Addressing Technical Issues in the Compilation of the AfCIOT and TiVA Indicators in Africa

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Table of Contents

ABSTRACT

This paper discusses the challenges faced during the compilation of the African Continental Input-Output Table (AfCIOT) and the calculation of Trade in Value Added (TiVA) indicators in Africa. Developed by the United Nations Economic Commission for Africa (ECA), the AfCIOT is a significant tool for supporting the African Continental Free Trade Area (AfCFTA). The paper details the methodologies adopted, including the standardization of national classifications, balancing of Supply-Use Tables (SUTs), and creating inter-country tables. It also discusses challenges such as data gaps and the use of machine learning for classification, alongside strategies for data dissemination. This study emphasizes the AfCIOT's potential to enhance statistical capacity and inform policymaking for regional integration in Africa.

1. INTRODUCTION

This paper describes the technical compilation process of the first African regional Input-Output table, the African Continental Input-Output Table (AfCIOT), led by the United Nations Economic Commission for Africa (ECA). The main objective of this tool is to support the implementation of the African Continental Free Trade Area (AfCFTA) through the calculation of Trade in Value Added (TiVA), carbon embodied in trade, and employment indicators for African countries. These indicators provide an in-depth understanding of countries' positioning in regional and global value chains, empowering governments, development partners, and other policymakers to make informed decisions for regional integration. The research responds to the question: How can a regional input-output table be developed to promote regional integration in a data-constrained environment?

The AfCIOT adopts a detailed representation of African countries through a “bottom-up” approach based on national Supply-Use Tables (SUTs), National Accounts (NAs), and trade statistics. It generates indicators for these countries and other foreign countries using the OECD’s Inter-Country Input-Output (ICIO) system. This process supports the statistical capacity development of African countries by identifying data gaps and fostering interactions with Member States.

The structure of this paper is as follows: The next section provides an introduction and a general overview of the methodology used in compiling the AfCIOT, detailing the key steps involved. The paper is divided into three main sections, each addressing one of the major stages in the compilation and construction of the AfCIOT and the calculation of TiVA indicators. The first stage covers input data collection; the second stage focuses on data processing, filling in data gaps, and balancing; and the third stage discusses data dissemination. The final section summarizes and concludes the paper.

2. METHODOLOGY

The development of the African Continental Input-Output Table (AfCIOT) closely follows the OECD’s methodology, with adaptations to accommodate the data limitations of the African region. The key steps, outline in Figure 1, are:

1) **Standardization of International Classifications:** Align local classifications with international standards to ensure compatibility across countries.

2) **Balancing and Harmonization of National SUTs:** Ensuring consistency with national accounts and updtaing SUTs to a common reference year to eliminate temporal discrepancies.
3) **Conversion from Purchasers to Basic Prices:** Converting the use table from purchasers' prices to basic prices, adjusting for trade margins, transport costs, taxes, and subsidies.
4) **Separation of the Use Table into Domestic and Import Matrices:** Distinguishing between locally produced and imported goods and services.
5) **Transformation from SUT to IOT:** Transform the standardized SUTs into a format suitable for input-output analysis, enhancing their utility for economic modeling and analysis.
6) **Construction and Balancing of the Inter-Country Use Table (ICUT) and Inter-Country Supply Table (ICST):** Integrating and aligning data across countries.
7) **Conversion to Input-Output Table (IOT):** Transforming the data into a comprehensive IOT format.
8) **Production of Indicators:** Generating Trade in Value Added (TiVA), carbon embodied in trade, and employment indicators for analysis and policymaking.

These steps ensure the AfCIOT is robust, comparable, and useful for analyzing economic activities within Africa and with the rest of the world. This paper highlights adapting these methods to the African context, ensuring the AfCIOT supports the implementation of the African Continental Free Trade Area (AfCFTA) and enhances the statistical capacity for regional integration.

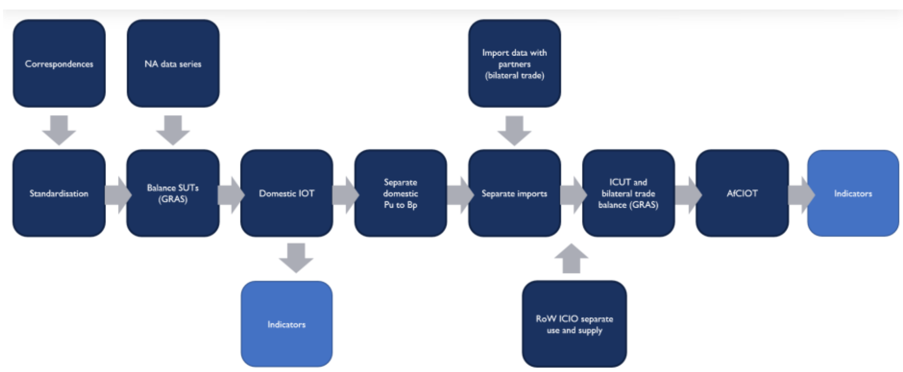


Figure 1: Schematic of the AfCIOT methodology.

3. DATA COLLECTION: DATA INPUTS AND ESTIMATION, CLASSIFICATION, AND STANDARDIZATION

Standardization is essential for integrating African Supply-Use Tables (SUTs) into the African Continental Input-Output Table (AfCIOT). It ensures consistency across diverse data streams from various African nations, enabling effective comparison and analysis on a continental scale.
The core objective of standardization is to make all SUTs comparable, akin to comparing "apples to apples." This involves aligning data from countries with varying economic structures, base years, and pricing systems into one shared system. For instance, if Country A's SUT is valued in 2010's

currency A for 20 industries and 10 products, and Country B's SUT is in 2015's currency B for 15 industries and 20 products, standardization recalibrates both SUTs to a common year (e.g., 2018) and currency (e.g., USD), with a uniform classification of industries and products. Additionally, discrepancies in valuation methods—such as supply valued at basic prices, use at purchasers' prices, imports at CIF, and exports at FOB—are aligned to basic prices (FOB) to ensure uniformity across all tables.

The production of National SUTs varies in quality, structure, and size between countries, reflecting their different economic structures and statistical systems. Currently, the dates of the SUTs in the database range from 2010 to 2020, with the number of products and industries varying widely. A key difference between AfCIOT and other TiVA databases is the entrance requirement for inclusion: AfCIOT requires the minimum national input that allows for TiVA analysis, enabling the inclusion of countries within Africa. The required inputs, and the starting point for the standardization process, are the existence of a national SUT and National Account indicators.

3.1. Data Inputs and Estimation

The African Continental Input-Output Table (AfCIOT) development relies on comprehensive data inputs from National Accounts, national Supply-Use Tables (SUTs), and disaggregated trade data. This section details the indicators required for balancing and updating the SUTs, the primary data sources, and the methods employed to estimate missing data for the indicators outlined in **Table 1**.

Table 1: Indicators Required for Balancing and Updating of SUTs

Indicator	Indicator description
B.1*g	Value added at basic prices.
B1_GE	GDP expenditure approach of national accounts
P1	output
P3	Final consumption
P31S14_P31S15	Final consumption of households, government, and NPISH
P31S14	Final consumption expenditure of households
P31S15	Final consumption expenditure of non-profit institutions serving households
P3S13	Final consumption expenditure of general government
P5	Capital formation
P51	Gross fixed capital formation
P52	Changes in inventories
P6	Total exports
P61	Exports of goods
P62CB	Cross-border exports of services
P34	Final consumption expenditure of non-resident households on the territory
P7	Total imports
P71	Imports of goods
P72CB	Cross-border imports of services
P33	Final consumption expenditure of resident households abroad

The data is sourced primarily from United Nations Statistics Division (UNSD) National Account Data from "National Accounts Estimates of Main Aggregates" and "National Accounts Official Country Data.[1] This is supplemented with data for imports and exports from the International Monetary Fund's (IMF) Balance of Payments (BoP).
The tables used:

- GDP by Type of Expenditure at current prices – National currency
- Gross Value Added by Kind of Economic Activity at current prices – National currency
- Gross domestic product by expenditures at currency prices
- Table 3.2 Individual consumption expenditure of households, NPISHs, and general government at current prices
- Table 2.6. Output, gross value added and fixed assets by industries at current prices (ISIC Rev. 4)
- Table 2.1 Value added by industries at current prices (ISIC Rev. 3)
- Table 2.3 Output, gross value added, and fixed assets by industries at current prices (ISIC Rev. 3)
- Table 2.4 Value added by industries at current prices (ISIC Rev. 4)
- Table 1.1 Gross domestic product by expenditures at current prices
- Table 3.1 Government final consumption expenditure by function at current prices

[1] https://data.un.org/Data

Within these datasets, instances of missing data necessitate using estimation techniques to bridge these gaps. The following methods are employed:

Step 1: Utilization of Algebraic Identities within National Accounts
When faced with incomplete national account data, algebraic identities such as the GDP Expenditure and value-added approaches are utilized. For example, if data on GDP, investment, government expenditure, exports, and imports are available, but consumption data is missing, the GDP Expenditure Approach (GDP = C + I + G + (X - M)) allows for estimating final consumption through subtraction. Gross Fixed Capital Formation (P51) is typically complete, whereas Changes in Inventories (P52) often require estimation due to their volatility. P52, combined with the Statistical Discrepancy, balances the GDP expenditure approach equation.

