Building AfCIOT and TiVA Indicators in Africa in Support of AfCFTA

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1. INTRODUCTION

In the interconnected global economy that exists today, traditional measures of economic activity fail to capture the true economic dynamics and interdependencies that exist between countries. Current analysis covering the African continent rests upon traditional trade statistics, which focus on gross values of goods and services, and overlook the intricate network of production and value creation that takes place across borders.

Trade in Value Added (TiVA) provides new statistical insights on Global Value Chains (GVCs), by decomposing gross trade flows based on the origin country and industry of the value-added. TiVA indicators are calculated in the framework of inter-country input-output tables (ICIO); while other regions have their own ICIOs (e.g., EUROSTAT Figaro database (EU), NAFTA-TiVA project (North America), ECLAC regional Input-Output Table project (South America), APEC-TiVA database (Asia-Pacific)). Africa remains the only region that has no ICIO yet, although the demand for such a tool to better inform industrialization and economic integration of the continent is high.

The Economic Commission for Africa (ECA), in collaboration with the Organization of Economic Cooperation and Development (OECD) and World Trade Organization (WTO), has embarked on a project to develop an African Continental Input-Output Table (AfCIOT). By the end of the project, the AfCIOT will be built and the areas for the improvement of the quality of SUTs will be identified and conveyed to Member Station, national capacity will be strengthened, and analytical indicators, such as TiVA will be compiled. Country analytical reports will be produced for the countries, providing insights into the country's trade and industrialization process, the countries' positions in GVCs and the Regional Value Chains (RVCs) in Africa.

A key part of transforming Africa over the next decade is trade. The signature of the African Continental Free Trade Area (AfCFTA) agreement constitutes an expression of interest from African countries in boosting intra-African trade and increasing participation in Global Value Chains (GVCs). Considering the number of countries participating (55), the AfCFTA is the world's largest free trade area. Its mandate is to create a single continental market with a population of about 1.3 billion people and a combined GDP of approximately US$ 3.4 trillion, being a key element of Agenda 2063: The Africa We Want, the African Union's long-term development strategy for the continent (AfCFTA, n.d.).

AfCIOT has the elements to contribute to AfCFTA's mandate, especially by providing evidence that will equip policymakers to eliminate trade barriers and boost intra-Africa trade. In particular,

it will provide detailed figures to advance trade in value-added production across all service sectors of the African Economy. AfCIOT will support AfCFTA in establishing regional value chains (RVCs) in Africa, enabling investment and job creation. The practical implementation of the AfCFTA has the potential to foster industrialization, job creation, and investment, thus enhancing the competitiveness of Africa in the medium to long term.

This paper sets out the methodological approach to be taken in developing the AfCIOT and its application in policymaking in Africa. The rest of this paper is structured as follows. Section 2 will be devoted to the scope and overview of the AfCIOT model, i.e., the principles and choices that have been made in its construction, including the coverage of the AfCIOT in terms of industries, countries, and years. Section 3 gives a listing of the contents of the AfCIOT database, including the data requirements, sources, gaps, and challenges. Section 4 describes the methodology for building the African Continental Input-Output Table (AfCIOT) in 15 steps, including harmonization and benchmarking of the SUTs on the National Accounts, the estimation of the imports in the Use table for which a bilateral trade database was built, how to derive the inter-country SUTs from national SUTs, how to combine the inter-country SUTs to yield a world SUT, which then is transformed into AfCIOT. Section 5 briefly introduces the analytical indicators that are currently constructed. The last section concludes.

2. SCOPE AND OVERVIEW OF THE AfCIOT MODEL

There are other multi-region IOT initiatives being undertaken by organizations around the world (as noted in Appendix A). There are four global databases: World Input-Output Database (WIOD), the Eora Global Supply Chain Database, the Global Trade Analysis Project (GTAP), and the WTO-OECD Trade in Value Added (TiVA) database. While the first three use more analytical models, the WTO-OECD database uses a statistical method to produce TiVA indicators from SNA, IOT/SUT, and trade data.

The AfCIOT model follows the best-practice statistical approach of the WTO-OECD model. In its 2021 edition, the WTO-OECD ICIO database covers 66 target countries (plus the Rest of the World), 45 unique industries, and all years for the period 1995 to 2018. Nonetheless, of those, only three countries are from Africa, with five more to be added this year. AfCIOT currently contains 16 African countries, while the remaining 38 are aggregated in one element called Rest of Africa (RoA) and the countries from the OECD model as Rest of World. Eventually, the model will cover all 54 African countries.

Currently, we are processing 16 African countries as part of the model. The remaining countries (currently unprocessed) are presented as one country, the Rest of Africa (RoA), for ease of the first iteration of the model. To estimate the SUT for RoA we first aggregate the 16 country SUTs into one total SUT. We then use African production information as boundaries and the average economic structure from the countries included in the model. This is similar to the methodology of OECD for estimating the Rest of the World (RoW) using world production figures.

3. DATA REQUIREMENTS, SOURCES, GAPS, AND CHALLENGES

3.1.Data Requirements

At the heart of the compilation of intercountry input out tables rest the issue of the availability of the data needed to represent and quantify the transactions that are taking place among different institutional sectors and among industries, even beyond national borders. The option chosen for AfCIOT to follow an ICIOT-building approach close to that of the OECD implies seeking close compliance with the data requirements specified by the OECD. While the requirements might be ideal, the reality of countries' data makes these requirements far from reach. The operational strategy, therefore, consists of starting off with the basics, but minimum, requirements and developing methods to fill gaps wherever possible. Ideally, there is a long list of ideal requirements for building TiVA models (listed in Appendix B), including:

- Annual series of supply and use tables with disaggregated industries and products, for instance at 2 digits level of ISIC Rev4 and corresponding products, and with breakdown variables (trade margins, transport margins, taxes, and subsidies on products) that lead from basic price transactions to purchaser prices.

