport margins.

\(^{15}\) Including the value of export taxes on intermediates that are imported.
Total value added can be further decomposed into labour ($V_{lab}$), capital, land and natural resources ($V_{cap}$), net taxes ($V_{tax}$) and margins ($V_{marg}$). The $V$ matrix represents the sum of these five value added matrices so that $V_{lab} + V_{cap} + V_{tax} + V_{marg} = V$. This identity holds for all VAE and final demand measures derived.

The value added exports matrix (VAE) is defined as $VAE = V * [I - A]^{-1} * E$ (see Box 2). In the GAMS programme this matrix is specified as

$$VAE_{w,c,r,a} = v_{w,c} * [I_{w,c,r,a} - a_{w,c,r,a}]^{-1} * e_{r,a}$$  \( (8) \)

where $E$ is a vector of gross exports, obtained by summing over all destinations and uses.

### 3.2. VAE decomposition

**Column: Value added used to produce gross exports**

27. The column dimension captures the input composition of exports. This information can be used to determine the share of domestic value added inputs used to produce exports (Figure 8): i.e. the decomposition shows domestic VA and foreign (imported) VA which add up to gross exports by construction.

28. In the example, the production of a unit of manufacturing exports of Utopia contains 91% domestic value added (8.2 units) and 9% imported value added (0.8 units). Thus, out of the 9 units that the Utopian manufacturing sector exports 8.2 are domestic and 0.8 are foreign. This means that the backward participation indicator, the share of foreign value added embodied in gross exports is 9%.

**Figure 7. Value added used to produce gross exports**

![Diagram of value added used to produce gross exports](image)

*Source: Gasiorek et al. (2015).*

**Row: Value added sold to produce gross exports**

29. The row dimension shows the VA contribution to the sector’s own exports and to total exports of a region. Further the decomposition shows the use of VA in the exports of partner regions.
30. The row dimension shows how Utopian manufacturing value added is used by other sectors and countries to produce exports (Figure 9). For example, the manufacturing sector in Utopia sells 0.4 units of value added to the Utopian service sector for it to produce its exports; it also sells 0.5 units of value added to the RoW manufacturing sector for the production of RoW manufacturing exports. The row sum is equal to 8.7, the total value added of the Utopian manufacturing sector in any country’s exports. The forward participation indicator in this example would be the non-domestic elements of this matrix (0.6) divided by the gross exports in the sector which were 9 giving a forward participation indicator of 6.67%.

Figure 8. Value added sold to produce gross exports

Note: Note that the output VAE is different from the forward participation rate which is calculated relative to gross exports. Source: Gasiorek et al. (2015).

3.3. Classic GVC indicators

31. GVC indicators capture different facets of engagement in the form of buying from (backward participation) and selling into (forward participation) GVCs and combinations thereof (participation and position indices).

Backward participation indicator

32. The backward participation indicator represents the foreign value added share in total exports from a reference country. It is calculated by dividing foreign VA (in column VAE decomposition) by gross exports of a sector.

33. The backward indicator is bound between 0 and 1 in the absence of significant subsidies to domestic value added factors (subsidies can result in negative value added contributions to exports).

34. For example, the backward indicator for manufacturing in Utopia (Figure 7) can be calculated as imported value added/gross exports=0.8/9 = 0.089.
Forward participation indicator

35. The forward participation indicator represents the share of a reference country’s value added that is exported and used by other countries to produce exports expressed as a share of the industry’s gross exports. It is calculated dividing the domestic VA in the exports of partner regions (in row VAE decomposition) by the gross exports of a sector.

36. The forward participation indicator includes the value added that is transferred through indirect linkages. For example, if there are 2 industries, agriculture and food, with agriculture exporting very little but being a major supplier of intermediates to food production and food production being a large exporter. Then agricultural value added embodied in food exports that are subsequently used to produce exports in other countries would count towards the forward participation indicator of agriculture (and depicted relative to agricultural exports). Thus, an industry’s forward indicator can be very large (well in excess of 1) if it has a low level of direct exports but a high level of indirect exports that are used in the production of other countries’ exports.

37. For example, the forward indicator for manufacturing in Utopia (Figure 7) can be calculated as \( \frac{\text{domestic value added used by other countries}}{\text{gross exports}} = \frac{0.6}{9} = 0.067 \).