Step 2: Incorporation of Supplementary Data from Alternative Sources
When data is absent from UNSD National Account datasets, supplementary data from sources like the International Monetary Fund (IMF) Balance of Payments (BOP), World Economic Outlook, and International Labor Organization (ILO) employment datasets are utilized. To mitigate currency-related discrepancies, data is normalized into ratio form.
To supplement employment information, ILO indicators such as employment by sex and age, labor force participation rates, and labor income share as a percent of GDP are incorporated.

Step 3: Application of Time Series Imputation Using a Kalman Filter
Time series imputation using a Kalman filter is employed to interpolate missing data for series with at least three values. The Kalman filter algorithm, as outlined by Kim and Bang (2018), provides estimates of unknown variables based on observed measurements over time, proving effective for data imputation.

Step 4: Utilization of Econometric Modeling Techniques
Econometric modeling estimates ratios of national account items relative to GDP or sub-items. For example, to estimate the ratio of Final Consumption Expenditure of Households (P31S14) to Final Consumption (P3) and the ratio of Changes in Inventories to GDP (P52/GDP). Independent variables are selected following rigorous testing, including regional dummies and sectoral value-added ratios. Econometric models are applied after time series imputation for output at basic prices (P1) and intermediate inputs at purchaser's prices (P2). The sectoral breakdown of Value Added at Basic Prices (B1G) estimates P1, and P2 is derived through subtraction (P1 - B1G).

Step 5: Median Imputation Based on Data from Neighboring and Similar Countries
In cases with no available values, median imputation using data from neighboring and similar countries is considered. This involves regional or subregional medians where applicable. Following time series estimation, econometric modeling is used with ratios derived from the sectoral breakdown of value-added and ILO variables. For any remaining missing values, the median imputation of the ratio of Compensation of Employees (D1) over Value Added at Basic Prices (D1/B1G) is applied, ensuring the imputed data does not exceed a ratio of 0.6.

Throughout each step, visual inspections and summary statistics verify that imputations do not significantly alter the median and standard deviation, preserving the algebraic identities of National Accounts. Iterations of the first step address any remaining gaps after subsequent steps.

3.2. Classifications

In Africa, the diversity in classification is particularly evident, often reflecting the continent's strong reliance on agriculture—a sector underrepresented in international classification systems. African SUTs frequently feature detailed breakdowns for agricultural products like coffee, bananas, and cassava while consolidating various manufacturing activities into broader categories. This tailored approach captures the nuanced economic activities that are significant locally but may not align with global categorization.

AfCIOT adopts the Classification of Products by Activity (CPA) for products and the International Standard Industrial Classification (ISIC) for industries. These classifications facilitate integration with the OECD's ICIO, which includes non-African countries.

The classification module aims to convert national product and industry classifications to the AfCIOT standards. AfCIOT uses 87 categories from CPA 2.1 at the two-digit level for products. For industries, it uses 45 industries adopted by ICIO. This process involves developing country-specific correspondence tables to match national descriptions with international standards CPC and ISIC 4 codes at a two-digit level.

Table 2: List of AfCIOT products and industries

Code (ICIO)	Industry (OECD's ICIO aggregation)	Industry (ISIC) / Products (CPA)
D01T02	Agriculture, hunting, forestry	01, 02
D03	Fishing and aquaculture	3
D05T06	Mining and quarrying, energy-producing products	05, 06
D07T08	Mining and quarrying, non-energy producing products	07, 08
D09	Mining support service activities	9
D10T12	Food products, beverages, and tobacco	10, 11, 12
D13T15	Textiles, textile products, leather and footwear	13, 14, 15
D16	Wood and products of wood and cork	16
D17T18	Paper products and printing	17, 18
D19	Coke and refined petroleum products	19
D20	Chemical and chemical products	20
D21	Pharmaceuticals, medicinal chemicals, and botanical products	21
D22	Rubber and plastic products	22
D23	Other non-metallic mineral products	23
D24	Basic metals	24
D25	Fabricated metal products	25
D26	Computer, electronic, and optical equipment	26
D27	Electrical equipment	27
D28	Machinery and equipment, nec	28
D29	Motor vehicles, trailers and semi-trailers	29
D30	Other transport equipment	30

Code (ICIO)	Industry (OECD's ICIO aggregation)	Industry (ISIC) / Products (CPA)
D31T33	Manufacturing nec; repair and installation of machinery and equipment	31, 32, 33
D35	Electricity, gas, steam, and air conditioning supply	35
D36T39	Water supply; sewerage, waste management, and remediation activities	36, 37, 38, 39
D41T43	Construction	41, 42, 43
D45T47	Wholesale and retail trade; repair of motor vehicles	45, 46, 47
D49	Land transport and transport via pipelines	49
D50	Water transport	50
D51	Air transport	51
D52	Warehousing and support activities for transportation	52
D53	Postal and courier activities	53
D55T56	Accommodation and food service activities	55, 56
D58T60	Publishing, audiovisual, and broadcasting activities	58, 59, 60
D61	Telecommunications	61
D62T63	IT and other information services	62, 63
D64T66	Financial and insurance activities	64, 65, 66
D68	Real estate activities	68
D69T75	Professional, scientific, and technical activities	69, 70, 71, 72, 73, 74, 75
D77T82	Administrative and support services	77, 78, 79, 80, 81, 82
D84	Public administration and defense; compulsory social security	84
D85	Education	85
D86T88	Human health and social work activities	86, 87, 88
D90T93	Arts, entertainment, and recreation	90, 91, 92, 93
D94T96	Other service activities	94, 95, 96
D97T98	Activities of households as employers; undifferentiated goods- and services-producing activities of households for own use	97, 98

An expert system for semi-automated classification was developed in R Shiny, incorporating machine learning, large language models (LLMs), text mining, and expert assessment. This system ensures accurate classification alignment, allowing for effective integration into AfCIOT.

To facilitate the classification of national data according to AfCIOT standards, we prepare data through the following steps:

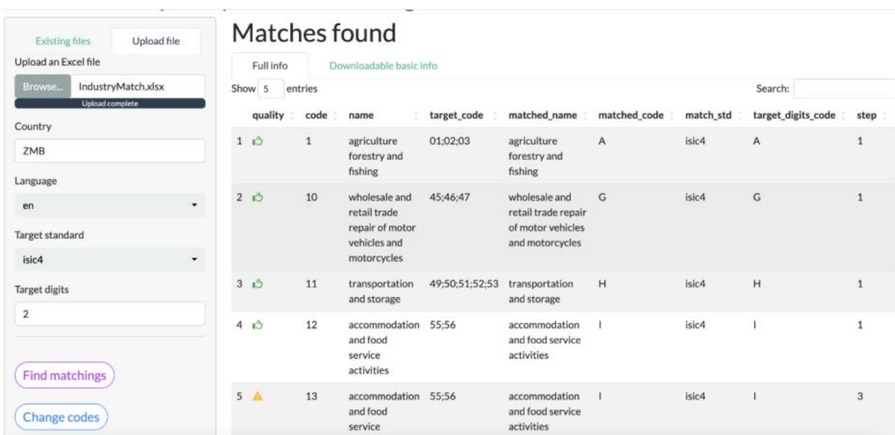
1) Excel File Preparation: Create an Excel file with two columns, one for national codes and the other for national descriptions.
2) Data Collection: Download the standards codes, descriptions, and correspondence files from UN Stats or the {concordance} R package. These files include various versions and languages of the standards used in AfCIOT.
3) Lemmatization: Break down words in the text descriptions of the standard categories to their dictionary forms (lemmas) using the {udpipe} package. Remove language-specific stop words using the {tidytext} and {tm} packages.

4) Table Preparation:
    - Create a table with all standards and their correspondence with the target standard.
    - Prepare a table with new codes and descriptions, including columns for country and language.
    - Compile a table with the lemmatized names of all standard categories and the corresponding lemmatization code for the languages used.

<u>Classification Process</u>: The classification task converts national product and industry classifications to the standard ones used in AfCIOT, specifically CPA 2.1 for products and ISIC for industries.

1) Matching Algorithm: For each new national category, the algorithm:
    - Looks for exact matches on the target and non-target standards.
    - Tokenizes and lemmatizes the new description.
    - Removes customized stop words.
    - Computes the number of matching lemmas and the distance between lemmas.
    - Chooses the code of the closest correspondence.
    - Adjusts the matching to the target number of digits.
2) Screenshot Example: The figure below shows a screenshot of the app after running the matching algorithm.

