National Seminar on Regional and Global Value Chains in Services

Services and Trade in Value Added: *Quantitative Methodology*

Christopher H. Onyango

Day Two

Outline

1. Measuring trade in value added: Theory
   - Input – Output tables
   - Extension of MRIOs
2. Measuring trade in value added: Application
3. Some examples
   - Tourism value chains in Ethiopia and Ethiopia
   - Comparisons with developed country scenario

1. Measuring Trade in Value Added: Theory

1. Start by considering how to construct an IO system for a single country, so leave trade to one side.

2. Examine the elements of the system, and the operations performed to derive quantities of interest.

3. Move to a multi-country multi-sector framework (MRIO), and present a simple example.

4. Derive the key result that makes it possible to produce GVC indicators.

1. Measuring Trade in Value Added: Theory

- Consider a country with two sectors, manufacturing (1) and services (2). For the moment, it is in autarky, i.e. no trade.

- We can break down the gross output of sector 1 as follows:

$$a_{11}x_{11} + a_{12}x_{12} + y_1 = x_1$$

- The first two terms summarize direct intermediate input use from sectors 1 and 2 respectively.

- Y is final demand for the output of sector 1.

- The A terms are input-output coefficients, showing how much of each sectors output is required as intermediate inputs for manufacturing output.
  - Note that manufacturing uses some of its own output as an intermediate input: think of car manufacturers using tires, also manufactured by other firms, to make finished cars.
  - For the cross-effect, think of cell phone manufacturers using circuit designs (services) developed by other firms to make their finished product.

1. Measuring Trade in Value Added: Theory

- We can do the same thing for sector 2:
- $a_{21}x_{21} + a_{22}x_{22} + y_2 = x_2$

- Similarly, we see the services sector using some of the manufacturing sector's output as an intermediate input (think of paper bought to run an office) and some of its own output as intermediate inputs (think of financial services supplied to firms).

- We can stack the two equations:
- $a_{11}x_{11} + a_{12}x_{12} + y_1 = x_1$
- $a_{21}x_{21} + a_{22}x_{22} + y_2 = x_2$

1. Measuring Trade in Value Added: Theory

From the stacked equations:

$$a_{11}x_1 + a_{12}x_2 + y_1 = x_1$$
$$a_{21}x_1 + a_{22}x_2 + y_2 = x_2$$

We can rewrite the equations using matrix multiplication:

$$\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

Or $AX + Y = X$

This is the most basic equation in IO analysis. It should immediately be obvious that it can be generalized from the one country two sector case to arbitrary numbers of both once matrices are used.

Need to keep track of the dimensions:

G = no. of countries = 1 in this case.

N = no. of industries = 2 in this case.

A = GN * GN

X = GN * 1

Y = GN * 1

1. Measuring Trade in Value Added: Theory

- Starting from $AX + Y = X$, we can perform some rearrangements, and solve for X:
  - $Y = X - AX$
  - $Y = (I - A)X$
  - $\therefore X = (I - A)^{-1}Y \equiv BY$
- In theory, this relationship shows how to obtain the amount of final output in each sector (X) required for a particular level of final demand (Y), assuming constant technology.
- Matrix B is the Leontief inverse, and deserves some further explanation.

1. Measuring Trade in Value Added: Theory

- What is so special about the Leontief inverse $B = (I - A)^{-1}$?
- A gives us the technical coefficients in a direct sense: how much of sector 1's output is directly used by sector 2 in producing its output, and so on.
- But it does not tell us anything about indirect effects:
  - Sector 2 uses some of sector 1's output…
  - But sector 1 also uses some of sector 2's output…
  - So the direct figure for sector 2's use of its own output does not tell the full story…
- The Leontief matrix captures both direct and indirect effects: in other words the total amount of extra output by sector required by an additional unit of final demand, taking account of direct and indirect linkages, but subject to constant technology.

1. Measuring Trade in Value Added: Theory

- Why is this true of matrix B?
- To see, we can rewrite it in a very helpful way:
  - $B = (I - A)^{-1} = I + A + A^2 + A^3 + \cdots$
- The Leontief inverse neatly captures an infinite series:
  - A is direct input requirements.
  - A^2 is input requirements taking account of direct and one step effects.
  - … and so on.
- So using this series expression (which you can verify in a Math text), we can see that the Leontief inverse indeed captures all direct and indirect input demand effects associated with a single unit increase in final demand.

1. Measuring Trade in Value Added: Theory

- Now that we have the basic idea, we can easily extend it to the MRIO case by changing the dimensions:
  - G = no. of countries.
  - N = no. of sectors.

- The unit of analysis is now the country-sector:
  - A given element of A summarizes input use of, say, country 1 industry 6 from country 10 industry 12.
  - For elements of A capturing use by one country of inputs originating in another country, we have a cross-border transaction: in the example, intermediate exports from country 10 to country 1.
  - For elements of A capturing use by one country of inputs originating in the same country, we have a domestic transaction. EG, country 5 industry 6 purchases inputs from country 5 industry 10.

- We look at a concrete example of this in the next section, to see exactly how the matrix is set up.

1. Measuring Trade in Value Added: Theory

- Before moving on, we should think about matrix A in terms of what we observe.
- Usually, IO tables record the value of inputs produced by each sector and used by each other.
- That is not A (technical coefficients) but AX, i.e. the technical coefficients multiplied by output.
- So as a preliminary matter, before calculating the Leontief inverse from a real IO table, we need to recover A by element wise division:
  - $a_{ij} = \frac{(AX)_{ij}}{X_i}$
- Calculating each element in this way gives us matrix A, from which we can easily calculate the Leontief inverse, matrix B.

1. Measuring Trade in Value Added: Theory

- Next we need to think about value added.

- Define $\hat{V}$ as the value added coefficients matrix:
  - $\hat{V} = I - diag\left(\sum_i^{GN} a_{i,1} \cdots \sum_i^{GN} a_{i,GN}\right)$

- What does this matrix capture?
  - It starts as a matrix with one on the diagonal…
  - From which we subtract the sums of the input coefficients from A
  - Intuitively, this is a summary of the value added share of each sector: the total (1 before we multiply by output) less the shares that are accounted for by direct inputs from each other sector.