- Imports matrix depicting the origins and destinations of the various products (goods and services) traded in the economy.

- Detailed bilateral trade (in goods and services) statistics.

The absence of this ideal data availability situation in African countries leads to exploring alternative ways to build the interconnection between economies and between institutional sectors beyond borders, starting with the available basic data.

3.2.Data Sources

This section gives an overview of the data being used for the construction of the AfCIOT.

Supply-Use tables in Africa: There are 45 counties in Africa that have indicated in 2022 having complied with a SUT at least once. Of these, 36 countries claimed to have done so with the 2008 SNA as a reference manual, implying in principle that these countries also have adopted ISIC Rev4 and CPC rev2.1 which serve as the basis for the harmonization of the SUTs in the framework of the development of AfCIOT. Besides the remaining 9 countries in which SUTs are aligned with the 1993 SNA, the level of detail remains a factor that can facilitate or further complexify the harmonization of SUTs across the continent. CPC rev2.1 identifies 71 product headings at the 2-digit level while ISIC rev4 has 99 divisions (2-digit categories) which are further grouped into 45 groups for harmonization in the OECD TiVA database process. SUTs whose dimensions are larger than 71 industries x 71 products offer more facility and accuracy in the hominization process while SUTs of smaller sizes pose challenges regarding the way to split the values into their aggregated industries and product groups according to the reference industries and products in the system.

SUTs received from countries vary in size, from 19x19 to 91x101. However, the majority of the SUTs are below 71x71 in dimension. The harmonization processes are described elsewhere in this paper.

One step further to the harmonization of the SUTs is to align the SUTs for common years. In this regard, the latest available SUTs from countries date from between 2008 and 2020, with the latest SUTs being compiled after 2015 in 23 countries. For countries that do not have SUTs for the years for which the TiVA indicators are being computed, projections on years missing SUT through interpolation extrapolation are performed, using national accounts aggregates as control variables.

Annual national accounts series: Almost all African countries produce and release annual national accounts series of GDP and its breakdown according to both expenditure and output approaches, real and at current prices. In most cases, the released breakdowns of GDP comprise sections level of gross value added by industry, FISIM (depending on the version of the series), and taxes less subsidies. From the expenditure point of view, public and private consumption, GCF, inventories, exports, and imports series are provided.

As only some African countries are included on an individual basis in the data system, the remaining countries are accounted for through their size downloaded from the UN data portal on annual national accounts main aggregates, with a built gross average structure. When SUTs are produced, the national accounts aggregates coincide well with their values in the SUTs.

Trade in goods and services statistics: Trade statistics are generally well-developed among African countries which compile merchandise trade statistics and report these to the United Nations Division, which publishes the data through the trade statistics portal COMTRADE. Countries' merchandise trade statistics are very detailed and allow good identification of partner countries of the flows of the various products. As it happens that some counties fail to produce or report their trade statistics through COMTRADE, the UNCTAD statistics database serves as a source to fill the gaps, given that UNCTAD already conducts some data gap-filling exercises.

Available SUTs provide, to the extent of the level of their detail, statistics on imports and exports of services. However, as this is often not the case that all countries compute a SUT on an annual basis, data on trade in services are harvested through the balance of payments from the IMF Financial Statistics database (where they are available for a few countries), collected from national authorities, especially the central banks and from the Balance of Payments (BoP). These trade in services lack however the needed depth in terms of granularity as well as trade partners involved in each case. This fact leads to investigating other datasets such as tourism satellite accounts or targeted business surveys to help disaggregate further the available aggregated services trade data.

3.3.Data Gaps and Challenges

National accounts and supply and use tables:

- Coverage issues: with the importance of an informal sector in most African countries, it is worth investigating the extent to which this sector is accounted for, the measure of the consumption vectors of industries operations in the informal sector as well as the transborder informal sector. This latter issue also concerns trade statistics.

- Consistency through time: Changes introduced upon change of base years can become sources of breaks in national accounts series rendering them incomparable over time. These need to be clarified with national accounts teams in the countries to identify how to treat broken series when these occur in the period that the indicators are being compiled.

Trade statistics:

- Systems of merchandise trade statistics: Merchandise trade statistics are reported according to different systems translating into different contents that might not reflect the actual economic interactions with their economic partners. For instance, reexports figures mean that not all imported goods are destined for the national economy and therefore need to be removed from the imports and exports to work only with the actual imports into the economy and the actual exports of goods proceed from the economy. There may also be inconsistencies in the import data of Country A from Country B, and the export data from Country B to Country A.

- Imports of services: Service level data is less available and less accurate than merchandise data. This is true globally, and even more so for Africa. Data is available from sources previously mentioned at an aggregate level for imports, but not by partner country.

- Import of second-hand goods: The existence of import data on used items in trade statistics means that they do not originate from the direct output of industries in sending countries, but rather from the inventories of those countries.

- Confidential good traded: The existence of the confidential good traded need to be investigated to ensure that they are accounted for during the computation of ICIOTs

- Direct purchases of Resident abroad and by foreigners: these transactions concern travelers and their inclusion into official statistics need to be verified and corrected if possible before proceeding further.

Necessary direct interaction with data producers in countries and international data exchange among regional TiVA initiatives:

- The reality behind the statistics communicated cannot be solely grasped through metadata which often does not provide all the details needed to understand the limitations and peculiarities of the data. To circumvent this lack of clarity, direct interactions with data producers have proven to be essential to obtain a comprehensive knowledge of the data which helps in their best use throughout the process. The results of surveys on SUT data availability and coverage by African countries are available in Appendix C.