Total participation indicator

38. To describe the overall engagement in GVCs Koopman et al. (2010) proposed the total participation indicator. It is defined as the sum of backward and forward participation indicators. Two countries can have identical values of the total participation index in a given sector while having very different degrees of position in GVCs (that is, whether they are more involved upstream or downstream in the value chain).

39. For example, the total participation indicator for manufacturing in Utopia (Figure 7) can be calculated as \( \text{backward indicator} + \text{forward indicator} = 0.089 + 0.067 = 0.158 \).

Position Indicator

40. To capture a country’s position, Koopman et al. (2010) also proposed the position index which is given by log ratio of forward and backward indicators: \( \ln(1 + \text{forward indicator}) - \ln(1 + \text{backward indicator}) \).

41. If the sector lies upstream in a supply chain, the first term tends to be large. On the other hand, if it lies downstream, then the second term tends to be large. For example, in the home electronics sector, if Japan specialises in providing components to assembly firms in China, the index tends to take on a high value for Japan and a low value for China.

42. For example, the position indicator for manufacturing in Utopia (Figure 7) can be calculated as \( \ln(1 + \text{forward indicator}) - \ln(1 + \text{backward indicator}) = \ln(1 + 0.067) - \ln(1 + 0.089) = -0.02 \).
4. Final demand: Direct and indirect value added

43. Tracing the flow of value added exports (VAE) is a well-established measure of GVC activity. However, other measures are available that can shed light on the nature of GVCs. Using similar algebra to that which estimates VAE matrix, it is possible to identify the source of value added in final demand (Johnson and Noguera, 2012). Furthermore, we can distinguish different routes through which a source country's VA arrives at destination country by partitioning the final demand matrix. That is, a source country's VA in final demand can be split between that which is embodied in products made in either the source country itself and exported to final demand, in the destination country using source country VA as intermediates, or third countries that export to the destination country. The first and second routes are termed direct VA and the third indirect VA. This approach also has the advantage of avoiding the problem of ‘double counting’ of value added flows which can arise when using measures of GVC activity based VAE.\(^{16}\)

44. In a first step final demand (from the ICIO) is added together and aggregated by commodity group. Two sets of measures are available:

i) **consumption demand** including household demand and government consumption and

ii) **final demand**, which is a sum of **consumption demand** and investment consumption.

45. The resulting **gross consumption/gross final demand** is decomposed into regions and sectors where value added was originally created. The decomposition is available by commodity group and shows VA flows of final demand commodity (group) by source region and final demand region. In addition, total value added is decomposed into its components: labour, land and capital, net taxes and margins.

46. **VA in consumption/final demand** depicts the VA the source region contributes to final demand of a commodity group in each region. It is the sum of direct and indirect VA flows explained below. Total final demand in value added and gross terms are equal, but the composition differs. Thus, the sum over source region equals the sum (over source region) of gross consumption.

47. **Direct VA in consumption demand/final demand** shows the VA that flows directly from one region to the next. Either the traded good is already for final demand (of a commodity group) or it is traded in form of an intermediate good and reprocessed inside the importing region. It also includes domestic VA flows, when VA source region and demand region are same.

---

\(^{16}\) Double counting exists if elements of a VAE matrix are summed across countries. This occurs as the column sum of the VAE matrix reflects gross exports. As products are imported as intermediates and then exported, and as some domestic value added is re-imported and then re-exported, double counting can occur. For a theoretical discussion on the decomposition of gross exports and double counting issues see Koopman et al. (2014) and Miroudot and Ming (2017).
48. **Indirect VA in consumption demand/final demand** depicts VA flows that reach final consumption (of a commodity group) over a third (or fourth…) region. Indirect flows thus capture the part of final consumption that is part of global value chains.

4.1. Deriving VA in final demand/consumption

49. Final demand is derived from the ICIO (see Figure 6) by adding up household, government and investment demand (FDP+FDG+FDI). Similarly, the matrix of final consumption is aggregating household and government demand (FDP+FDG).