1. Measuring Trade in Value Added: Theory

- Next, we set up a matrix E with gross exports by country-sector on the main diagonal, and zeros elsewhere.

- We can then combined these ingredients to obtain a measure of the value added origin of gross exports by country-sector:
  - $T_v = \hat{V}BE = \begin{bmatrix} \widehat{v_1} & 0 & \cdots \\ 0 & \widehat{v_2} & 0 \\ \vdots & 0 & \ddots \end{bmatrix} \begin{bmatrix} b_{11} & b_{12} & \cdots \\ b_{21} & b_{22} & \cdots \\ \vdots & \vdots & \ddots \end{bmatrix} \begin{bmatrix} e_1 & 0 & \cdots \\ 0 & e_2 & 0 \\ \vdots & 0 & \ddots \end{bmatrix}$

- This is the key output of the exercise. Each element of T_v gives the value added content of each country-sector that is shipped to each other country-sector.
  - By combining elements, we can obtain measures like total domestic value added in exports (DVA), total foreign value added in exports (FVA), and the services share of value added in exports.
  - Obtaining T_v takes some work, but once we have it the real work begins: manipulating and using it to produce results that are informative from a policy perspective!

2. Measuring Trade in Value Added: Application

- As has been previously noted, the real magic in estimating trade in value added is in the data, not the math. The math is quite straightforward, subject to setting all the inputs up in the right way.

- Next we will look at how to perform the relevant calculations using Eora data, and how to apply some pre-programmed “short cuts”.

- To fix ideas, though, it helps to look at a fully worked through example using a “toy” model.
  - Eora has 190 countries and 26 sectors, so not great for whiteboard work.
  - We will work with an example that uses 3 countries and 4 sectors: much more tractable, but all the operations are exactly the same as the ones we would perform on the ”big” matrix.

2. Measuring Trade in Value Added: Application

Before starting, let's consider the simplest possible MRIO: G=2; N=1.

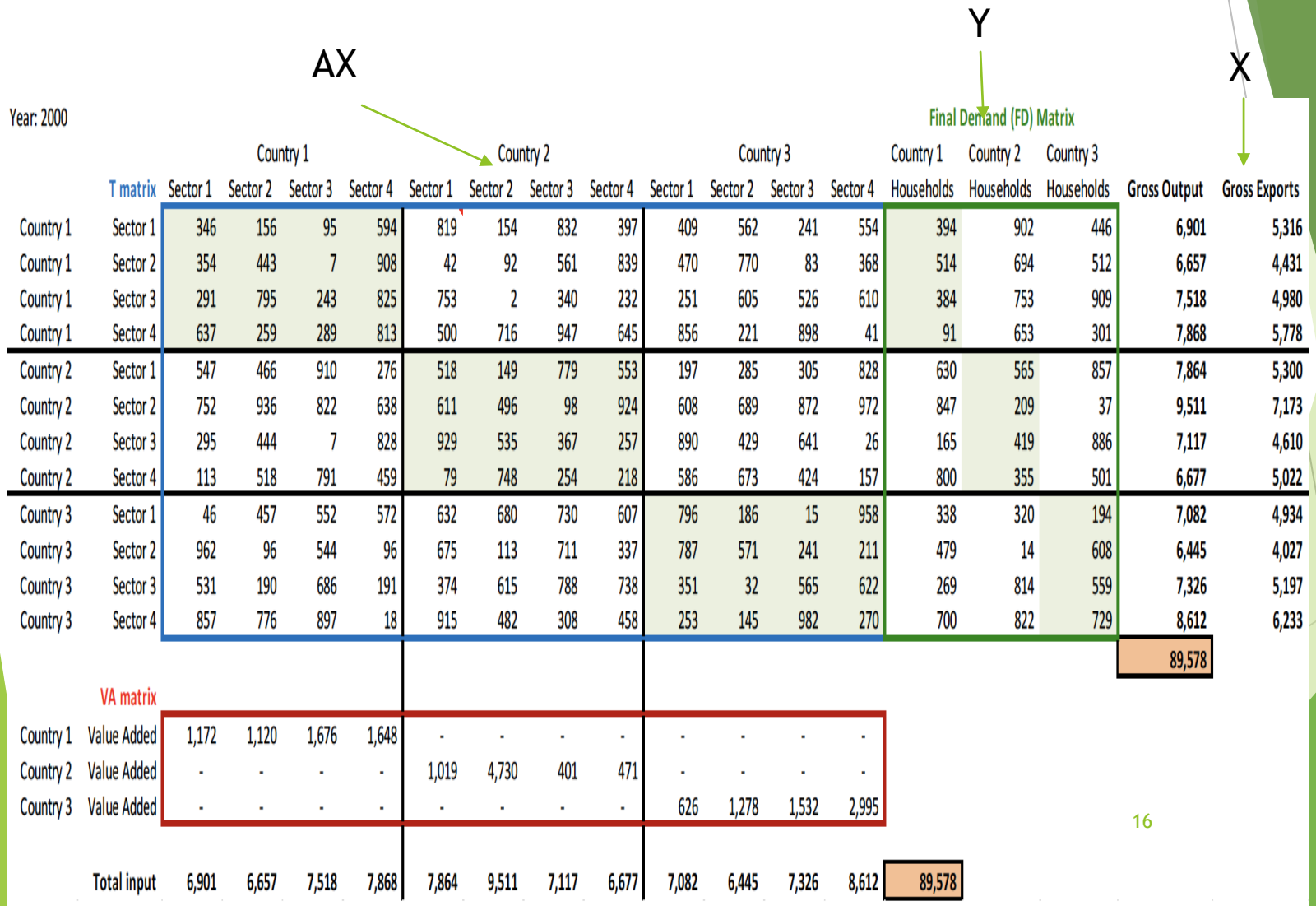
		Intermediate Use		Final Demand		Gross Output
		Country A	Country B	Country A	Country B	
		Sector 1	Sector 1	Sector 1	Sector 1	
Country A	Sector 1	ntermediate use of domestic output	Intermediate use by B of exports from A	Final use of domestic output	Final use by B of exports from A	X_A
Country B	Sector 1	ntermediate use by A of exports from B	Intermediate use of domestic output	Final use by A of exports from B	Final use of domestic output	X_B
Value Added		V_A	V_B			
Gross Output		X_A	X_B			