- Beyond the continental context, an efficient ICIOT for African countries needs to be able to provide ground to analyze trade implications in changes of policy from specific trade partners, especially large partners outside the African continent. The integration of non-African economies for such purposes will require cooperation and data exchange from institutions leading ICIO initiatives in the regions covering those countries. In the current

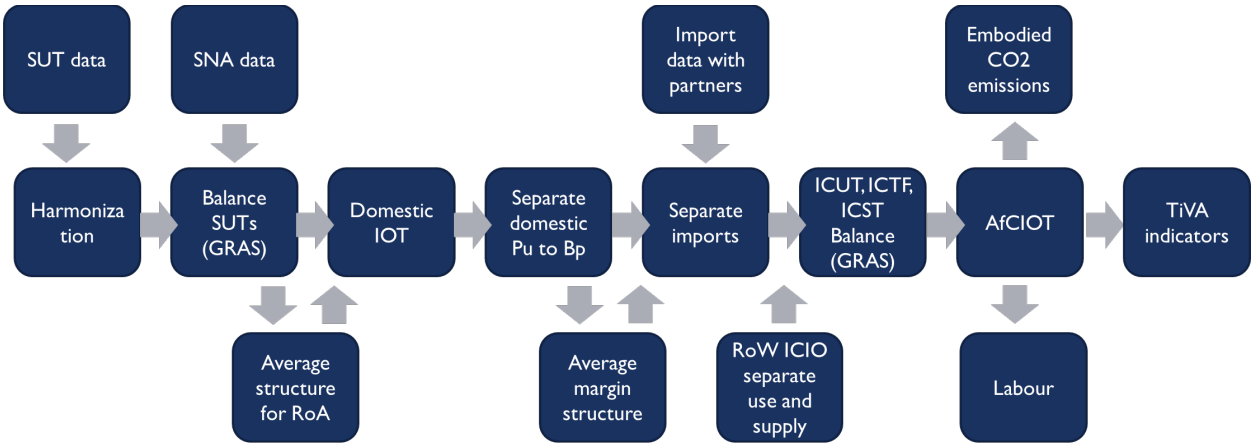
stage, AfCIOT relies on data in the OECD database to slice blocs of non-African partners for a fast move towards achieving the first TiVA estimates. However, in the longer run, the inclusion of individual economies will be more suitable.

4. THE METHODOLOGY FOR BUILDING THE AfCIOT

The methodology for building AfCIOT is based on that of OECD, supplementing with African country SUTs and following best-practice estimation methods based on, for example, time series analysis, cross-sector regression analysis, and economic characteristics such as size, level of industrialization, and employment structure.

The AfCIOT building process can be summarized by the steps in Figure 1.

Figure 1: AfCIOT workflow from input data to analytical applications.



4.1.Data Collection

The first stage is the collection of country SUT and SNA data from national statistical offices (NSOs) across Africa. To identify the data gaps (against the minimum requirements for the TiVA model) a data repository has been developed and each SUT has been cataloged. This catalog will be regularly updated and allow for tracking of country data as NSOs' capacity strengthens and countries update to the latest SNA methodology. This information is supplemented by the UN data catalog of official country data and Analysis of Main Aggregates published by UNSD.

4.2.Harmonization of National SUTs

Once the basic data is compiled, the harmonization process transforms the national data into international classifications. Automatic classification using programming matches the national classification with either the Classification of Products by Activity (CPA) for products or the International Standard Industrial Classification of All Economic Activities (ISIC) for industries at a two-digit level. Following the approach used by ECLAC for the South American IOT there are four possible options:

Type	Relationship (national to standardized)	Description
Fusion (F)	Many to one	Where the national SUT has more than one category that fits in to the two-digit CPC or letter ISIC. In this case, the two or more sectors are aggregated. This process is straightforward and consists of adding sectors of the relevant national SUTs. Those that were most commonly aggregated were agriculture (where some African countries separate a main agricultural product e.g. bananas, cassava, coffee).
Opening (O)	One to many	Where the national SUT has fewer, less detailed, categories than the two-digit CPC or letter ISIC. In this case, the national SUT category needs to be divided into the appropriate categories by estimation, based where possible on data.
Direct allocation (D)	One to One	Where the national SUT category directly matches the two-digit CPC or letter ISIC.
A sector with no production (NP)	N/A	For some countries, they do not produce in a particular sector. This is particularly the case for publishing industries.

The complex relationship is one to many, where currently we apply an even division to the national value among the international classifications. The results are 87 * 99 matrices, ISIC is then mapped to the 45 industries published by the WTO-OECD ICIO for ease of integration.

4.3.Balancing and Updating of SUTs

Once the SUTs have been compiled, the next crucial step is to balance and update them to a common base year, in this case, 2018 as the most recent and common data pre-covid for which countries have produced SUTs in the region. This balancing and updating process is carried out individually for each country's SUT using the Generalized RAS (GRAS) method, which is implemented in the R programming language. This is an advancement from the traditional RAS method which scaled the original matrix to meet exogenously given totals but does not allow either for higher aggregation levels or negative values (Stone and Brown, 1962; Bacharach, 1970; Lahre and de Mesnard, 2004). However, in the balancing of SUTs negatives may appear, for example in changes in inventories or in subsidy columns. The Generalised RAS method (GRAS) solves this issue by using reciprocals of the exponential transformations of the Lagrange multiplier (Gunluk-Sensen and Bates, 1988; Junius and Oosterhaven, 2003).