50. Final demand is depicted in the ICIO which contains information on the commodity consumed (a) by agent (i) in region (r) and the origin of this good (w, imported from w). The matrix is diagonalised and depicts final demand of commodity group (cagg) and commodity/sector (a) by consuming region (r) and the region where the goods where sourced from (w):

\[ y_{w,a,r,w,cagg} = \sum_i a$ cagg ICIO_{w,a,r,i} \]

where \( i = FDP + FDG + FDI \); \( a = c; \) and \( a \in cagg \)

Similar to the VAE matrix, final demand is multiplied with the Leontief inverse and V: \( V = [I - A]^{-1} \ast Y \) (Box 2). Where matrix V stands for total value added (V) and the contributions to V of labour (\( V_{lab} \)), capital and land (\( V_{caplnd} \)), net taxes (\( V_{tax} \)) and trade margins (\( V_{marg} \)) respectively, where \( V_{lab} + V_{caplnd} + V_{tax} + V_{marg} = V \).

The resulting matrix (VAY) depicts VA source region (ws) and source sector (c), in final demand by commodity group (cagg) in region (r) and the region where the final demand good was sourced from (w):

\[ VAY_{ws,c,r,w,cagg} = v_{ws,c} \ast [I_{ws,c,w,a} - a_{ws,c,w,a}]^{-1} \ast y_{w,a,r,w,cagg} \]

The measure for final consumption is derived the same way, but for final consumption Y contains only \( i = FDP + FDG \).

For example, assume there are three regions, A, B and C. Region 1 exports food products worth 100$ to region B which adds 10$ VA and exports 110$ food products to region C where the food is consumed (Figure 1). Then final food demand in C imported from B is specified as \( Y_{regB,a,regC,regB,food} = \sum_i a$food ICIO_{regB,a,regC,i} = 110 \).

From the ICIO we know how food in B was created and can derive the value added source for inputs (Box 2). Combining this information we can derive the source of value added in final demand of C, indicating also the source sector (c) of this value added:

---

17 It is worth noting that when working with aggregate regions trade within countries of these regions are classified as domestic flows. For example, when working with an aggregate EU, Exports of Brazil beef for consumption in Germany would be classified as direct flow, even when pre-processed in Poland.
4.2. Total, direct and indirect value added in final demand

51. VAY shows final demand by commodity group, the origin by sector and region (reg3) of value added and the transit region (reg1). There are several possibilities for VA to flow to final demand.

52. **Direct value added** shows the VA that flows directly from one region to the next. There are several possibilities; first, VA is a domestic flow and not traded when all three regional dimensions (reg1, reg2, reg3) depict the same region. Second, there are (simple) bilateral trade flows when (source) reg3 ≠ (transit) reg1 = (final) reg2, then intermediate imports are processed domestically and then consumed. Third, another bilateral relation would be when (source) reg3 = (transit) reg1 ≠ (final) reg2, then the source region already exports goods processed for final demand.

53. **Indirect value added** depicts real integration into global value chains, when commodities cross multiple borders before reaching final demand. Thus, we define flows as indirect VA if (source) reg3 ≠ (transit) reg1 ≠ (final) reg2. A good that is sent abroad for reprocessing, when (source) reg3 = (final) reg2 ≠ (transit) reg1, is also classified as indirect flow.

54. **Total value added in final demand** is the sum of direct and indirect VA. It is depicted by commodity group (cagg), source region where value added was originally created (reg3), and region where it is consumed (reg2). It is obtained by summing the VAY matrix over c and reg1 (the ‘transit’ country).
5. Output of the ICIO-TiVA module in METRO

Box 3. ICIO-TiVA Module in short

A module for the analysis of global value chains in METRO base data and model output. Several types of indicators and types of Value Added decomposition are available.

**Programme:** METRO-ICIO.gms

**Input:** Result files from simulation (and base data from calibration); Directory Results/simulation *with active intermediate input nesting!*

**Output:** Directory Results/ICIO-TiVA

- Inter-Country-Input-Output table.
- Value added exports
  - Value added exports matrix
  - VA composition of exports: domestic VA, foreign VA (backward linkage), gross exports
  - VA used in exports: sector VA in total exports, in own sector’s exports, in partner region’s exports (forward linkage)
- GVC indicators:
  - Backward indicator;
  - Forward indicator;
  - Position;
  - Participation
- Direct and indirect VA in final demand by product group:
  - Gross consumption;
  - Total VA in final demand;
  - Direct VA in final demand;
  - Indirect VA in final demand
55. The ICIO-TiVA module consists of a GAMS programme (METRO_ICIO.gms) that creates an ICIO and GVC indicators based on a simulation (or calibration from the base data) that was previously run. Every simulation results file created with METRO can serve as possible input to create an ICIO\textsuperscript{18}. 

