Patterns of Regional and Global Value Chain Participation in the EAC

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Abstract

Using global Multi-Region Input-Output (MRIO) data from 2005-2015, this paper empirically investigates the extent and patterns by which EAC countries have integrated into international production and Global Value Chains (GVC's), and the share of this integration accounted for by regional value chains. The detailed exposition is followed by an econometric analysis seeking to quantify the economic effects of this integration on member countries. Results imply that foreign value added makes up about 20% of exports in most EAC countires, and a significant development in the 2005-2015 period is only visible in Tanzania and Kenya. Regional Value Chains are very small, only making up about 3% of value-added trade. Regressions suggests that higher fore ign content in exports increases productivity with an elasticity of around 0.3 within 2 years time. Increased future integration into GVC's is thus likely to benefit growth in the EAC.

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1 Introduction

Global Value Chains (GVCs) have become a central topic in trade and development policy. GVC's refer to the quickly expanding internationalization of production networks. While some work has been done on regional value chains in East Africa within specific industries, such Maize value chains studied by Daly et al. (2016), there has not been a detailed exposition of the GVC participation of East African Countries using comprehensive data sources such as MRIO tables.

One of the few comprehensive analyses of GVC's in Africa is provided by Foster-McGregor et al. (2015) using the EORA 25 sector database over the periods from 2000-2011. They find that Africa as a region is more involved in GVCs than many other developing regions but much of the GVC involvement of Africa is in upstream production, and involves in particular, the supply of primary goods into production of final goods in other regions and countries. Downstream involvement in GVCs is relatively small, and has shown little sign of improving in the last 15 years. Furthermore they find that there is a great deal of heterogeneity in GVC involvement across African countries, with a number of relatively successful countries that are heavily involved in GVCs and with a relatively large share of their involvement being in downstream GVCs.

At a sectoral level, Foster-McGregor et al. (2015) state that manufacturing and high-tech sectors are typically not major contributors to GVC participation in African countries. While manufacturing tends to play a larger role in downstream involvement in GVCs, the agricultural sector still accounts for the largest part of downstream GVC involvement across African countries.

Foster-McGregor et al. (2015) also note that Intra-African GVCs are not particularly important for most African countries, with a number of exceptions in southern Africa. The EU tends to be the biggest GVC partner for Africa, with some evidence to suggest that the contributions of East and South-East Asia, and transition countries are increasing.

The authors also compute various indicators on social upgrading indicating that a minority of African countries have been able to upgrade (prominent examples including Egypt, Nigeria and Tunisia). For most African countries the extent of upgrading is lower than that for the average developing country. Finally, the authors note that due to the overall low volume of exports in some countries, the importance of GVCs may be overstated.

A broader research perspective for developing countries is provided in Kummritz & Quast (2016) and Kummritz (2016). Kummritz & Quast (2016) examine pattens of GVC integration in low-and middle income countries using the OECD TiVA database covering 61 countries and 34 industries for the years 1995, 2000, 2005, and 2008 to 2011. They find that, with exception of the agricultural sector, developing countries are typically located more downstream in the value chain, and export more final goods than high-income countries. They take this as evidence of high-income economies using GVCs to outsource low value added downstream production stages and eventually reimport the final goods. Looking over time they find evidence suggesting that many developing economies have succeeded in moving up the value chain and that the general trend points to a more even distribution of value added across the different countries. Examining different regions, they find that South-East Asia has the highest levels of GVC integration while Latin America and the Caribbean is more heterogenous with Chile and Costa Rica performing very well. In Africa, Tunisia has developed backward linkages into GVCs, especially with the EU.

Their overall finding suggest that low- and middle-income countries have become an integral part of GVCs, where the foreign content of global value-added exports attributable to these countries has risen from 9% in 1995 to 24% in 2011, and the share in re-exported exports has increased from 9% to 23%. Low- and middle-income countries are increasingly becoming the drivers of GVC expansion and are proceeding up the value chain to more upstream tasks. The authors stipulate that moving upstream should bring greater gains for developing country industrialization.

A more broadly developing country focussed review is also provided by Kowalski et al. (2015).

This paper uses the EORA Global MRIO tables Lenzen et al. (2012, 2013) to analyze patterns of production in the EAC and compute standard GVC indicators for the years 2005-2015. The goal of this research is to map the structure of regional and international production and exports in the EAC, and to produce some first evidence of the potential benefits of GVC integration for East Africa at the aggregate and sector level.

The analysis will follow for the most part the seminal works of Hummels et al. (2001), Koopman et al. (2014), Wang et al. (2013), as well as Kummritz (2016) and Kummritz & Quast (2016).

2 Data

Most GVC analysis uses Inter-Country Input-Output tables (ICIOs), such as those published by the OECD and WTO (TiVA) or the World Input Output Database (Timmer et al., 2012). These tables state supply and demand relationships in gross terms between industries within and across countries (Kummritz & Quast, 2014). The former two databases are however limited to high-income or larger developing countries, with limited or no coverage of Sub-Saharan Africa.

This research therefore uses the EORA Global MRIO tables (Lenzen et al., 2012, 2013), which have an extensive coverage of 189 countries but rely on more sophisticated supercomputing methods to harmonize data across countries and are therefore considered less reliable than the OECD or WIOD tables.

The EORA database comes in a Full version with heterogenous sector disaggregations as provided by country SUT tables, and an aggregated 26 sector version that is harmonized across countries. This research considers the EORA 26 databse, of which data until 2015 is available. Since GVC's are a recent phenomenon, particularly in Africa, and the EAC customs union only became operational in 2005, with Rwanda and Burundi becoming full EAC members in 2007, this research considers the sequence of EORA 26 tables from 2005-2015.

To increase the interpretation of results while preserving some level of detail about the non-EAC world, as well as reduce the strain on computational resources required to obtain results, the non-EAC countries are aggregated into 11 geographic and trade regions as summarized in Table 1. This reduces the size of the transaction tables from $189 \times 25 = 4915$ rows and columns to $(6 + 11) \times 26 = 442$ rows and columns. The 26 sectors are summarized in Table 2 [1].

[1]Sector codes are assigned and used throughout the paper, but are not found in the EORA 26 database.

Table 1: COUNTRIES AND REGIONS

Region	*Description*	*Countries*
EAC	East African Community	UGA, TZA, KEN, RWA, BDI, SSD
SSA	Sub-Saharan Africa (Excluding EAC)	AGO, BEN, BFA, BWA, CAF, CIV, CMR, COD, COG, COM, CPV, ERI, ETH, GAB, GHA, GIN, GMB, GNB, GNQ, LBR, LSO, MDG, MLI, MOZ, MRT, MUS, MWI, NAM, NER, NGA, SDN, SEN, SLE, SOM, STP, SWZ, SYC, TCD, TGO, ZAF, ZMB, ZWE
EUU	European Union + GBR	AUT, BEL, BGR, CYP, CZE, DEU, DNK, ESP, EST, FIN, FRA, GBR, GRC, HRV, HUN, IRL, ITA, LTU, LUX, LVA, NLD, POL, PRT, ROU, SVK, SVN, SWE, MLT
ECA	Europe and Central Asia (Non-EU)	ALB, AND, ARM, AZE, BIH, BLR, CHE, CHI, FRO, GEO, GIB, GRL, IMN, ISL, KAZ, KGZ, LIE, MCO, MDA, MKD, MNE, NOR, RUS, SMR, SRB, TJK, TKM, TUR, UKR, UZB, XKX
MEA	Middel East and North Africa	ARE, BHR, DJI, DZA, EGY, IRN, IRQ, ISR, JOR, KWT, LBN, LBY, MAR, OMN, PSE, QAT, SAU, SYR, TUN, YEM
NAC	North America and Canada	BMU, CAN, USA
LAC	Latin America and Carribean	ABW, ARG, ATG, BHS, BLZ, BOL, BRA, BRB, CHL, COL, CRI, CUB, CUW, CYM, DMA, DOM, ECU, GRD, GTM, GUY, HND, HTI, JAM, KNA, LCA, MAF, MEX, NIC, PAN, PER, PRI, PRY, SLV, SUR, SXM, TCA, TTO, URY, VCT, VEN, VGB, VIR
ASE	ASEAN	BRN, IDN, KHM, LAO, MMR, MYS, PHL, SGP, THA, VNM
SAS	South Asia	AFG, BGD, BTN, IND, LKA, MDV, NPL, PAK
CHN	China	CHN, HKG, TWN
ROA	Rest of Asia	ASM, GUM, JPN, KOR, MAC, MNG, MNP, NCL, PRK, PYF, TLS
OCE	Oceania	AUS, FJI, FSM, KIR, MHL, NRU, NZL, PLW, PNG, SLB, TON, TUV, VUT, WSM

Table 2: Sectors

Sector Code	*Description*
AGR	Agriculture
FIS	Fishing
MIN	Mining and Quarrying
FBE	Food & Beverages
TEX	Textiles and Wearing Apparel
WAP	Wood and Paper
PCM	Petroleum, Chemical and Non-Metallic Mineral Products
MPR	Metal Products
ELM	Electrical and Machinery
TEQ	Transport Equipment
MAN	Other Manufacturing
REC	Recycling
EGW	Electricity, Gas and Water
CON	Construction
MRE	Maintenance and Repair
WTR	Wholesale Trade
RTR	Retail Trade
AFS	Hotels and Restraurants
TRA	Transport
PTE	Post and Telecommunications
FIB	Finacial Intermediation and Business Activities
PAD	Public Administration
EHO	Education, Health and Other Services
PHH	Private Households
OTH	Others
REI	Re-export & Re-import

The values recorded in EORA are in thousands of current USD at basic prices[2]. To examine the data, I compute global GDP by region and sector as well as EAC GDP by sector. Figure 1 shows Global GDP by region. The impact of the 2009 global financial crisis is clearly visible and GDP also has declined in 2015. According to this data EAC GDP at basic prices has increased both in absolute value from 43.6 billion USD in 2005 to 101.6 billion USD in 2015, and as a share of global GDP from 0.096% in 2005 to 0.137% in 2015.

Figure 2 shows global GDP by sector. In 2015, 25% of global GDP was produced by financial and business services (FIB), followed by the education, health and other services category at 11.7%. Agriculture and Fishing together only accounted for 4.2% of global GDP in 2015.

[2]The basic price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any tax payable, and plus any subsidy receivable, by the producer as a consequence of its production or sale. It excludes any transport charges invoiced separately by the producer

Figure 1: Global GDP by Region
Millions of current USD at Basic Prices

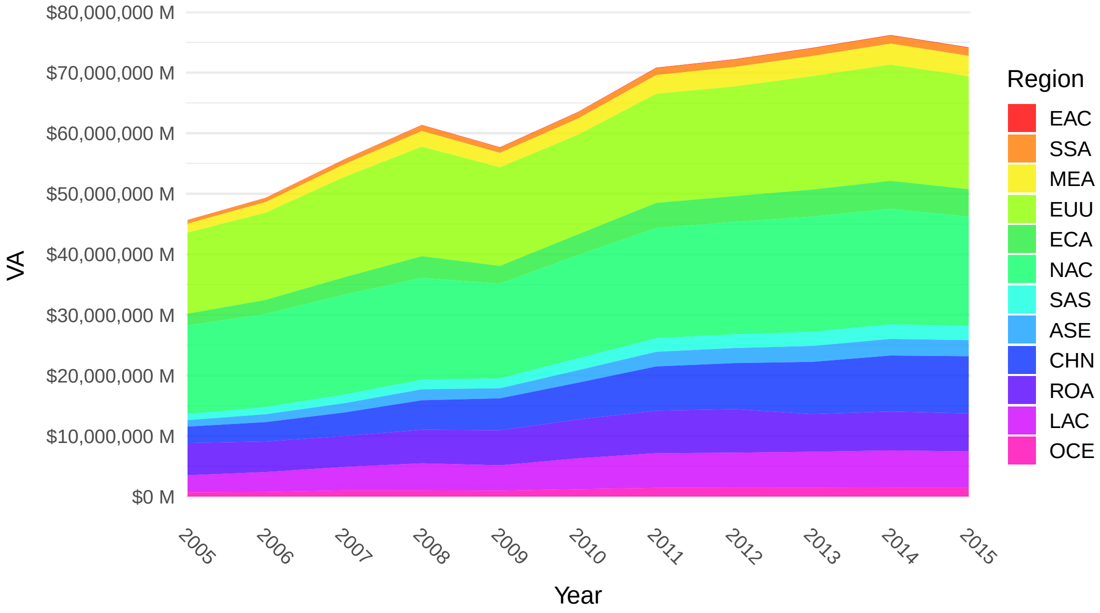


Figure 2: Global GDP by Sector
Millions of current USD at Basic Prices

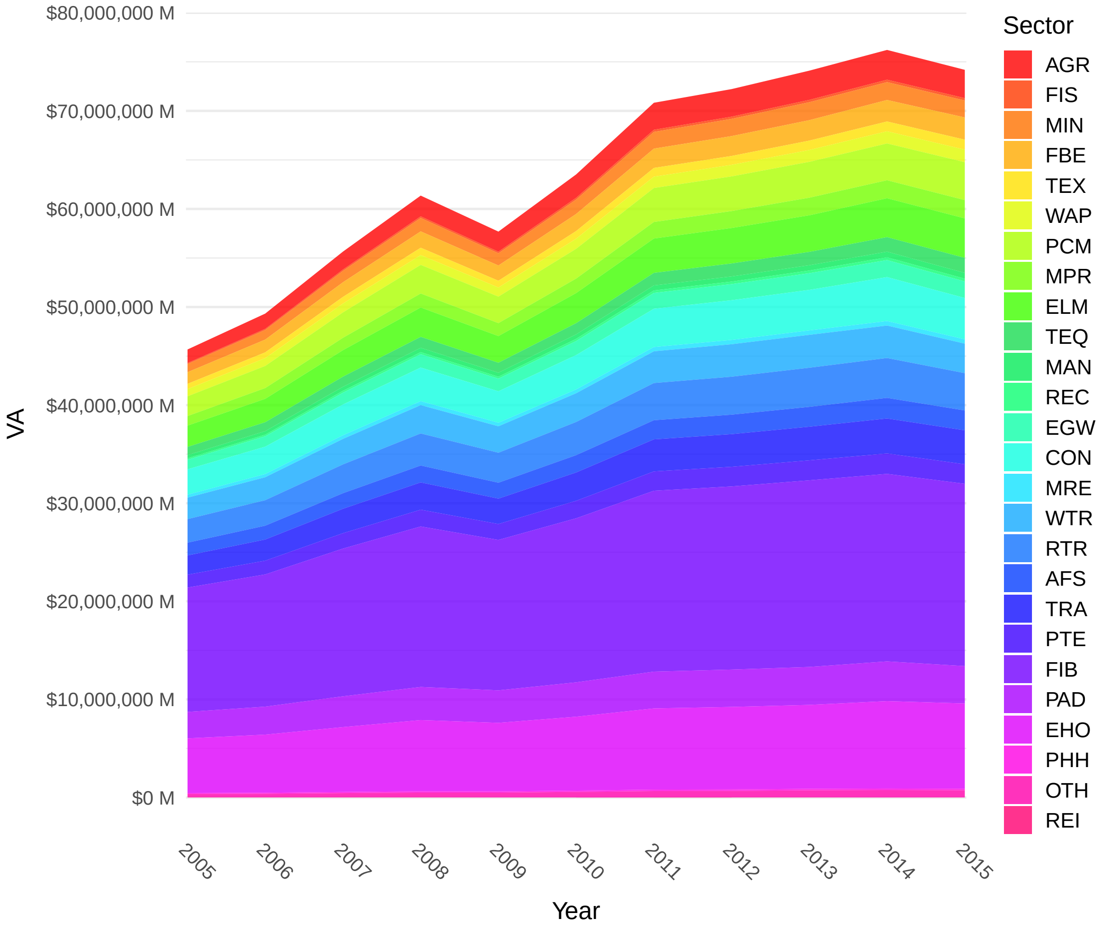
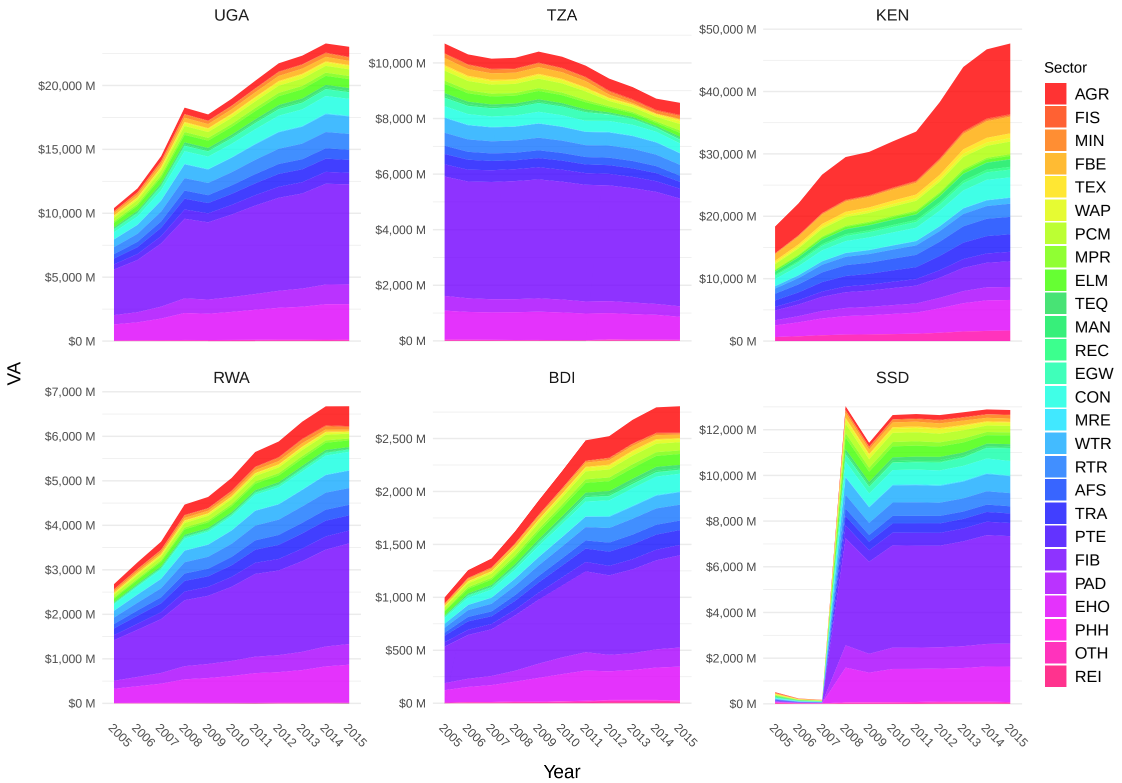


Figure 3 shows EAC GDP by sector. Here discrepancies between this harmonized data and the real world are very visible. By 2015, agricultural value added in Uganda was still around 30% of GDP, whereas it is blow 20% of GDP in the EORA data. The level of GDP at basic prices seems to be broadly in line, as GDP was around 27 billion USD at current prices in 2015, up from 9 Billion in 2005. The growth path however seems to be too strong in the years 2005-2008, and too flat from 2009-2015 compared to the real trajectory. Of the other countries, apart from moderate mismatches in sectoral value added shares for all EAC countries, there seems to be a major problem with the data for Tanzania. Tanzanian GDP was at 18.4 Billion in 2005 and increased to 47.4 Billion in 2015. The EORA data show an initial GDP for Tanzania of 10.5 Billion at basic prices in 2005, which declines over the sample period to 8.5 Billion at basic prices.

Figure 3: EAC GDP by Sector



All of this of course strongly calls into question the reliability of this data to analyze developments in the EAC. The creators of this database write:

> The current Eora tables that have been constructed with emphasis on a) representing large data items and b) fulfilling balancing conditions for large countries.
>
> The goal of Eora is to to make a consistent global model. When smaller or developing economies have inconsistent or missing data the tables for these countries can become distorted during the process of building a consistent global model.

Thus the analysis and results presented below should be treated with caution, particularly for Tanzania, as the data analyzed was not constructed to accurately reflect macroeconomic aggregates in developing countries. Nevertheless EORA is the only global IO database currently in existence and may be used to get at least a rough idea about production sharing and integration into Global Value Chains in the EAC.

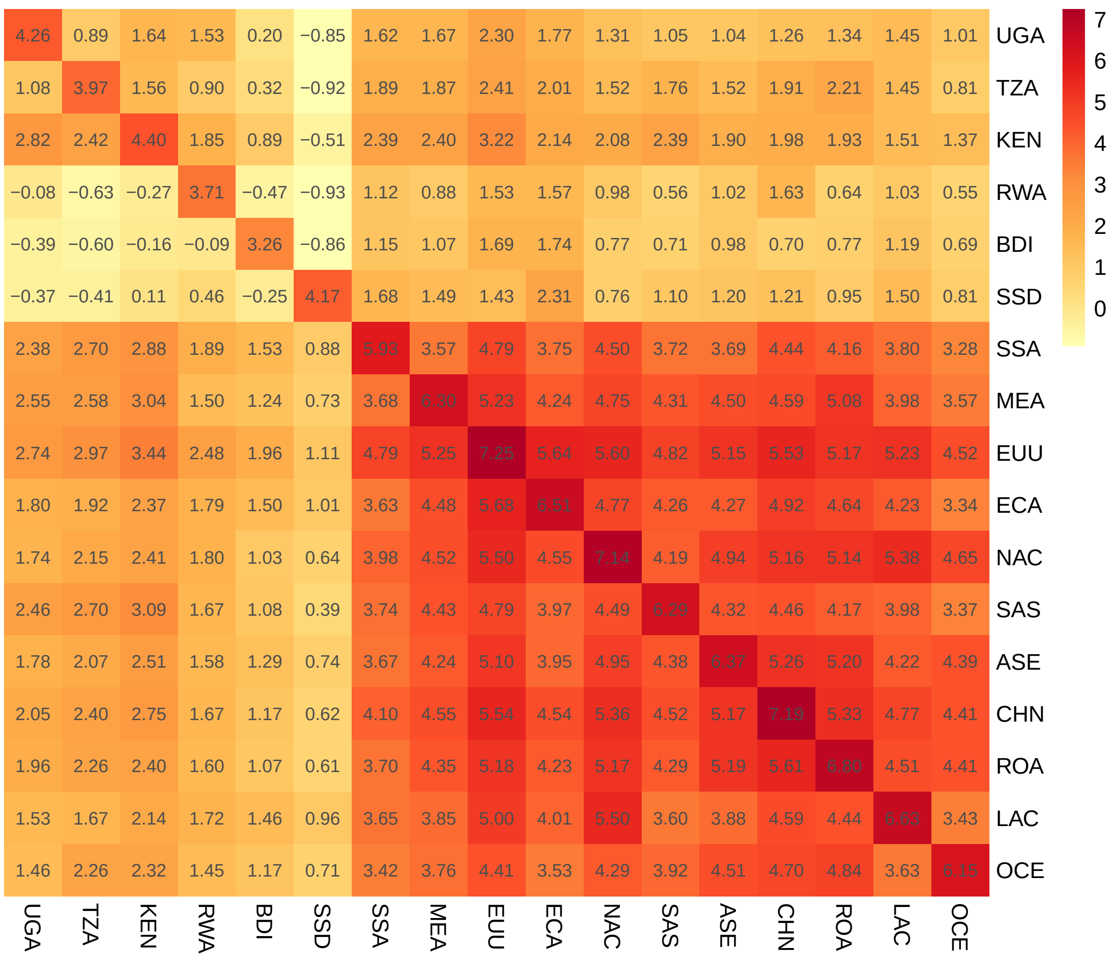
3 Gross Flows

In light of the macroeconomic inconsistencies flagged above and the fact that value added flows are estimated from gross flows, it is useful to first consider the raw data in more detail before diving into detailed decompositions of trade flows.