Figure 2: Matching algorithm results



3.3. Standardization

Once the automated system maps local categories to CPA and ISIC correspondence tables are finalized through manual verification, to ensure local nuances and unique economic activities are captured. The relationship between national and international classifications can then be understood; critical for applying the correct data treatment for standardization.

The relationships can be:

Commented [EK1]: Do we need to put this here and in the table?

- **Many-to-One (M:1)**: Multiple national categories fit into one international category. Example: "plantain," "cassava," and other vegetables fit into "fresh vegetables" CPA. These categories are aggregated.
- **One-to-Many (1:M)**: One national category split into multiple international categories. For example, "manufacturing" might be split into "metal manufacturing," "plastic manufacturing," and "furniture manufacturing" in ISIC. This division requires assumptions about distribution ratios.
- **One-to-One (1:1)**: Exact match between national and international classifications. Example: "crude oil" matches "crude petroleum" in CPA. No manipulation is needed.

Table 3: Relationships in the construction of correspondence tables

Match	Description	Example	Treatment
m:1	many to one: where many national products fit into one international standard category.	In Africa, it is common to separate key agricultural products such as cassava, banana, cocoa, and coffee. These all fit into CPA 01 Agricultural products.	Aggregate.
1:m	one to many: where one national product fits into many international products.	For example, many African countries group all types of manufacturing into one Manufacturing industry, whereas in ISIC, there are 24 types of manufacturing at the two-digit level.	Divide by several categories matched with (for example, by 24 in the case of manufacturing).
1:1	one to one: where there is an exact match between the national and international classification	This is common for mining categories (coal, gas, quarrying, and support services) and services such as education and health.	No change.

<u>Processing of SUTs</u>

Once the relationship between national and international categories has been identified for each product and industry, the SUT can be processed. First, the products are approached, aligning according to the relationships identified, where M:1 relationships are summed, 1:M relationships are divided equally among the matched international categories, and 1:1 relationships remain unchanged. After products, the SUT is transposed and the process is mirrored for industries, ensuring that industry classifications also align with international standards. There are specific categories each for the supply and use table that also need to be adjusted accordingly. In the use table, components such as value added are treated as products, and final demand components are treated as industries. In the supply table, primary inputs (P1) are considered products, while imports and margin categories are treated as industries.

Quality Assurance and Checks

After the standardization is performed, the following checks are conducted to assess whether the standardization was accurate:

- **Economic identities:** check that each total of the standardized SUT aligns with the original SUT, and verify key economic identities such as:
  - Input (Value Added + Intermediate Consumption) = Output (by industry)
  - Total Supply at Purchasers' Prices = Total Use at Purchasers' Prices (by-product)
- **Sectoral analysis:** ensuring that sector-specific data such as services or agriculture are accurately captured and reflect the economic significance within the national context.
- **Temporal consistency:** checking data over time to ensure that changes in classifications or economic conditions do not introduce anomalies.
- **International comparison:** comparing the standardized data with similar economies to check for outliers or significant deviations that might indicate issues in data collection or classification.

4. DATA PROCESSING: BALANCE, HARMONIZATION, CONVERSION, AND INTEGRATION

Once all country SUTs are following the international categories, they can be updated and balanced to a common year, such as the base year 2018. This is done using publicly available national account data for 2018 which forms the boundary, or totals, with which to align the information inside the SUT. Several balancing steps using RAS-based methods are then performed to harmonize individual country data with the national accounts.

4.1. Balancing and Harmonization of National SUTs

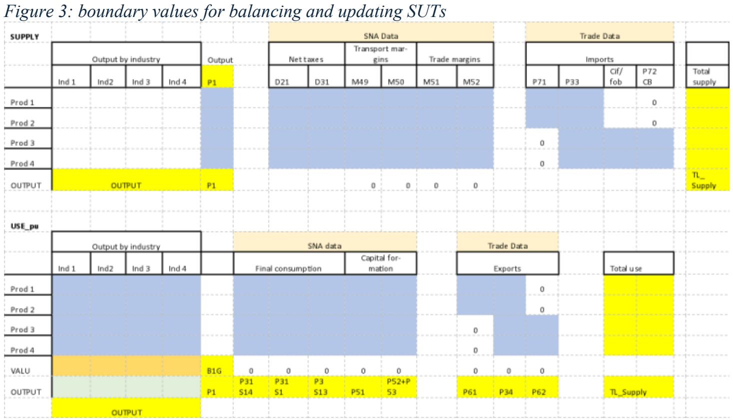
Boundary Development and Application

The SUT updated totals that are required are twofold: the row totals, or the total supply at purchasers' prices, which is equal to the total use at purchasers' prices by-product, as a key identity of the SUT; and the column totals, which is the output by industry in the case of the supply table, and the intermediate consumption in the case of the use table.

These are taken from indicators in the national accounts. The first step is to fix the value added by each sector; value added is fixed first due to its critical nature as an economic indicator, and to its often more reliable estimation. In the second step, the output by each sector is established, ensuring it aligns with the economic data. Intermediate consumption is then calculated as the different between output (P1) and value added (B1g). While some data exists on industry breakdowns of these indicators, currently the implemented approach is to break down totals by the 45 ICIO industries using underlying standardized SUTs.

For calculating supply, the relevant figures are imports, and valuation matrices (trade, transport, and tax margins); for the use table they are exports, and the final expenditure indicators and capital formation. Most of this data exists, where it does not exist at an itemized level, it can be found at an aggregated level which can then be broken down into more detailed components through econometric analyses of similar countries. All SUTs are balanced in their local currency unit, and then converted into US Dollars.

Figure 3: boundary values for balancing and updating SUTs



GRAS Method for Balancing SUTs

The Generalized RAS (GRAS) method is an iterative technique used to balance and update the SUT according to the boundaries described above. It uses "correct" boundaries to re-estimate the internal part of the matrix such that the row and column totals are aligned to these correct totals. It does this in an iterative procedure: first adjusting the row (row normalization), followed by columns (column normalization). This continues until the internal entries of the matrix converge to match the known margin totals closely.

Applying GRAS and Setting Boundaries

The GRAS procedure is applied to four parts of the SUT. The supply table is balanced first. The "final demand" component of the supply table is balanced using the total supply at purchasers' prices and updated output, imports, and net tax totals from the SNA as shown in Balance 1 of the diagram. Once this is balanced, the output column (P1 by-product) provides the row total or boundary for the make matrix (the intermediate part of the supply table), along with the output estimated by industry which makes the column totals as shown in Balance 2 of the diagram. This balances the supply table.

The use table is then balanced. First, the final demand component of the table is balanced. The purchasers' prices from the supply table is used as the rowboundary for the use table; maintaining the key SUT identity supply equals demand. The column total boundaries are total intermediate consumption, exports, final consumption and capital formation as shown in Balance 3 of the diagram. Again, the intermediate consumption column from the balanced final demand component forms the row total boundary for the next stage. To balance the intermediate consumption, the intermediate consumption estimated by industry from the boundary development is used (see

Balance 4 of the diagram). This then balances both tables, updating to 2018 and harmonizing with the SNA.

Balance 1: "Final demand" of supply table

Table 4: implementation of balancing "final" demand of supply table in AfCIOT.

Product / Industry	Total output (P1)	Imports of goods (P71)	Imports of services cross border (P72CB)	Direct purchases of residents abroad (P33)	Trade margins (M45M47)	Transport margins (M49M52)	Net taxes (D21_D31)	Total supply (TL_SUP)
87 CPA Products	Original SUT data	Original SUT data	Original SUT data	Original SUT data	Original SUT data	Original SUT data	Original SUT data	TL_SUP by SUT proportions
Total	National Account 2018 data	National Account 2018 data	National Account 2018 data	National Account 2018 data	0	0	National Account 2018 data	TL_SUP = rowSums

Balance 2: "Intermediate" supply table

Table 5: "Intermediate" supply table.

Product/ Industry	45 ICIO industries	Total output (P1)
87 CPA Products	Original SUT data	P1 by product from Step 1
Total	Total decomposed by SUT proportions	Total from National Accounts 2018

Balance 3: Final demand of use table

Table 6: Final demand of use table.

Product/ Industry	Total intermediate consumption (IC)	Exports of goods (P61)	Exports of services cross border (P62CB)	Direct purchases of non-residents in territory (P34)	Final demand (FD) units	Total use (TL_USE)
CPA Products 2 digit	Original SUT data	Original SUT data	Original SUT data	Original SUT data	Original SUT data	TL_SUP from supply table

Total	Total IC from SNA P1 – SNA B1	BoP IMF – SNA estimation	BoP IMF – SNA estimation	BoP IMF – SNA estimation	2018 National Accounts	Total supply = Total use from 2018 national accounts

Balance 4: Intermediate consumption

Table 7: Intermediate consumption.