56. The module creates various tables and indicators as described in the sections above. To help navigate through the module output the remainder of this section lists the tables, items and indicators that are available in the viewer of the METRO interface.

5.1. The Inter-Country-Input-Output Table (ICIO)

57. The Inter-Country-Input-Output Table (ICIO) serves as basis for GVC analysis, all indicators and value added decompositions are derived from it. The structure of the ICIO table is described in the next section. It has 4 dimension, 2 rows and 2 columns, which are indicated in the viewer by ‘source region’, ‘inputs’ and ‘destination region’, ‘demand’.\textsuperscript{19}

5.2. The value added exports matrix (VAE)

58. The value added exports matrix (VAE) identifies the origin of the value added that is embodied in gross exports by source and destination region and sector. The matrix is derived from the ICIO through traditional matrix calculations and serves as basis for the calculation of GVC indicators.

59. The column of the VAE matrix shows the composition of value added in the exports of a particular country-sector: the value of domestic value added and foreign value added (backward linkage) in a sector’s exports. That is, the VAE matrix traces the value of exports back along the production chain to the remuneration of primary production factors – or value added – that are ultimately used in producing the exported good or service. In doing so, the column sum of domestic and foreign value added equals gross exports. In GVC indicator terms backward participation is the foreign value added that is used to produce exports, which can thought of as the buying part of GVCs. In addition, a decomposition of the different components of this value added is also available so that domestic and foreign value added can be further decomposed into (1) labour, (2) capital, land and natural resources, (3) net taxes and (4) margins.

60. The row of the VAE matrix shows how the value added of a particular region and sector is used by all other sectors and regions to produce exports. This is the total of the direct value added of the sector to its own exports (value added content in the sector’s own exports) as well as the indirect value added that is sold to other sectors for these to produce exports (value added content of a sector in total exports\textsuperscript{20}). The forward linkage shows the use of a sector’s value added in exports of partner regions. That is, the sum of the non-domestic rows of the VAE matrix, which can be thought of as the selling element of GVCs. Again, the measure can be decomposed into different value added components.

\textsuperscript{18} Under the condition that it is created with the intermediate input module switched on.

\textsuperscript{19} When working with aggregate regions trade within countries of these regions are classified as domestic flows.

\textsuperscript{20} Including value added content in the sector’s own exports.
5.3. GVC indicators

61. The value added exports values can be expressed in form of so-called GVC indicators: **Backward participation indicator** represents the foreign value added share in total exports from a reference country (green arrows, A and B₁, in Figure 4). **Forward participation indicator** represents the share of a reference country’s value added exports in the total value of their trading partners’ exports, expressed as a share of the industry’s direct exports (red arrows, B₁ and C, in Figure 4). The indexes measure very different forms of engagement. For example, a country that is predominantly assembling products into final goods and subsequently exporting these will have a strong backward participation index but a weak forward participation measure. Conversely, a country which predominantly supplies intermediates to an assembler will have a strong forward participation indicator but a small backward participation measure. These participation measures therefore give a metric of engagement in the form of buying from (backward participation) and selling into (forward participation) GVCs.

62. The total **participation indicator** is defined as the sum of the backward and forward participation indicators (Koopman et al., 2010). To capture a country’s position, Koopman et al. (2010) also proposed the **position index**: Two countries can have identical values of the total participation index in a given sector while having very different degrees of position in GVCs (that is, whether they are more involved upstream or downstream in the value chain). To capture a country’s position the position index (Koopman et al., 2010) is given by log ratio of forward and backward indicators: \( \ln(1 + \text{forward indicator}) - \ln(1 + \text{backward indicator}) \). If the sector lies upstream in a supply chain, the first term tends to be large. If it lies downstream, then the second term tends to be large. For example, in the home electronics sector, if Japan specialises in providing components to assembly firms in China, the index tends to take on a high value for Japan and a low value for China.

The GVC indicators are further decomposed in VA items into (1) labour, (2) capital, land and natural resources, (3) net taxes and (4) margins.
5.4. Direct and indirect value added in final demand

63. An alternative way to explore GVCs is through the source and final destination of value added. Domestic value added can end up in foreign final demand through a number of pathways. It can flow directly from one country to the next – a bilateral flow – or it can flow indirectly through a third (or fourth and so on) country – via other countries.

64. In a first step *gross consumption* of good c in region i is decomposed into regions and sectors where value added was originally created. The decomposition is available by commodity group and shows VA flows of final demand commodity (group) by source region and final demand region.