AX

Y

X

2. Measuring Trade in Value Added: Application



	T matrix	Country 1 Sector 1	Country 1 Sector 2	Country 1 Sector 3	Country 1 Sector 4	Country 2 Sector 1	Country 2 Sector 2	Country 2 Sector 3	Country 2 Sector 4	Country 3 Sector 1	Country 3 Sector 2	Country 3 Sector 3	Country 3 Sector 4	Country 1 Households	Country 2 Households	Country 3 Households	Gross Output	Gross Exports
Country 1	Sector 1	346	156	95	594	819	154	832	397	409	562	241	554	394	902	446	6,901	5,316
Country 1	Sector 2	354	443	7	908	42	92	561	839	470	770	83	368	514	694	512	6,657	4,431
Country 1	Sector 3	291	795	243	825	753	2	340	232	251	605	526	610	384	753	909	7,518	4,980
Country 1	Sector 4	637	259	289	813	500	716	947	645	856	221	898	41	91	653	301	7,868	5,778
Country 2	Sector 1	547	466	910	276	518	149	779	553	197	285	305	828	630	565	857	7,864	5,300
Country 2	Sector 2	752	936	822	638	611	496	98	924	608	689	872	972	847	209	37	9,511	7,173
Country 2	Sector 3	295	444	7	828	929	535	367	257	890	429	641	26	165	419	886	7,117	4,610
Country 2	Sector 4	113	518	791	459	79	748	254	218	586	673	424	157	800	355	501	6,677	5,022
Country 3	Sector 1	46	457	552	572	632	680	730	607	796	186	15	958	338	320	194	7,082	4,934
Country 3	Sector 2	962	96	544	96	675	113	711	337	787	571	241	211	479	14	608	6,445	4,027
Country 3	Sector 3	531	190	686	191	374	615	788	738	351	32	565	622	269	814	559	7,326	5,197
Country 3	Sector 4	857	776	897	18	915	482	308	458	253	145	982	270	700	822	729	8,612	6,233
																	89,578	
Country 1	Value Added	1,172	1,120	1,676	1,648	-	-	-	-	-	-	-	-					
Country 2	Value Added	-	-	-	-	1,019	4,730	401	471	-	-	-	-					
Country 3	Value Added	-	-	-	-	-	-	-	-	626	1,278	1,532	2,995					
	Total input	6,901	6,657	7,518	7,868	7,864	9,511	7,117	6,677	7,082	6,445	7,326	8,612	89,578				

2. Measuring Trade in Value Added: Application

- Step One: Sum intermediate (AX) and final (Y) demand:

1585	3104	2212
2226	2228	2203
2538	2080	2901
2089	3461	2317
2829	2564	2472
3995	2338	3178
1739	2507	2872
2681	1654	2341
1965	2969	2149
2177	1850	2418
1867	3329	2129
3248	2985	2379

- GN = 12 rows because we have each country and sector.
- N = 3 columns, because we are summing by destination at this stage.
- Verify that 1585 = 346+156+95+594+394. This is gross output of country 1 sector 1 shipped to country 1.

2. Measuring Trade in Value Added: Application

- Step 2: Sum gross-output by country-sector (i.e., across all destinations) to recover total gross output. For ease of later manipulations, repeat sums across cells within a column:

6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612
6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612
6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612
6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612
6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612
6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612
6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612
6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612
6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612
6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612
6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612
6901	6657	7519	7867	7865	9511	7118	6676	7083	6445	7325	8612

- Verify that 6901 = sum of row 1 in previous matrix, i.e. total output shipped to all destinations of country 1 sector 1.

- Each column is total gross output of a different country-sector.

2. Measuring Trade in Value Added: Application

- Step 3: Divide AX elementwise by X to obtain A.

0.050	0.023	0.013	0.076	0.104	0.016	0.117	0.059	0.058	0.087	0.033	0.064
0.051	0.067	0.001	0.115	0.005	0.010	0.079	0.126	0.066	0.119	0.011	0.043
0.042	0.119	0.032	0.105	0.096	0.000	0.048	0.035	0.035	0.094	0.072	0.071
0.092	0.039	0.038	0.103	0.064	0.075	0.133	0.097	0.121	0.034	0.123	0.005
0.079	0.070	0.121	0.035	0.066	0.016	0.109	0.083	0.028	0.044	0.042	0.096
0.109	0.141	0.109	0.081	0.078	0.052	0.014	0.138	0.086	0.107	0.119	0.113
0.043	0.067	0.001	0.105	0.118	0.056	0.052	0.038	0.126	0.067	0.088	0.003
0.016	0.078	0.105	0.058	0.010	0.079	0.036	0.033	0.083	0.104	0.058	0.018
0.007	0.069	0.073	0.073	0.080	0.071	0.103	0.091	0.112	0.029	0.002	0.111
0.139	0.014	0.072	0.012	0.086	0.012	0.100	0.050	0.111	0.089	0.033	0.025
0.077	0.029	0.091	0.024	0.048	0.065	0.111	0.111	0.050	0.005	0.077	0.072
0.124	0.117	0.119	0.002	0.116	0.051	0.043	0.069	0.036	0.022	0.134	0.031

- Verify that 0.050 = 346 (from AX(1,1)) / 6901 (from X(1,1))
- Verify that 0.023 = 156 (from AX(1,2)) / 6657 (from X(2,1))
- This is the matrix of technical coefficients, i.e. direct input requirements for an extra unit of output in each country-sector.