The GRAS method ensures that the SUTs are consistent with the values provided by the System of National Accounts (SNA) data. During the balancing and updating process, the boundaries of the SUTs are fixed based on the values derived from the SNA data. These boundary values correspond to the total values of intermediate consumption, final consumption, gross capital formation, exports, and imports as reported by the SNA. The fixed boundaries provide a framework within which the SUT cells need to be adjusted.

To address discrepancies that often exist, the remaining cells of the SUTs are increased or decreased by the model to meet the overall constraints. The objective is to align the SUTs in a way that ensures internal consistency and coherence while also adhering to the boundary values specified by the SNA data.

The Generalized RAS method in the R programming language performs the iterative calculations required to achieve a balanced and updated set of SUTs. It uses optimization techniques to adjust the cells incrementally while considering the constraints imposed by the fixed boundaries and the aggregated values provided by the SNA data. This iterative process continues until the SUTs satisfy the required constraints and achieve internal consistency.

Eventually, the model will move to MR-GRAS for updating multiregional SUTs plus additional aggregation constraints for GDP by income and GPD by expenditure (Hutniczak, 2022).

4.4.Conversion to Basic Prices

The valuation aspect is treated at this stage using margins, provided in the supply table as the difference between supply at purchaser's prices and supply at basic prices. The margins consist of trade margins, transport margins, and taxes less subsidies. These are applied to the use table to convert it into basic prices.

Basic prices are the preferred method in the 2008 SNA for valuing output in the accounts. This price basis reflects the amount received by the producer from the purchaser for a unit of goods, minus any taxes payable, plus any subsidy receivable on that unit as a consequence of production or sale (for instance, the cost of production). It is thus the most relevant price for producers' decision-making (UNSD, 2018).

$$Basic\ prices = amount\ received\ by\ producer\ from\ purchaser\ for\ a\ unit\ of\ goods - taxes\ payable + subsidies\ receivable\ for\ production\ or\ sale\ of\ good$$

Purchasers' prices are those prices payable by the purchaser and include transport costs, trade margins, and taxes (unless the taxes are deductible by the purchaser). Use tables are provided in purchasers' prices as the price most relevant for the users of products.

$$\begin{aligned} Purchasers'\ prices \\ &= producers'prices + any\ non \\ &- deductible\ VAT\ or\ similar\ tax\ payable\ by\ purhcaser \\ &+ transport\ costs\ paid\ separately\ by\ purhcaser + trade\ margins \end{aligned}$$

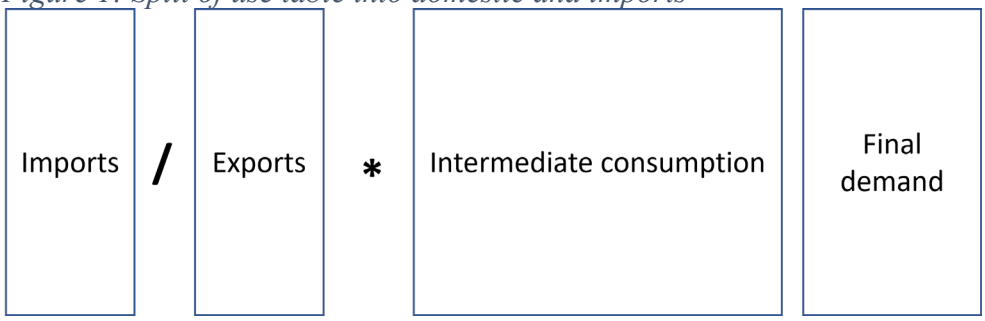
Detailed information on margins does not always exist across African SUTs. Where missing, an alternative method for calculation whereby the total supply at basic prices for each product is used as the boundary for the use table at basic prices.

4.5.Separation of Import Use Tables

The use table is then separated into the domestic use table (DUT) and the imports use table (IUT).

DUT and IUT: For splitting the use table into domestic and imports we use the row proportions assumption. This assumes that imports are distributed according to the proportions that consumption happens within the economy. For example, if 50% of printing products are supplied by media companies, we assume that 50% of the use of printing products is imported by media companies. To do this, imports in the supply table are taken as a percentage of the total supply of the product, and this ratio is applied to the Use table. The below diagram demonstrates the calculation.

Figure 1: Split of use table into domestic and imports



This is quite a simplistic assumption, and as we develop the model over time we will incorporate more country-specific aspects, such as the availability of production in-country.

Import partners: The imports from partners for merchandise are established based on trade data from the UNSD Comtrade statistics dataset and the *Compendium on Intra-African and International Trade*. The IMF Balance of Payment (BoP) dataset is used for trade in services. Imports by products are provided by Harmonized System (HS) classification and converted into CPA, while imports for services are provided by the Extended Balance of Payments (EBOP) classification and converted into CPA. While trade in goods is well captured by partner and product, data for trade in services exist to a lesser extent. Estimation by the partner is carried out using gravity models. Once import data are obtained, they need to be separated to reflect whether the importing country uses the goods and services as intermediate consumption or final demand. This is done based on the Broad Economic Classifications (BEC) from the UNSD Comtrade statistics dataset.

4.6.Multi-Country Model and Balancing

The next step is the compilation of the inter-country use table (ICUT), the inter-country supply table (ICST), and the inter-country trade flow (ICTF). There is then another stage of balancing to ensure that the imports and exports of each industry are equal. For this GRAS is applied to a modified ICTF. The balancing of international trade is done in three stages: (i) Goods, services, and direct purchases; (ii) Sectoral trade flows; (iii) Bilateral trade flows.

4.7.Transformation From Multi-Country SUT to Multi-Country IOT

For the transformation of SUTs into IOTs, various assumptions have to be made.