3.1 Intermediate Inputs

An aggregated EORA 26 MRIO Table for the year 2015 is shown in Figure 4. The columns of the table constitute production functions showing the intermediate inputs required by each of the column-countries or regions from each of the row-countries or regions to produce their output. Conversely the rows show quantities supplied by each row-country or region to each column-country or region. Flows are reported on a log10 scale due to their vastly different magnitudes. Among the EAC countries, the table shows a significant intermediate input supplier role of Kenya, supplying $10^{2.82} = 661$ million USD to Uganda, $10^{2.42} = 263$ million USD to Tanzania and $10^{1.85} = 71$ million USD to Rwanda. Tanzania and Uganda have less of a supplier role with Tanziania supplyzing 12 million USD to Uganda, 40 million to Kenya and 8 million to Rwanda, and Uganda supplying 8 million to Uganda, 44 million to Kenya and 34 million to Rwanda. Rwanda appears to be insignificant in terms of it supplier role, supplying less than 1 million USD in inputs to any of its EAC partners. Burundi and South Sudan appear insignificant both as suppliers and consumers of intermediate inputs. With the rest of the World, Uganda, Tanzania and Kenya each import between 250 and 800 million USD if intermediate imports from the rest of Sub-Saharan Africa, and a similar magnitude from the Middle East, South Asia and China. The larges supplier of Inputs to each of the EAC countries appears to be the European Union supplying $10^{2.74} = 550$ million USD to Uganda, $10^{2.97} = 993$ million to Tanzania, $10^{3.44} = 2754$ million to Kenya, $10^{2.48} = 302$ million to Rwanda $10^{1.96} = 91$ million to Burundi and $10^{1.11} = 13$ million to South Sudan.

Figure 4: Aggregated MRIO Table: EAC and World Regions
Millions of 2015 USD at Basic Prices on a Log10 Scale



Visualizing global flows to the EAC at the sector level is not feasible, but below I examine large sector level flows between the EAC and the rest of the World, and then inter-EAC flows. Table 3 shows the 20 largest flows between EAC sectors and sectors outside the EAC, with and without Kenia. The left column shows that the largest flow of almost 460 million USD is Kenyan agricultural inputs into EU food processing industries, followed by 272 million agricultural goods exports which are just re-exported by the EU. In places 3 and 4 of the largest flows we have inputs from Middle Eastern and EU transport industries to the Kenyan transport industry. The remaining largest flows in the left panel comprise mostly of EU inputs into Kenyan petro-chemicals, construction and electrical machinery. It is also notable that Kenya provides food processing intermediates worth 137 million USD for EU food processing, in addition to the 460 million raw agricultural input and the 272 million re-exported agricultural goods.

If Kenya is taken out, the largest flows, shown on the right hand side of Table 3 are EU inputs to Tanzanian and Ugandan electric machinery. Tanzania provides agricultural inputs worth 67 million USD to the food processing industries in the rest of Asia (including Japan and South Korea), and Uganda provides agricultural inputs worth 49 million to EU food-processing industries.

Table 3: Largest Intermediates Flows Between the EAC and the World
Millions of 2015 USD at Basic Prices

#	**Flow**	**Value**	**Non-Kenia Flow**	**Value**
1	KEN.AGR → EUU.FBE	459.214	EUU.ELM → TZA.ELM	128.665
2	KEN.AGR → EUU.REI	271.547	EUU.ELM → UGA.ELM	86.675
3	MEA.TRA → KEN.TRA	186.499	SAS.PCM → TZA.PCM	73.558
4	EUU.TRA → KEN.TRA	178.775	TZA.AGR → ROA.FBE	66.674
5	EUU.ELM → KEN.CON	165.829	EUU.PCM → TZA.PCM	62.432
6	EUU.PCM → KEN.PCM	142.660	MEA.ELM → UGA.ELM	62.200
7	KEN.FBE → EUU.FBE	137.057	SAS.ELM → TZA.ELM	49.312
8	EUU.ELM → TZA.ELM	128.665	UGA.AGR → EUU.FBE	48.568
9	OCE.AGR → KEN.FBE	128.317	SSA.ELM → TZA.ELM	44.663
10	EUU.PCM → KEN.AGR	118.039	SSA.PCM → TZA.PCM	43.131
11	EUU.PCM → KEN.CON	103.888	ROA.WTR → TZA.WTR	41.891
12	EUU.REI → KEN.CON	95.865	MEA.ELM → TZA.ELM	41.537
13	MEA.PCM → KEN.CON	95.677	TZA.AGR → EUU.FBE	39.506
14	EUU.ELM → KEN.ELM	93.319	SAS.ELM → UGA.ELM	37.466
15	SAS.PCM → KEN.PCM	90.327	EUU.ELM → TZA.TEQ	35.433
16	EUU.FBE → KEN.FBE	88.536	EUU.ELM → RWA.ELM	33.555
17	KEN.FBE → EUU.REI	88.051	CHN.ELM → TZA.ELM	31.674
18	EUU.ELM → UGA.ELM	86.675	OCE.ELM → TZA.ELM	31.160
19	SAS.ELM → KEN.CON	82.360	SAS.PCM → UGA.PCM	30.212
20	EUU.PCM → KEN.FBE	77.832	EUU.PCM → UGA.PCM	29.267

A disaggregated view of the inter-EAC part of Figure 4 is presented in Figure 5. It confirms the supplier role of Kenya, particularly in petrol, chemical and mineral products, and other manuracturing sectors such as metal products, electrical machinery, transport equipment as well as trade, transoort, telecommunications, financial and business services. As Figure 5 is difficult to interpret in detail, Table 4 additionally records the 20 largest intra-EAC intermediate input flows, with and without Kenyan participation.

Figure 5: Disaggregated MRIO Table: EAC

Millions of 2015 USD at Basic Prices on a Log10 Scale

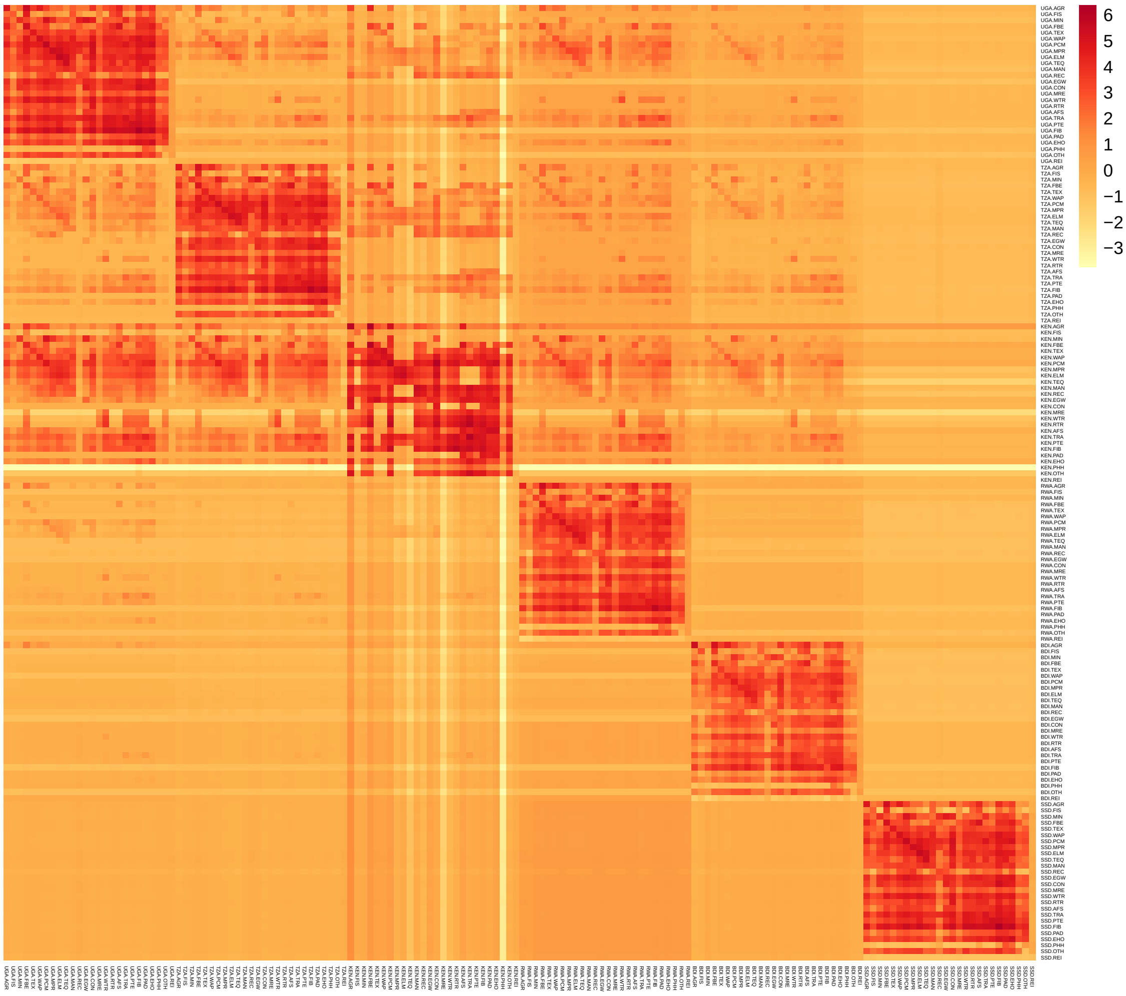


Table 4 shows that the 3 largest inter-country intermediate input flows in the EAC, with values betwen 37 and 95 million USD, are inputs from Kenyan mining and petrol, chemical and mineral industries to Ugandan and Tanzanian petrol, chemical and mineral industries. The only of the largest 20 inter-EAC flows not originating from Kenya is the flow of Ugandan Agricultural inputs into Kenyan food processing industries, worth 24 million USD. When Kenya is taken out, Uganda becomes the largest supplier of inputs, particularly to Rwandan manufacturing industries. Tanzania supplies mining worth about one million to Ugandan petro-chmeicals and food and bevarages worth less than 1 million to Ugandan food processing and hotels / restaurants. All other flows in the right-hand side of Table 4 originate from Uganda. Both Rwanda and Tanzania appear to play an insignificant supplier role in the EAC, although it could be dangerous to conclude this about Tanzania given the mismatch of value added shown in Figure 3.

Table 4: Largest Inter-Country Intermediate Flows within the EAC
Millions of 2015 USD at Basic Prices

#	Flow	Value	Non-Kenia Flow	Value
1	KEN.MIN → UGA.PCM	95.270	UGA.PCM → RWA.PCM	2.539
2	KEN.PCM → UGA.PCM	63.854	UGA.TRA → RWA.PAD	2.497
3	KEN.PCM → TZA.PCM	37.412	UGA.MPR → RWA.MPR	2.091
4	KEN.WAP → UGA.WAP	29.109	UGA.TRA → RWA.TRA	2.003
5	KEN.ELM → UGA.ELM	25.912	UGA.FBE → RWA.FBE	1.958
6	UGA.AGR → KEN.FBE	24.319	UGA.MPR → RWA.ELM	1.443
7	KEN.TRA → UGA.PAD	23.140	UGA.ELM → RWA.ELM	1.346
8	KEN.PCM → UGA.EHO	20.892	UGA.FBE → RWA.AFS	1.175
9	KEN.TRA → UGA.TRA	20.085	UGA.WTR → RWA.WTR	1.124
10	KEN.MIN → UGA.EGW	18.863	UGA.PCM → TZA.PCM	1.088
11	KEN.MIN → TZA.PCM	18.044	TZA.MIN → UGA.PCM	0.992
12	KEN.WAP → TZA.WAP	15.156	UGA.AGR → RWA.FBE	0.824
13	KEN.FBE → UGA.FBE	14.913	UGA.PCM → RWA.EHO	0.817
14	KEN.WAP → UGA.CON	14.288	UGA.WAP → RWA.WAP	0.813
15	KEN.MPR → UGA.ELM	13.857	TZA.FBE → UGA.FBE	0.742
16	KEN.PCM → TZA.EHO	11.961	UGA.ELM → TZA.ELM	0.631
17	KEN.ELM → UGA.MPR	11.708	UGA.MPR → RWA.CON	0.535
18	KEN.ELM → TZA.ELM	11.688	UGA.MPR → RWA.TEQ	0.479
19	KEN.ELM → UGA.TEQ	11.555	TZA.FBE → UGA.AFS	0.471
20	KEN.PCM → UGA.PAD	11.140	UGA.PCM → RWA.PAD	0.453

3.2 Exports

Gross exports of EAC countries are shown in Figure 6. Here the level of Tanzanian exports is more in line with the level recorded by the World Bank. In terms of composition, it is evident that Uganda focuses on agricultural exports, comprising 38% of exports over the analyzed period, while Rwanda has a disproportionate share in mining exports of about 24%. The other EAC countries have a more balanced export mix, with Tanzania and Kenya also maintaining shares of 24% and 29%, respectively, in agriculture.

Figure 6: EAC Gross Exports

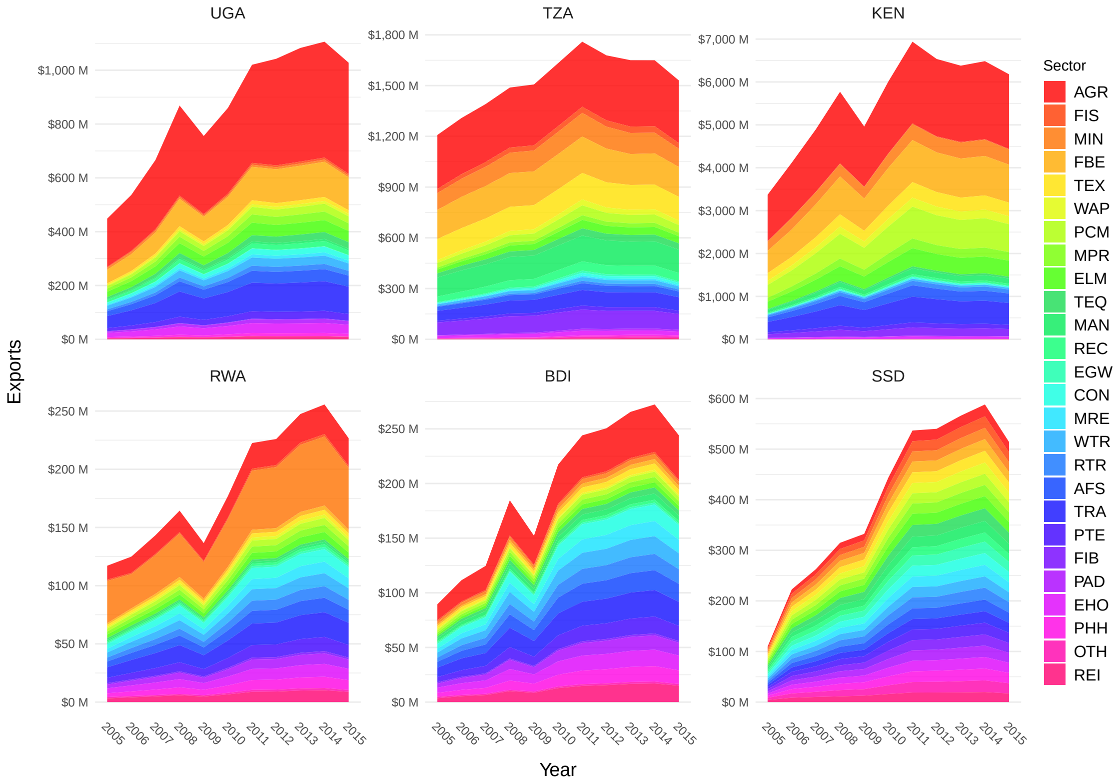


Figure 7 shows the percentage of gross exports going to EAC member countries. It is evident that Uganda and Kenya both have shares of 30% of their exports to the EAC, and that for Uganda the largest part of these exports are agricultural, while for Kenya the largest part is manufacturing, in particular petro-chemicals, metal products and electric machinery. The other EAC members don't export very much to the EAC, in particular Rwanda, Buruindi and South Sudan where the data suggests an EAC export share below 2% in 2015.

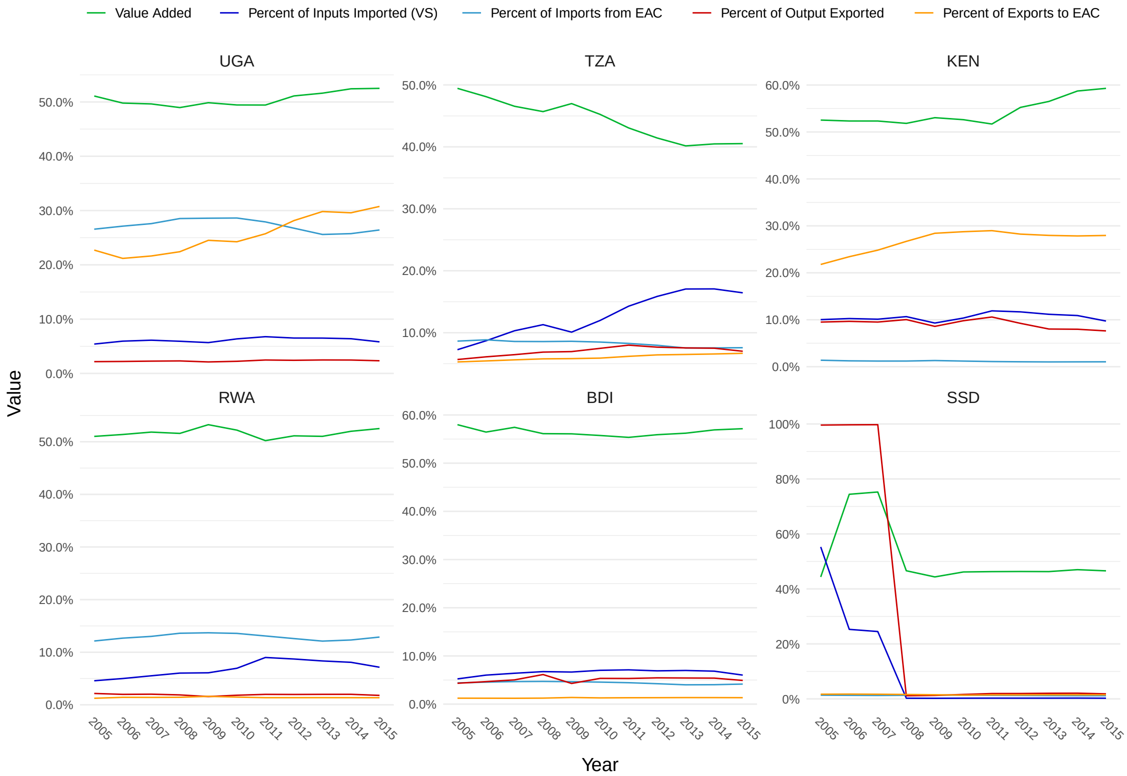
Figure 7: Percentage of Gross Exports Going to EAC Members

3.3 Decompositions

Figure 8 shows an aggregate decomposition of output and exports into import and export shares, and shares from the EAC. Value Added gives the total share of domestic value added in output (VAS), which appears to be stable around 50-60% for all countries apart from Tanzania where it seems to have dropped down to 40% (which might be due to inconsistencies in domestic data for Tanzania). The remainder of output (1-VAS) is comprised of domestic or imported intermediate goods. The Percent of Inputs Imported gives the share of intermediate inputs that is imported. It is a gross measure of vertical specialization and backward GVC integration, although not the measure proposed by Hummels et al. (2001), which is defined in value added terms. Of those imported inputs, the Percent of Imports from EAC shows the percentage coming from the EAC. It is a measure of backwards regional integration relative to the overall level of a countries international integration. Similarly on the export side Figure 8 reports both the overall percentage of output exported (i.e. not consumed domestically) and the percentage of exports going to the EAC neighbours.

The most curious finding presented by Figure 8 is the remarkable stability of shares, with few exceptions, suggesting only a very moderate increase in regional and global economic supply chains at the aggregate level. The starting levels of the countries are very different, with Uganda maintaining shares of exports and imports around 30% with the EAC, whereas Tanzania, Rwanda and Burundi show much lower levels of integration. In Uganda and Kenya the percent of exports going to the EAC increased slightly over the sample period, while maintaining stable imported inputs and exported output shares. The overall increase in the percent of inputs imported in Tanzania may be due to a decline in domestic intermediates reflecting the decline in GDP, and should thus also be taken with extreme caution.