65. **Direct VA in final demand** shows the VA that flows directly from one region to the next. Either the traded good is already for final demand or it is traded in form of an intermediate good and reprocessed inside the importing region. It also includes domestic VA flows, when VA source region and demand region are same.

66. **Indirect VA in final demand** depicts VA flows that reach final consumption over a third (or fourth…) region. Indirect flows thus capture the part of final consumption that is part of global value chains.

67. **Total VA in final demand** depicts the VA a region contributes to final demand in each region. It is the sum of direct and indirect VA flows.

68. The measures are available for (i) final demand including private and public consumption and investment, and (ii) for final consumption depicting private and government consumption. Similar to the VAE measures VA in final demand is further decomposed in value added items.
6. Conclusions

69. The ICIO-TiVA module described in this document gives the user a tool to describe GVCs using various GVC indicators, and VA decompositions of exports, final demand and consumption. In addition, the decomposition of value added into its various parts allows for a more detailed analysis of value added flows. The module is based on output from the METRO model. It is possible to derive and compare indicators for the base data as well as for any set of simulation results.

70. For the analysis of the module output (and this type of GVC indicators in general) it is important to keep in mind several factors.

71. First, the assumptions employed in constructing the database (as mentioned in section 1 and described for example in Ahmad et al., 2017). Most importantly, country coverage and sectoral aggregation can give a broad view only as it is ultimately firms that engage in GVCs.

72. Second, the structure of the model is key for the use and interpretation of changes in a policy simulation. Issues that come directly to mind are the relationship between matrices used to derive GVC indicators: VAE and VAY are composed of value added (V), intermediate inputs (A), exports (E), and final demand (Y).

73. The relation between VA and intermediates as well as the intermediate input matrix itself are at the core of the GVC analysis. The production structure in the model governs the responsiveness to changes. In the standard model intermediate inputs are aggregated in fixed shares using Leontief technology and a constant elasticity of substitution (CES) function governing substitutability between (further CES nested) VA and intermediates. In the GVC context, the production structure comes into focus and also the production elasticities employed. Changes in exports are driven by trade elasticities and the response of final demand is mainly governed by closure conditions (the macroeconomic setup of the model).

74. Regarding value added itself it is interesting to see how taxes or tariffs influence GVC indicators and how they trigger through the GVC. The METRO model and its ICIO-TiVA module decomposes value added into labour, land and capital, net taxes and margins and thus allows for this type of analysis.

75. Third, as explained in Box 3, GVC indicators describe a certain situation but a higher indicator or stronger integration cannot be interpreted as better. What matters at the end are changes in level of value added.
References


Annex A. How to use the ICIO/TiVA module

Input and assumptions

The ICIO and GVC indicators are computed as post-simulation analysis. In the GUI select the workstep “Post-simulation analysis” and the task “ICIO-TiVA module”. The output is based on result files generated when running the model. (Indicators for the base data will originate from the base scenario that is produced during the calibration run.)

To be used in the ICIO-TiVA module the respective simulation file **MUST be created with the intermediate input nesting module activated** in the model setup (Calibration step). If it is not activated the programme will abort!

METRO results contain information on import use by sector and bilateral imports used as intermediates. The construction of an ICIO requires the combination of these two parameters, i.e. the import use by sector and source region. An assumption is needed to add this additional dimension. The module currently assumes **proportionality** to distribute bilateral imports across sectors. Thus, while the sectors differ by the values of imports used (of each intermediate commodity), the bilateral composition of these imports is equal among sectors.

Output

The results can be viewed and compared in the viewer; click on “Exploit results” and select the data set and file(s) you want to view.
The output: a small example

**VAE Decomposition**

*Column: value added composition of exports of a region (backward)*

- Domestic value added in exports of a sector in a region is the sum across all rows representing domestic sources of VA (yellow cells in Annex Table 1): European ag&food exports incorporate domestic VA of 121,570 Mio US$ (69,206 + 973 + 11,505 + 3,511 + 36,375)
- Total foreign value added in exports from a sector in a region is the sum across all rows representing foreign sources of VA, (grey cells in Annex Table 1): 15,387 Mio US$.
- Gross exports=total domestic value added + total foreign value added. This is the column sum.