2. Measuring Trade in Value Added: Application

- Step 4: Calculate the Leontief inverse

1.272	0.241	0.223	0.295	0.349	0.159	0.389	0.306	0.321	0.304	0.243	0.236
0.266	1.276	0.201	0.336	0.237	0.154	0.346	0.367	0.334	0.340	0.214	0.203
0.279	0.346	1.250	0.338	0.345	0.147	0.340	0.302	0.308	0.324	0.291	0.250
0.378	0.333	0.317	1.408	0.384	0.274	0.497	0.436	0.477	0.326	0.404	0.243
0.319	0.318	0.346	0.282	1.333	0.167	0.401	0.351	0.307	0.290	0.274	0.285
0.464	0.499	0.449	0.437	0.457	1.278	0.448	0.544	0.497	0.468	0.453	0.396
0.286	0.309	0.237	0.354	0.381	0.218	1.360	0.326	0.420	0.306	0.316	0.205
0.235	0.299	0.309	0.282	0.246	0.216	0.300	1.283	0.342	0.327	0.262	0.195
0.268	0.348	0.329	0.345	0.370	0.245	0.418	0.393	1.426	0.295	0.258	0.323
0.360	0.239	0.284	0.242	0.344	0.154	0.383	0.301	0.380	1.317	0.239	0.210
0.310	0.277	0.319	0.268	0.310	0.221	0.394	0.379	0.327	0.246	1.310	0.264
0.383	0.384	0.368	0.271	0.400	0.213	0.367	0.372	0.333	0.292	0.379	1.249

- The difference between the Leontief inverse (B) and A is that the latter only takes account of direct input requirements for an extra unit of output, while the former takes account of direct AND indirect requirements.
- So to increase output of Country 1 Sector 2 by one unit, we will need 0.241 extra units of Country 1 Sector 1's output.

2. Measuring Trade in Value Added: Application

- Step 5: Calculate the value added shares matrix.

0.170	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.168	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.223	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.210	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.129	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.497	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.057	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.071	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.089	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.198	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.209	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.348

- Verify that 0.170 = 1 – sum of column 1 of A above.

- This matrix tells us that the value added share of total output in country 1 sector 1 is 17%, in country 1 sector 2 it is 16.8%, etc.

2. Measuring Trade in Value Added: Application

- Step 6: Calculate the export vector.

5316
4431
4981
5778
5301
7173
4611
5022
4934
4027
5196
6233

- To do this:
  - Use an indicator matrix with first four rows of column 1 = 1, second four rows of column 2 = 1, etc., to identify countries.
  - Multiply the indicator matrix elementwise by X, to give domestic shipments (production and consumption in the same country)
  - Subtract the result from X to get bilateral exports.
  - Take sums by row to get country-sector sums (12 rows).
- Verify from above that 5316 = 3104 + 2212, and that 4431 = 2228 + 2203.

2. Measuring Trade in Value Added: Application

- Step 7: Calculate the value added trade matrix per the formula above.

1146.33	181.30	188.16	289.18	313.71	193.49	304.35	260.26	268.41	207.37	214.06	249.03
237.96	951.85	168.80	326.76	211.54	186.11	268.33	310.31	277.91	230.31	187.30	212.77
330.81	341.91	1387.33	435.82	407.48	234.80	349.10	337.75	338.86	291.16	336.58	347.59
421.18	309.68	330.64	1705.48	427.10	412.49	479.99	458.68	492.81	274.99	440.42	317.31
219.23	182.39	222.91	211.17	914.83	154.91	239.29	228.17	196.20	151.37	184.11	229.55
1227.14	1098.41	1112.56	1256.01	1205.32	4556.53	1027.81	1358.10	1218.66	936.21	1170.62	1228.40
85.95	77.49	66.82	115.90	114.48	88.63	355.08	92.59	117.20	69.85	92.91	72.27
88.23	93.48	108.45	114.97	91.82	109.34	97.48	454.65	119.20	93.00	96.07	85.55
126.51	137.01	145.55	176.82	174.03	156.23	171.17	175.35	624.65	105.48	119.27	178.97
379.71	209.53	279.99	276.93	360.86	218.79	349.86	299.36	371.60	1050.83	245.89	259.43
344.14	256.50	332.66	323.86	343.16	330.93	380.10	397.97	337.16	207.14	1423.40	343.66
708.80	591.46	637.14	545.09	736.66	530.73	588.44	648.83	571.33	409.28	685.35	2708.45

- Diagonalize the exports vector, and pre-multiply by the product of the value added shares matrix and the Leontief Inverse.

Applications……

- What does the sum of the yellow cells indicate?

		Kenya				Ethiopia				Nigeria			
		Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining
Kenya	Transport	1146.33	181.3	188.16	289.18	313.71	193.49	304.35	260.26	268.41	207.37	214.06	249.03
	Finance	237.96	951.85	168.8	326.76	211.54	186.11	268.33	310.31	277.91	230.31	187.3	212.77
	Agriculture	330.81	341.91	1387.33	435.82	407.48	234.8	349.1	337.75	338.86	291.16	336.58	347.59
	Mining	421.18	309.68	330.64	1705.48	427.1	412.49	479.99	458.68	492.81	274.99	440.42	317.31
Ethiopia	Transport	219.23	182.39	222.91	211.17	914.83	154.91	239.29	228.17	196.2	151.37	184.11	229.55
	Finance	1227.14	1098.41	1112.56	1256.01	1205.32	4556.53	1027.81	1358.1	1218.66	936.21	1170.62	1228.4
	Agriculture	85.95	77.49	66.82	115.9	114.48	88.63	355.08	92.59	117.2	69.85	92.91	72.27
	Mining	88.23	93.48	108.45	114.97	91.82	109.34	97.48	454.65	119.2	93	96.07	85.55
Nigeria	Transport	126.51	137.01	145.55	176.82	174.03	156.23	171.17	175.35	624.65	105.48	119.27	178.97
	Finance	379.71	209.53	279.99	276.93	360.86	218.79	349.86	299.36	371.6	1050.83	245.89	259.43
	Agriculture	344.14	256.5	332.66	323.86	343.16	330.93	380.1	397.97	337.16	207.14	1423.4	343.66
	Mining	708.8	591.46	637.14	545.09	736.66	530.73	588.44	648.83	571.33	409.28	685.35	2708.45

- Verify: sum of column 1 = Kenya's gross exports of transport services = 5316.

Applications……

- What does the sum of the red cells indicate?