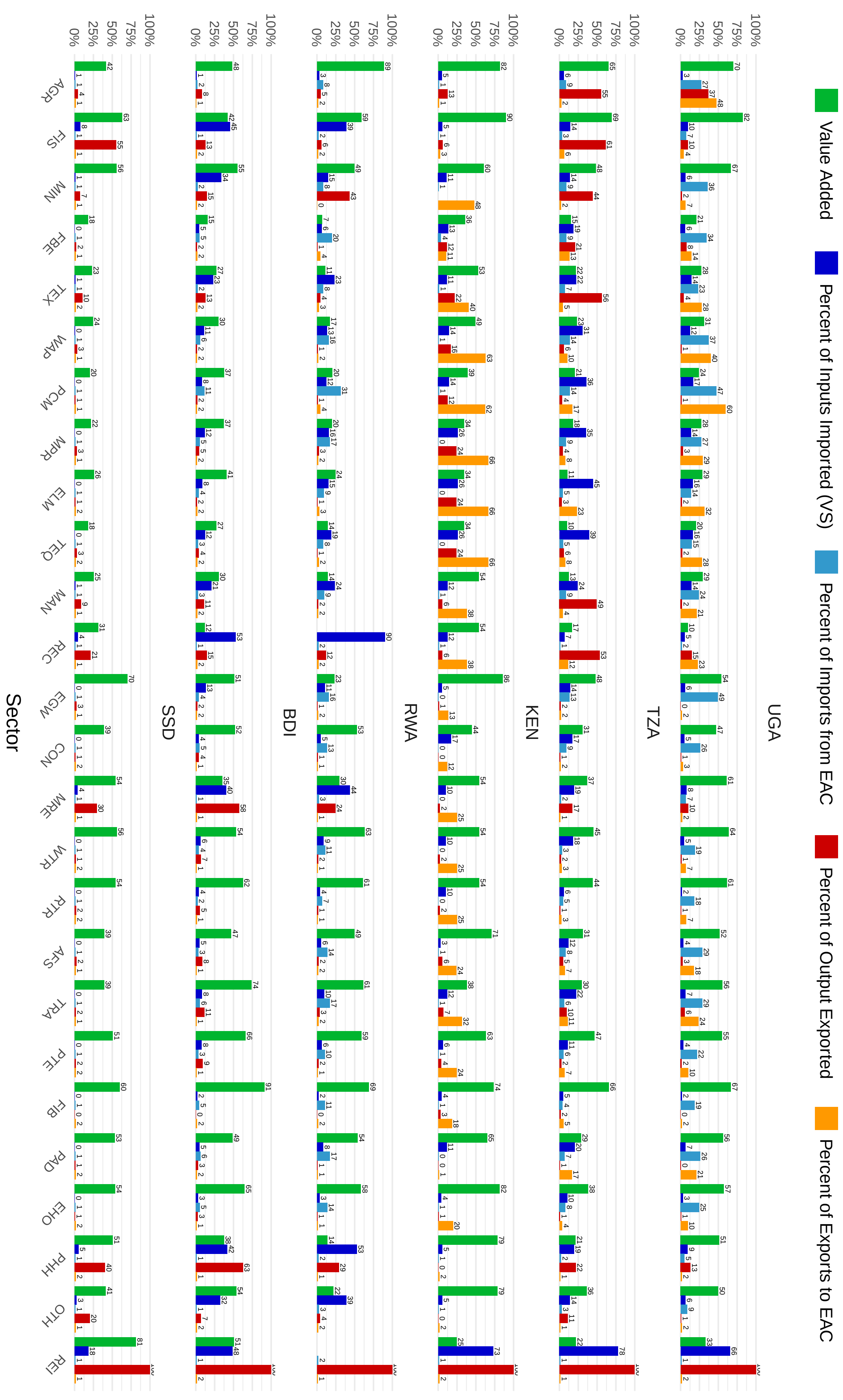
Figure 8: Decomposition of Output and Exports



An industry level view of these metrics for the year 2015 is provided in Figure 9. It shows some similarities but also some quite stong differences in the structure of production of different EAC countries. For example Agriculture is a high domestic value added and low imported inputs sector in all EAC countries. Uganda and Tanzania export 37 and 55% of their Agricultural produce, while Kenya only appears to export around 13% of its production, and the remaining EAC countries have agricultural export shares below 10%. A major difference between Uganda and Tanzania is that Uganda obtains 27% of its imported inputs in agriculture from the EAC, and sends 48% of its agricultural exports to the EAC, whereas Tanzania only imports 9% of imported intermediates from the EAC and only exports 2% of its agricultural exports to the EAC.

A pattern visible across most manufacturing sectors and supporting services is that Uganda maintains overall lower export and import shares in it's production, but in those has significant shares of 20-40% with it's EAC partners. Tanzania appears to have high shares of imported intermediates in it's core manufacturing sectors, ranging from 30-45% of inputs being imported. Only around 5-15% of these imports are however from the EAC. The sectoral data also show that Tanzania does not export much of it's manufacturing output, with the exception of textiles (56%), other manufacturing (49%) and recycling (53%). Thus Tanzania does not appear to engage in significant processing trade but produces manufactured goods with high imported content mostly for domestic consumption. In Kenya, the domestic value added shares in manufacturing are higher and the share of imported intermediates lower than in Tanzania, with around 10-25% of intermediates imported in the core manufacturing sectors. In contrast to Tanzania, Kenya also exports around 15-25% of its output, and most of these exports (around 60%) are to it's EAC neighbours. Thus Kenya figures as an important supplier of manufactured goods in the EAC. Rwanda imports around 10-20% of its manufacturing inputs of which about 10-30% are obtained from it's EAC neighbours. Rwanda however exports only a negligible fraction of it's manufacturing outputs, and of these exports also only a negligible amount goes to the EAC.

Figure 9: Decomposition of Sectoral Output and Exports



To summarize, the decomposed gross flows data presented in Figures 8 and 9 suggest that economic integration from the production side has proceeded very gradually, both with the rest of the World and inside the EAC. The various EAC countries take on quite different roles in this process, with Kenya being the major EAC supplier of manufacturing inputs, and Tanzania the country that imports most inputs from abroad to produce for domestic consumption. Uganda shows modest amounts of overall economic integration, but retrieves a significant share of it's imported inputs from the EAC, and also exports a significant share of is exports to the EAC - in particular agricultural exports feeding into Kenyan food processing industries. Rwanda and Burundi import around 10-15% of their intermediates, of which about 10-20% come from the EAC. These countries hardly export any intermediate goods. South Sudan does not appear to be economically integrated with EAC production.

4 Value Added Flows

While gross flows provide useful information about direct productive relationships and the amounts of goods traded therein, a problem of gross flows IO tables, is that they do not reveal how much of the value was added in the supplying industry, and how much of the value was added in previous stages of production, performed by other industries or even countries. The Leontief decomposition of gross trade flows solves this problem by reallocating the value of intermediate goods used by industries to the original producers (Kummritz & Quast, 2014).

4.1 The Leontief Decomposition of Gross Trade Flows

Let $\mathbf{A}$ be a row-normalized ICIO table where each element a_{ij} gives the units of sector (row) i's output required for the production of one unit of sector (column) j's output, $\mathbf{x}$ the vector of outputs of each country-industry and $\mathbf{d}$ a vector of final demands such that the following productive relationship holds:

$$\mathbf{x} = \mathbf{A}\mathbf{x} + \mathbf{d}. \tag{1}$$

The classical Leontief (1936) insight was that one can solve this equation for $\mathbf{x}$ to get the amount of output each industry should produce given a certain amount of final demand:

$$\mathbf{x} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{d} = \mathbf{B}\mathbf{d}, \tag{2}$$

where the Leontief Inverse was denoted $\mathbf{B} = (\mathbf{I} - \mathbf{A})^{-1}$. This matrix is also often called the total requirement matrix since it gives the total productive input requirement from each sector to produce one unit of final output. Specifically each element in b_{ij} in $\mathbf{B}$ gives the output required from sector i for the production of one unit of the final good j. Thus the first column of $\mathbf{B}$ gives all the productive input required from all sectors for the production of one unit of the final good in sector 1, and the first row of $\mathbf{B}$ gives all the input required from sector 1 to produce one unit of the final good in each sector. Now the amount of direct value added in each unit of output for each sector is given by:

$$\mathbf{v} = \mathbf{1} - \mathbf{A}'\mathbf{1} \tag{3}$$

where $\mathbf{1} = (1, 1, 1, ..., 1)'$ is a column-vector of 1's such that the above expression amounts to summing up the entries in each column of $\mathbf{A}$ (representing the intermediate input shares for 1 unit of output) and subtracting them from 1. Let $\mathbf{V}$ be the matrix with $\mathbf{v}$ along the diagonal and 0's in the off-diagonal elements. Multiplying Eq. 2 with $\mathbf{V}$ therefore gives the value added in each sector:

$$\mathbf{V}\mathbf{x} = \mathbf{V}(\mathbf{I} - \mathbf{A})^{-1}\mathbf{d} = \mathbf{V}\mathbf{B}\mathbf{d}. \tag{4}$$

The term $\mathbf{VB} = \mathbf{V}(\mathbf{I} - \mathbf{A})^{-1}$ is known as the matrix of value added multipliers or value added shares, which can be used to obtain the amount of value added generated in each industry ($\mathbf{Vx}$) when producting to satisfy final demand ($\mathbf{d}$). More generally, the matrix $\mathbf{VB}$ contains the amount of valued added by each sector (row) to the production of one unit of each sector's (column's) output. To see this, note first that it can be proven that the columns of $\mathbf{VB}$ sum to 1:

$$(\mathbf{VB})'\mathbf{1} = \mathbf{B}'\mathbf{V}'\mathbf{1} = \mathbf{B}'\mathbf{v} = (\mathbf{I}-\mathbf{A}')^{-1}(\mathbf{1}-\mathbf{A}'\mathbf{1}) = (\mathbf{I}-\mathbf{A}')^{-1}(\mathbf{I}-\mathbf{A}')\mathbf{1} = \mathbf{1}. \quad (5)$$

It can also easily be proven that the sum $(\mathbf{Vx})'\mathbf{1}$ is equal to the sum $\mathbf{d}'\mathbf{1}$: Using Eq. (1) yields $\mathbf{d} = \mathbf{x} - \mathbf{Ax}$, and Eq. (3) yields $\mathbf{Vx} = \mathbf{vx} = \mathbf{x} - \mathbf{A}'\mathbf{x}$, so that $(\mathbf{Vx})'\mathbf{1} = \mathbf{x}'\mathbf{1} - \mathbf{x}'\mathbf{A1}$ and $\mathbf{d}'\mathbf{1} = \mathbf{x}'\mathbf{1} - (\mathbf{Ax})'\mathbf{1}$. Now since $\mathbf{A}$ is row-normalized by output $\mathbf{x}$, $\mathbf{Ax}$ simply gives the vector of intermediate use of each industries output, which is summed across industries through transposing and multiplication by $\mathbf{1}$. $\mathbf{A1}$ gives the vector of intermediate shares in each industries output, which is converted to quantity and summed through pre-multiplying by $\mathbf{x}'$.

Thus Eq. 4 actually gives us a transformation of the finally demanded quantities $\mathbf{d}$ to the value added origins of those same quantities $\mathbf{Vx}$. As mentioned before, each element of $\mathbf{VB}$ represents the share of value added of the row country-industry to the production of one unit of the column country-industry's final product.

Another way to arrive at this, following Wang et al. (2013), is to consider the value added generated by producing one unit of final output in each sector. The direct value added at the final stage of production in each sector is $\mathbf{V}$, but this would exclude the value added by suppliers supplying intermediate inputs to this output. The additional value added by other sectors supplying intermediate inputs to this final output is $\mathbf{VA}$ [3], which needs to be added to the final value added $\mathbf{V}$. Now in order to generate inputs, the supplying sectors also require intermediate inputs from other sectors, of magnitude $\mathbf{AA}$, generating a value added $\mathbf{VAA}$. The process continues through many rounds of production needed to produce those final intermediates needed to produce one unit of output, and the value added generated can be expressed as an infinite geometric series:

$$\mathbf{V} + \mathbf{VA} + \mathbf{VAA} + \mathbf{VAAA} + \cdots = \mathbf{V}\sum_{i=0}^{\infty}\mathbf{VA}^i = \mathbf{V}(\mathbf{I}-\mathbf{A})^{-1} = \mathbf{VB} \quad \text{as} \quad a_{ij} \leq 1 \quad \forall\, i,j. \quad (6)$$

Thus $\mathbf{VB}$ is the value added matrix which sums up the total value added generated by each sector both as a final producer and as a supplier of inputs that is needed to produce one unit of final output in each sector.

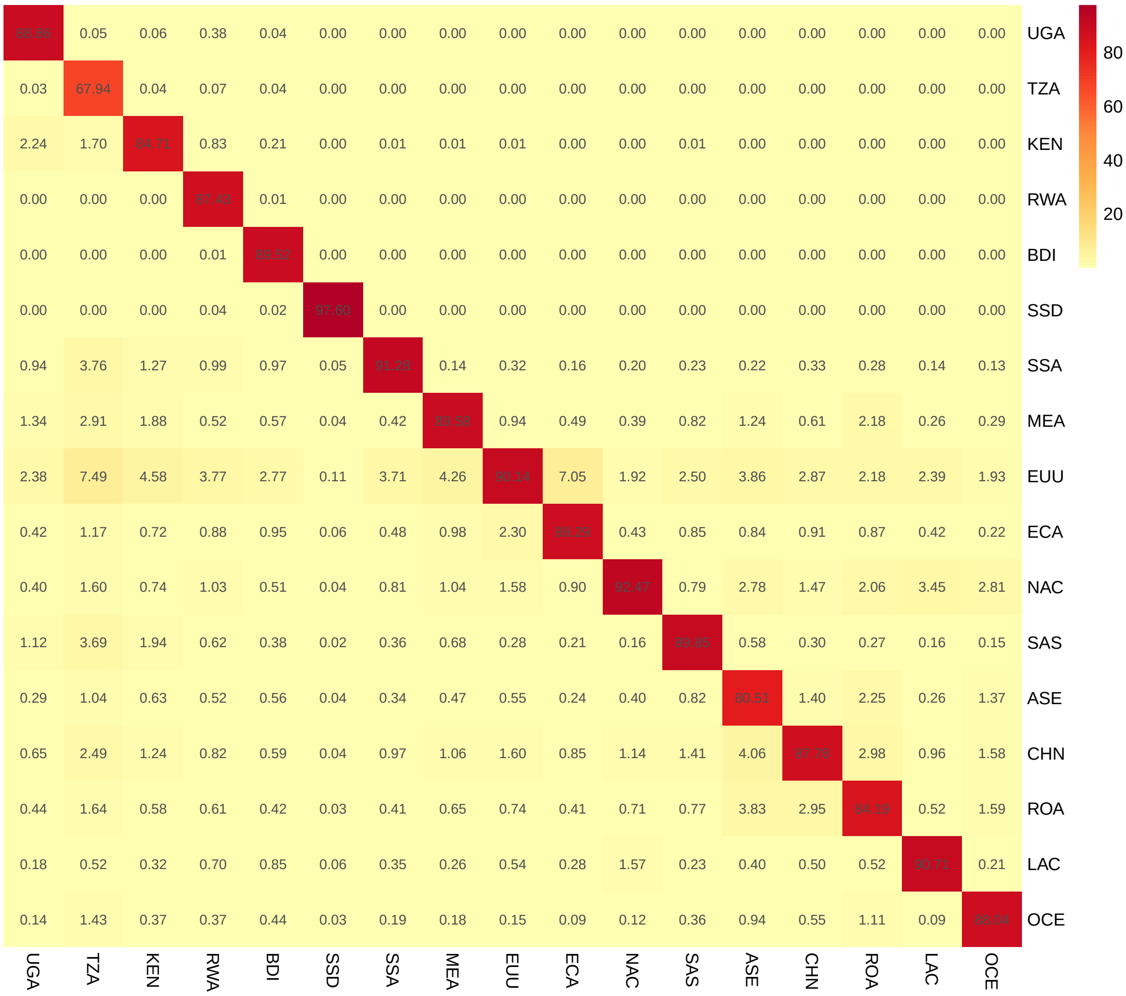
If we assume that the production technology of goods is the same no matter whether they are domestically consumed or exported, then we may also apply the matrix $\mathbf{VB}$ to exports to obtain the value added origins thereof. Before analyzing quantities, let us visualize the matrix $\mathbf{VB}$ at both the aggregate and EAC disaggregated levels.

4.2 Value Added in Final Production

Figure 10 shows the aggregate value added share matrix at the EAC country and world region level. In most EAC countries (Uganda, Kenya, Rwanda and Burundi), approx. 85-90 percent of the value is added by domestic producers. Notable exceptions are Tanzania with 69 percent domestic value added and South Sudan with 98 percent domestic value added. On the supply side, the EU is the largest supplier of intermediate inputs to the production of most EAC countries, followed by South Asia, the Middle east and Kenya, with significant supplier roles also taken by China, North America, and the rest of Sub-Saharan Africa. Within the EAC, Kenya clearly takes on the largest supplier role, adding 2.24 percent of the value in Ugandan production, 1.7 percent in Tanzanias production and 0.83 percent in Rwanda's production. Of the other EAC nations, only Uganda seems to play a non-negligible supplier role for Rwanda, where it supplies 0.38 percent of value added in Rwandan production.

[3] $\mathbf{A}$ gives the units of intermediate input required from each sector (row) for the production of one unit of the sector's (column's) output.

Figure 10: Aggregated Value Added Share Matrix (**VB**) 2015
Shares in Percentage Terms, Columns Sum to 100 Percent



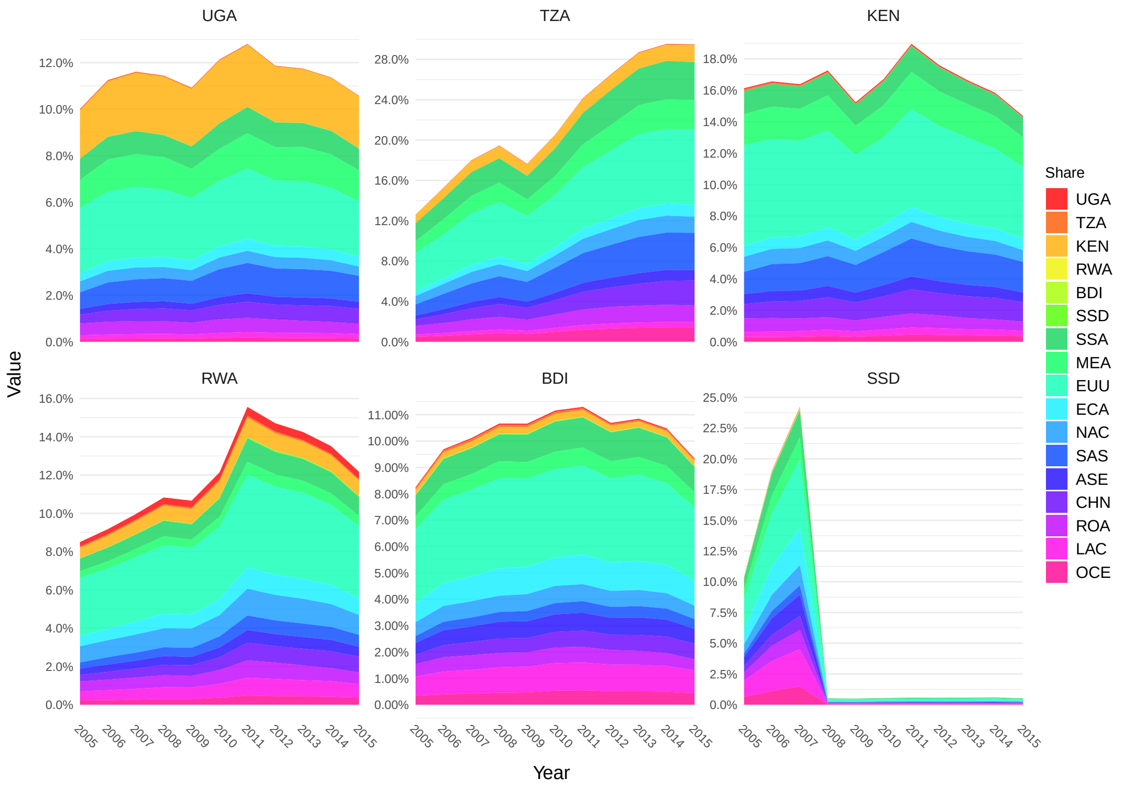
The foreign value added share in domestic production and exports is what Hummels et al. (2001) termed 'Vertical Specialization' (VS), and is the most widely used measure of backward GVC integration. Consider the VA share matrix **VB** with elements $\mathrm{vb}_{oi,dj}$ where o is the VA origin country and i the VA origin industry (along the rows) and d is the VA using country and j the VA using industry (along the columns). Then the VS ratio for a particular country-industry may be expressed as:

$$\mathrm{VS}_{uj} = \sum_{oi,\ o \neq u} \mathrm{vb}_{oi,uj} \quad \forall uj, \tag{7}$$

in other words we are summing the elements of **VB** in each column, excluding any VA shares components from domestic country-industries. Figure 11 gives a breakdown of the VS for EAC countries by supplier country-region over the sample period. When comparing it to the foreign intermediates share in gross flows shown in Figure 8, it is evident that the VS computed from value added data is about 1.5 times greater in nearly all EAC countries, owing to the fact that the foreign content in domestic intermediates which is now taken into account is a lot greater than the domestic content in foreign intermediates which is subtracted in value added flows data.