Product/ Industry	ICIO industries	Total Intermediate consumption
CPA Products 2 digit	Original SUT boundary	Intermediate Consumption by Product from Step 3
Total	Estimated B1 by 45 ICIO industries– estimated P1 by ICIO	From Step 3

Quality Checks and Adjustments

This process also helps to ensure some of the basic requirements for SUTs and key identities hold. Firstly, it ensures that supply at purchasers' prices is equal to use at purchasers' prices for every product. This check ensures that all recorded transactions are balanced within the table, reflecting accurate tracking of economic flows. In addition to this there must be consistency in the calculation of Gross Value Added (GVA) across the three primary estimation techniques—production, expenditure, and income approaches. We also then put in place some additional checks to ensure key economic identities such as value added plus intermediate consumption equals output hold true across the balanced tables.

The application of these balancing techniques and quality checks ensures that the SUTs used in the AfCIOT are both accurate and harmonized, providing a reliable basis for economic analysis and decision-making across Africa.

4.2. Conversion from Purchasers to Basic Prices

Now that all the African SUTs included in AfCIOT have the same 87 products, 45 industries, are balanced and updated to 2018 and in dollars, we can begin processing for production of multipliers and TiVA. The first step is to convert the use table from purchasers' prices to basic prices, and separate the domestic and imports use table, allowing for the conversion to the domestic IOT.

Conversion Principles

The conversion from purchasers' prices to basic prices involves removing valuation matrices; i.e. adjusting for trade margins, transport costs, taxes, and subsidies that are included in the purchasers' prices but not in the basic prices. This adjustment is necessary to isolate the producers' costs and revenues directly associated with the production process to return the use table to the basic price as is recorded in the supply table.

Valuation Matrices

Valuation matrices play a key role in this conversion process. They account for the various additions and subtractions required to move from purchasers to basic prices: trade and transport margins are removed as they represent costs added after the production process, such as distribution and retailing; and adjustments are made to remove taxes levied on products and include subsidies provided on the production.

Step-by-Step Conversion

In an ideal world, the basic prices would be estimated through reverse engineering. Achieving price conversion through this methodology would require possession of separate domestic and import use tables, as the costs associated with these can differ significantly, particularly in terms of transport and tariffs. The trade and transport margins are then reassigned to the relevant rows of the domestic production; for example, if an apple cost $1 at purchaser's prices but this includes a 10% trade and transport margin, then the basic price is $0.9 and the $0.1 gets added to the trade and transport industries. Finally, taxes such as VAT, excise duties, and import tariffs are removed from the respective table prices, while subsidies that directly affect production costs are added to the basic prices of (usually) domestic production.

Practical Implementation in AfCIOT

Due to varying levels of detail in national SUTs, the conversion process often relies on generalized assumptions. In particular, currently no African countries in our system supply a separate imports use table. Margin and tax matrices are constructed based on the available data. Detailed data is often lacking, thus matrices use the columns provided by the supply table and average proportions derived from the underlying SUT. Currently, taxes are also aggregated into a single net tax column, and a matrix is created using SUT proportions. Finally, the resulting basic price table is separated into the import and domestic use via the import proportionality assumption. This assumes that imports are utilized in similar proportions across all industry inputs and final uses, with adjustments made based on the specific economic sector and known trade patterns.

The conversion process can be broken down into three major steps:

1) **Margin Matrices:** Calculate and apply adjustments for trade and transport margins based on their proportion in the total costs associated with each product.
2) **Tax Matrices:** Adjust for taxes and subsidies using proportionality to reflect their impact on the price. This results in the use table at basic prices.
3) **Import Adjustment:** Apply the import proportionality assumption to separate the imports and domestic use tables at basic prices.

Balanced Updated Supply Table

Product/ir	D01T02	D03	D05	P1	D21_D31	M45M52	P71_P72CI	cif/fob ad	P33	TL_SUP
01	21	21	0	41	0.0	0.5	9.7		0.0	52
02	21	21	0	41	0.0	0.5	9.7		0.0	52
03	12	12	170	194	-1.0	-1.0	20.6		3.0	215
04	0	0	23	23	0.0	0.0	0.0		0.0	23
Total (P1)	54	54	193	300	-1	0	40		3	342

Balanced Updated Use Table (Purchasers' Prices)

Product/ir	D01T02	D03	D05	TIC	P31S14_P	P5	TL_USE
01	3	3	16	22	18	0	40
02	3	3	16	22	18	0	40
03	32	29	73	134	52	3	189
04	5	5	11	22	0	0	22
Total (IC)	44	40	116	200	88	3	
VA	10	14	77				
				100			

Trade and Transport Margins

Product/ir	D01T02	D03	D05	TIC			Total
01	-0.50	0.00	0.00	-0.50			-0.5
02	0.00	-0.50	0.00	-0.50			-0.5
03	0.50	0.50	0.00	1.00			1.0
04	0.00	0.00	0.00	0.00			0.0
Total (IC)							

Margin proportions

Product/ir	D01T02	D03	D05	TIC			1/s
01							2%
02							2%
03	100%	100%	100%	100%			0%
04							4%

Revised Use Table

Product/ir	D01T02	D03	D05	TIC	P31S14_P	P5	Total
01	3.72	2.96	15.95	22.64	17.72	0.00	40.4
02	3.22	3.46	15.95	22.64	17.72	0.00	40.4
03	31.18	28.63	73.20	133.01	52.27	3.00	188.3
04	5.45	5.01	11.25	21.71	0.00	0.00	21.7
Total (IC)							

Revised Use Table Proportions

Product/ir	D01T02	D03	D05	TIC	P31S14_P	P5	TL_USE
01	9%	7%	40%	56%	44%	0%	1
02	8%	9%	40%	56%	44%	0%	1
03	17%	15%	39%	71%	28%	2%	1
04	25%	23%	52%	100%	0%	0%	1

Figure 4: Step 1.

Net Tax Margins

Product/ir	D01T02	D03	D05	TIC	P31S14_P	P5	Total
01	0.00	0.00	0.00	0.00	0.00	0.00	0.0
02	0.00	0.00	0.00	0.00	0.00	0.00	0.0
03	-0.17	-0.15	-0.39	-0.71	-0.28	-0.02	-1.0
04	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Total (IC)							

Use Table at Basic Prices

Product/ir	D01T02	D03	D05	TIC	P31S14_P	P5	Total
01	3.72	2.96	15.95	22.64	17.72	0.00	40.4
02	3.22	3.46	15.95	22.64	17.72	0.00	40.4
03	31.34	28.78	73.59	133.72	52.55	3.02	189.3
04	5.45	5.01	11.25	21.71	0.00	0.00	21.7
Total (IC)							

Use Table Proportions v3

Product/ir	D01T02	D03	D05	TIC	P31S14_P	P5	TL_USE
01	9%	7%	40%	56%	44%	0%	1
02	8%	9%	40%	56%	44%	0%	1
03	17%	15%	39%	71%	28%	2%	1
04	25%	23%	52%	100%	0%	0%	1

Figure 5: Step 2.

Use Table at Basic Prices

Product/ir	D01T02	D03	D05	TIC	P31S14_P	P5	Total
01	3.72	2.96	15.95	22.64	17.72	0.00	40.4
02	3.22	3.46	15.95	22.64	17.72	0.00	40.4
03	31.34	28.78	73.59	133.72	52.55	3.02	189.3
04	5.45	5.01	11.25	21.71	0.00	0.00	21.7
Total (IC)							

Use Table Proportions v3

Product/ir	D01T02	D03	D05	TIC	P31S14_P	P5	TL_USE
01	9%	7%	40%	56%	44%	0%	1
02	8%	9%	40%	56%	44%	0%	1
03	17%	15%	39%	71%	28%	2%	1
04	25%	23%	52%	100%	0%	0%	1

Imports table

Product/ir	D01T02	D03	D05	TIC	P31S14_P	P5	Total
01	0.70	0.56	3.00	4.25	3.33	0.00	7.6
02	0.61	0.65	3.00	4.25	3.33	0.00	7.6
03	2.99	2.75	7.03	12.78	5.02	0.29	18.1
04	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Total (IC)							

Import proportions

Product/ir	D01T02	D03	D05	TIC	P31S14_P	P5	Total
01	0.19	0.19	0.19	0.19	0.19	0.19	0.4
02	0.19	0.19	0.19	0.19	0.19	0.19	0.4
03	0.10	0.10	0.10	0.10	0.10	0.10	0.2
04	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Total (IC)							

Domestic Use Table

Product/ir	D01T02	D03	D05	TIC	P31S14_P	P5	Total
01	3.02	2.41	12.96	18.39	14.39	0.00	32.8
02	2.62	2.81	12.96	18.39	14.39	0.00	32.8
03	28.35	26.03	66.56	120.94	47.53	2.73	171.2
04	5.45	5.01	11.25	21.71	0.00	0.00	21.7
Total (IC)							

Figure 6: Step 3.