		Kenya				Ethiopia				Nigeria			
		Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining
Kenya	Transport	1146.33	181.3	188.16	289.18	313.71	193.49	304.35	260.26	268.41	207.37	214.06	249.03
	Finance	237.96	951.85	168.8	326.76	211.54	186.11	268.33	310.31	277.91	230.31	187.3	212.77
	Agriculture	330.81	341.91	1387.33	435.82	407.48	234.8	349.1	337.75	338.86	291.16	336.58	347.59
	Mining	421.18	309.68	330.64	1705.48	427.1	412.49	479.99	458.68	492.81	274.99	440.42	317.31
Ethiopia	Transport	219.23	182.39	222.91	211.17	914.83	154.91	239.29	228.17	196.2	151.37	184.11	229.55
	Finance	1227.14	1098.41	1112.56	1256.01	1205.32	4556.53	1027.81	1358.1	1218.66	936.21	1170.62	1228.4
	Agriculture	85.95	77.49	66.82	115.9	114.48	88.63	355.08	92.59	117.2	69.85	92.91	72.27
	Mining	88.23	93.48	108.45	114.97	91.82	109.34	97.48	454.65	119.2	93	96.07	85.55
Nigeria	Transport	126.51	137.01	145.55	176.82	174.03	156.23	171.17	175.35	624.65	105.48	119.27	178.97
	Finance	379.71	209.53	279.99	276.93	360.86	218.79	349.86	299.36	371.6	1050.83	245.89	259.43
	Agriculture	344.14	256.5	332.66	323.86	343.16	330.93	380.1	397.97	337.16	207.14	1423.4	343.66
	Mining	708.8	591.46	637.14	545.09	736.66	530.73	588.44	648.83	571.33	409.28	685.35	2708.45

- DVA = 2136.28, domestic value added from all sectors incorporated in Kenya's exports of transport services.

Applications……..

- What does the sum of the green cells indicate?

		Kenya				Ethiopia				Nigeria			
		Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining
Kenya	Transport	1146.33	181.3	188.16	289.18	313.71	193.49	304.35	260.26	268.41	207.37	214.06	249.03
	Finance	237.96	951.85	168.8	326.76	211.54	186.11	268.33	310.31	277.91	230.31	187.3	212.77
	Agriculture	330.81	341.91	1387.33	435.82	407.48	234.8	349.1	337.75	338.86	291.16	336.58	347.59
	Mining	421.18	309.68	330.64	1705.48	427.1	412.49	479.99	458.68	492.81	274.99	440.42	317.31
Ethiopia	Transport	219.23	182.39	222.91	211.17	914.83	154.91	239.29	228.17	196.2	151.37	184.11	229.55
	Finance	1227.14	1098.41	1112.56	1256.01	1205.32	4556.53	1027.81	1358.1	1218.66	936.21	1170.62	1228.4
	Agriculture	85.95	77.49	66.82	115.9	114.48	88.63	355.08	92.59	117.2	69.85	92.91	72.27
	Mining	88.23	93.48	108.45	114.97	91.82	109.34	97.48	454.65	119.2	93	96.07	85.55
Nigeria	Transport	126.51	137.01	145.55	176.82	174.03	156.23	171.17	175.35	624.65	105.48	119.27	178.97
	Finance	379.71	209.53	279.99	276.93	360.86	218.79	349.86	299.36	371.6	1050.83	245.89	259.43
	Agriculture	344.14	256.5	332.66	323.86	343.16	330.93	380.1	397.97	337.16	207.14	1423.4	343.66
	Mining	708.8	591.46	637.14	545.09	736.66	530.73	588.44	648.83	571.33	409.28	685.35	2708.45

- FVA = 3179.71, foreign value added from all sectors and origins incorporated in Kenya's exports of transport services.
  - Known as "VS" in the technical literature.
  - Known of backward participation in the policy literature

Applications……..

- What does the sum of the light blue cells less DVA indicate?

		Kenya				Ethiopia				Nigeria			
		Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining
Kenya	Transport	1146.33	181.3	188.16	289.18	313.71	193.49	304.35	260.26	268.41	207.37	214.06	249.03
	Finance	237.96	951.85	168.8	326.76	211.54	186.11	268.33	310.31	277.91	230.31	187.3	212.77
	Agriculture	330.81	341.91	1387.33	435.82	407.48	234.8	349.1	337.75	338.86	291.16	336.58	347.59
	Mining	421.18	309.68	330.64	1705.48	427.1	412.49	479.99	458.68	492.81	274.99	440.42	317.31
Ethiopia	Transport	219.23	182.39	222.91	211.17	914.83	154.91	239.29	228.17	196.2	151.37	184.11	229.55
	Finance	1227.14	1098.41	1112.56	1256.01	1205.32	4556.53	1027.81	1358.1	1218.66	936.21	1170.62	1228.4
	Agriculture	85.95	77.49	66.82	115.9	114.48	88.63	355.08	92.59	117.2	69.85	92.91	72.27
	Mining	88.23	93.48	108.45	114.97	91.82	109.34	97.48	454.65	119.2	93	96.07	85.55
Nigeria	Transport	126.51	137.01	145.55	176.82	174.03	156.23	171.17	175.35	624.65	105.48	119.27	178.97
	Finance	379.71	209.53	279.99	276.93	360.86	218.79	349.86	299.36	371.6	1050.83	245.89	259.43
	Agriculture	344.14	256.5	332.66	323.86	343.16	330.93	380.1	397.97	337.16	207.14	1423.4	343.66
	Mining	708.8	591.46	637.14	545.09	736.66	530.73	588.44	648.83	571.33	409.28	685.35	2708.45

Applications……

- What does the sum of the light blue cells less DVA indicate?

		Kenya				Ethiopia				Nigeria			
		Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining
Kenya	Transport	1146.33	181.3	188.16	289.18	313.71	193.49	304.35	260.26	268.41	207.37	214.06	249.03
	Finance	237.96	951.85	168.8	326.76	211.54	186.11	268.33	310.31	277.91	230.31	187.3	212.77
	Agriculture	330.81	341.91	1387.33	435.82	407.48	234.8	349.1	337.75	338.86	291.16	336.58	347.59
	Mining	421.18	309.68	330.64	1705.48	427.1	412.49	479.99	458.68	492.81	274.99	440.42	317.31
Ethiopia	Transport	219.23	182.39	222.91	211.17	914.83	154.91	239.29	228.17	196.2	151.37	184.11	229.55
	Finance	1227.14	1098.41	1112.56	1256.01	1205.32	4556.53	1027.81	1358.1	1218.66	936.21	1170.62	1228.4
	Agriculture	85.95	77.49	66.82	115.9	114.48	88.63	355.08	92.59	117.2	69.85	92.91	72.27
	Mining	88.23	93.48	108.45	114.97	91.82	109.34	97.48	454.65	119.2	93	96.07	85.55
Nigeria	Transport	126.51	137.01	145.55	176.82	174.03	156.23	171.17	175.35	624.65	105.48	119.27	178.97
	Finance	379.71	209.53	279.99	276.93	360.86	218.79	349.86	299.36	371.6	1050.83	245.89	259.43
	Agriculture	344.14	256.5	332.66	323.86	343.16	330.93	380.1	397.97	337.16	207.14	1423.4	343.66
	Mining	708.8	591.46	637.14	545.09	736.66	530.73	588.44	648.83	571.33	409.28	685.35	2708.45

- DVX = 1679.37, indirect domestic value added in exports, i.e., VA from Kenya's transport services sector that is embodied in the exports of other countries.
  - Known as "VS1" in the technical literature.
  - Known as forward linkages in the policy literature.
- GVC Participation Index (%) = (VS+VS1)/Gross Exports

Applications……

- What does the sum of the pink cells indicate?