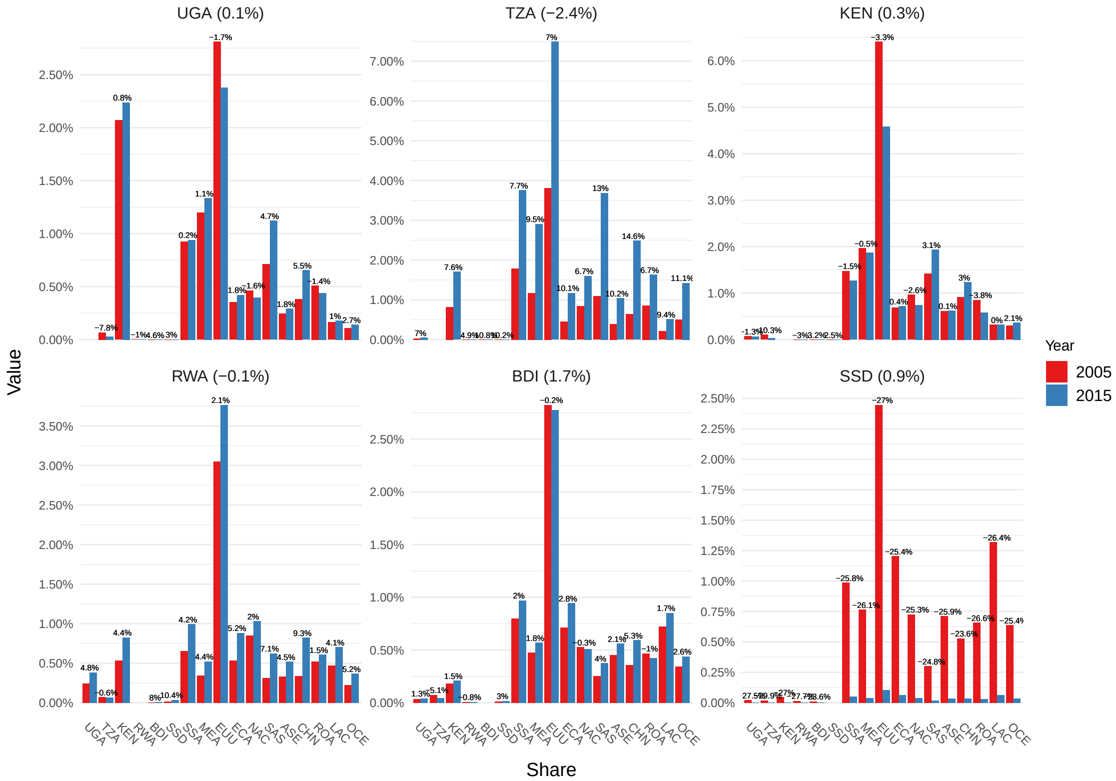
Figure 11 shows that the share of foreign value added in Ugandan production has been fluctuating between 10 and 12% over the analyzed period. 2% of the value of Ugandan produce comes from Kenya, about 1% from the rest of Sub-Saharan Africa, 1.5% from the MENA region, about 3-4% from the EU and 1-1.5% from South Asia. The other regions make up the remaining 2%. Tanzania and Kenya have similar relative VA contributions of SSA, MENA, EU and SAS regions to their production, at overall higher foreign content shares of around 29% foreign VA content in Tanzanian production by 2015, and around 15% in Kenya. Kenya adds around 1-2% to Tanzanian production, and Uganda adds about 0.25% to Kenyan produce. The value added share of Kenya and Uganda in Rwandan production of around and 1% and 0.5%, respectively is also visible. It is curious to observe the VS appears to have declined in Uganda, Kenya, Randa and Burundi from 2011 onwards, whereas in Tanzania it appears to have increased.

Figure 11: Foreign Value Added Shares in EAC Production (VS)



To better summarize the movements in VA shares by different origins over the analyzed period, Figure 12 shows bars giving the value added share in 2005 and in 2015, and above the two bars the annualized average growth rate in the share over this period. The annualized average growth rate of the domestic value added share is also reported in round brackets behind the country code for each EAC country. Figure 12 makes it clear that the foreign value added share has increased substantially in Tanzania and also in Rwanda, but decreased slightly in Kenya and Uganda between 2005 and 2015. Examining more closely the inner EAC shares, it appears that Tanzania's VA share in Ugandan production has halved between 2005 and 2015, whereas Kenya's share has increased by 0.8% annually. For Tanzania the VA share of Kenya has almost doubled from about 0.8% to 1.8%. Rwanda has also seen increases in the shares of Ugandan and Kenyan VA of about 5% each year. In Burundi it appears foreign VA declined by 1.7% over the sample period with only minor changes in the shares of different suppliers. The data for South Sudan is considered unreliable, also minding that the country only became independent in 2011.

Figure 12: Change in Foreign Value Added Shares in EAC Production

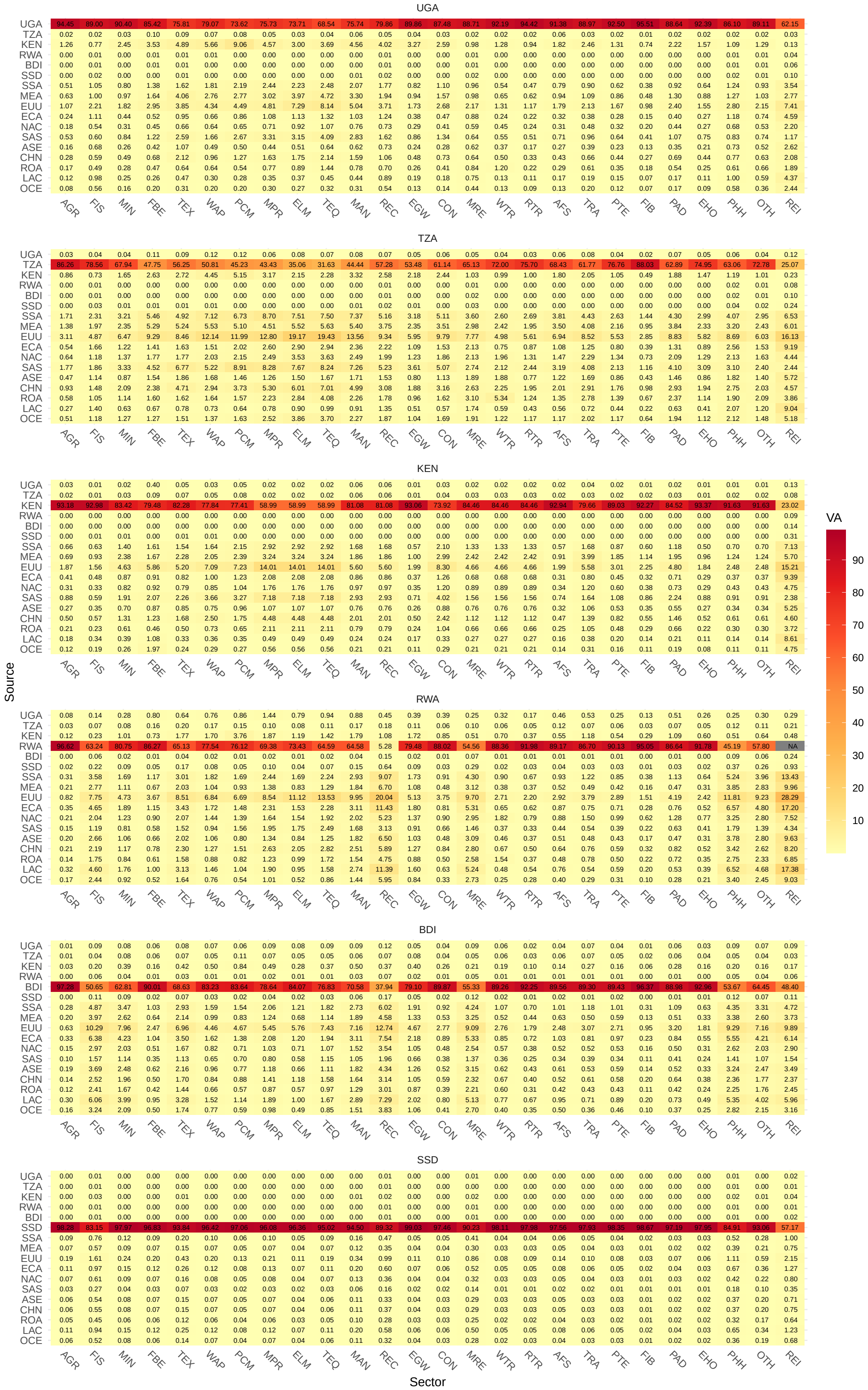


A full sector level view of **VB** for the EAC is not very informative due to the prevalence of very low shares. Figure 13 gives a partial sector disaggregation showing the value added in each EAC sector from different EAC countries and world regions. Across the different countries the domestic value added shares are lowest in the manufacturing sectors, coming as low as 30-35% in Tanzanian electrical machinery and transport equipment. Kenya is an important supplier of inputs and therefore of VA to these manufactured outputs, accounting for as much as 9% of the VA in Ugandan petro-chemicals. It was mentioned above than Uganda supplies a significant part of its Agricultural exports to Kenyan food and beverage industries. In VA terms Figure 13 suggests these inputs nevertheless only account for 0.5% of the VA in this industry in Kenya, which is likely explained by the high amount of VA in processing as well as by other inputs. Uganda has a greater role in Rwandan production, accounting for around 0.5-1% of the value added in several Rwandan manufacturing sectors.

In terms of other world regions, it is evident that the EU has significant shares in the produce of EAC manufacturing sectors, accounting for a much as 20% of VA in Tanzanian electrical machinery and transport equipment, and 14% of VA in Kenyan metal products, electrical machinery and transport equipment. In Uganda the EU shares are lower at 7.3% for electrical machinery and and 8.1% for transport equipment. It is also evident that Rwanda, and to a lesser extent Burundi maintain highly international recycling industries, with significant inputs from all world regions. Other significant contributions to VA in EAC manufacturing come from South Asia, China and the rest of Sub-Saharan Africa, with shares ranging between 2 and 8%, depending on the country and sector.

Figure 13: Disaggregated Value Added Share Tables: EAC in 2015

Shares in Percentage Terms, Columns Sum to 100 Percent



4.3 Value Added Exports

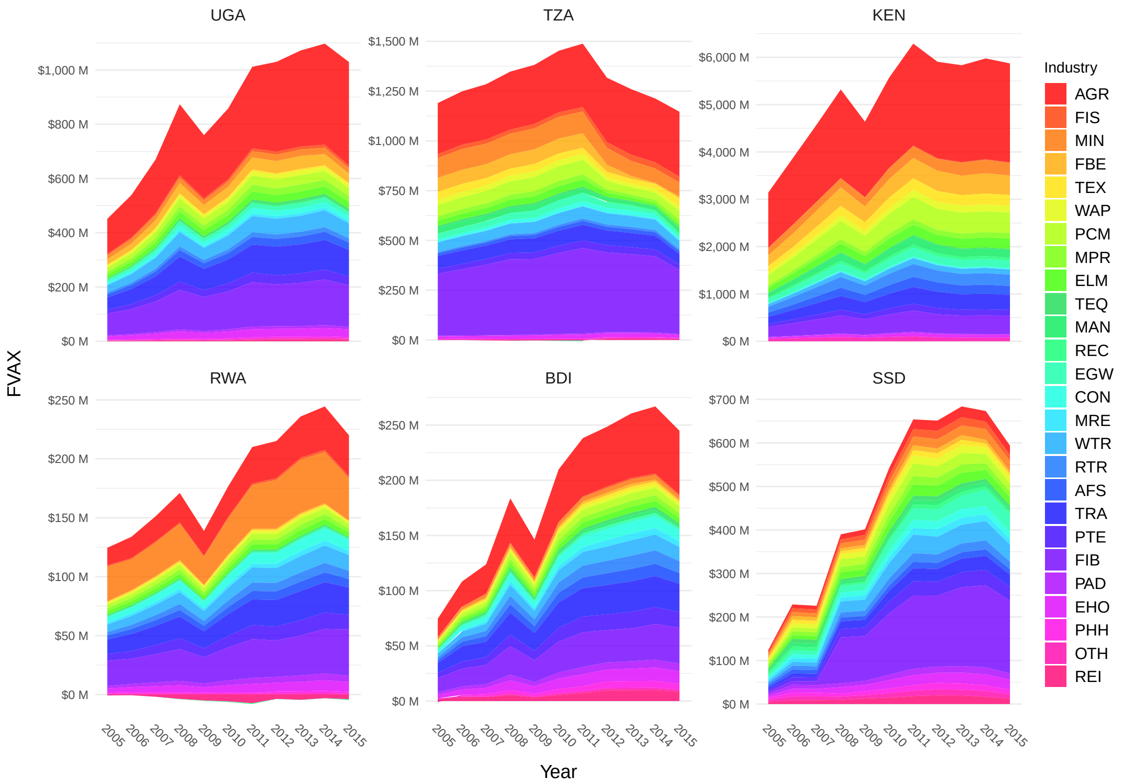
The matrix **VB**, reflecting the structure of international production, allows us to decompose any gross flow coming from any country-industry into it's value-added origins by country-industry. The literature frequently considers a decomposition of gross exports into its VA origins, given by the matrix **VBE** where **E** is a diagonal matrix with exports by country-industry along the diagonal.

Figure 14 shows the EAC value added in global exports, which is obtained, for each country-industry, by simply summing the corresponding row of **VBE**.

$$\text{VAE}_{oi} = \sum_{uj} \text{vbe}_{oi,uj} \quad \forall\ oi. \tag{8}$$

Note that this therefore includes VA in exports to other EAC countries as well as VA in exports that are ultimately consumed at home. Figure 14 shows that the Ugandan VA in globally exported goods at the end of 2015 was around 1 billion USD in basic prices, whereas Kenya contributed around 6 billion USD to the value of gloabal exports in that year.

Figure 14: EAC Domestic Value Added in Global Exports



Next to VS or the imported content of production and exports visualized in detail in Figure 11 which functions as a measure of backward GVC integration, Hummels et al. (2001) also introduced the share of domestic exports that enters foreign countries exports, which they called VS1, as a measure of forward GVC Integration. This measure was first computed and explored by Daudin et al. (2011). It is defined as

$$\text{VS1}_{oi} = \frac{1}{E_{oi}} \sum_{uj, u \neq o} \text{vbe}_{oi,uj} \quad \forall\ oi, \tag{9}$$

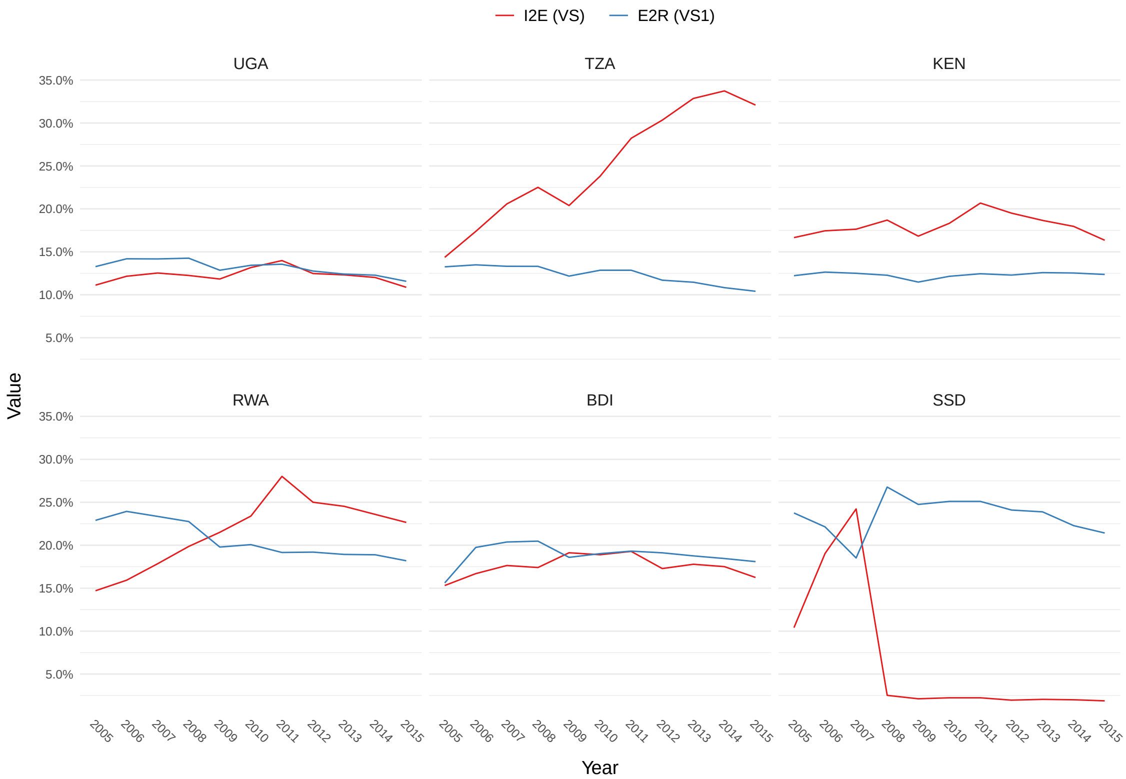
where E_{oi} are the gross exports of country-industry oi which is used to normalize the sum along the rows of **VBE** (excluding domestic industries) which capture the use of VA from a domestic sector oi in the exports of all foreign sectors uj. For completeness I note that VS can be defined in an analogous way as

$$\text{VS}_{uj} = \frac{1}{E_{uj}} \sum_{oi,o\neq u} \text{vbe}_{oi,uj} \quad \forall\ uj, \tag{10}$$

however since $\sum_{oi} \text{vb}_{oi,uj} = 1\ \forall\ uj$, the exports cancel out and Eq. 10 reduces to Eq. 7.

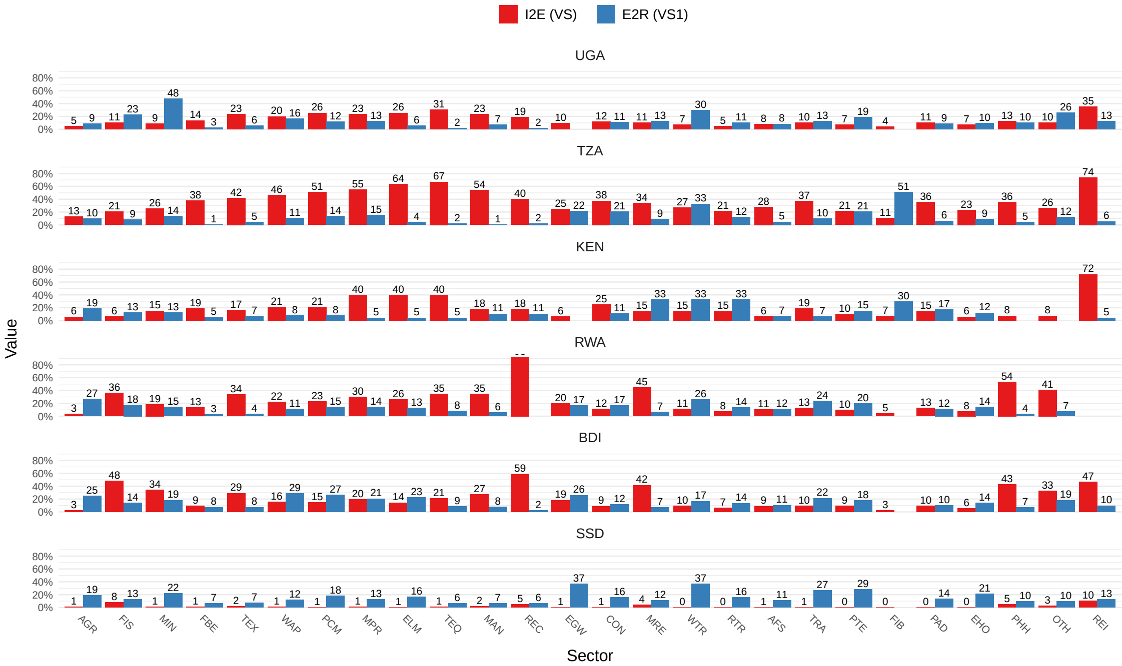
Figure 15 shows the aggregate VS and VS1 for each EAC member country over time. VS1 is called E2R (export to re-exports), and VS I2E (import to exports) by Kummritz & Quast (2016) (following Baldwin & Lopez-Gonzalez (2015)), which also developed the *gvc* R package to compute these measures. For Uganda, both VS and VS1 are at 11-12% of exports towards the end of 2015, whereas VS1 was higher at around 14% of exports in 2005. Tanzania, as already noted shows a remarkable increase in backward GVC participation to above 30% of VA in its produce generated abroad, but a slight decline in forward GVC participation down to 11% of exports being re-exported in 2015 - similar to Uganda. Kenya exhibits a stable development with VS of around 17% and VS1 around 12.5%. Rwanda increased in VS from 15% in 2005 to 22.5% in 2015, and at the same time showed a decrease in VS1 from initially 22.5% down to 16% in 2015. It is noteworthy that while a few members like Tanzania and Rwanda appear to have succesfully increased their use of foreign intermediates, none of the members significantly increased it's role as supplier of inputs in the global market. Overall the GVC situation appears stagnant in Uganda, Kenya and Burundi.