Challenges and Limitations

The main challenges in this conversion arise from incomplete data and the need to make assumptions about the distribution of costs and margins. These challenges are addressed currently by applying the SUT proportions for distributing these margins. However, by not having the breakdown of types of taxes, all taxes are applied in the same way to both domestic and import use tables. Similarly, as separate import use tables are not available, the same trade and transport margins are also applied to both domestic and import products.

4.3. Conversion from SUT to IOT

The conversion of Supply-Use Tables into Input-Output Tables is a key stage in creating an analytical framework that supports economic analysis and policymaking. This step is also used as a check on the processing and conversions made up to this stage through comparison of economic multipliers between countries and industries, and between the processed and original SUT.

The UN Handbook details four sets of assumptions (or models) for the conversion of SUTs into IOTs. Models A and B convert the SUT to product-by-product tables, whereas Models C and D convert to industry-by-industry tables. In practice, Models A and D are commonly utilized by national statistics offices (NSOs) because of their practical applicability. Model D is notably popular as it simplifies the transformation process and avoids the potential for negative outputs that can occur in Models A and C. This fixed product sales assumption (Model D) posits that each product has a specific sales structure across different industries. This model is favored for industry-by-industry IOTs and is particularly used in policy-making due to its straightforward application and relevance.

Implementation of Model D

To convert the SUTs now at basic prices into IOTs, AfCIOT applies Model D. The four steps involved in implementing Model D are:

1) **Constructing the Market Share Matrix (T):** Begin by constructing the market share matrix where each cell of the supply table is divided by the total output of the row. This matrix represents the proportion of each product's total output that each industry contributes.
2) **Transposing the Market Share Matrix:** Transpose this matrix to align industries to products, resulting in a matrix dimension of ni×np (industries by-products).
3) **Matrix Multiplication:** Multiply the transposed market share matrix by the use table converted to basic prices. This multiplication integrates both the intermediate consumption and final demand components, producing an IOT of industries by industries (ni×ni)
4) **Normalization:** Finally, normalize each column in the IOT by the total production of the industry. This normalization yields the technical coefficient matrix (A), essential for further economic analysis using Leontief's model.

Analytical Applications

Once the IOT is established, significant economic analysis can be performed, including calculations of economic output, value-added multipliers, labor outcomes, and environmental impacts. These analyses are pivotal in understanding the economic interdependencies of different policy strands and assisting in effective policy formulation.

4.4. Integration of IOTs into AfCIOT

Introduction

Integrating standardized national economy Supply-use Tables (SUTs) for the African Continental Input-Output Table (AfCIOT) with each other requires the separation of imports by partner. This task involves separating and classifying imports from AfCIOT countries, and non-AfCIOT countries, and addressing the remaining balance, also known as the Rest of the World (RoW). This section of the paper will methodically detail the theory of integration through imports through three distinct steps:

- Step 1: Separation of AfCIOT Countries' Imports (column 3 of Figure 7)
- Step 2: Separation of Non-AfCIOT Countries' Imports Separation of AfCIOT Countries' Imports (column 1 and 2 of Figure 7)
- Step 3: RoW (remaining balance) (column 4 and row 4 of Figure 7)

A mixture of theoretical discussion, methodological exposition, and practical examples support each of these steps, illustrating the complexities involved in handling international trade data within a unified economic modeling framework.

Figure 7: Illustration of AfCIOT

		1	2	3	4
		ICIO Country 1	ICIO Country n	RoW 1 (AfCIOT Country 1)	RoW 2 (Remaining)
1	ICIO Country 1	ICIO A (IO)	ICIO B	AfCIOT	ICIO E
2	ICIO Country n	ICIO B	ICIO A (IO)	AfCIOT	ICIO E
3	RoW 1 (AfCIOT Country 1)	ICIO C	ICIO C	AfCIOT (IO)	ICIO F
4	RoW 2 (Remaining)	ICIO D	ICIO D	AfCIOT	ICIO G (IO)

Purpose and Integration with ICIO

The table above represents how the standardized African countries are integrated, and the OECD's ICIO. This step requires deconstructing the OECD's ICIO tables and integrating its countries as trade partners with AfCIOT countries. On the diagonal, there are the domestic Input-Output tables of each country. On the off-diagonal, there are the imports of each country from the country indicated on the left-hand side, i.e. the yellow highlighted cell indicates what ICIO's Country 1 imports from ICIO Country n.

So far in the integration, we have effectively produced the domestic IO for the AfCIOT countries (22 currently). We have also developed an import use table of the total imports of each AfCIOT country from the World. As a first step, we have to break this into each of the import countries represented in the model, i.e. the 21 other AfCIOT countries, the ICIO countries, and the remaining balance (Rest of the World). This column (column 3) represents all matrices estimated from the underlying SUTs of the African countries combined with trade data. These countries, except the African countries explicitly in the ICIO model, all form part of the RoW in the OECD's model. Thus, the creation of this column effectively split up the ICIO's RoW into the AfCIOT countries and the "remaining balance". At the same time the AfCIOT countries also split the ICIO's RoW into two; using trade data we can estimate the imports of the ICIO country from each African country and estimate a revised RoW on the remaining balance.

Step 1: Separation of AfCIOT Countries' Imports
The first step is to separate AfCIOT countries' imports. This approach is different from that taken for non-AfCIOT countries as we are working with the underlying SUTs. As an African-focused model, our focus is on receiving data from African NSOs and estimating data gaps sufficient for global integration. We then merge these with IOTs already processed into the OECD global database.

The methodology for this integration is centered around the import proportionality assumption, a key concept in the African input-output model designed to estimate the distribution of imported goods and services across various industries and final use categories. This assumption was previously used to separate domestic and import use tables for production of domestic national IOTs, we now apply the imports by partner.

Purpose and Data Requirements

This Component requires both the standardized supply and use table and the trade boundaries. The trade boundaries are produced by taking data from Comtrade for trade in goods, and WTO/OECD's BaTIS database for trade in services, which separate trade by partner. A conversion from the database's used classification (Harmonized System – HS – for Comtrade and EBOPS for BaTIS) to the 87 CPA products is carried out.

The partners here include AfCIOT countries and those in the OECD's Inter-Country Input Output (ICIO) model that we will be incorporating. It also produces boundaries for each country's RoW (i.e. the remaining amount after removing AfCIOT and ICIO countries from total imports).

Methodology Overview

The import proportionality assumption posits that imports are utilized in similar proportions across all industry inputs and final uses, except exports and re-exports. To implement this, the ratio of imports by each partner to domestic supply for each product is determined first. This ratio is then used to proportionally allocate the imports across each product used by industries as intermediate inputs and by final use categories, excluding exports. For example, if 50% of semiconductors are imported from Country B, it is assumed that each industry using semiconductors also imports 50% of its semiconductor needs from Country B. This approach ensures a uniform distribution of imports across different uses, highlighting the significance of detailed product categorization in the SNA for achieving accuracy.

Implementation Process

The implementation involves first taking the proportion of partners' imports by CPA as per the trade boundaries and producing a proportion out of the total supply. This proportion is then applied to the use table at basic prices. The mathematical expression for this is provided below, where mp are the partner imports, sbp is the supply table at basic prices, Ubp is the use table at basic prices, and Ux- is the intermediate consumption and Uf is the final demand.

This then provides us with the imports for each country by partner.

Evaluation and Adjustment

After applying the proportionality assumption, it is crucial to evaluate the results for reasonableness and make necessary adjustments based on the specific operations of each economy. This method not only aids in correcting imbalances in GDP calculations and the distribution of Gross Value Added (GVA) by industry but also addresses challenges in allocating imports for changing inventories, necessitating careful handling of negative values.

Step 2&3: Integration with OECD's ICIO

Methodology for Integrating Non-AfCIOT Imports

The key challenge in integrating the ICIO lies in redefining what constitutes the Rest of the World (RoW) for the OECD, separating it into African countries now part of the AfCIOT and the remaining RoW. This separation is crucial as it impacts how imports are accounted for within the AfCIOT framework. The steps include:

- Component A (Domestic IO ICIO Tables)
- Component B (Imports between ICIO Countries)
- Component C (Estimating ICIO's Imports from Africa)
- Component D: Re-calculating ICIO's Remaining Imports from RoW
- Component E: Estimating RoW's Imports from ICIO Countries
- Component F: Estimating RoW's Imports from AfCIOT Countries

		ICIO Country 1		ICIO Country n		RoW		
		A	B	A	B	A	B	Total
ICIO Country 1	A	0	10	1	9	49	31	100
	B	10	0	9	1	31	49	100
ICIO Country n	A	7	3	2	2	41	45	100
	B	3	7	8	8	39	35	100
RoW	A	23	57	49	37	10	24	200
	B	57	23	31	43	30	16	200

Total	100	100	100	100	200	200

Figure 8: Example of OECD's ICIO.