		Kenya				Ethiopia				Nigeria			
		Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining
Kenya	Transport	1146.33	181.3	188.16	289.18	313.71	193.49	304.35	260.26	268.41	207.37	214.06	249.03
	Finance	237.96	951.85	168.8	326.76	211.54	186.11	268.33	310.31	277.91	230.31	187.3	212.77
	Agriculture	330.81	341.91	1387.33	435.82	407.48	234.8	349.1	337.75	338.86	291.16	336.58	347.59
	Mining	421.18	309.68	330.64	1705.48	427.1	412.49	479.99	458.68	492.81	274.99	440.42	317.31
Ethiopia	Transport	219.23	182.39	222.91	211.17	914.83	154.91	239.29	228.17	196.2	151.37	184.11	229.55
	Finance	1227.14	1098.41	1112.56	1256.01	1205.32	4556.53	1027.81	1358.1	1218.66	936.21	1170.62	1228.4
	Agriculture	85.95	77.49	66.82	115.9	114.48	88.63	355.08	92.59	117.2	69.85	92.91	72.27
	Mining	88.23	93.48	108.45	114.97	91.82	109.34	97.48	454.65	119.2	93	96.07	85.55
Nigeria	Transport	126.51	137.01	145.55	176.82	174.03	156.23	171.17	175.35	624.65	105.48	119.27	178.97
	Finance	379.71	209.53	279.99	276.93	360.86	218.79	349.86	299.36	371.6	1050.83	245.89	259.43
	Agriculture	344.14	256.5	332.66	323.86	343.16	330.93	380.1	397.97	337.16	207.14	1423.4	343.66
	Mining	708.8	591.46	637.14	545.09	736.66	530.73	588.44	648.83	571.33	409.28	685.35	2708.45

Applications……

- Start with Tv from the toy model, but assume sector 2 is services.
- What does the sum of the pink cells indicate?

		Kenya				Ethiopia				Nigeria			
		Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining	Transport	Finance	Agriculture	Mining
Kenya	Transport	1146.33	181.3	188.16	289.18	313.71	193.49	304.35	260.26	268.41	207.37	214.06	249.03
	Finance	237.96	951.85	168.8	326.76	211.54	186.11	268.33	310.31	277.91	230.31	187.3	212.77
	Agriculture	330.81	341.91	1387.33	435.82	407.48	234.8	349.1	337.75	338.86	291.16	336.58	347.59
	Mining	421.18	309.68	330.64	1705.48	427.1	412.49	479.99	458.68	492.81	274.99	440.42	317.31
Ethiopia	Transport	219.23	182.39	222.91	211.17	914.83	154.91	239.29	228.17	196.2	151.37	184.11	229.55
	Finance	1227.14	1098.41	1112.56	1256.01	1205.32	4556.53	1027.81	1358.1	1218.66	936.21	1170.62	1228.4
	Agriculture	85.95	77.49	66.82	115.9	114.48	88.63	355.08	92.59	117.2	69.85	92.91	72.27
	Mining	88.23	93.48	108.45	114.97	91.82	109.34	97.48	454.65	119.2	93	96.07	85.55
Nigeria	Transport	126.51	137.01	145.55	176.82	174.03	156.23	171.17	175.35	624.65	105.48	119.27	178.97
	Finance	379.71	209.53	279.99	276.93	360.86	218.79	349.86	299.36	371.6	1050.83	245.89	259.43
	Agriculture	344.14	256.5	332.66	323.86	343.16	330.93	380.1	397.97	337.16	207.14	1423.4	343.66
	Mining	708.8	591.46	637.14	545.09	736.66	530.73	588.44	648.83	571.33	409.28	685.35	2708.45

- Total services sector value added embodied in Kenya's exports of transport services.
  - Domestic origin (first two highlighted rows), and foreign origin (other two highlighted rows)

Applications……..

- Aggregating in this way can help provide results that are policy relevant:
  - DVA and FVA shares over time.
  - GVC participation index over time.
  - Services DVA and FVA shares over time, as an indicator of the degree of servicification of value chains in different sectors and countries.
- NOTE
  - FVA = Gross exports - DVA
  - DVX = Total Value Added – DVA
  - GVC Participation index (%) = (DVX +DVA)/Gross exports
  - Backward Linkages = 100%*FVA/Gross exports
  - Forward Linkages = 100%*DVX/Gross exports

Some Examples

- UNCTAD has produced a set of GVC indicators using Eora data. They are in free access.

- Different aggregations are already presented for all available years; participants can explore them at leisure.
  - Data by country.
  - Data by country-sector.

- However, the webpage does not present the full Tv matrix, so we will have to calculate that ourselves in order to do really detailed research, particularly on services.
  - For instance, the proportion of a country-sector's exports that incorporate value added from another country is interesting… but less interested than identifying services and goods sectors separately in that other country.
  - Note that the raw Eora data require some cleaning up, best done in your favorite statistical package, before they can be used as set out here.

- In what follows, we present some selected results from Eora based on the methodology above, focusing just on two countries, Ethiopia and Kenya.