Example based on from 5_8_5 base data.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>Agriculture and Food</td>
<td>136.958</td>
<td>121.570</td>
<td>15.387</td>
</tr>
<tr>
<td></td>
<td>Natural resources</td>
<td>32.045</td>
<td>29.762</td>
<td>2.283</td>
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<td>Manufacturing</td>
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<td>1.361.175</td>
<td>334.695</td>
</tr>
<tr>
<td></td>
<td>Transport services</td>
<td>167.940</td>
<td>143.214</td>
<td>24.726</td>
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<td></td>
<td>Services</td>
<td>559.521</td>
<td>526.936</td>
<td>32.584</td>
</tr>
</tbody>
</table>
### Annex Table 1 Value Added Exports – MATRIX

<table>
<thead>
<tr>
<th>VA source region</th>
<th>exporting good</th>
<th>North America</th>
<th>Asia</th>
<th>Rest of the World</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>Ag&amp;Food</td>
<td>69,206</td>
<td>310</td>
<td>1,148</td>
</tr>
<tr>
<td></td>
<td>Nat. res</td>
<td>973</td>
<td>121</td>
<td>265</td>
</tr>
<tr>
<td></td>
<td>Manufacturing</td>
<td>11,505</td>
<td>1,603</td>
<td>701</td>
</tr>
<tr>
<td></td>
<td>Transport</td>
<td>3,511</td>
<td>192</td>
<td>103</td>
</tr>
<tr>
<td></td>
<td>Services</td>
<td>36,375</td>
<td>1,483</td>
<td>772</td>
</tr>
<tr>
<td>North America</td>
<td>Ag&amp;Food</td>
<td>328</td>
<td>8</td>
<td>858</td>
</tr>
<tr>
<td></td>
<td>Nat. res</td>
<td>163</td>
<td>18</td>
<td>89</td>
</tr>
<tr>
<td></td>
<td>Manufacturing</td>
<td>992</td>
<td>14,815</td>
<td>549</td>
</tr>
<tr>
<td></td>
<td>Transport</td>
<td>132</td>
<td>4,125</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Services</td>
<td>1,099</td>
<td>43,428</td>
<td>800</td>
</tr>
<tr>
<td>Asia</td>
<td>Ag&amp;Food</td>
<td>829</td>
<td>97</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Nat. res</td>
<td>179</td>
<td>75</td>
<td>89</td>
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<tr>
<td></td>
<td>Manufacturing</td>
<td>1,948</td>
<td>2,905</td>
<td>549</td>
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<td></td>
<td>Transport</td>
<td>236</td>
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<td>Services</td>
<td>1,370</td>
<td>1,666</td>
<td>800</td>
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<td>ROW</td>
<td>Ag&amp;Food</td>
<td>2,482</td>
<td>1,590</td>
<td>1,361</td>
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<td></td>
<td>Transport</td>
<td>419</td>
<td>305</td>
<td>200</td>
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<td></td>
<td>Services</td>
<td>1,711</td>
<td>1,422</td>
<td>877</td>
</tr>
<tr>
<td>sum: gross exports</td>
<td>136,958</td>
<td>32,045</td>
<td>167,940</td>
<td>113,958</td>
</tr>
</tbody>
</table>

Columns indicate exporting regions and the good that is exported. Rows indicate where the value added had been created by (source) region and (source) sector. For example, Ag&Food exports in Europe include 992 Mio US$ generated by manufacturing in North America.

Yellow cells are the domestic flows of value added. Grey cells are the international flows of value added. Boxed cells indicate a country-sectors own value added exports.

**METRO DEVELOPMENT: THE ICIO-TIVA-MODULE**

For Official Use
Alternative way to decomposition value added exports of a region (forward)

- Sector VA in own sector exports: Value added content the sector contributes to its own exports = cells where source country is also the exporting country, and source sector is similar to exported good (boxed cells in VAE matrix above). European ag&food exports contain VA that originates from domestic ag&food production worth USD 69,206 million.

- Sector VA in total exports: Value added a sector contributes to total exports in a region. This includes own sector’s exports and VA that is exported in form of other goods. For example, direct exports of cotton and cotton that is processed into textiles inside the country and then exported. The sector VA in total exports = sum over exporting sectors for each region where source region equals the exporting region (yellow cells in Annex Table 1). European ag & food production contributes USD 89,851 million to all exports of Europe (of which USD 69,206 million are in form of ag & food exports).