<u>Step 2: Separation of Non-AfCIOT Countries' Imports</u>

Step 2 of the paper, focusing on the separation of Non-African/Non-AfCIOT Countries' Imports, extends the analysis to encompass imports originating from countries outside of the AfCIOT. This inclusion is crucial for a comprehensive integration of global trade dynamics within the AfCIOT framework. In particular, for Africa, where the majority of imports and exports are still outside of the continent, the dynamics of these relationships are important to incorporate.

<u>Methodology</u>

Component A (Domestic IO ICIO Tables): This involves segregating the countries from the integrated matrix into their separate parts, which is achieved by selecting the column of a specific country, transposing, and then re-selecting the country to isolate its domestic input-output table.

		ICIO Country 1	
		A	B
ICIO Country 1	A	0	10
	B	10	0
ICIO Country n	A	7	3
	B	3	7
RoW	A	23	57
	B	57	23
	Total	100	100

Figure 9: Select Country 1.

		ICIO Country 1	
		A	B
ICIO Country 1	A	0	10
	B	10	0

Figure 10: Transpose and select Country 1.

Component B (Imports between ICIO Countries): Each of the other ICIO countries is then selected one by one to define the imports input-output matrix and the final demand components for each country.

		ICIO Country 1	
		A	B
ICIO Country n	A	7	3
	B	3	7

Figure 11: Imports between ICIO countries.

Component C (Estimating ICIO's Imports from Africa): This step estimates the trade matrices between each ICIO country, and each African partner included in the AfCIOT model using the trade boundaries estimated. These boundaries are converted from CPA classification to ICIO classification, and then applied to generate the import use table by the African partner.

ICIO Country 1's imports

ICIO industry	AfCIOT Country 1	RoW
A	3	20
B	2	10

Figure 12: Trade boundaries data.

Each country in the ICIO model has a RoW import matrix. We thus use the proportions of the RoW imports in use table and assume this is representative of the distribution for each country in AfCIOT. We apply these import use table proportions to the trade boundary by the ICIO industry to produce the import use table by an African partner.

Figure 7: RoW proportions for ICIO Country 1

		ICIO Country 1	
RoW	A	29%	71%
	B	71%	29%

Figure 13: RoW proportions for ICIO Country 1.

For each ICIO country, we then need to estimate the imports IO tables for African countries which are not yet estimated in OECD's model, but rather form part of the RoW grouping. The usual method to calculate this we apply the import proportionality assumption; first use the imports by product and partner, calculate the ratio of imports to supply; and then apply these proportions to the use table. However, we do not have the country's supply table – rather we have the IO table. The adjusted methodology, therefore, is to use the proportions of imports from RoW (according to the IO of the RoW in the OECD model) as representative of African countries. The proportions then apply to the trade by the ICIO industry and African partners and are distributed according to these IO proportions.

ICIO imports from Africa

		ICIO Country 1	
		A	B
AfCIOT 1	A	0.9	2.1
	B	1.4	0.6

Figure 14: Estimated import matrix between ICIO Country 1 and AfCIOT Country 1.

Addressing Non-AfCIOT Imports in SUTs

The methodology discussed also highlights how imports from non-African/non-AfCIOT countries are differentiated from African imports in the SUTs and the implications this has for economic analysis within the AfCIOT framework.

Step 3: RoW (Remaining Balance)

Step 3 of the paper addresses the Rest of the World (RoW) category, which encapsulates all other global economic interactions not previously covered in the integration of African and non-African/non-AfCIOT countries' imports within the AfCIOT framework. This step is crucial for ensuring that the economic activities of non-participating regions are accurately and coherently represented in the AfCIOT.

Defining the RoW Category

Purpose: Reconstructing the OECD's Rest of the World (RoW) category by removing African countries now included in the AfCIOT.

The RoW category within the context of AfCIOT SUTs includes all countries and regions not explicitly categorized under AfCIOT or non-AfCIOT entities. This comprehensive grouping ensures that global interactions impacting the African continent are considered, even if they originate from countries outside of the direct trade data networks of AfCIOT and ICIO (Inter-Country Input-Output) participants.

Methodology for Estimating RoW Imports

The process of recalculating and integrating RoW imports is segmented into several key components:

Component D: Re-calculating ICIO's Remaining Imports from RoW: This component focuses on adjusting the ICIO's RoW IO in the OECD model by removing the aggregated imports attributed to the newly included African countries within AfCIOT. This recalibration is essential to accurately reflect the remaining RoW's economic interactions after accounting for direct African engagements.

ICIO imports from RoW

		ICIO Country 1	
RoW	A	22.1	54.9
	B	55.6	22.4

Figure 15: ICIO's "remaining" imports from RoW.

Component E: Estimating RoW's Imports from ICIO Countries: RoW's imports from ICIO countries are recalculated by subtracting the African countries' imports from the total ICIO imports, using established trade boundaries that summarize trade across all non-AfCIOT and non-ICIO countries by the 45 ICIO industries.

RoW imports			

	African Country 1	ICIO Country 1	ICIO Country n
A	15	30	20
B	35	10	15

Figure 16: Trade boundaries for RoW.

The trade proportions of RoW with each ICIO country are then applied to distribute these revised trade boundaries, providing updated estimates of RoW's import matrices from each ICIO country.

RoW's import proportions from ICIO Country 1		RoW	
		A	B
ICIO Country 1	A	61%	39%
	B	39%	61%

RoW's import proportions from ICIO Country n		RoW	
		A	B
ICIO Country 1	A	48%	52%
	B	53%	47%

Figure 17: RoW proportions of imports from ICIO Country 1 and Country n.

RoW's imports from ICIO		RoW	
		A	B
ICIO Country 1	A	18	12
	B	4	6

RoW's imports from ICIO		RoW	
		A	B
ICIO Country 1	A	10	10
	B	8	7

Figure 18: Applying these proportions to the trade data provides us with estimates of the import matrix of RoW imports from each ICIO country.

Component F: Estimating RoW's Imports from AfCIOT Countries: To calculate RoW's imports from AfCIOT countries, trade boundary data, which provide the estimated imports of RoW from these countries, are utilized.

RoW proportions		RoW	
		A	B
ICIO Country 1	A	29%	71%
	B	65%	35%

Figure 19: RoW IOT proportions.

The distribution of these imports across industries follows the structure of RoW's existing IOT, assuming similar industry distribution patterns as those observed within AfCIOT.

RoW's imports from Africa		RoW	
		A	B
AfCIOT Country 1	A	4	11
	B	23	12

Figure 20: Estimation of RoW imports from Africa.

Component G: Domestic RoW Input-Output Table: The final step involves adjusting the RoW's IO table in the OECD's ICIO model by subtracting the IO tables of each AfCIOT country. This adjustment reflects the revised economic interactions of the RoW after accounting for direct engagements with AfCIOT countries.

		African Country 1	
		A	B
African Country 1	A	3	2
	B	2	3

Figure 21: IOT from AfCIOT for AfCIOT Country 1.

		RoW	
		A	B
RoW	A	7	22
	B	28	13

Figure 22: Revised RoW IOT.

The key check here is that the total world balance, the sum of all columns and rows, should remain the same. So, the total output and input of Product A should be equal, and the same as the world production of Product A. By leaving the Rest of the World as a remaining balance this ensures this condition is met. Each country's RoW should still be checked for accuracy along with all other estimated matrices.

Future improvements

Specific Product Considerations: Certain products like crude oil or food items have straightforward allocations due to their limited use in the domestic economy. The import proportionality assumption may also utilize the Broad Economic Categories (BEC) classification, which categorizes imports into intermediate, consumer, and capital goods. Although this method is resource-intensive, particularly during initial setup, it is essential for generating detailed allocation ratios and percentages for each import category and accommodates secondary outputs where products are used in non-typical industries.

Non-AfCIOT country integration: Currently the integration of ICIO bases on Input-Output tables, assuming a diagonal supply table, and applying the import proportionality assumption. It would be better to move to a system of integration with supply and use tables.

5. DATA DISSEMINATION: TOOL AND STRATEGY

Once indicators are produced from the model, which is still in finalization, dissemination of the results will be a critical phase. In particular, the Economic Commission for Africa (ECA) will play a leading role in promoting understanding of the TiVA indicators and producing analytical materials. Focus will be on practical applications in the context of the African Continental Free Trade Area (AfCFTA).

A new development for dissemination will be the AfCIOT app; an innovative and interactive visualization tool designed to explore and derive insights from various indicators calculated by the AfCIOT model. Developed in R Shiny, the app offers several key features that enhance its functionality and user experience..

5.1. Dissemination Tool

The landing page of the app features a map that visually represents the countries included in the current version of the app, providing users with an immediate geographical context. To cater to the diverse linguistic needs of the United Nations Member States, the app supports multiple languages, including all six official UN languages, with English and French serving as the primary working languages. This multilingual support ensures that the app is accessible and useful to a broad audience.