For product-by-product IOTs either:
- The product technology assumption (whereby each product is produced in its own specific way, irrespective of the industry where it is produced); or

- The industry technology assumption (whereby each industry has its own specific way of production, irrespective of its product mix).

For industry-by-industry IOTs either:
- Fixed industry sales structure assumption (whereby each industry has its own specific sales structure, irrespective of its product mix); or

- The fixed product sales structure assumption (whereby each product has its own specific sales structure, irrespective of the industry where it is produced).

This model follows the fixed sales structure assumption, meaning that each product has its own specific sales structure, irrespective of the industry where it is produced (Model D). The conversion into industry-by-industry ICIO is thus a multiplication of a transposed ICST as a proportion, with the ICUT.

4.8. Integration of Rest of World (RoW)

At this stage the Rest of the World (RoW) is integrated, i.e., the non-African countries. They are obtained from the combination of 57 countries from ICIO. Since ICIO is already in the IOT stage, it is not included in the ICUT, ICST, and ICTF tables.

The first step to integrating the ICIO tables is to separate each country's domestic IOT and import IOTs with other RoW countries. Then, there are two additional tables that need to be constructed: (i) the imports from African to RoW countries; and (ii) the imports from RoW countries to African countries.

Imports from African countries to RoW: To construct this the RoW supply table is required as the exporting country. As we follow the Model D assumption, the supply table is only required in proportion form. We assume a diagonal structure to the supply table, following the CPA to ICIO mapping of products to industries. This assumes that each product is supplied by organizations within the same industry e.g. agricultural products are supplied by the agricultural industry. The extent to which this is true depends on the format of the survey for SUT construction, where those with more specific categorization follow a more diagonal structure. However, for average across RoW it is the best approach at present. This is then multiplied by the relevant import partner use table separated from each African country's total use table estimated in Step 5.

Imports from RoW countries to African countries: To construct these we can use the assumed supply table from step (i) to back-reverse from IOT to imports Use table at basic prices for the RoW countries. African countries in our model (with the exception of the three that currently exist in the ICIO framework), make up the RoW of the ICIO model. Applying the African

country shares as a percentage of all African country imports, we can then separate the African country import use tables. Multiplying this with the transformed African country supply table we create the imports by African countries to RoW countries.

4.9.Validation

To validate data quality and consistency different checks were conducted. These controls can be distinguished into two stages: check regarding national IOTs and check regarding construction and assembly.

5. ANALYTICAL INDICATORS

5.1.Production of TiVA Indicators

Currently, three TiVA indicators are being calculated from AfCIOT:

- DVA: Domestic value-added content of exports, by industry i in country/region c to partner country/region p, represents the exported value added that has been generated anywhere in the domestic economy (i.e. not just by the exporting industry).

$$DVA_{c,i,p} = V_c * B_{c,c} * EXGR_{c,i,p}$$

- FVA: Foreign value-added content of gross exports captures the value of imported intermediate goods and services that are embodied in a domestic industry's exports. The value added can come from any foreign industry upstream in the production chain.

$$FVA_{c,v} = V * B_{c,i} * EXGR_{c,i}$$

- DVX: Direct domestic value-added content of exports measures the direct value-added contribution made by industry *i* in country *c* to the production of goods and services exported by industry i to the world.

$$DVX_c = V_c * diagB_c * EXGR_c$$

The next indicators to be calculated are backward and forward participation in GVCs as percentages of the total gross exports of the value-added source country. Validation exercises are carried out on the resulting TiVA indicators. By employing ranges and sensitivity analysis to test the reliability and credibility of TiVA indicators.
From these key TiVA indicators, policy simulation and analysis can be applied to produce insights into a country's position in GVCs, the strength of RVCs, and country-specific industry-level analysis.

The development of AfCIOT as a tool aims to allow stakeholders, especially statisticians of African NSOs that do not compile SUTs often, to identify the benefits of obtaining country-specific analytical outputs from a regional model.

To allow for policymakers to have access to this analysis the AfCIOT will have a user-friendly interface. The chosen framework for the tool is Shiny, an R package that facilitates the creation of interactive web apps straight from the R coding environment. The app is expected to be hosted on a webpage, providing dashboards where the user can select which indicators to visualize and compare them among specific countries or group of countries (based on African geographical sub-regions and Regional Economic Communities – RECs). The tool has been designed to be user-friendly and accessible.

The production of TiVA indicators allows the identification of the foreign value-added contents in exports; domestic value added driven by foreign final demand; main destination markets for exports; main import partners; service content of gross exports, among other key information for policymakers. Particular analysis for countries included in the database can be drawn, as has been done by OECD through country notes (OECD, 2022).

There are two extensions that will be made to the TiVA database; employment and the environment. An outline of these is provided below.

5.2. Labour and Productivity Value-Chains

One of the key SDGs required for standards of living to improve in African countries is decent employment. An employment extension to TiVA will be based on the compensations to employees row in the Use table, as a breakdown of value-added, productivity, and employment data from national sources (such as Labour Force Surveys (LFS), or UN labor market data. The two main assumptions required are that, for detailed industries, exporting firms have (Horvat et. al, 2020).

- The same labor productivity (output/employment) as firms producing for the domestic market.

- The share of intermediates to final demand is the same as domestic firms.

However, this may not be the case for African countries, where exporting firms often have higher labor productivity, required in order to be competitive on the global market. The impact of their low level on GVCs, and the differing levels of value chain integration between countries in the region may also affect these assumptions. Accuracy for service sectors may be difficult to capture due to lack of data.