- Sector value added in exports of partner regions = sum over exporting sectors for partner regions (grey cells). USD 6,070 million of VA created in European ag & food production is reprocessed and again exported by partner regions.

<table>
<thead>
<tr>
<th>Source region</th>
<th>Source sector</th>
<th>Sector VA in own sector exports - [value]</th>
<th>Sector VA in total exports - [value]</th>
<th>Sector VA in partner exports - [value]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Europe</td>
<td>Agriculture and Food</td>
<td>69,206</td>
<td>89,851</td>
<td>6,070</td>
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<td>Natural resources</td>
<td>21,820</td>
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<td>Services</td>
<td>477,976</td>
<td>974,820</td>
<td>118,394</td>
</tr>
</tbody>
</table>

GVC indicator calculations

- Backward participation = foreign value added in total exports = backward va/total gross exports. For example Europe’s ag & food sector’s backward participation rate is 0.11 = 15,387/136,958. Which means that 11% of the value of ag & food exports is originates from domestic VA.

- Forward participation = the share of a regions value added exports in their trading partners’ exports (sum of grey cells of industry row), expressed as a share of the industry’s gross exports. For example, Europe’s ag & food sector’s forward participation rate is 0.04 = 6,070 / 136,958. This is 4% of Europe’s ag & food exports are contributing to exports in partner regions.

- Participation index = sum of forward and backward indicator.

- Position index = ln(1 + forward indicator) – ln(1 + backward indicator) If sector lies upstream in a supply chain, the first term (numerator) tends to be large, if it lies downstream, the second term (denominator) tends to be large. For example, in the home electronics sector, if Japan specialises in providing components to assembly firms in China, the index tends to take on a high value for Japan and a low value for China.
Direct-indirect VA – the VAY matrix

VAE showed the VA composition of exports, now we are looking on the VA composition of final demand. Two versions are available: i) ‘final demand’ including household and government consumption as well as investment demand (see Annex Table 2); and ‘final consumption’ including household and government demand (the concept similar to final demand and thus not iterated in this example).

- The first column in Annex Table 2 shows gross final demand of agricultural (and food) products in Europe. Europe consumes agricultural (and food) products worth USD 981,453 million of which 915,432 are from European production, 9,285 are imported from North America and so forth.
- VA in final demand shows where the VA in final demand originates. Total final demand in VA terms equals gross consumption. But the table below shows that in VA terms, the intra-European contribution is smaller, this indicates that European food processing is using imported intermediates. These originate partly from North America that contributes VA worth USD 27,750 million compared to gross imports of final demand goods of USD 9,285 million.
- USD 26,475 million of this trade flow from North America to Europe is direct: goods are either exported by North America as final demand goods for consumption in Europe or are exported in form of intermediate goods and further processed in Europe directly from North America to Europe without intermediary countries.
- Agriculture (and food) goods indirectly traded amount to USD 1,275 million. This means that at least one additional country was involved to produce the good, between value added creation in North America and final demand in Europe.
- The direct VA flow from Europe to Europe (812,581) shows the value that is not traded. Indirect VA where Europe is source region and consuming region (1,918) indicates the amount of reimports, e.g., a good is sent for processing to another region and then reimported for consumption.

Annex Table 2. VA composition of final demand

<table>
<thead>
<tr>
<th>Commodity group</th>
<th>Source region</th>
<th>gross final demand - [value]</th>
<th>VA in final demand - [value]</th>
<th>direct VA - [value]</th>
<th>indirect VA - [value]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>Europe</td>
<td>915,432</td>
<td>814,499</td>
<td>812,581</td>
<td>1,918</td>
</tr>
<tr>
<td>Agriculture</td>
<td>North America</td>
<td>9,285</td>
<td>27,750</td>
<td>26,475</td>
<td>1,275</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Asia</td>
<td>12,889</td>
<td>44,211</td>
<td>42,406</td>
<td>1,805</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Rest of the World</td>
<td>43,848</td>
<td>94,994</td>
<td>94,071</td>
<td>923</td>
</tr>
<tr>
<td>Agriculture</td>
<td>Europe</td>
<td>915,432</td>
<td>814,499</td>
<td>812,581</td>
<td>1,918</td>
</tr>
<tr>
<td><strong>Sum</strong></td>
<td></td>
<td>981,453</td>
<td>981,453</td>
<td>975,533</td>
<td>5,920</td>
</tr>
</tbody>
</table>