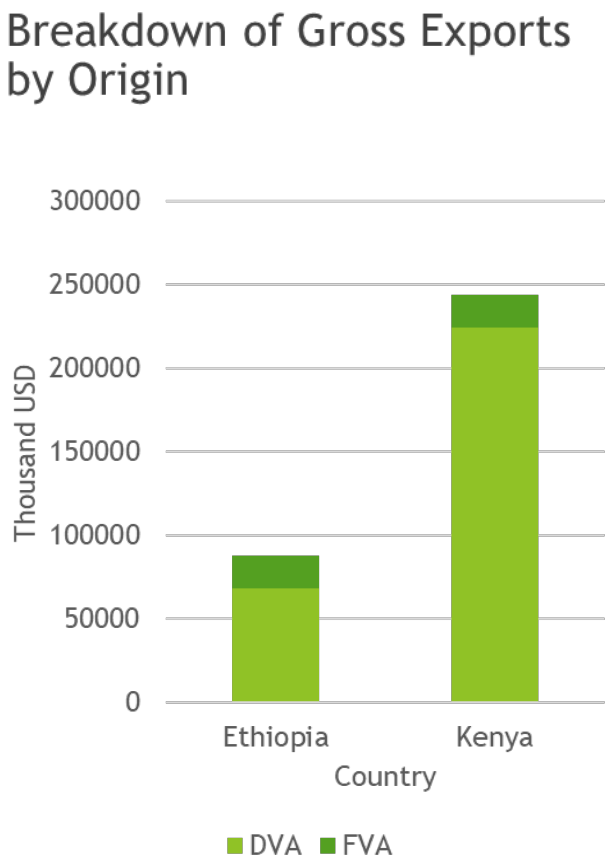
Tourism value chains in Kenya and Ethiopia

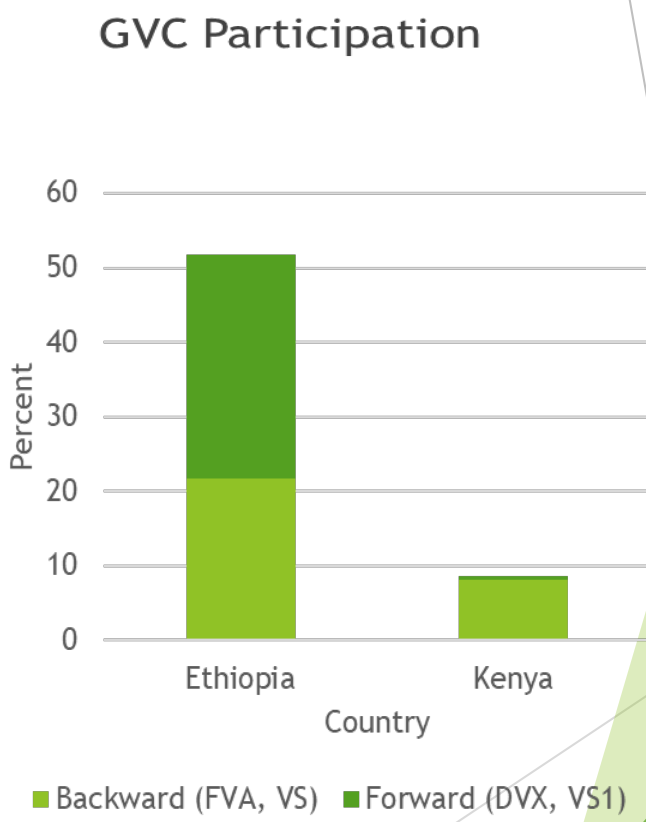
- Tourism is not identified as a separate sector in Eora, or in common sectoral classifications used in trade data or the national accounts.

- The best to do is to look at “hotels and restaurants”, knowing that this is a sector that is heavily involved in tourism.
  - But package tours, travel, and other tourist and recreational services are split across other sectors.

- After cleaning the data, calculate Tv for 2012. What follows is based on those results.
  - Note that Tv contains over 20,000,000 data points, so if you can, you should work with it in statistical software: Excel is laborious!

Tourism Value Chain in Kenya and Ethiopia





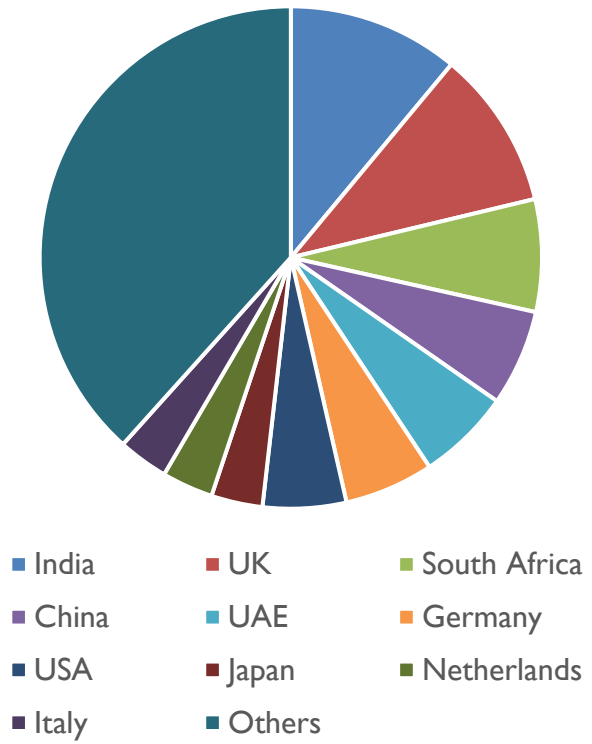
Tourism Value Chain in Kenya and Ethiopia

- The data suggest that although Kenya's sector is much larger than Ethiopia's, the latter is more involved in RVCs/GVCs through both backward and forward linkages.

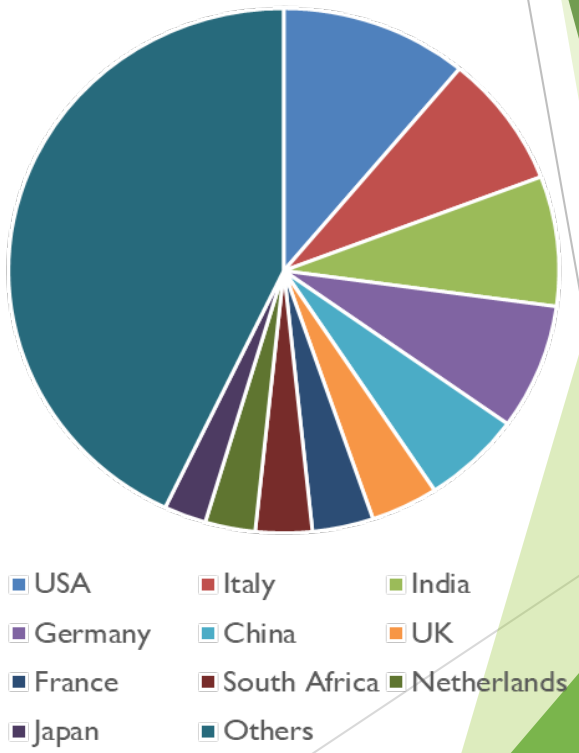
- What can we say about the source of FVA, and thus the regional or global nature of each country's value chain?