The app provides comprehensive availability and metadata for each indicator. This includes detailed information such as the indicator code, name, units, and dimensions, which are crucial for users to understand the scope and specifics of each indicator. Additionally, the app offers insights on policy simulations, allowing users to explore potential policy impacts based on the data. Groupings by Regional Economic Communities (RECs), subregions, and world zones are also available, facilitating comparative and regional analysis.

Indicators are described in each language, enhancing accessibility and understanding. The dimensions of the Trade in Value Added (TiVA) indicators are included, providing detailed analytical dimensions. The app also lists industry codes and descriptions in multiple languages, which is essential for cross-referencing and international comparisons. Geographical data is provided at various levels, including individual countries, regions (comprising several countries), the World (WLD), and specific areas such as the Rest of the World (ROW) or the Rest of Africa (ROA). This multi-level geographical information supports nuanced and detailed analysis.

The AfCIOT App also features detailed country profiles, offering users a comprehensive view of each country's economic data and indicators. Data visualization tools within the app facilitate in-depth analysis, allowing users to create visual representations of the data for better understanding and communication. Time series analysis capabilities enable users to examine data trends over time, providing insights into temporal changes and developments. The app also supports ranking of indicators and countries, which can be useful for comparative analysis and benchmarking. Additionally, matrix visualization options are available, allowing users to view data in a structured, tabular format for enhanced clarity and analysis.

5.2. Dissemination strategy

The AfCIOT could inform policymakers and foster regional integration in Africa in several ways, including the implementation of AfCFTA. Beyond merely intra-trade information, the AfCIOT offers insights into the intricate interactions among various intra-country and inter-country branches through its continental Input-Output Table. This data is indispensable for understanding the depth of economic and regional integration. For instance, it delineates Kenya's financial sector exports utilized in Tanzania's transport infrastructure, and also, Tunisia's agricultural sector exports employed in Algeria's catering industry. Such cross-border exchanges underscore the interconnectedness of regional economies and emphasize the importance of collaborative policy initiatives.

The AfCIOT offers insights into various trade-in-value-added indicators, including:

- Domestic Value Added – The Domestic Value Added in Gross Exports estimates the value added by an economy in producing goods and services for export. It is calculated as the difference between gross output at basic prices and intermediate consumption at purchasers' prices, according to OECD (2013).
- Indirect Domestic Value Added - The Indirect Domestic Value Added in exports refers to the value added embodied in the exports of other countries, representing the upstream contributions of domestic value added from other industries. This is also termed as Domestic Value Added sent to third economies.
- Foreign Value Added – The Foreign Value Added in Exports measures the value added in exports whose inputs are sourced from foreign industries.
- Backward Participation and Forward Participation - The proportions of Foreign Value Added and Indirect Domestic Value Added in gross exports signify backward and forward participation or linkages, respectively; and and
- Global Value Chain - These components enable the estimation of Global Value Chain Participation, which is the aggregate of backward and forward participation. This metric illustrates the extent to which a country or sector is integrated into the global or regional value chain. In addition to economic implications, global value chains also have a positive impact on social factors such as education, health, and inequality. Durongkaveroj (2023) discovered that increased integration into global value chains could serve as a policy tool to bolster recovery from ongoing health and economic crises, as evidenced by findings from Thailand.

<u>Key uses and benefits</u>

- Understanding Economic Interdependencies
    - Example: The AfCIOT can reveal the extent to which Kenya’s manufacturing sector depends on raw materials from Tanzania and the extent to which Tanzanian agriculture relies on fertilizers produced in Morocco. This information helps policymakers identify key sectors for investment and development to enhance economic integration.
    - Impact: By understanding these interdependencies, countries can coordinate policies to strengthen these linkages, thereby promoting regional economic stability and growth.
- Identifying Value-Added Contributions

- Example: TiVA indicators can show how much value is added by each country in the production of goods. For instance, if Ghana exports cocoa to Côte d'Ivoire, which then processes it into chocolate and exports it to Europe, TiVA can quantify the value added at each stage.
- Impact: This information helps countries identify and develop high-value segments of their industries, enhancing their positions in regional and global value chains.

- Formulating Targeted Trade Policies

  - Example: The AfCIOT can highlight sectors where countries have comparative advantages and identify potential trade complementarities. For instance, Nigeria might have a comparative advantage in oil production, while Ethiopia excels in coffee production.
  - Impact: Policymakers can use this data to negotiate trade agreements that leverage these strengths, fostering mutually beneficial trade relationships and enhancing the overall competitiveness of the region.

- Enhancing Supply Chain Resilience

  - Example: During disruptions such as the COVID-19 pandemic, the AfCIOT can be used to map out critical supply chains and identify vulnerabilities. For instance, if a disruption in South African automotive parts affects vehicle assembly in Egypt, the table can highlight this link.
  - Impact: Policymakers can then take steps to diversify sources or build strategic reserves, thus making supply chains more resilient and reducing dependency on a single supplier.

- Monitoring and Evaluating AfCFTA Impact

  - Example: By comparing TiVA indicators before and after the implementation of AfCFTA, policymakers can assess the agreement's impact on regional trade flows and value addition. For example, they can evaluate if the share of intra-African trade in total exports has increased.
  - Impact: This enables continuous improvement of trade policies and strategies, ensuring that the benefits of AfCFTA are maximized and equitably distributed.

- Promoting Sustainable Development

  - Example: AfCIOT can provide data on the environmental impact of different sectors, such as carbon emissions in manufacturing vs. agriculture. This helps in identifying sectors where green technologies can be introduced.
  - Impact: Policymakers can promote sustainable practices and investments in green technologies, aligning economic growth with environmental sustainability goals.

6. SUMMARY AND CONCLUSION

This paper elucidates the intricate process of compiling the African Continental Input-Output Table (AfCIOT). It highlights its significant potential to drive informed policymaking and foster regional African integration amidst data constraints. The AfCIOT represents a groundbreaking initiative to overcome technical challenges in compiling Trade in Value Added (TiVA) indicators in Africa, contributing to the realization of the African Continental Free Trade Area (AfCFTA).

The AfCIOT construction relies on data from various sources, primarily Supply-Use Tables (SUTs), National Accounts (NAs), and international trade statistics. Key data sources include the UNSD National Account data, particularly the "National Accounts Estimates of Main Aggregates" and "National Accounts Official Country Data" from National Statistics Offices.

To address instances of missing data, several methods were adopted:

- Utilization of algebraic identities within National Accounts.
- Incorporation of supplementary data from alternative sources.
- Application of time series imputation using a Kalman filter.
- Use of econometric modeling techniques.
- Median imputation based on data from neighboring and similar countries.

Since SUTs are not produced annually, the most recent available SUTs close to the base years were used. Established balancing methods, such as the GRAS method, were employed to align the SUTs with the National Accounts of the base years. The GRAS procedure was applied across four components of the SUT:

1) The "final demand" component of the supply table.
2) Industry-estimated output within the supply table.
3) The final demand component of the use table.
4) Industry-estimated intermediate consumption within the use table.

For the AfCIOT, aggregated international trade statistics by product, service, and trade partners were utilized extensively. Correspondence tables were employed to harmonize classifications, such as transitioning from CPA to CPC, HS to CPA for goods, and EBOPS to CPC for services. Additionally, OECD's ICIO data for non-African countries complemented the AfCIOT. Exchange rate information was used to convert values from local currency to USD.

The AfCIOT development adhered to the OECD's methodology while considering African contexts regarding data limitations, data quality, classifications used, and the integration of new statistical methods such as machine learning and Large Language Models (LLMs). The AfCIOT encompasses 87 product categories from CPA 2.1 at the two-digit level and 45 industries, aligning local industries with ISIC rev 4.

Key steps in building the AfCIOT methodology included:

- Standardization of Products and Industries.
- Harmonization of Base Year.
- Currency Conversion.
- Price Level Adjustments.
- Separation of Domestic and Import Uses.
- Conversion from SUT to IOT.

A crucial step in building the AfCIOT was the conversion from purchasers to basic prices, which involves adjusting for trade margins, transport costs, taxes, and subsidies. The conversion of Supply-Use Tables into Input-Output Tables is pivotal for creating an analytical framework supporting economic analysis and policymaking. Bilateral trade flows are essential for constructing and balancing the inter-country input-output table and elaborating the rest of the world block.

The AfCIOT carries significant implications both statistically and economically. On the statistical side, the AfCIOT App serves as an innovative, interactive visualization tool for exploring and gaining insights from various indicators calculated by the AfCIOT model. It includes features like a map illustrating included countries, multilingual options, indicator availability and metadata, country profiles, and data visualization tools for analysis.