Where employment or productivity data is missing, but countries have the compensation of employees built into the SUT, the share of this against value added (CEshVA) can be used to fill gaps. If this is still missing, the time series methodology used by OECD will be followed (Horvat et. al, 2020). This uses the CEshVA ratio of the nearest higher industry aggregate *j* to fill in employment by industry (EMPN) for industry *i.*

$$EMPN_{i,t} = VALU_{i,t} * CEshVA_{i,t} * EMCE_{j,t}$$

Another issue to consider is the size of the informal market in developing countries, for which productivity can be hard to estimate, although it is thought to be relatively low. Informal market activity will use light satellite data (the light intensity approach) alongside Predictive Mean Matching (PMM) to estimate the size of the informal economy (Medina et. al, 2017). The size of the informal economy is estimated to vary between 25% and 65% of GDP, and 30% to 90% of non-agricultural employment in sub-Saharan Africa (IMF, 2017). Productivity is estimated as 25% of small formal firms and 19% of medium-sized formal firms, based on real output per employee. The size of the informal economy has a weak correlation with trade openness, but is more dependent on income level, and quality or strength of institutions. The industry level breakdown of informal economy may be more difficult to estimate, but country-level research on informal markets (such as national LFSs) may indicate an average structure across the continent.

From the employment extension, employment indicators can answer the questions such as: which industries are jobs most dependent on GVCs, to what extent do trade in the different sectors in the economy result in value added, and who are the main trade partners creating jobs (Mroudot et. co, 2016).

5.3.Environmental Indicators

Considering the emergency of the climate crisis, many African economies present high vulnerabilities and are looking for policies to adapt and increase resilience. At the same time, there is a tendency for emerging economies to accelerate their development through participation in higher stages of production of intermediate goods.

Therefore, the inclusion of carbon emissions indicators in AfCIOT allows an in-depth understanding of the differences among territorial-based greenhouse gas (GHG) emissions, consumption-based emissions, and production-based emissions. Thus, it is possible to observe the degree to which countries outsource the production of emissions (Yamano and Guilhoto, 2020).

Furthermore, the understanding of emission flows embedded in trade may support instruments such as Green, Social, and Sustainable (GSS) bonds, which are an alternative to meet Africa's enormous financing needs to recover from the Covid-19 pandemic and respond to the climate goals (UNECA, 2022).

6. CONCLUSION

In conclusion, while this project is still in an early phase, the importance of the database as the first to put African countries at the center of TiVA analysis is undeniable. The lack of IO data in Africa has been raised by several researchers. Although recent efforts have been made to address this gap, such as the Eora MRIO database, statistically sound inter-country SUTs and IOTs are still lacking detailed representation of African countries.

This paper sets out how the model adapts the best practice in terms of methodology and techniques to the African context and data challenges. It is a statistical model built on the data and statistics collected and compiled by African countries. This approach aligns with the global

efforts to achieve the Sustainable Development Goals (SDGs) by enabling evidence-based trade policies that can contribute to poverty reduction, inequality reduction, and sustainable resource management (Nicita et. al, 2014; Li et. Al, 2022; Dilekli and Cazcarro, 2019).

One notable application is the support it can provide to the African Continental Free Trade Area (AfCFTA), which aims to promote intra-African trade and economic integration. The TiVA database can contribute to a deeper understanding of trade dynamics, value-added contributions, and supply chain linkages within the continent, enabling evidence-based decision-making and policy formulation to maximize the benefits of the AfCFTA. In particular, the visualization tool to be developed will allow access to policymakers for easy use in policy decisions.

Overall, the development of a TiVA database for Africa represents a significant step forward in enhancing the understanding of trade dynamics and economic relationships on the continent. By placing African countries at the forefront, utilizing robust methodologies, and supporting policy analysis, this project has the potential to contribute to sustainable development, inclusive growth, and effective trade policies in Africa. The hope is that production of this African TiVA database will support policymakers to pursue value-creation and decent employment for their citizens, and assist in achieving the SDGs.

Appendix A

Database name	Organisation	Year released	Paper	Countries covered	Years covered	Industries	Comments
APEC (Asian international IOTs)	Asian Development Bank (AdB)	2014	Meng et. al (2013)	25 Asian and Pacific countries 62 economies (90% of GDP)		35 industries (based on ISIC Rev 3)	Completed the region for WIOD Prioritises NSO data but five countries are estimates from research
South American IOT	IPEA and ECLAC	2016	Organization publication	10 South American countries	2005	40	NSO data
UNCTAD-Eora (Eora multi-region IOTs)	UNSD		Lenzen and others (2013) Casella et. Al (2019)	189 countries and "Rest of World"	1990 to 2021	26	Analytical model drawing many sources and interpolating missing points
FIGARO (full international and global accounts for research in IO analysis)	Eurostat, National Accounts and DG Joint Research Centre	2015	Remond-Tiedrez (2019) Rueda-Cantuche and others (2017)	28 countries planned as part of 2015 group	Base 2010 – 2015 (Annual)	10	
Global MRIO Lab			Lenzen and others (2016)				
GTAP (multi-region input-output table)	Purdue University	2020	Peters, Andrew, and Lennox (2011)	121 countries plus 20 regions	2004, 2007, 2011, 2014	65	Extensions such as end land use, carbon dioxide emissions and migration
OECD ICIO (inter-country input-output table)	OECD	2018 (latest release)	Yamano and Webb	64	2005 to 2018	45 industries (more detail available in underlying framework)	NSO data

WIOD (World Input-Output Database)	Growing Growth and Development Centre	2016 (latest release)	Dietzenbacher and others (2013) and Timmer (2012)	43 economies	2000-2014	56	Prioritises use of imports data scrutinized by NSO and central banks
EXIOBASE			Tukker and others (2013)	44 EU countries + 5 rest of world regions	1995-2013	200	
NAFTA-TiVA		Expected 2021	Hallren et. al (2017)	3 countries			