Sources of FVA in Kenya and Ethiopia

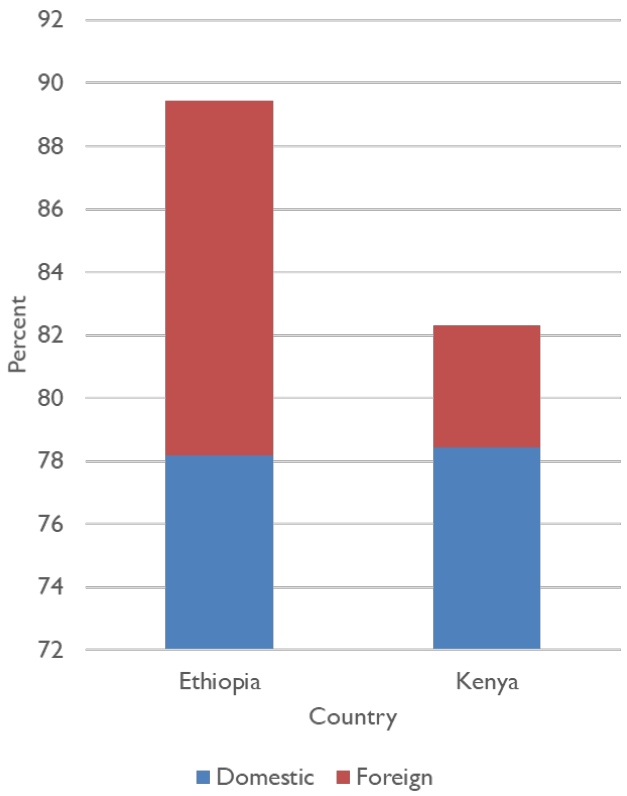
Breakdown of FVA (Ethiopia)



Breakdown of FVA (Kenya)

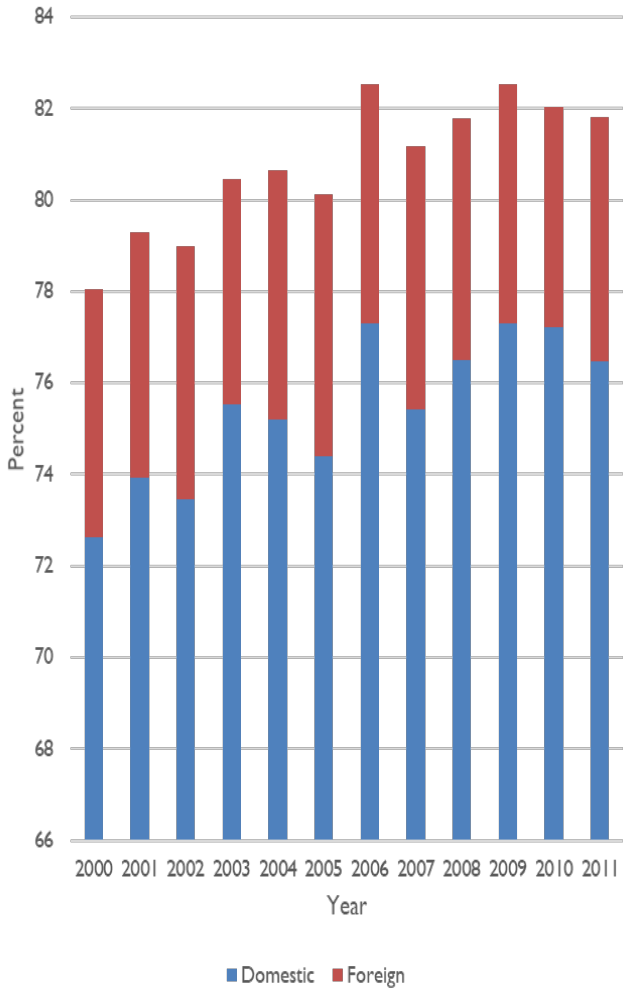


Tourism Value Chains in Ethiopia and Kenya



- The origin of hotels & restaurants sector exports is mostly services in both countries.
- But there is a much higher proportion of imported services in Ethiopia.
- Note that the sector's exports are not "all" services—other sectors, like agriculture, also account for a significant share (not shown).

Comparison with a developed country scenario



- As a point of comparison, consider Australia: an OECD country with a large tourism sector.
- Total services VA % gross exports in the sector is similar to Kenya, less than Ethiopia.
- Foreign services VA % gross exports is higher than in Kenya, but much lower than in Ethiopia
  - Even though Australia has relatively open services markets (see: OECD STRI).

Key Takeaways

1. Calculating trade in value added requires a lot of data and hard work, and a little math.

2. The basic ingredients are trade data and IO tables, which are then linked together to produce a harmonized MRIO.

3. The algebra involves basic input-output relations and the Leontief inverse, which have been well understood since the 1950s but only recently applied to trade.

4. Working with a “toy” model helps fix ideas and get the intuition straight, before moving to real data.

5. Knowledge of a statistical package is necessary to produce the full matrix of value added by origin, but once this is available, aggregate results can in theory be produced using Excel (with a bit of work and willingness to manipulate 20,000,000 data points).

Additional Resources

- Data:
  - Eora raw data: http://worldmrio.org. Sign up for a trial account!
  - UNCTAD Eora GVC indicators: http://worldmrio.com/unctadgvc/.

- Reading:
  - Bastiaan Quast and Victor Kummritz (2015) “decompr: Global Value Chain Decomposition in R”, https://bit.ly/2RZkxUR.
  - Aqib Aslam et al. (2017) “Calculating Trade in Value Added.” (IMF), https://bit.ly/2QTCCDO.