Figure 15: GVC Integration of EAC Members: Aggregate



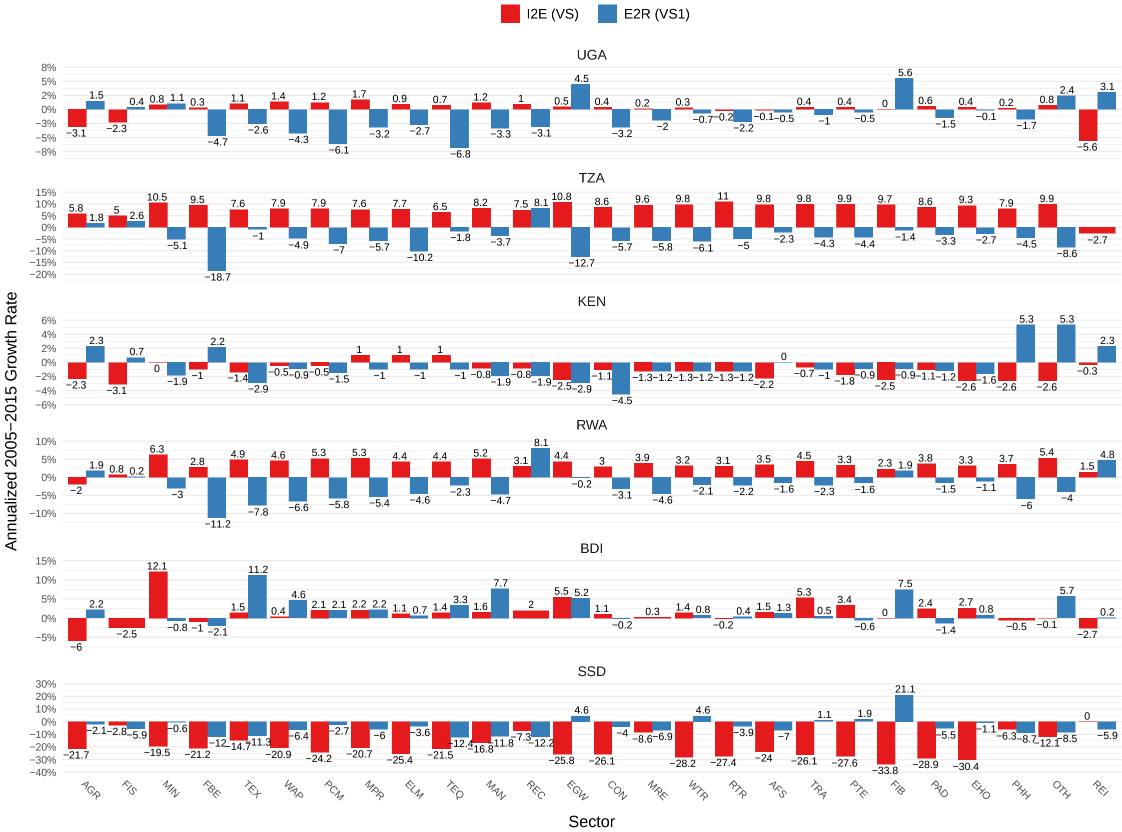
A sector-level snapshot of VS and VS1 for the year 2015 is provided in Figure 16. It shows the large share of foreign content in manufacturing, particularly in Tanzania. Rwanda and Burundi recycle a lot of foreign garbage. In terms of VS1, aroud 48% of Ugandan mining exports are manufactured into goods that are re-exported by receiving countries. Wholesale and retail trade also appears to have shares above 20% of exported goods being re-exported in all countries.

Figure 16: GVC Integration of EAC Members: Sector Level: 2015



To provide at least a rough overview of the sector-level dynamics over the last 10 years, Figure 17 shows the annualized average growth rates of VS and VS1. The axes are now on different scales for each country to reflect the large differences in sector level changes between countries. In Uganda and Kenya, developments are very moderate. Most Ugandan manufacturing sectors increased their imported content (VS) by 1-2% per annum, while at the same time reducing the share of intermediates for re-export (VS1) by 2-4% per annum. In Kenya the picture is more diverse, but with similarly small annual changes of 1-4%. A similarity between Uganda and Kenya is that both countries reduced their VS in Agriculture by around 3% per annum while increasing the share of exports for re-export (VS1) by 2%. In Tanzania nearly all manufacturing sectors exhibit annual gains in VS of 8-10%. I note again that the data reliability for Tanzania is very low and these estimates should be interpreted with great caution. Rwanda shows a similar development to Tanzania, but on a smaller scale. Here most manufacturing sectors appear to have increased their VS by 4-5% per annum, while reducing VS1 by a similar amount.

Figure 17: GVC Integration of EAC Members: Annual Growth 2005-2015



4.4 Regional Integration in Value Added Trade

So far we have explored standard country and industry level metrics of backward and forward GVC integration, VS and VS1, and examined the overall level of GVC integration of EAC countries and sectors. The result of this examination was that apart from increases in the import content of production and exports (VS) in Tanzania and Rwanda, the situation is relatively stable over time, with moderate amounts of heterogeneity at the sector level.

This section builds on these findings and introduces some metrics to track regional EAC integration through VA in supply chains, relative to any global developments experienced by each member country. The first such metric computed is the share of foreign VA in a members production / exports accounted for by it's EAC partner states. It is computed as

$$\mathrm{VS}_{uj}^{EAC} = \frac{1}{\mathrm{VS}_{uj}} \sum_{oi \in EAC,\ o \neq u} \mathrm{vb}_{oi,uj} \quad \forall\ uj \in EAC, \tag{11}$$

where VS_{uj} is defined as in Eq. 7. VS^{EAC} is thus a relative measure tracking the EAC share in VS, such that the overall EAC VA share in domestic production can be computed as $\mathrm{VS}_{uj}^{EAC} \times \mathrm{VS}_{uj}\ \forall\ uj$. We can define an analogous measure for VS1 as the proportion of domestic VA in re-exported exports that is exported by EAC partner states.

$$\mathrm{VS1}_{oi}^{EAC} = \sum_{uj \in EAC, u \neq o} \mathrm{vbe}_{oi,uj} \Big/ \sum_{uj, u \neq o} \mathrm{vbe}_{oi,uj} \quad \forall\ oi \in EAC. \tag{12}$$

These two metrics effectively track the role of the EAC in forming the interaction of each member country with the rest of the world in terms of production and export linkages. They do however not account for the import side, that is the overall role of the EAC in providing goods and services to each member country relative to the rest of the world. Therefore we will compute two additional metrics to capture this aspect of regional integration. The first metric is the share of EAC VA in the imports received by each member, which we shall denote by VAI^{EAC}. Consider

E_u to the vector of VA exports to EAC using country $u \in EAC$ from each country-sector[4].Then we can find the VA origins of these exports to country u by pre-multiplying with $\mathbf{VB}$ to give

$$E_u^{VA} = \mathbf{VB}E_u, \tag{13}$$

where E_u^{VA} denotes the vector, with elements $e_{oi,u}^{VA}$, of VA supplied by each country-industry (oi) in these imports of country u. From E_u^{VA} the share of EAC VA is easily computed as

$$\text{VAI}_u^{EAC} = \sum_{oi \in EAC, o \neq u} e_{oi,u}^{VA} \Big/ \sum_{oi, o \neq u} e_{oi,u}^{VA}. \tag{14}$$

VAI_u^{EAC} thus gives us a country-level measure of the VA by it's EAC partners in it's import mix, excluding any domestic VA in imports. This VA may however enter into produced goods and be exported again, thus it is a measure of the EAC contribution to (non-domestic) production and consumption in a particular member country. To single out the EAC share in imported consumption goods, we need to consider only exports for final demand, which exclude exports feeding into production as intermediates. Let FE_u therefore denote the final exports to country u from each country-industry. Then $FE_u^{VA} = \mathbf{VB}FE_u$ denotes the decomposition of those exports into VA components, and we can define

$$\text{VAFI}_u^{EAC} = \sum_{oi \in EAC, o \neq u} fe_{oi,u}^{VA} \Big/ \sum_{oi, o \neq u} fe_{oi,u}^{VA} \tag{15}$$

as the EAC VA share in final goods exported to a particular member u.

Figure 18: EAC VA Shares in Members VS, VS1, Imports and Final Imports

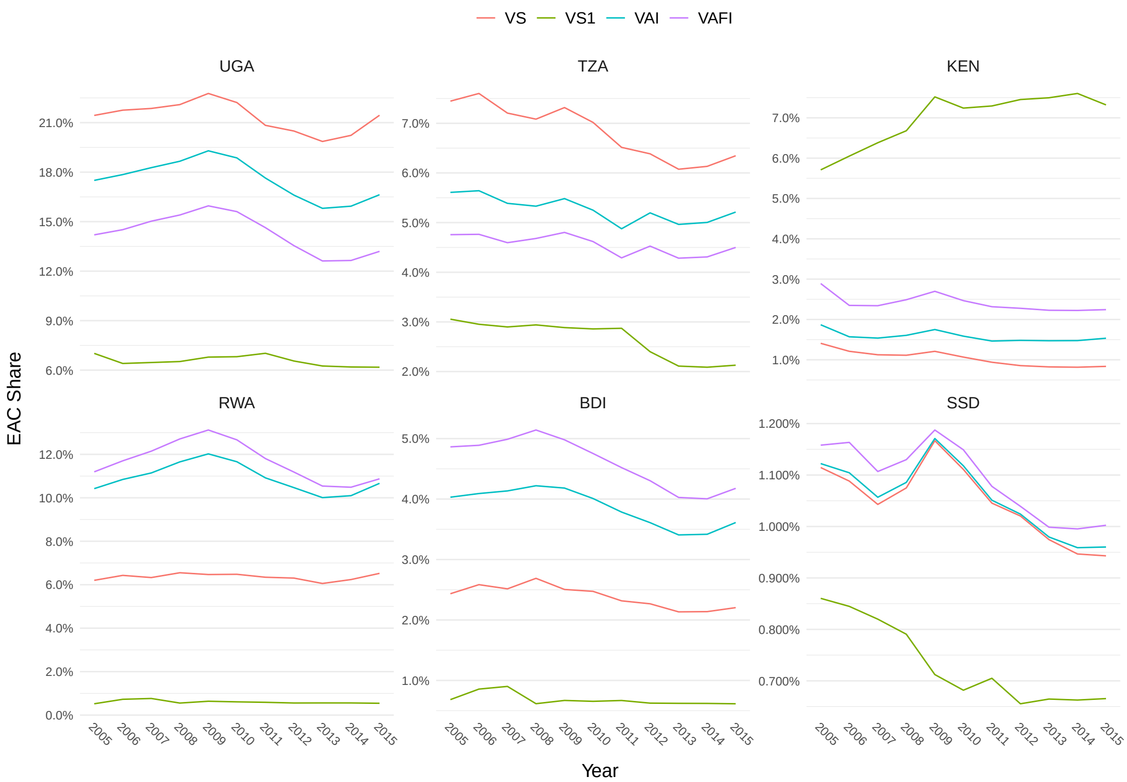


Figure 18 reports the results. It is evident that Uganda and Tanzania follow very similar regional integration patterns, though at very different levels. In Uganda, around 21% of VS (the foreign content of production) is accounted for by the EAC, whereas in Tanzania this was 6.3% at the end of 2015. In Uganda the EAC share of VS1 (re-exported exports) was close to 6% end of

[4]Note that since we don't have final demand disaggregated by sector, we cannot compute VAI^{EAC} by receiving sector, but only by receiving country.

2015, whereas in Tanzania it ended at 2%. In-between we have the EAC share in Ugandan imports (VAI) and final imports (VAFI) at around 16.5% and 14.5% in 2015, whereas for Tanzania these shares were 5.2% and 4.5%, respectively.

Overall this suggests that both countries have stronger backward GVC linkages with the EAC, with EAC countries (in particularly Kenya), supplying inputs into the production, whereas both countries play only a moderate role as suppliers of intermediates for export. In Kenya we observe the opposite pattern, where around 7.4% of Kenya's re-exported exports (VS1) are exported by it's EAC partners, but only about 0.9% of its imported inputs (VS) is accounted for by EAC partners. On the import side, less than 3% of the VA in Kenyan imports is generated by it's EAC partners, but it is interesting that the EAC share in final imports is higher at 2.3% than the EAC share in overall imports at 1.5%, confirming that Kenya imports relatively more final goods than intermediates from it's EAC partners. Rwanda and Burundi also follow a similar pattern of EAC integration. In both countries the final import share of the EAC is highest, at around 11% in Randa and 4.3% in Burundi in 2015. This is followed, with some distance, by the EAC share in VS, at 6.5% in Rwanda and 2.2% in Burundi. Both countries have a negligible supplier role for the EAC, with <1% of their re-exported exports exported by EAC partners. In South Sudan the data suggest EAC shares in VS, VAI and VAFI of around 1% in 2015, indicative of it low-level of economic integration with its EAC partners. Overall, the progression of these indicators over time suggests a stagnant or, in the case of Tanzania and Burundi, even declining level of regional integration through value chains, measured on relation to an also mostly stagnant overall level of value chain integration of the EAC member countries.

4.5 Koopman Wang Wei Decomposition of Gross Exports

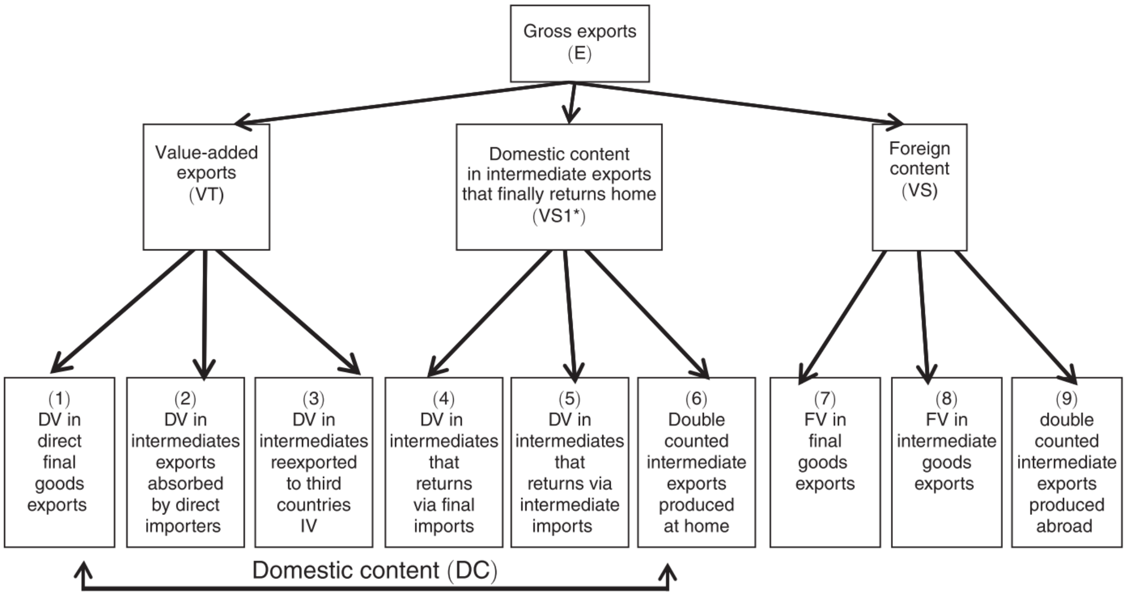
One problem with the Leontief decomposition of gross exports into VA origins is that it also captures so called pure double counted items, which are items that that are traded two or more times between the same trading partners. For example if on a value chain for chemical products an intermediate product would be first exported from Uganda to Kenya, processed further in Kenya and then imported again by Uganda to produce a final good that is the exported. The Leontief decomposition will correctly allocate the share of VA in this product to Uganda and Kenya, but Ugandan gross exports themselves would overstate the amount of VA in either of the two countries, because it includes both the export of the intermediate produce to Kenya, and the export of the final good to the rest of the world. So this kind of double counting in gross exports is incurred whenever there exists two-way trade in intermediate goods.

Secondly, the Leontief decomposition provides no information as to where and how the VA in exports is absorbed, it only provides the origin of VA in gross exports. To account for double counted items in gross exports and also to better understand where and how VA is absorbed, which indicates how countries integrate into GVCs, a number of increasingly complex GVC decompositions have been developed. The simplest and most well known of these is the Decomposition of country-level gross exports into 9 VA components proposed by Koopman, Wang and Wei (2014), henceforth KWW (Koopman et al., 2014). The 9 terms fo the KWW decompostion are given schematically in Figure 19[5].

The decomposition splits exports first into foreign content (VS) and domestic content. Domestic content is then further split into VA exports that are absorbed abroad, and content that eventually returns home and is absorbed domestically. Each of these thee categories can be subdivided further according to how the VA is utilized. In both the domestic content returning home and foreign content, there are double counted categories, which split double counted VA arising from two-way trade in intermediate goods according to their domestic and foreign VA. In the example given above: if an intermediate is first exported from Uganda to Kenya, then re-imported by Uganda and finally exported, then the VA in that first export from Uganda to Kenya would be assigned to the domestic and foreign double counted terms (depending on where the value of the intermediate at that stage originated).

[5] A mathematical expression for each of the 9 terms is provided in Eq. 36 of the Koopman et al. (2014) paper.

Figure 19: KWW Decomposition of Gross Exports



4.5.1 Aggregate KWW Decomposition

The KWW decomposition of gross exports is computed for each of the EAC members and shown in Figure 20. To connect this decomposition to the aggregate measures of GVC integration VS and VS1 obtained from the Leontief decomposition and shown in Figure 15: VS the share of FVA in gross exports is the sum of FVA_{FIN} (7), FVA_{INT} (8) and FDC (9), while VS1 is the sum of DVA_{INTrex} (3), RDV_{FIN} (4), RDV_{INT} (5) and DDC (6) (approximately equal to DVA_{INTrex} here since RDV_{FIN}, RDV_{INT} and DDC are close to 0 in all EAC countries).

Figure 20: KWW Decomposition of Gross Exports

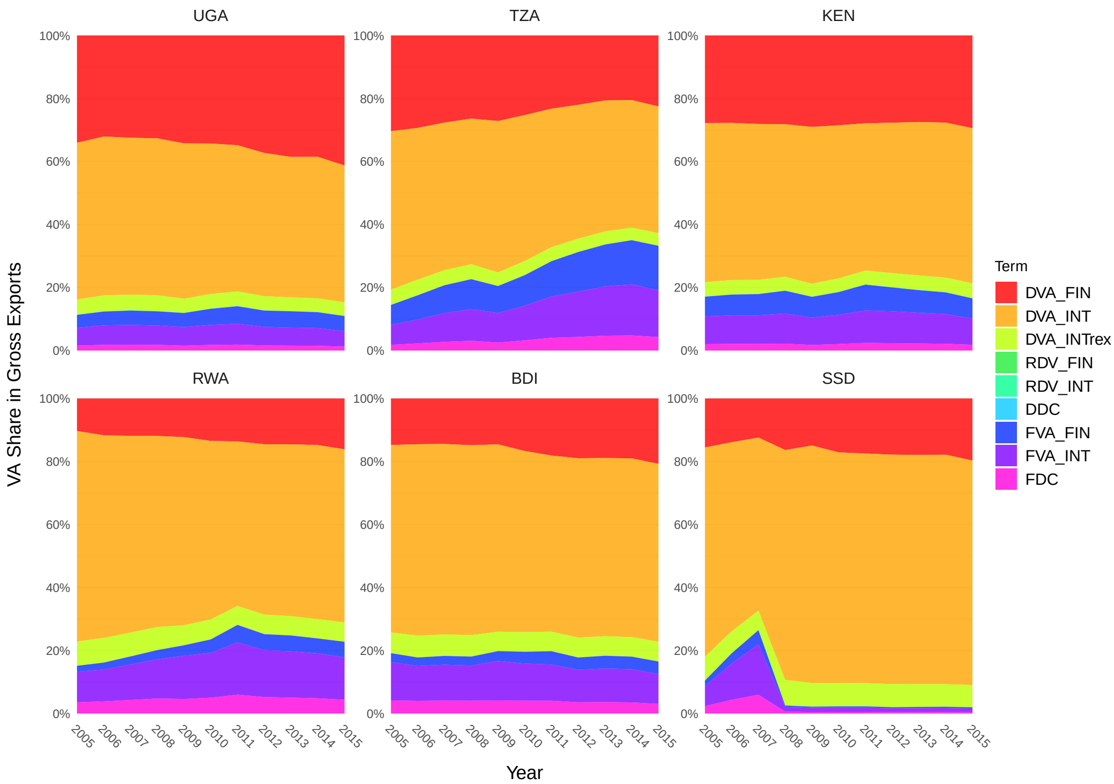


Figure 20 shows that double counted items constitute up to 10% of gross exports in EAC countries, but that most of this double counting occurs with VA produced abroad. The domestic content in intermediate exports that finally returns home is practially 0 for all EAC members, indicating an overall insignificant role of these countries as suppliers of inputs to their own final imports[6]. In all members furthermore the largest share of exports is domestic VA in intermediate exports absorbed by direct importers. Only a small share of DVA in intermediate exports is re-exported indicating that EAC countries predominantly export basic inputs to products manufactured for home consumption in the importing countries. In Uganda furthermore around 40% of exports constitute DVA in final goods exports. Apart from Tanzania, the share of DVA in final goods exports has increased over time. Tanzania is also the only country with a significant share of FVA in final goods exports, indicating some assembly and processing tasks. Rwanda on the other hand has a high share of FVA in intermediate exports[7].