In terms of policy, AfCIOT has the potential to inform policymakers and promote regional integration in Africa, particularly by facilitating the implementation of the AfCFTA and providing intra-trade information. It also offers insights into trade-in-value-added indicators, such as Domestic Value Added, Indirect Domestic Value Added, Foreign Value Added, Backward Participation, Forward Participation, and Global Value Chain. These insights extend beyond economic implications, affecting social factors like education, health, and inequality.

<u>Future Improvements and Recommendations</u>

Future improvements are essential to enhance the robustness and applicability of AfCIOT. These measures include:

- Expanding the database of SUTs by engaging with African governments and national statistical offices (NSOs).
- Developing country-specific correspondence tables and refining allocation shares between local classifications and international counterparts.
- Improving the availability and accuracy of valuation matrices for estimating basic prices for the import use table.
- Integrating sophisticated econometric models and advanced data integration techniques to address gaps in data, methodology, and technology.

By ensuring that the AfCIOT is accurate, comprehensive, and reflective of the diverse economic environments across Africa, policymakers and researchers can better understand economic dynamics and craft policies that foster sustainable growth and development.

<u>Appendix I</u>. Balancing: description of balancing methodologies and existing challenges; discussion on the construction of boundaries

Although countries routinely produce National Accounts data on an annual basis, the collection of Supply and Use Tables (SUTs) is infrequent. Stanger (2018) emphasizes that SUTs entail a substantial amount of data and that numerous countries do not consistently possess such detailed information. The author highlights that crafting a thorough and accurate SUT demands considerable time, complicates the compilation process, and requires additional expertise to prevent subjective or biased adjustments. Due to resource constraints in many nations, SUTs are typically assembled only every few years, presenting a notable challenge.

In several African countries, the most recent SUT data predates 2015. For instance, according to Table 1 of the Progress report on the implementation of the 2008 System of National Accounts and related statistical systems in Africa at the eighth meeting of the Economic Commission for Africa Statistical Commission for Africa (United Nations, 2022), Angola and Seychelles have SUTs data from 2014, Ghana from 2013, Zimbabwe from 2012, Nigeria and Zambia from 2010, and Liberia from 2008. Additionally, the report indicates that other African nations, including Eritrea, Lesotho, Libya, Namibia, Sierra Leone, Somalia, South Sudan, and Sudan, lack available SUTs.

To construct IO Tables, having SUTs for the base years is crucial. However, in the absence of SUTs for these years, balancing methods are employed to estimate them. For example, although Kenya's last available SUT is from 2016, if we aim to develop our AfCIOT for the years 2017, 2018, and later 2022, balancing methods enable us to approximate SUTs for these years while maintaining the original SUT's structure and preserving the values of the National Accounts for the respective years.

Eurostat (2019) emphasizes that Balancing serves not only to ensure consistency between supply and use for each product and between output and input for each industry but also to identify discrepancies in fundamental data and estimation methods. Moreover, it is advantageous to balance the supply and use system at both current and constant prices simultaneously to ensure the accuracy and reliability of the data.

Even when SUTs are generated for base years, discrepancies with National Accounts values can arise due to various factors: differences in methodology, levels of aggregation, classifications used, or statistical errors. The methodology used to estimate values for national accounts differs from that used for SUTs; the latter involves more intricate and disaggregated methodologies, necessitating the determination of interactions among different sectors, whereas national accounts primarily deal with aggregate values. Stanger (2018) highlights those differences in methodologies, survey errors, classification inconsistencies, and varying levels of aggregation contribute to such discrepancies.

Consider the example of household wheat production discussed by Eurostat (2019). Eurostat (2019) thought that a discrepancy was attributed to the assumption that all household-produced wheat was consumed by households for their use, without changes in inventory or involvement in trade activity. This discrepancy was interpreted as representing household wheat production, with its value serving as the balancing item.

The standard procedure for mechanical adjustment involves the proportional distribution of discrepancies. To illustrate, consider a simple scenario with three branches, three products, and a single sector (household) for final use, as depicted in Table 1 below.

Table 8: Example of production and use.

	Intermediate Use			Final use			
	Agriculture	**Industry**	**Services**	**Household**	**Total row**	**Output**	**Balancing**
Crops	25	15	12	40	92	100	8
Factories	7	20	5	20	52	58	6
Services	10	17	30	30	87	90	3

Balancing entails ensuring that the sum of the rows equals the outputs while maintaining consistent proportions. To achieve this, each element in the first row is multiplied by 100 and divided by 92, each element in the second row is multiplied by 58 and divided by 52, and each element in the third row is multiplied by 90 and divided by 87, resulting in Table 2.

Table 9: Balancing the Total rows.

	Intermediate Use			Final use			
	Agriculture	**Industry**	**Services**	**Household**	**Total row**	**Output**	**Balancing**
Crops	27.17	16.30	13.04	43.48	100	100	0
Factories	7.81	22.31	5.58	22.31	58	58	0
Services	10.34	17.59	31.03	31.03	90	90	0

The primary challenge of proportion distribution arises when you need to balance both the total row and the total column simultaneously. Let's consider the example of an array representing the availability of intermediate requests by branch, where discrepancies exist with the total column.

Table 10: Example of production and use.

	Intermediate Use			Final use			
	Agriculture	**Industry**	**Services**	**Household**	**Total row**	**Output**	**Balancing**
Crops	25	15	12	40	92	100	8
Factories	7	20	5	20	52	58	6
Services	10	17	30	30	87	90	3
Total column	42	52	47	90			
Intermediary demand	40	60	50	90			
Balancing	-2	8	3	0			

By using the proportion method to balance total rows, Table 4 is obtained, resulting in adjustments to the discrepancies in the total columns.

Table 11: Balancing the Total rows.

	Intermediate Use			Final use			
	Agriculture	**Industry**	**Services**	**Household**	**Total row**	**Output**	**Balancing**
Crops	27.17	16.30	13.04	43.48	100	100	0
Factories	7.81	22.31	5.58	22.31	58	58	0
Services	10.34	17.59	31.03	31.03	90	90	0
Total column	45.33	56.20	49.65	96.82			
Intermediary demand	40	60	50	90			
Balancing	-5.33	3.80	0.35	-6.82			

Now, we will balance the total column using the proportion method.

Table 12: Balancing the total Columns.

	Intermediate Use			Final use			
	Agriculture	**Industry**	**Services**	**Household**	**Total row**	**Output**	**Balancing**
Crops	23.98	17.41	13.13	40.42	94.94	100	5.06
Factories	6.89	23.82	5.62	20.74	57.06	58	0.94
Services	9.13	18.78	31.25	28.85	88.00	90	2.00
Total column	40.00	60.00	50.00	90.00			
Intermediary demand	40	60	50	90			
Balancing	0.00	0.00	0.00	0.00			

Thus, when balancing the total columns, the total rows become unbalanced, and vice versa if we start by balancing the row columns before the row total. Each time one of the total rows or columns is balanced, the other becomes unbalanced. Automatic methods have been developed to iteratively address this issue until both total rows and columns are balanced. For instance, the RAS method is widely recognized and commonly used for balancing Supply-Use Tables and Input-Output Tables, as noted by Trinh and Phong (2013). They mention that with the assistance of software, this procedure becomes efficient and rapid, regardless of whether the iteration is performed seven times or seven million times.

The Generalized RAS (GRAS) function serves as an automated mechanism to compile all iterations until balancing both dimensions. According to Temurshoev (2013), the GRAS function is a commonly employed bi-proportional technique for balancing/updating Input-Output (IO) matrices, accommodating both positive and negative elements. One of the notable features of the GRAS method is the availability of its analytical solution, facilitating its straightforward utilization in iterative procedures.

While attempting to balance Table 4 by total columns, the previously balanced total rows became unbalanced, yet the degree of discrepancies is lower compared to those in the former table (Table

3). Thus, with each iteration, the degree of discrepancies decreases relative to their previous levels when the other dimension is balanced. After several iterations, both total rows and columns may become balanced. However, in some cases, instead of the discrepancies decreasing with each iteration, they may increase after a certain point. These discrepancies may not converge to zero but diverge, even when using the GRAS function.

For instance, in constructing the AfCIOT, many countries have faced challenges where the GRAS function could not balance all four parts of the SUTs. In some countries, only one part of the SUT has been balanced using the GRAS function, while in others, two or three parts have been balanced. These issues often arise due to significant disparities between the SUTs and the National Accounts or simply because of algebraic problems in the iterative process.

Given these limitations in balancing using the GRAS function, alternative methods have been developed to balance SUTs and IOTs with National Accounts. For example, Stanger (2018) introduced the Supply and Use Table Balancing tool (SUTB), using the Cholette-Dagum regression-based reconciliation method. This approach involves least squares techniques of simultaneous equations, enabling multidimensional non-iterative distribution of discrepancies. In the construction of the AfCIOT, the proportion method was utilized in cases where convergence with the GRAS function was not achieved.

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