Appendix B

IDEAL REQUIREMENTS FOR SUTS (OECD, WTO, UN)

Use tables

- Intermediates at both purchasers' prices and basic prices
- Value added and output at basic prices
- Total, domestic and import tables
- Household consumption by product
  - Domestic territory by residents
  - Domestic territory by non-residents
  - Domestic purchases abroad by residents
- Exports by product
  - Domestic exports and re-exports
  - Consumption by non-residents in domestic territory
  - Cif/fob adjustments

- Supply table
  - Output at basic prices
  - Valuation columns : taxes, subsidies, import duty, wholesale and retail, transport margins by mode
  - Retained imports and re-exports
- Symmetric Input-Output table
  - Industry-by-industry / product-by-product
  - Total, domestic and import tables
  - Basic prices
- Sufficient industry detail (ISIC Rev.4)
- Time series SUTs, from 1995, coherent with latest revision of National Accounts time series.

IDEAL REQUIREMENTS FOR TRADE DATA

- FOB and CIF
- Beyond HS 6-digit level (i.e. Comtrade) for secondhand goods (e.g. cars)
- Same product breakdown as SUTs (with concordance table)
- Adjustments from HS to BoP/SNA (processing, merchanting, etc.)
- No confidential trade

- Re-export data by product and by partners (origin and destination), differentiating between transit trade and trade passing through entrepôts (margins incurred)
- Additional information on used capital goods, and on scrap and waste
- Detailed trade in services, BPM6, maximum EBOPS categories for best conversion to ISIC or CPA (about 30-40 services products)

Appendix C

Table 1: Status of National Accounts and SEEA in Countries.

Country	Current situation			Frequency of SUTs updated			The latest SUTs are for (year)
	SNA Used	Base year of Real GDP	Available SUTs	Every year	Every 2 years	≥ 5 years	
Algeria	2008 SNA	2001	Y	√			2020
Angola	1993 SNA	2002	Y	√			2014
Benin	2008 SNA	2015	Y	√			2017
Botswana	2008 SNA	2016	Y			√	2016
Burkina Faso	2008 SNA	2015	Y	√			2017
Burundi*	2008 SNA	2015	Y	√			2019
Cabo Verde	2008 SNA	2015	Y	√			2016
Cameroon	2008 SNA	2015	Y	√			2020
Central African Republic	1993 SNA	2005	Y	√			2017
Chad	2008 SNA	2017	Y	√			2018
Comoros	1993 SNA	2007	Y	√			2020
Congo *	1993 SNA	2016	Y	√			2016
Cote d'Ivoire	2008 SNA	2015	Y	√			2019
Democratic Republic of the Congo *	1993 SNA	2005	Y	√			2019
Djibouti	2008 SNA	2013	Y	√			2014
Egypt	2008 SNA	2012	Y		√		2016-2017
Equatorial Guinea	1993 SNA	2006	Y	√			2017
Eritrea	1993 SNA	2006	N				
Eswatini	2008 SNA	2011	Y			√	2017
Ethiopia	2008 SNA	2015	Y			√	
Gabon *	2008 SNA	2019	Y	√			2016
Gambia	2008 SNA	2013	N				
Ghana	2008 SNA	2013	Y			√	2013
Guinea *	1993 SNA	2006	Y	√			2020
Guinea-Bissau	2008 SNA	2015	Y	√			
Kenya	2008 SNA	2016	Y			√	2016
Lesotho	2008 SNA	2012	N				

Country	Current situation			Frequency of SUTs updated			The latest SUTs are for (year)
	SNA Used	Base year of Real GDP	Available SUTs	Every year	Every 2 years	≥ 5 years	
Liberia	2008 SNA	2016	Y			√	2008
Libya	1993 SNA	2013	N				
Madagascar	1993 SNA	2007	Y			√	
Malawi	2008 SNA	2017	Y			√	2017
Mali	2008 SNA	2015	Y	√			2019
Mauritania	2008 SNA	2014	Y	√			2018
Mauritius	2008 SNA	2006	Y			√	2018
Morocco	2008 SNA	2007	Y			√	2019
Mozambique	2008 SNA	2014	Y			√	2017
Namibia	2008 SNA	2015	N				
Niger	2008 SNA	2015	Y	√			2018
Nigeria	2008 SNA	2010	Y			√	2010
Rwanda	2008 SNA	2011	Y			√	2017
Sao Tome and Principe	2008 SNA	2015	Y	√			2016
Senegal	2008 SNA	2014	Y	√			2018
Seychelles	2008 SNA	2014	Y			√	2014
Sierra Leone	1993 SNA	2006	N				
Somalia	2008 SNA	2017	N				
South Africa	2008 SNA	2010	Y	√			2019
South Sudan	2008 SNA	2009	N				
Sudan	1968 SNA	1981/82	N				
Togo	2008 SNA	2016	Y	√			2019
Tunisia	1993 SNA	2010	Y	√			2020
Uganda	2008 SNA	2010	Y			√	
United Republic of Tanzania	2008 SNA	2015	Y			√	2015
Zambia	2008 SNA	2010	Y			√	2010
Zimbabwe	2008 SNA	2016	Y			√	2012

REFERENCES

AfCFTA. (n. d.). About the AfCFTA. Visited 15 May 2023, at https://au-afcfta.org/about/

Casella, B., Bolwijn, R., Moran, D., & Kanemoto, K. (2019). Improving the analysis of global value chains: the UNCTAD-Eora Database. Transnational Corporations, 26(3), 115-142.