4.5.2 Upstreamness and Downstreamness in GVC Participation

The KWW decomposition also lets us asses the position of countries in GVCs regardless of their overall level of GVC integration[8]. According to Kummritz & Quast (2016) and Wang et al. (2013), High FVA in final exports relative to total foreign content in exports indicates downstreamness (assembly tasks), while high DVA in intermediate exports relative to total DVA in exports indicates upstreamness (specialization in tasks adding a lot of value to an unfinished product). I follow these authors in computing the ratios as shown in Equations 16 and 17, and plot them in Figure 21.

$$\text{Upstreamness} = \frac{\text{DVA}_{INT} + \text{DVA}_{INTrex} + \text{DDC}}{\text{DVA}_{FIN} + \text{DVA}_{INT} + \text{DVA}_{INTrex} + \text{RDV}_{FIN} + \text{RDV}_{INT} + \text{DDC}} \quad (16)$$

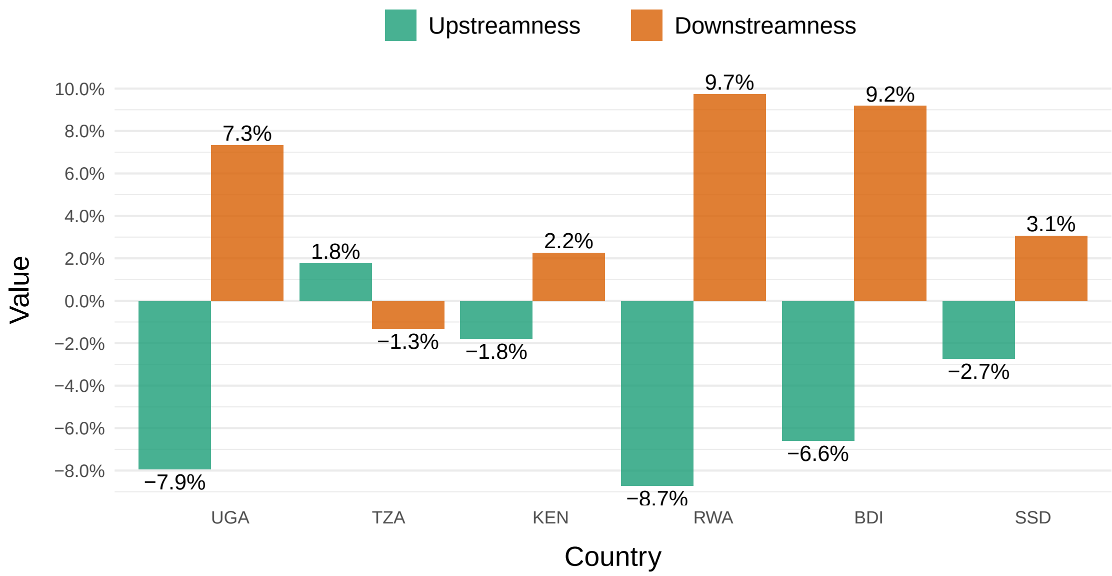
$$\text{Downstreamness} = \frac{\text{FVA}_{FIN}}{\text{FVA}_{FIN} + \text{FVA}_{INT} + \text{FDC}}, \quad (17)$$

Figure 21: Upstreamness and Downstreamness Ratios

[6]This is prevalent in the export composition of high-income countries, see e.g. (Kummritz & Quast, 2016).
[7]Primary the recycling sector as shown in Figure 24.
[8]As measured by VS and VS1.

From Figure 21 it appears that the smaller countries are situated more upstream in GVCs, but this is also a consequence of them generally exporting less final goods. More meaningful than the levels of these ratios is their change over time. Figure 21 suggests that apart from Tanzania all EAC members became more downstream in their GVC integration, with less domestic content in intermediate exports and more FVA in final goods exports. To better exhibit these findings, Figure 22 shows the difference in the Upstreamness and Downstreamness ratios between 2005 and 2015. It is evident that Uganda and Kenya moved downstream in these years, with more foreign value added going into final goods than intermediate goods, and also more DVA going into final goods. This could, especially for the smaller countries Rwanda and Burundi, also indicate a general increase in Final goods exports that has nothing to do with shifting patterns of GVC integration. Only Tanzania appears to have mived slightly upstream over this time period, with more domestic and foreign VA going into intermediate exports.

Figure 22: Upstreamness and Downstreamness Ratios, Difference 2005-2015

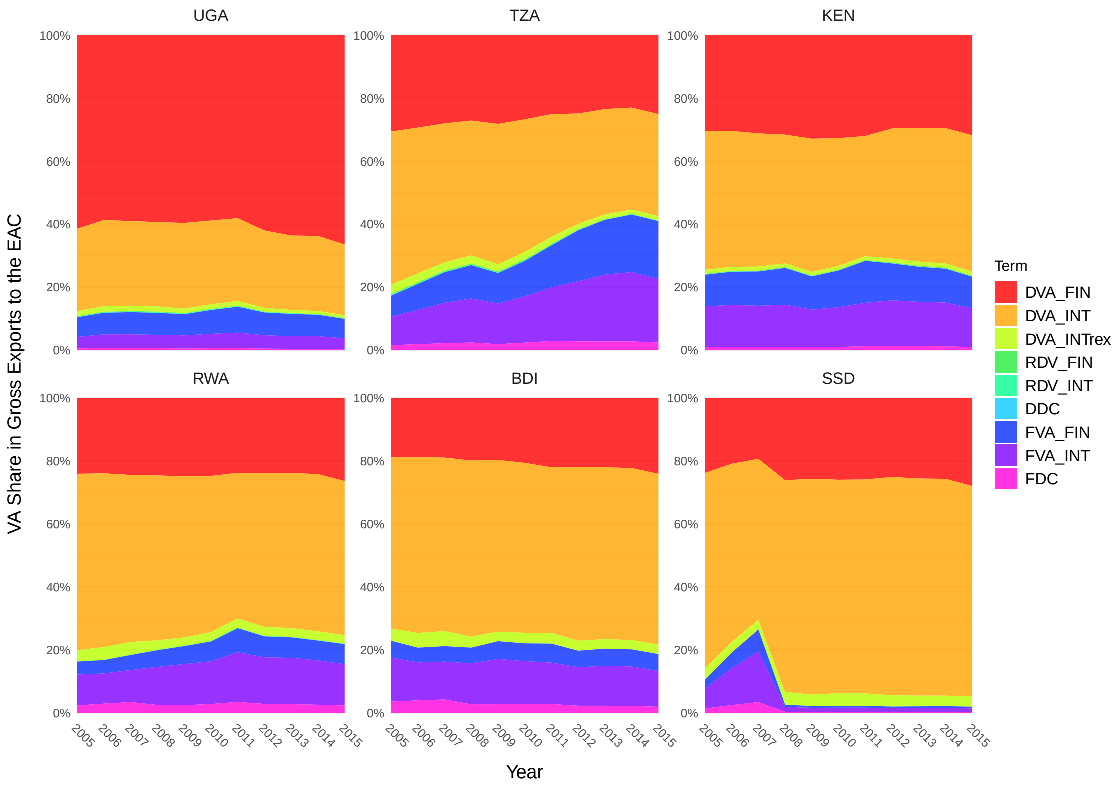


4.5.3 KWW Decomposition of EAC Exports to the EAC

Whereas the KWW decomposition is only defined at the country-level, Wang et al. (2013) derived a much more detailed decomposition that decomposes gross exports into 16 terms at the bilateral and sector-level. To consider 16 terms is a bit over the top given the very low data quality for developing countries. It is however possible to add up these 16 terms to get the 9 terms of KWW at a disaggregated level.

Figure 23 shows the KWW decomposition of gross exports to other EAC countries. Overall it is very similar to the overall export decomposition in Figure 20, but with a couple of noteworthy differences. The first is that in all EAC countries DVA_{FIN} has a higher and DVA_{INT} a lower share in exports to the EAC than in overall exports, implying that final goods exports are more prevalent in inner-EAC trade than in the overall trade mix of member countries. Secondly, DVA_{INTrex} and FDC components are both a lot lower in inner-EAC trade. Since both exports of intermediates and double counted components are features of GVCs, this therefore suggests that EAC member countries engage relatively more in GVCs with the rest of the World than with their EAC partners, or at least that inner-EAC value chains are shorter than other value chains EAC members engage in (Kummritz & Quast, 2016).

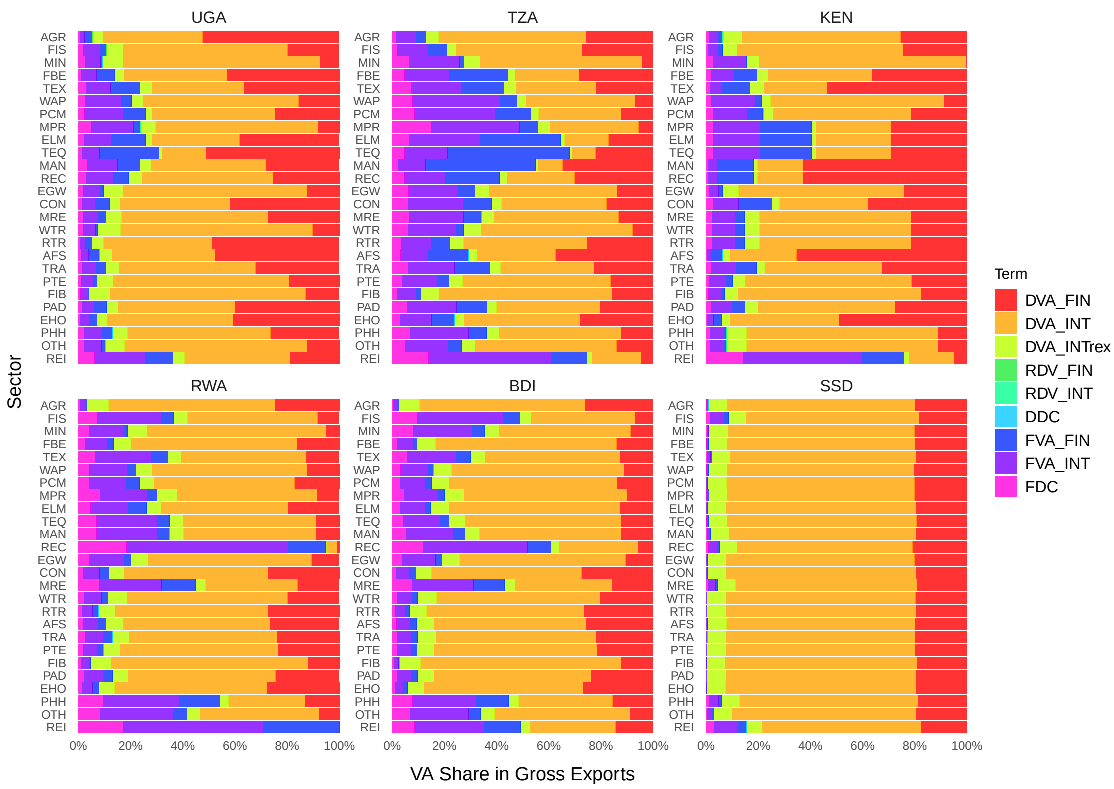
Figure 23: KWW Decomposition of Gross Exports to the EAC



4.5.4 Sectoral-Level Decomposition

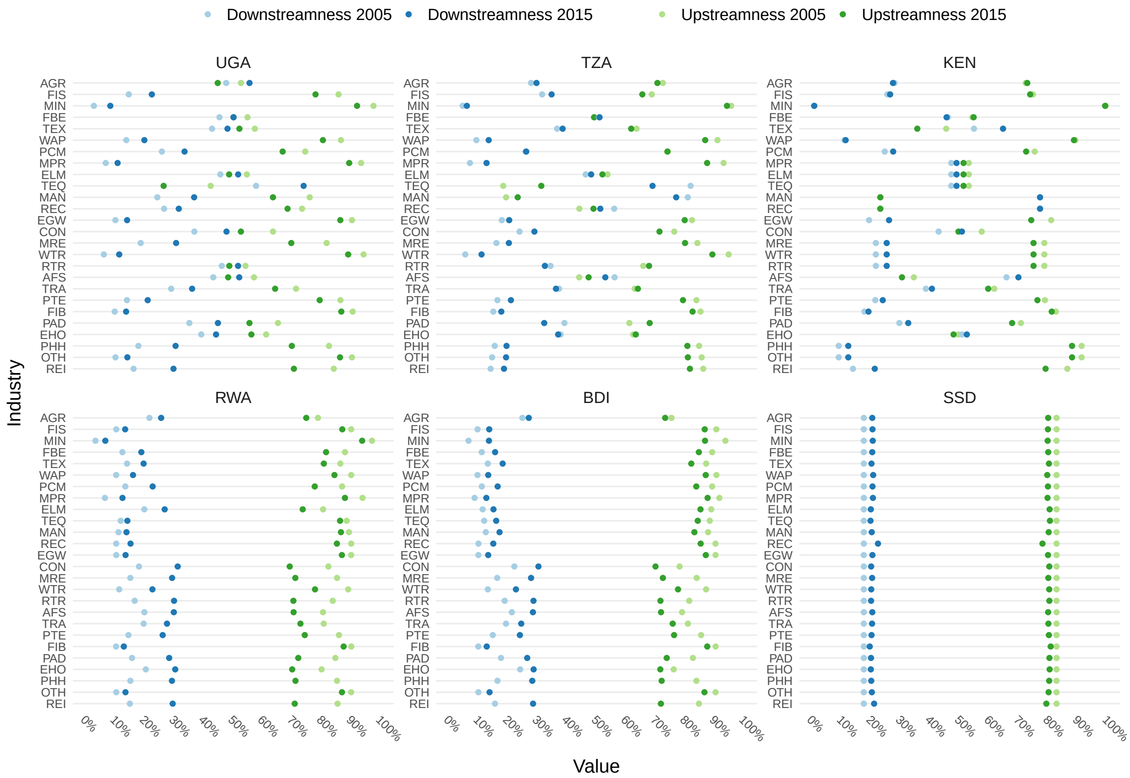
The decomposition of Wang et al. (2013) decomposes trade flows at the sector level, from which the sector-level KWW decomposition is easily obtained. Figure 24 shows this sectoral KWW decomposition for the year 2015. In general, manufacturing sectors have higher shares of FVA, including FDC, in all EAC countries. In some cases such as Rwanda's highly international recycling sector FVA is over 90%, where compared to Figure 16, Figure 24 provides the additional information that most of this recycling is re-exported as intermediate inputs.

Figure 24: KWW Decomposition of Sector-Level Gross Exports in 2015



While Figure 16 already gives an indication of the overall share of FVA in sectoral exports for the year 2015, the more detailed decomposition in Figure 24 permits further investigation regarding the relative share of final goods vs. intermediates in both domestic and foreign VA. This information is difficult to read off Figure 24 but summarized by the Upstreamness and Downstreamness ratios computed above at the aggregate level, which Figure 25 now computes at the sector-level. To also gauge whether sectors have moved upstream of not, Figure 25 shows the values of Upstreamness and Downstreamness for both the firs and last year of the analysis period.

Figure 25: Upstreamness and Downstreamness by Sector, 2005 and 2015



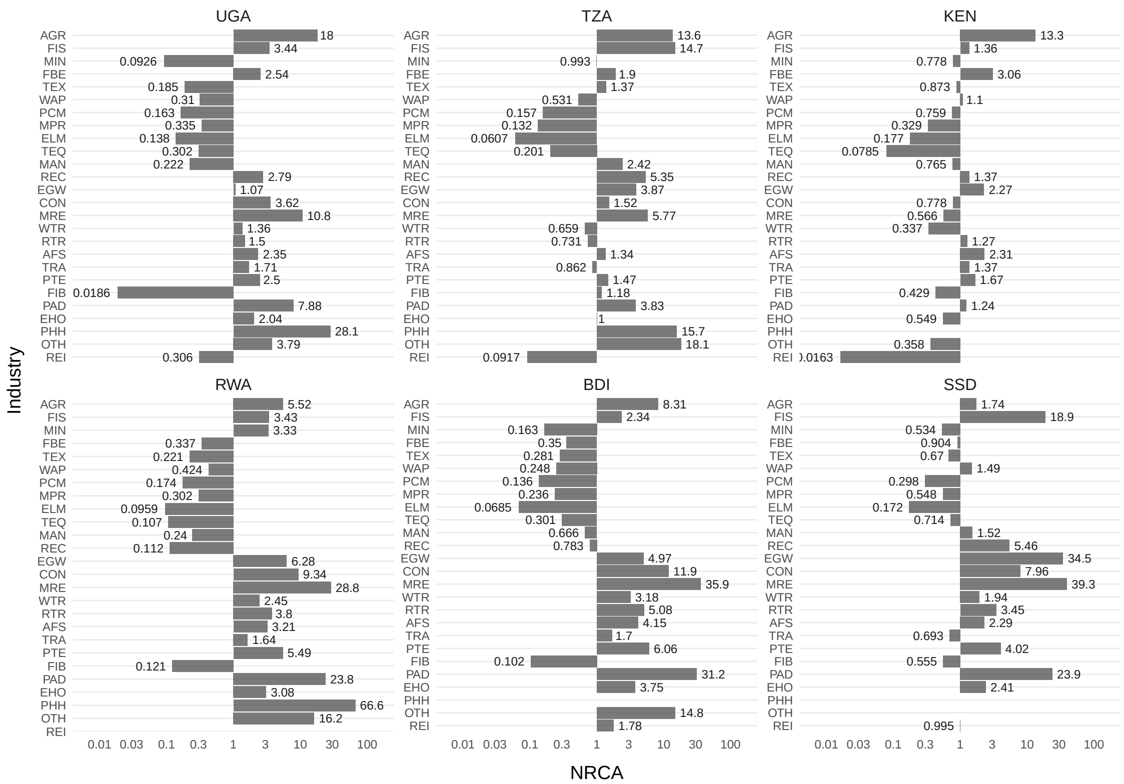
While there is a great deal of sectoral heterogeneity in Figure 25, two findings stand out. The first is that in Rwanda and Burundi manufacturing sectors appear to be relatively more upstream than other sectors, which is not generally the case in Uganda, Tanzania and Kenya. The second more striking fact is that nearly all sectors in all EAC countries (including Tanzania) have moved downstream, that is to say exports have shifted more towards final goods than intermediates. In this regard movements at the sector level are very homogeneous and in line with the aggregate movement towards final goods production conveyed by Figures 21 and 22. This downstream shift will likely not increase the benefits EAC member countries can gain from participation in GVCs, as most of the technology transfer is likely to happen in upstream production tasks than in downstream assembly tasks. More research needs to be done however with regards to the nature and causes of this downstream shift before jumping to conclusions about its economic implications.

4.6 New Revealed Comparative Advantage

A popular measure to empirically measure Ricardo's concept of comparative advantage in international trade is the measure of revealed comparative advantage proposed by Balassa (1965). It is computed as the share of a sector in gross country exports, divided by the share that of that sector in gross World exports. A ratio above 1 indicates a comparative advantage of the country in this sector. The traditional index based on gross flows however does not take account of double counting in gross exports, and may thus be noisy and misleading. Koopman et al. (2014) therefore propose a new index based on VA flows, which considers the domestic VA in gross exports (or domestic GDP in exports, the sum of terms 1-5 of the KWW decomposition), to compute a new revealed comparative advantage (NRCA) index.

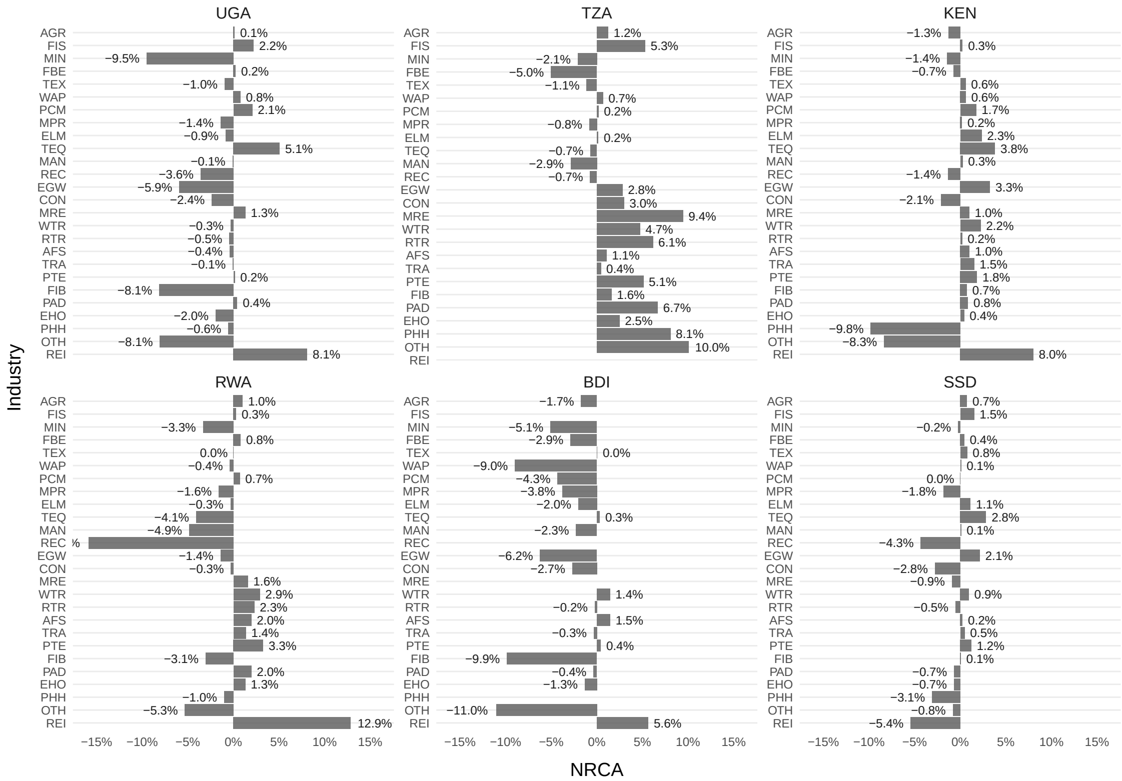
Figure 26 shows the NRCA for EAC countries in the year 2015. It is evident that all EAC members have a NRCA in agriculture and fishing, which is higher than 10 for agriculture in Uganda, Tanzania and Kenya. Also all EAC members have a comparative disadvantage in core manufacturing sectors such a petro-chemicals, metral products and electrical machinery. The remaining sectors show more heterogeneity across EAC countries, where Kenya appears to be different from the other countries. In Uganda, Tanzania, Rwanda, Burundi and South Sudan activities of private households (self-employment) seem to have a strong comparative advantage, and also maintenance and repair activities have a strong comparative advantage, whereas in Kenya both sectors appear to have a comparative disadvantage.

Figure 26: New Revealed Comparative Advantage in 2015



As we have 10 years of data, it will be interesting to see whether there were significant changes in the revealed comparative advantage of sectors. Figure 27 therefore shows the annualized growth rate in NRCA over the 2005-2015 period. It is evident that comparative advantage has not changed much in agriculture, with minor annual gains or losses within the [-2%, 2%] range. All EAC members seem to have gained comparative advantage in fishing, particularly Uganda and Tanzania with gains of 2.2% and 5.3%, respectively. Also all EAC members had lost comparative advantage in mining, especially Uganda. All EAC countries have gained comparative advantage in re-exporting goods. In other sectors developments are rather heterogeneous. Uganda for example appears to have gained comparative advantage in exporting transport equipment by around 5.1% annually, whereas Rwanda lost comparative advantage in the same sector by -4.1% annually. There were also hardly any movements of sectors from comparative disadvantage (NRCA < 1) to comparative advantage (NRCA > 1) in this time period, only Tanzania's mining sector moved to a slight comparative disadvantage of 0.99 in 2015, from 1.23 in 2005.

Figure 27: NRCA Annualized 2005-2015 Growth Rate

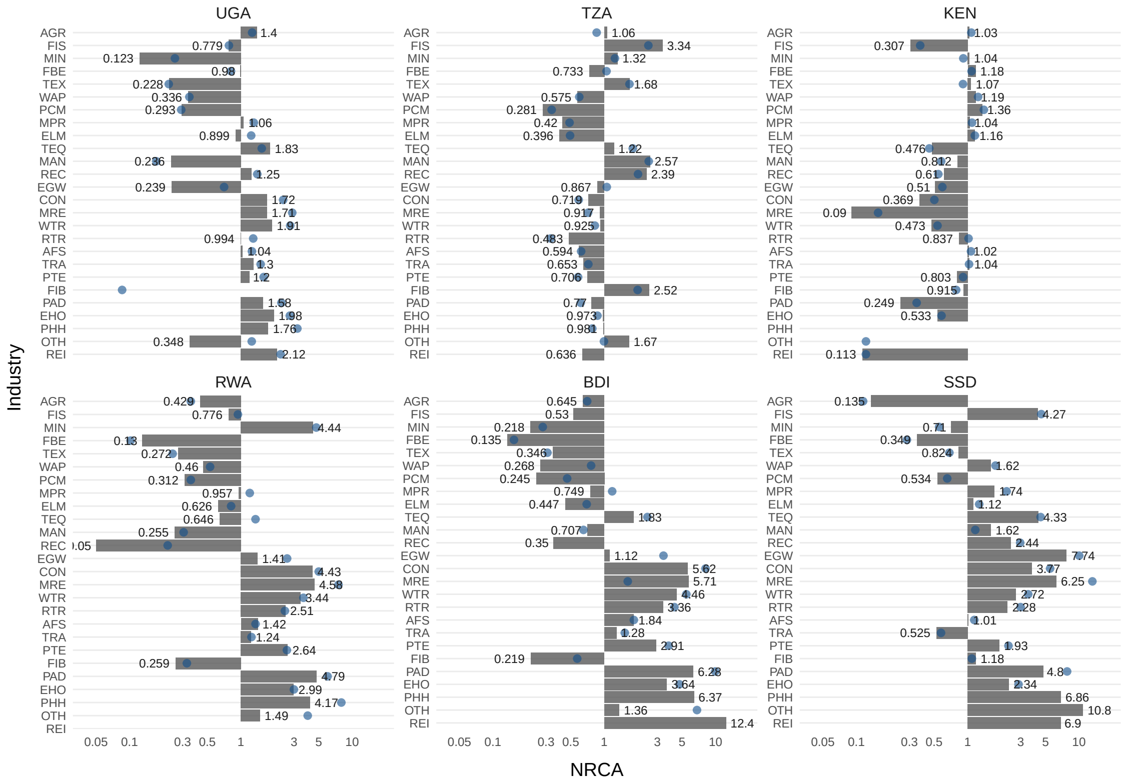


4.6.1 NRCA Relative to the EAC

Figures 26 and 27 have shown that relative to the rest of the world EAC members exhibit similar patterns of comparative advantage with a general advantage in agriculture and disadvantage in manufacturing. This could be constitutive to forming a common trade block with the rest of the world, supported by a currency union as is currently planned for 2024/25. Nevertheless comparing the EAC with the rest of the world may mask rivalries and shifts in comparative advantage between member countries. A final exercise in this section of the paper is thus to compute comparative advantage relative to the EAC as the share of a sector in country VA exports to the share of the sector in EAC VA exports. Figure 28 shows the results, where in addition to the bars for the year 2015, I have added a blue dot giving the 2005 value - to avoid having to draw two charts while still enabling a comparison over time as well.

It is evident from Figure 28 that relative to other EAC members Uganda has a comparative advantage in agriculture, Tanzania has a comparative advantage in fishing, Rwanda has a comparative advantage in mining, and Kenya has a comparative advantage in core manufacturing sectors such as wood and paper, petro-chemicals, metal products and electrical machinery. In addition, it appears that Rwanda and Burundi, and to a weaker extent Uganda, have a comparative advantage in construction, maintenance and repairs, wholesale and retail trade, whereas Tanzania appears to have a comparative advantage in other manufacturing, recycling, and financial and business services. Other sectors are more heterogeneous between countries and sectors. The afore mentioned comparative advantage relations appear to be stable since 2005, without major shifts within or across sectors between 2005 and 2015.

Figure 28: NRCA Relative to EAC

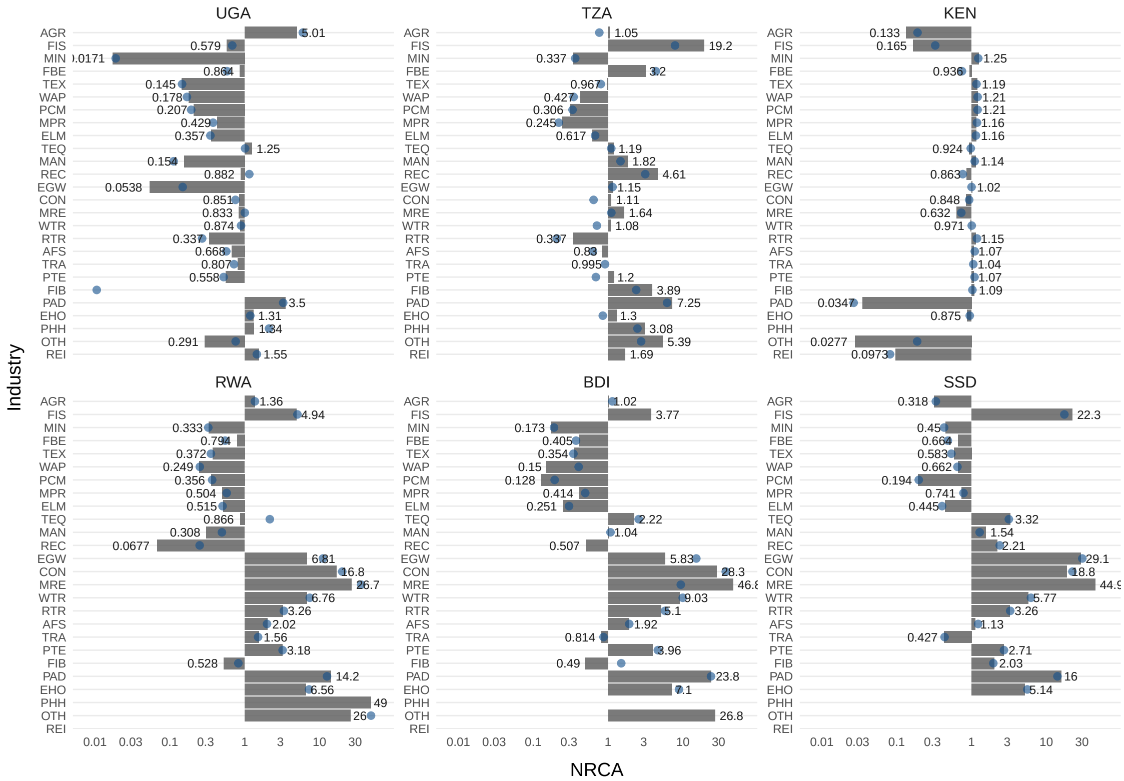


4.6.2 NRCA in Inner-EAC Trade

A final exercise that can be conducted around revealed comparative advantage in the EAC, is to compute NRCA only considering EAC trade with the EAC, and thus disregarding any trade flows between the EAC and the rest of the World. This can be useful to consider the evolution of trade relationships within the EAC itself, rather than questions of how the EAC as heterogenous trade block might engage with the rest of the World.

The results are shown in Figure 29, and are surprisingly similar to Figure 28. When considering only trade within the EAC, Uganda's comparative advantage in Agriculture and Tanzania's comparative advantage in fishing, recycling and financial and business services, as well as Rwanda's and Burundi's comparative advantage in construction, maintenance and repairs, wholesale and retail trade become more pronounced, whereas Kenya maintains a comparative advantage in core manufacturing sectors. An visible difference to Figure 28 is that Rwanda's comparative advantage in mining has disappeared and turned into a comparative disadvantage, indicating that the majority of Rwandese mining exports are to the outside World.

Figure 29: NRCA for Inner-EAC Trade



5 GVC's and Industrial Development in the EAC

Several papers have been written focussing on the global links between GVC integration and industrial development. As one of the first Kummritz (2016) assessed the role of GVCs for labour productivity and domestic value added using a novel IV strategy. He showed that an increase in GVC participation leads to higher domestic value added and productivity for all countries independent of their income levels. His results imply that a 1 percent increase in backward GVC participation leads to 0.11% higher domestic value added in the average industry, and a 1 percent increase in forward GVC participation leads to 0.60% higher domestic value added and to 0.33% higher labour productivity (Kummritz, 2016).

The literature duscussed by Kummritz (2016) outlines several channels through which GVC participation increases the value added and productivity of its participants. The main channels are learning-by-doing, technology transfer or spillovers, gains from specialization and as terms of trade effects (Kummritz, 2016). He concludes that whether GVC integration provides net benefits for a particular country or sector is theoretically ambiguous.

Foster-McGregor et al. (2015) discusses industrial development in Africa through GVC's in the context of upgrading,

Four types of upgrading are often distinguished (Humphrey, 2004), the four types being: (i) process upgrading, which involves increased productivity in existing activities within a GVC; (ii) product upgrading, which is the movement into higher value-added products within a GVC; (iii) functional upgrading, which involves the movement into more technologically sophisticated or more integrated aspects of a production process; and (iv) inter-sectoral or chain upgrading, which involves a movement into higher value-added supply chains. The.

In theri analysis In our analysis Foster-McGregor et al. (2015) construct three alternative indicators, intended to capture one or more aspects of upgrading within GVCs.

-> They compare export unit values to export market shares The use trade data aggregated to EORA Sectors.

.

Compute Herfindahl Index of Value added exports and see how it varies with GVC involvement (Sum of VS and VS1 like in GVC in Africa Paper). Also compute oher upgrading and export difersification indicators. Take total GVC Involvement measure as in paper VS + VS1.

Combine GVC with your ES Analysis and look at innovtion measures.

5.1 GVC Integration and Growth

A first natural idea would be to see if higher imported content in exports is associated with higher domestic value added produced and exported. This is examined using a simple specification regressing the log of VA on the imported content share (I2E) and the re-exported content share (E2R). The specification is

$$log(VA_{cst}) = \sum_{i=0}^{p} \beta_{1i} I2E_{cs,t-i} + \sum_{i=0}^{p} \beta_{2i} E2R_{cs,t-i} + \alpha_{cs} + \beta_{ct} + \gamma_{st} + \epsilon_{cst}, \tag{18}$$

where p is a suitable number of lags to include in the regression to allow changes in production (in particular I2E) to feed into greater productivity with a lag. In the most general setting we can control for 3 sets of unobservable effects: country-sector effects, country-year effects and sector-year effects. There is also the possibility to estimate a first-difference estimator which is more efficient if the autocorrelation in the error term is > 0.5[9]

$$\Delta log(VA_{cst}) = \sum_{i=0}^{p} \beta_{1i} \Delta I2E_{cs,t-i} + \sum_{i=0}^{p} \beta_{2i} \Delta E2R_{cs,t-i} + \Delta\beta_{ct} + \Delta\gamma_{st} + \Delta\epsilon_{cst}. \tag{19}$$

For this regression I use data for Uganda, Tanzania, Kenya, Rwanda and Burundi, South Sudan was Excluded due to unreliable data. From the data for these countries I further remove sectors where $I2E$ or $E2R$ are greater or smaller than 1. This should usually not be the case but is the case in recycling and re-import/export sectors in Rwanda, Tanzania and Burundi, in the financial intermediation and business sectors in Burundi, Rwanda and Uganda, and in Kenyan and Ugandan electricity gas and water. This is likely due to both bad data quality and very unusual economic activity in these sectors. For the estimation these four sectors (REC, REI, FIB, EGW in Table 2) are removed from the sample. Other sectors which have a too high re-export ratio and are removed from the sample are are Kenyan private housholds and Kenyan others (PHH and OTH). Summary statistics for the excluded sectors are shown in Table 5.

Table 5: Excluded Sectors

GVC Measure	Sector	N	Mean	SD	Min	Max
I2E	EGW	55	0.143	0.055	0.063	0.248
I2E	FIB	55	0.059	0.024	0.027	0.110
I2E	REC	55	0.435	0.258	0.173	1.018
I2E	REI	55	0.821	0.384	0.352	1.787
I2E	OTH (KEN)	11	0.097	0.010	0.088	0.113
I2E	PHH (KEN)	11	0.097	0.010	0.088	0.113
E2R	EGW	55	0.750	0.539	0.158	1.828
E2R	FIB	55	4.603	5.225	0.294	19.275
E2R	REC	55	0.027	0.058	-0.108	0.137
E2R	REI	55	0.028	0.100	-0.223	0.138
E2R	OTH (KEN)	11	15.076	3.473	8.201	21.512
E2R	PHH (KEN)	11	15.076	3.473	8.201	21.512

I end up with a balanced panel of $N = 1188$ observations in $CS = 108$ country-sectors and $T = 11$ time periods. Summary statistics are shown in Table 6, where I also added a the domestic

[9] In particular, if $\epsilon_{cst} = \rho\epsilon_{cs,t-1} + u_{cst}$, then $var(\epsilon_{cst}) = \rho^2\sigma_\epsilon^2 + \sigma_u^2$ but for the first-differenced model $var(\Delta\epsilon_{cst}) = var(\epsilon_{cst} - \epsilon_{cs,t-1}) = var(\rho\epsilon_{cs,t-1} + u_{cst} - \epsilon_{cs,t-1}) = (\rho-1)^2\sigma_\epsilon^2 + \sigma_u^2$. So the FD estimator is more efficient if $(\rho-1)^2 < \rho^2$ or if $\rho > 0.5$.

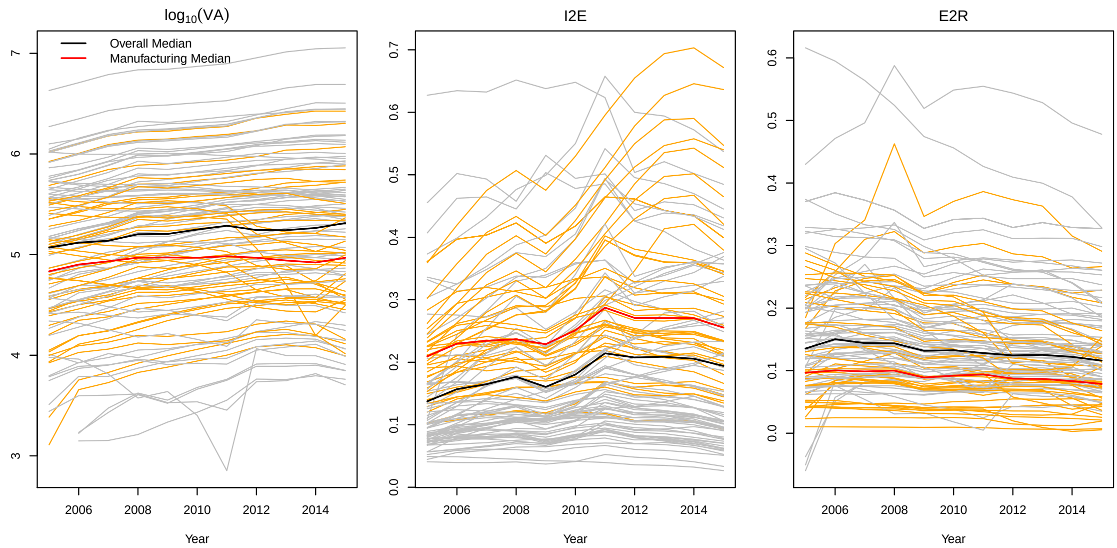
content in exports computed as $DVA_{EX} = EX \times (1 - I2E)$ where EX is a country-sectors gross exports.

Table 6: Summary Statistics of Variables

Variable	Trans.	N/T	Mean	SD	Min	Max
VA	Overall	1,188	463,749	964,556	-1,501	11,335,675
VA	Between	108	463,749	925,229	3,247	7,854,686
VA	Within	11	463,749	285,538	-3,120,453	3,944,737
DVA_{EX}	Overall	1,188	59,562	170,744	382	1,727,299
DVA_{EX}	Between	108	59,562	168,811	627	1,474,635
DVA_{EX}	Within	11	59,562	29,941	-416,992	312,225
I2E	Overall	1,188	0.2123	0.1314	0.0266	0.7032
I2E	Between	108	0.2123	0.1250	0.0402	0.5879
I2E	Within	11	0.2123	0.0421	0.0131	0.3713
E2R	Overall	1,188	0.1514	0.0947	-0.0598	0.6161
E2R	Between	108	0.1514	0.0920	0.0086	0.5139
E2R	Within	11	0.1514	0.0240	-0.0037	0.2973

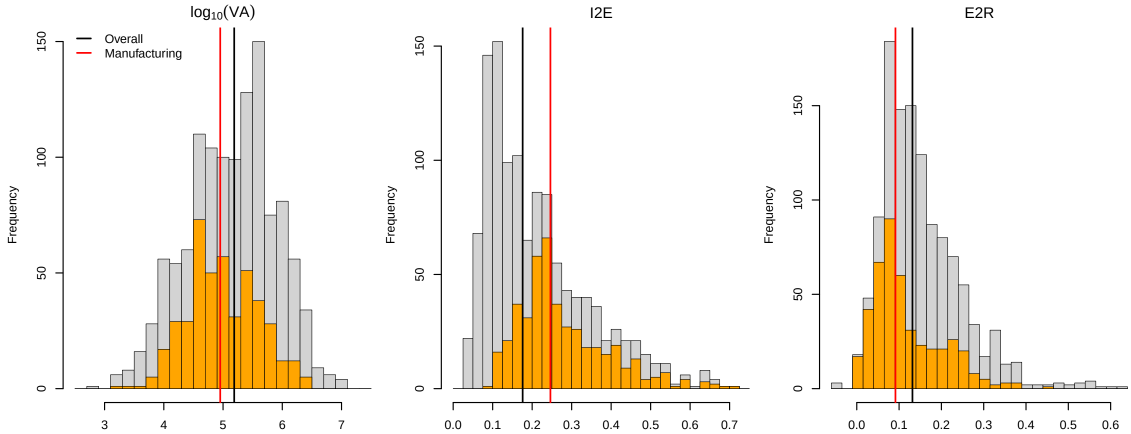
To further expose the manufacturing sectors in these countries whose productivity is likely most affected by changing integration in GVCs, I also run regressions for a subsample of manufacturing sectors (FBE, TEX, WAP, PCM, MPR, ELM, TEQ, MAN) in Table 2. To better understand the data and the manufacturing subsample of sectors, Figure 30 visualizes the data, where each orange line is a manufacturing sector in some EAC country, grey lines are other sectors, the red line represents the median value across all manufacturing sectors in a given year and the black line is the median across all sectors.

Figure 30: Time Series of Variables



It is evident from Figure 30 that manufacturing sectors have a lower than average VA, a higher I2E share, and a lower E2R share, indicating that these sectors import more inputs that other economic sectors but export more final goods. The trend line is broadly parallel to the overall trend, but in the VA chart it appears that manufacturing sectors grew slower than the average. For a final step of visual investigation, 31 shows histograms conveying the same information as Figure 30. They show that in terms of VA manufacturing is a bit lower but well-centered in the distribution. In terms of I2E manufacturing sectors make up the bulk of the upper part of the distrubution, but still form an acceptable distribution themselves. For E2R the opposite is the case, and one could have concern that the distribution is a bit strongly skewed to the right.

Figure 31: Histograms of Variables



Now regarding the specification in Eq. 19, I first select the appropriate lag length by running the regression with fixed effects and first-differences and examining up to which order lags of I2E and E2R affect value added. Together with some judgement I opt for $p = 2$, which is a sensible choice as it might take up to 2 years for an innovation or change in supply chain to fully dissipate to output and productivity. Then, to determine whether the specification given in Eq. 19 is appropriate, I run a series of Hausman tests, including 2 lags of I2E and E2R on the regression. The first test evaluated the consistency of the random effects estimator against the the simple fixed effects estimator with country-sector fixed effects, using the original χ^2 distributed quadratic form proposed by Hausman (1978). It rejects the null of random effects consistency $\chi^2_6 = 73.05$, $P < 0.01$. Then, I demean the data by country-sector and run a second Hausman test with country-year fixed effects. This test also rejects $\chi^2_6 = 53.4$, $P < 0.01$. Finally, I iteratively demean the data by country-sector and country-year until convergence and run a third Hausman test against sector-year fixed effects. This test also rejects $\chi^2_6 = 48.55$, $P < 0.01$, but a robust version of the test based on an auxiliary regression as specified in Wooldridge (2010)[10] fails to reject the null $\chi^2_6 = 9.37$, $P = 0.15$. I nevertheless keep the sector-year fixed effects in the model, as the coefficient is practically identical to the one without them, and keeping them reduces a bit the serial correlation in the error term.

Serial correlation in the error term, $\epsilon_{cst} = \rho\epsilon_{cs,t-1} + u_{cst}$ for $\rho > 0$ might obscure conducting inference on the model and render the first-difference estimator more efficient. In practice it is difficult to determine the value of ρ, given that the are errors in the fixed effects model are unobservable[11], but I use $\hat{\epsilon}_{cst}$ to obtain a crude estimate using OLS. After estimating Eq. 19 with the full set of fixed effects, I estimate $\hat{\rho}_{FE} = 0.53$, $P < 0.01$[12]. A formal panel-test based on the residuals of the first-differenced model also rejects the null of no serial correlation in the error term $\hat{\rho}_{FD} = -0.011$, $P = 0.77$ and $P[\hat{\rho}_{FD} \neq -0.5] =< 0.01$[13]. First-differencing in itself does not remove terms $\Delta\beta_{ct}$ and $\Delta\gamma_{st}$, corresponding to unobserved country-year or sector-year specific shocks from the equation, which may also be correlated with the explanatory variables and bias the coefficient estimates in the FD-equation. Running Hausman tests for the presence of these effects in the first-difference equation yields inconclusive results, the outcome depends on the method used to run the Hausman test. There is also a danger that putting fixed effects on a first-differenced equation estimated on data of not very high quality removes too much useful information.