CEPAL. (2016). The South American input-output table: Key assumptions and methodological considerations. LC/W.722. https://hdl.handle.net/11362/40832

Dietzenbacher, E., Los, B., Stehrer, R., Timmer, M., & De Vries, G. (2013). The construction of world input–output tables in the WIOD project. Economic systems research, 25(1), 71-98.

Dilekli, N., & Cazcarro, I. (2019). Testing the SDG targets on water and sanitation using the world trade model with a waste, wastewater, and recycling framework. *Ecological Economics*, *165*, 106376. https://doi.org/10.1016/j.ecolecon.2019.106376

Hertel, T. W. (1997). Global trade analysis: modeling and applications. Cambridge university press.

Horvát, P., Webb, C., & Yamano, N. (2020). Measuring employment in global value chains. OCDE. https://doi.org/10.1787/00f7d7db-en

Hutniczak, B. (2022). Efficient updating of regional supply and use tables with the national-level statistics. *Journal of Economic Structures*, *11*(1), 16. https://doi.org/10.1186/s40008-022-00274-8

Lenzen, M., Moran, D., Kanemoto, K., & Geschke, A. (2013). Building Eora: a global multi-region input–output database at high country and sector resolution. Economic Systems Research, 25(1), 20-49.

Li, H., Liu, X., Wang, S., & Wang, Z. (2022). Impacts of international trade on global inequality of energy and water use. *Journal of Environmental Management*, *315*, 115156. https://doi.org/10.1016/j.jenvman.2022.115156

Measuring employment in global value chains (OECD Science, Technology and Industry Working Papers Nº 2020/01). (2020). https://doi.org/10.1787/00f7d7db-en

Medina, L., Jonelis. A., & Cangul., M. (2017). *The informal economy in sub-saharan africa : Size and determinants*. International Monetary Fund.

Meng, Bo, et al. Compilation, (2012). *Application and Challenge of IDE-JETRO's International Input-Output Tables. IDE Discussion Paper, 375, Institute of Developing Economies, Japan External Trade Organization(JETRO),* RePEc - Econpapers, https://econpapers.repec.org/paper/jetdpaper/dpaper375.htm.

Nicita, A., Olarreaga, M., & Porto, G. (2014). Pro-poor trade policy in Sub-Saharan Africa. *Journal of International Economics*, *92*(2), 252-265. https://doi.org/10.1016/j.jinteco.2014.01.001

OECD. (2022). Trade in Value Added TiVA indicators Guide to Country Notes. www.oecd.org/sti/ind/TiVA-2021-guide-to-country-notes.pdf

Ofori, P. E., Asongu, S. A., Tchamyou, V. S., & Salahodjaev, R. (2023). The synergy between governance and trade openness in promoting female economic inclusion in Sub-Saharan Africa. *Women's Studies International Forum*, *96*, 102672. https://doi.org/10.1016/j.wsif.2022.102672

Opoku-Mensah, E., Yin, Y., Oppong, A., Darko, P. A., Sai, R., & Tuffour, P. (2021). African Continental Free Trade Area treaty and CO2 : A volatility-driven CO2 mitigation pathways model for ratified countries. *Journal of Cleaner* Production, *328*, 129570. https://doi.org/10.1016/j.jclepro.2021.129570

Peluso, A., Medeiros, G., Young, J., Hallren, R. J., Jones, L., Nugent, R., & Wickramarachi, H. (2017). An Overview on the Construction of North American Regional Supply-Use.

Peters, G. P., Andrew, R., & Lennox, J. (2011). Constructing an environmentally-extended multi-regional input–output table using the GTAP database. Economic Systems Research, 23(2), 131-152.

Remond-Tiedrez, I., & Rueda-Cantuche, J. M. (Eds.). (2019). EU Inter-country Supply, Use and Input-output Tables: Full International and Global Accounts for Research in Input-output Analysis (FIGARO). Luxembourg: Publications Office of the European Union.

Simola, A., Boysen, O., Ferrari, E., Nechifor, V., & Boulanger, P. (2022). Economic integration and food security – The case of the AfCFTA. *Global Food Security*, *35*, 100651. https://doi.org/10.1016/j.gfs.2022.100651

Stadler, K., Wood, R., Bulavskaya, T., Södersten, C. J., Simas, M., Schmidt, S., ... & Tukker, A. (2018). EXIOBASE 3: Developing a time series of detailed environmentally extended multi-regional input-output tables. Journal of Industrial Ecology, 22(3), 502-515.

Steen-Olsen, K., Owen, A., Barrett, J., Guan, D., Hertwich, E. G., Lenzen, M., & Wiedmann, T. (2016). Accounting for value added embodied in trade and consumption: an intercomparison of global multiregional input–output databases. Economic Systems Research, 28(1), 78-94.

UNECA - United Nations Economic Commission for Africa. (2022, June 22). The opportunity of green, social, and sustainable (GSS) bonds to finance development in Africa | Visited on 15 May 2023, at https://www.uneca.org/stories/the-opportunity-of-green%2C-social%2C-and-sustainable-%28gss%29-bonds-to-finance-development-in

UNECA - United Nations Economic Commission for Africa. (2022). Progress report on implementation of the 2008 System of National Accounts and related statistical systems in Africa. E/ECA/STATCOM/8/2022/10.

UNSD. United Nations Statistics Division. (2018). Handbook on Supply and Use Tables and Input-Output Tables with Extensions and Applications. ST/ESA/STAT/SER.F/74/Rev.1 https://unstats.un.org/unsd/nationalaccount/docs/SUT_IOT_HB_Final_Cover.pdf

Yamano, N., & Guilhoto, J. (2020). CO2 emissions embodied in international trade and domestic final demand : Methodology and results using the OECD Inter-Country Input-Output Database. OCDE. https://doi.org/10.1787/8f2963b8-en

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