[10] This test is based on an auxiliary specification $\tilde{y}_{it} = \tilde{X}_{it}\beta + \dot{X}_{it}\gamma + \epsilon_{it}$ that can be estimated with robust standard errors, where $\tilde{y}_{it}$ and $\tilde{X}_{it}\beta$ are the quasi-demeaned data for RE estimation and $\dot{X}_{it}$ are the time-demeaned predictors capturing the individual-variation in X. The test is an F-test of the exclusion restriction of $\dot{X}_{it}$. If the test rejects, RE is likely inconsistent. See Wooldridge (2010) sec. 10.7.3.

[11] $\hat{\epsilon}_{cst}$ is not a clean estimate of ϵ_{cst}, but an estimate of the multiply-centered version of ϵ_{cst}.

[12] Wooldridge (2010) sec. 10.5.4 observes, under the null of no serial correlation in the errors, the residuals of a FE model must be negatively serially correlated, with $cor(\hat{u}_{it}, \hat{u}_{is}) = -1/(T-1) = -0.1$ with $T = 11$ in this case.

[13] This is the case because, for each $t > 1$, $var(\Delta u_{it}) = var(u_{it} - u_{i,t-1}) = var(u_{it}) + var(u_{i,t-1}) = 2\sigma^2$ with the assumptions of no serial correlation in u_t and constant variance. Because the residual has a zero mean and symmetric ACF, the covariance is $E[\Delta u_{it} \cdot \Delta u_{i,t+1}] = E[(u_{it} - u_{i,t-1})(u_{i,t+1} - u_{it})] = E[u_{it}u_{i,t+1}] - E[u_{it}^2] - E[u_{i,t-1}u_{i,t+1}] + E[u_{i,t-1}u_{it}] = -E[u_{it}^2] = -\sigma^2$, because of the no serial correlation assumption. Because the variance is constant across t, $cor(\Delta u_{it}, \Delta u_{i,t-1}) = cov(\Delta u_{it}, \Delta u_{i,t+1})/var(\Delta u_{it}) = -\sigma^2/2\sigma^2 = -0.5$.

The approach I will adopt following this discussion is to estimate 3 models: The simple FD specification, the FD specification with country-year and sector-year FE, and a FE specification with the full set of fixed-effects. Table 7 shows the results. These models are estimated in log-level form as specified in Eq. 19. To the right of these specifications, Table 7 also shows equivalent log-log / elasticity estimates where the log is also taken of the RHS variables.

The coefficients from all specifications show a negative contemporaneous relationship between VA and I2E. This is probably a quite mechanical result by the nature of the close relation between VA and I2E being the foreign content share of VA. A domestic shock of any form may cause VA to increase/decrease and the imported share to fall/rise in the current period. It is therefore more interesting to examine the lagged relation of I2E and VA. Here the coefficients of the preferred FD specification signify a significant positive effect. The coefficients imply that a 0.01 unit increase in I2E is associated with a 0.7% increase in VA after one year. The elasticity specification yields that a 1% increase in I2E is associated with a 0.19% increase in VA after one year. There is also a further effect after two years which is about half of the first year effect. The total effect of a 0.01 unit / 1% increase in I2E after 2 years is thus a 1.16% / 0.3% increase in VA, as taken from the FD specifications. The FD-TFE and FE specifications do not pick up an effect after one year but a larger effect of comparable magnitude after 2 years. As noted because of significant serial correlation FD are more efficient here, but both estimators are consistent. The FE elasticity specification yields small and insignificant coefficients.

Table 7: VALUE ADDED REGRESSIONS

Model:	FD (1)	FD-TFE (2)	FE (3)	FD E (4)	FD-TFE E (5)	FE E (6)
(Intercept)	0.0718***			0.0725***		
	(0.0044)			(0.0028)		
I2E	-2.425***	-6.839***	-6.34***	-0.1314***	-0.6563***	-0.4517***
	(0.7864)	(1.682)	(1.166)	(0.0443)	(0.1155)	(0.1053)
L1.I2E	0.7023	-0.0509	-0.4972	0.1923***	0.1229*	0.0148
	(0.5121)	(0.6959)	(1.207)	(0.0203)	(0.0673)	(0.1175)
L2.I2E	0.4633**	1.318*	1.691**	0.1032***	0.0677**	0.0237
	(0.2330)	(0.7502)	(0.6582)	(0.0213)	(0.0278)	(0.0537)
E2R	4.983***	1.779***	1.894***	1.021***	0.9252***	0.9537***
	(1.303)	(0.6449)	(0.6191)	(0.0189)	(0.0395)	(0.0365)
L1.E2R	1.179***	0.0801	-0.1841	0.0419	-0.0263	-0.0082
	(0.3184)	(0.3969)	(0.3258)	(0.0347)	(0.0220)	(0.0455)
L2.E2R	0.2633	-0.0035	-0.6123*	0.0588**	-0.0156	-0.0869**
	(0.2915)	(0.2656)	(0.3061)	(0.0227)	(0.0179)	(0.0352)
Fixed-Effects:						
cs (N)	–	–	108	–	–	108
cy (N)	–	40	45	–	40	45
sy (N)	–	176	198	–	176	198
Cluster SE	cs	cs cy sy	cs cy sy	cs	cs cy sy	cs cy sy
Observations	864	864	972	861	861	969
R^2	0.328	0.735	0.997	0.823	0.974	0.999
Within R^2		0.445	0.473		0.946	0.910

Note: *p<0.1; **p<0.05; ***p<0.01

For E2R, results also imply a large contemporaneous relationship with VA with an elasticity around 1. Also in this case caution needs to be exerted towards interpreting this as a structural shift in production, it could be for example that supply chain shocks contemporaneously lead all participating countries to export more and thus trigger an increase in both VA and E2R. However the contemporaneous relationship between VA and the E2R is less obvious than the relationship between VA and I2E. The lagged coefficients on E2R for the FD equation are not as robust between the log-level and the log-log specification as for I2E, and the FE coefficients are negative and largely insignificant. Combining the effects of the two lags on the FD coefficients imply that a 0.01 unit / 1% increase in E2R yields a 1.44% / 0.11% increase in VA within 3 years time. It should be noted here that there are some significant outliers affecting especially the log-level regressions. The omission of these does not dramatically change the conclusion of the analysis but can shift the relative magnitude of coefficients on the lagged values a bit. For example excluding the 6 most influential data points in the first FD specification yields significant coefficients 0.91 and 0.61 on L1.E2R and L2.E2R, respectively, which are more in line with the decay pattern observed for I2E.

To examine the effects of outliers on the coefficients in a more comprehensive manor, the regressions are re-estimated by a robust MM estimation method following Yohai (1987) and Koller & Stahel (2011), that downweights outliers and high-leverage data points using a highly efficient Iteratively Reweighted Least Squares (IRLS) procedure with 50% breakdown point and 95% asymptotic efficiency for normal errors[14]. The robust coefficient estimates are reported in Table 8.

Table 8: VALUE ADDED REGRESSIONS: ROBUST MM ESTIMATES

Model:	FD (1)	FD-TFE (2)	FE (3)	FD E (4)	FD-TFE E (5)	FE E (6)
I2E	-1.0776^{***} (0.2114)	-3.9504^{***} (0.2742)	-4.9836^{***} (0.3027)	-0.0973	-0.6367^{***} (0.0549)	-0.5007^{***} (0.0673)
L1.I2E	0.5139^{***} (0.1594)	0.4860^{***} (0.1617)	0.2969 (0.3397)	0.1549	0.1086^{**} (0.0488)	-0.0826 (0.0718)
L2.I2E	0.3990^{***} (0.1372)	0.1665 (0.1685)	0.8143^{***} (0.2270)	0.1220	0.0103 (0.0278)	0.0181 (0.0326)
E2R	4.7265^{***} (0.5046)	1.0287^{***} (0.3114)	1.4117^{***} (0.2803)	1.0534	0.9158^{***} (0.0211)	0.9642^{***} (0.0163)
L1.E2R	0.9430^{***} (0.2799)	0.2522^{*} (0.1483)	-0.0355 (0.2181)	0.0790	-0.0166^{*} (0.0087)	-0.0467^{***} (0.0122)
L2.E2R	0.7037^{***} (0.2134)	-0.0534 (0.1385)	-0.4540^{***} (0.1300)	0.0519	-0.0088 (0.0066)	-0.0541^{***} (0.0132)
Constant	0.0708^{***} (0.0032)	0.0010 (0.0012)	-0.0004 (0.0012)	0.0696	0.0003 (0.0007)	-0.0002 (0.0009)
Fixed-Effects:						
cs (N)	–	–	108	–	–	108
cy (N)	–	40	45	–	40	45
sy (N)	–	176	198	–	176	198
SE	HAC	HAC	HAC	HAC	HAC	HAC
Observations	864	864	972	861	861	969
R^2	0.413	0.562	0.723	0.868	0.946	0.937
Adjusted R^2	0.409	0.560	0.721	0.867	0.946	0.937
Residual SE	0.070	0.030	0.035	0.055	0.200	0.027
IRLS Coverged	Yes	Yes	Yes	No	Yes	Yes

Note: *p<0.1; **p<0.05; ***p<0.01

In comparison to the OLS estimates in Table 7, the coefficients in Table 8 spread the effect more evenly across the lags in the FD specification, and also let the FD specification with time fixed-effects move closer to the plain FD specification. It should also be noted here that multicollinearity between the various lagged values is low, at a maximum VIF of 1.3 in all models. interpret furteher?

[14] Estimation is done by a robust MM proceudure using IRLS with a bi-square redescending score function, resulting in a highly robust and highly efficient estimator (with 50% breakdown point and 95% asymptotic efficiency for normal errors), Implemented in the R package *robustbase* (Rousseeuw et al., 2020).

Tables 9 and 10 reports equivalent regressions run for the manufacturing sub-sample of sectors.

Table 9: Value Added Regressions: Manufacturing

Model:	FD (1)	FD-TFE (2)	FE (3)	FD E (4)	FD-TFE E (5)	FE E (6)
(Intercept)	0.0678***			0.0752***		
	(0.0088)			(0.0038)		
I2E	-1.488**	-5.526***	-5.952**	-0.1546*	-0.8395***	-0.6364**
	(0.5558)	(1.892)	(2.449)	(0.0901)	(0.2898)	(0.2812)
L1.I2E	-0.9133	-3.216	-5.472	0.1360***	-0.3627**	-0.6820***
	(0.5808)	(3.368)	(5.684)	(0.0337)	(0.1647)	(0.1900)
L2.I2E	0.5380**	2.48	6.195	0.1782***	0.3872	0.4091*
	(0.2403)	(1.625)	(4.257)	(0.0506)	(0.2602)	(0.2211)
E2R	3.99**	0.4527	1.434	0.9845***	0.8140***	0.8362***
	(1.479)	(0.4625)	(1.001)	(0.0505)	(0.0867)	(0.0643)
L1.E2R	2.446***	-0.2512	-0.8829	0.2056**	0.0725	0.1013
	(0.4453)	(0.4383)	(0.9402)	(0.0771)	(0.0519)	(0.0837)
L2.E2R	0.2386	-0.3984	-0.8486	0.0417	-0.0192	-0.1399
	(0.2851)	(0.3696)	(0.5726)	(0.0337)	(0.0230)	(0.0908)
Fixed-Effects:						
cs (N)	–	–	40	–	–	40
cy (N)	–	40	45	–	40	45
sy (N)	–	64	72	–	64	72
Cluster SE	cs	cs cy sy	cs cy sy	cs	cs cy sy	cs cy sy
Observations	320	320	360	320	320	360
R^2	0.390	0.837	0.995	0.813	0.978	0.999
Within R^2		0.173	0.178		0.892	0.925
Note:				*p<0.1; **p<0.05; ***p<0.01		

The results from the log-log specification are broadly in line with the equivalent regression in Table 7 indicating a negative contemporaneous effect of I2E but a cumulative lagged elasticity of 0.3. For E2R, the cumulative lagged elasticity is 0.25, which is about twice as large as the 0.11 measured in Table 7. The log-level specification shows a sizeable effect of 2.45 on L1.E2R than is 2 times larger than the effect measured in Table 7. However the log-level specification is again affected by outliers much more than the log-log specification. Removing the 6 most influential observations lets the coefficient on L1.I2E shrink to -0.22 and remain insignificant at the 10% level, and the coefficient on L1.E2R decreases to 1.96 while the coefficient on L2.E2R increases to 0.64. The fixed effects specifications largely show insignificant lagged effects and again suffer from strong serial correlation. The robust estimates in Table 10 again distributes the effect more evenly among the lagged coefficients in the FD specification. The robust FD-elasticity specification confirms a combined elasticity of around 0.3 on both lagged values of I2E and E2R. The robust FD specification with time-fixed effects and the FE specifications report mostly insignificant and negative coefficients. This could be interpreted as evidence that the true effect is negative or zero, but in this case, given that the necessity of time-fixed effects in the FD specification could not be conclusively established, I would favor an interpretation holding that additional fixed effects just remove too much useful information from already low-quality data, and the negative coefficients may also be caused by attenuation bias from measurement error in the noisy data that remains after removing all cross-sectional variation and time series variation at the country and sector level.

Table 10: Value Added Regressions: Manufacturing: Robust MM Estimates

Model:	FD (1)	FD-TFE (2)	FE (3)	FD E (4)	FD-TFE E (5)	FE E (6)
I2E	-0.5524	-2.4579^{***}	-5.9545^{***}	-0.0545	-0.8511^{***}	-0.7222^{***}
	(0.3610)	(0.5795)	(1.1946)	(0.0678)	(0.1373)	(0.1886)
L1.I2E	0.1088	0.3573	0.8177	0.1185^{***}	-0.2472^{**}	-0.4732^{*}
	(0.2573)	(0.6005)	(1.1756)	(0.0455)	(0.1249)	(0.2638)
L2.I2E	0.4730^{**}	0.8345^{**}	1.4843^{**}	0.1592^{***}	0.2535^{*}	0.1105
	(0.2377)	(0.4161)	(0.7338)	(0.0458)	(0.1404)	(0.1833)
E2R	6.2433^{***}	0.1768	0.8435^{**}	0.9901^{***}	0.8081^{***}	0.8488^{***}
	(0.5826)	(0.1489)	(0.3522)	(0.0465)	(0.0452)	(0.0543)
L1.E2R	1.6521^{***}	-0.0723	-0.2776	0.2336^{***}	0.0246	0.0897
	(0.3461)	(0.1590)	(0.4348)	(0.0441)	(0.0215)	(0.0711)
L2.E2R	0.8146^{***}	-0.1095	-0.5303^{*}	0.0731^{***}	-0.0168	-0.0802
	(0.2500)	(0.1171)	(0.3107)	(0.0210)	(0.0349)	(0.0920)
Constant	0.0718^{***}	-0.0038^{**}	-0.0040	0.0728^{***}	0.0006	-0.0002
	(0.0044)	(0.0015)	(0.0024)	(0.0038)	(0.0010)	(0.0013)
Fixed-Effects:						
cs (N)	–	–	108	–	–	108
cy (N)	–	40	45	–	40	45
sy (N)	–	176	198	–	176	198
SE	HAC	HAC	HAC	HAC	HAC	HAC
Observations	320	320	360	320	320	360
R^2	0.541	0.136	0.299	0.871	0.907	0.956
Adjusted R^2	0.532	0.119	0.287	0.869	0.905	0.955
Residual SE	0.066	0.024	0.039	0.049	0.016	0.021
IRLS Coverged	Yes	Yes	Yes	Yes	Yes	Yes

Note: *p<0.1; **p<0.05; ***p<0.01

In summary, Tables 9 and 10 present similar results than Tables 7 and 8. The elasticity of VA to I2E within two years time is around 0.3 for both the manufacturing sectors and all other sectors taken together, suggesting a gain from foreign technology in production. When looking at forward GVC integration (E2R), all sectors together have an cumulative growth elasticity of around $0.11 - 0.15$, but the manufacturing sectors have an elasticity of $0.25 - 0.3$, which is more than twice as large. Thus manufacturing sectors in the EAC benefit equally from backward and forward GVC integration, whereas other sectors benefit mostly from backward GVC integration. This is a very sensible result, as for example increased forward integration in primary products like agriculture or mining is not necessarily associated with domestic productivity gains, but if manufactured exports feed into a value chain to be re-exported, they likely have to be of sufficient quality.

Also report estimations using DVA in Exports?. If not also remove the summary statistics.

5.2 GVC Integration and the Composition of Value Added

Since ICIO tables also provide a breakdown of VA, into compensation of employees ($\approx$ wages and salaries), taxes on production, subsidies on production, net operating surplus ($\approx$ profits), net mixed income and consumption of fixed capital, another investigation at the sector level could be to examine whether increased GVC integration makes companies more profitable or workers receive higher wages. I therefore use the share of compensation of employees (COE) and net operating surplus (NOS) in total VA to estimate a specification of the form

$$\Delta Y_{cst} = \sum_{i=0}^{p} \beta_{1i} \Delta I2E_{cs,t-i} + \sum_{i=0}^{p} \beta_{2i} \Delta E2R_{cs,t-i} + u_{cst}, \tag{20}$$

where $Y_{cst} \in COE_{cst},\ NOS_{cst}$ expressed as a share of VA. The first-difference specification is again preferred over fixed-effects because of strong serial correlation in the error term. Lag order $p = 2$ also carries through from the VA estimations. Eq. 20 can be also be estimated in log-log form, which will also be reported to obtain coefficients that can be interpreted as elasticities, and to make the estimation more robust to the presence of outliers.

Usually, all VA component shares apart from subsidies, which enter with a negative sign, should be between 0 and 1. It is however possible, in the presence of massive subsidies, to have COE and NOS shares greater than 1, or even negative COE and GOS shares if subsidies are so large to turn VA negative. In the sample of $N = 1188$ used to run VA regressions in the previous section, there are 17 cases where $\text{COE}_{Share} < 0$, $\text{COE}_{Share} > 1$, $\text{NOS}_{Share} < 0$ or $\text{NOS}_{Share} > 1$. These cases are shown in Table 11. Curiously all such cases occurred in Tanzania in the years 2012 and onwards. The range of extreme NOS shares is larger than that of COE shares, but overall remains between -0.83 and 3.48, which are possible values given the effect of massive subsidies in shrinking the value-added of a sector. Thus these cases will not be removed from the estimation sample, but their influence on the coefficients is carefully examined.

Table 11: CASES WHERE $COE_{Share} < 0 \mid > 1$ OR $NOS_{Share} < 0 \mid > 1$

Year	Country	Sector	VA_{SUM}	SUB	COE_{Share}	NOS_{Share}
2012	TZA	FBE	102,862	-57,004	0.2566	1.1536
2013	TZA	FBE	32,737	-124,197	0.8806	3.4788
2014	TZA	ELM	-30,968	-50,479	-0.1451	-0.4052
2014	TZA	FBE	-82,780	-174,184	-0.1889	-0.8310
2014	TZA	MAN	7,066	-3,737	0.3185	1.0634
2014	TZA	MIN	28,618	-14,570	0.0578	1.2906
2014	TZA	PCM	73,113	-25,112	0.1658	1.0185
2014	TZA	TEQ	10,342	-8,250	0.3466	1.2392
2015	TZA	ELM	-54,832	-61,732	-0.0277	-0.0837
2015	TZA	FBE	-115,877	-205,176	-0.1245	-0.5948
2015	TZA	MAN	-3,165	-6,458	-0.1995	-0.7606
2015	TZA	MIN	33,475	-16,250	0.0507	1.2868
2015	TZA	MPR	10,079	-7,533	0.4336	1.1186
2015	TZA	MRE	2,610	-2,327	0.4625	1.3046
2015	TZA	PCM	47,769	-30,143	0.1842	1.2735
2015	TZA	TEQ	-6,623	-13,209	-0.1770	-0.7176
2015	TZA	TEX	3,346	-3,262	0.4001	1.4279

Table 12 shows summary statistics for the COE and NOS variables used in the estimation, both in levels (constant 2015 US$ at basic prices)and VA shares.

millions?

Table 12: SUMMARY STATISTICS OF COE AND NOS

Variable	Trans.	N/T	Mean	SD	Min	Max
COE	Overall	1,188	177,522	437,196	373	4,733,560
COE	Between	108	177,522	416,280	609	3,029,210
COE	Within	11	177,522	138,966	-1,229,228	1,881,872
NOS	Overall	1,188	176,514	436,585	146	5,836,330
NOS	Between	108	176,514	414,798	294	3,754,908
NOS	Within	11	176,514	141,418	-1,561,404	2,257,936
COE + NOS	Overall	1,188	354,037	823,338	1,001	10,569,890
COE + NOS	Between	108	354,037	782,059	2,020	6,784,118
COE + NOS	Within	11	354,037	267,251	-2,790,631	4,139,809
COE_{Share}	Overall	1,188	0.3990	0.1721	-0.1995	0.8806
COE_{Share}	Between	108	0.3990	0.1694	0.0297	0.7860
COE_{Share}	Within	11	0.3990	0.0344	0.0046	1.1327
NOS_{Share}	Overall	1,188	0.4187	0.2372	-0.8310	3.4788
NOS_{Share}	Between	108	0.4187	0.2002	0.1076	0.9253
NOS_{Share}	Within	11	0.4187	0.1286	-1.2080	3.1017
$COE + NOS_{Share}$	Overall	1,188	0.8177	0.1786	-1.0199	4.3595
$COE + NOS_{Share}$	Between	108	0.8177	0.0756	0.6537	1.0060
$COE + NOS_{Share}$	Within	11	0.8177	0.1619	-1.1449	4.2344

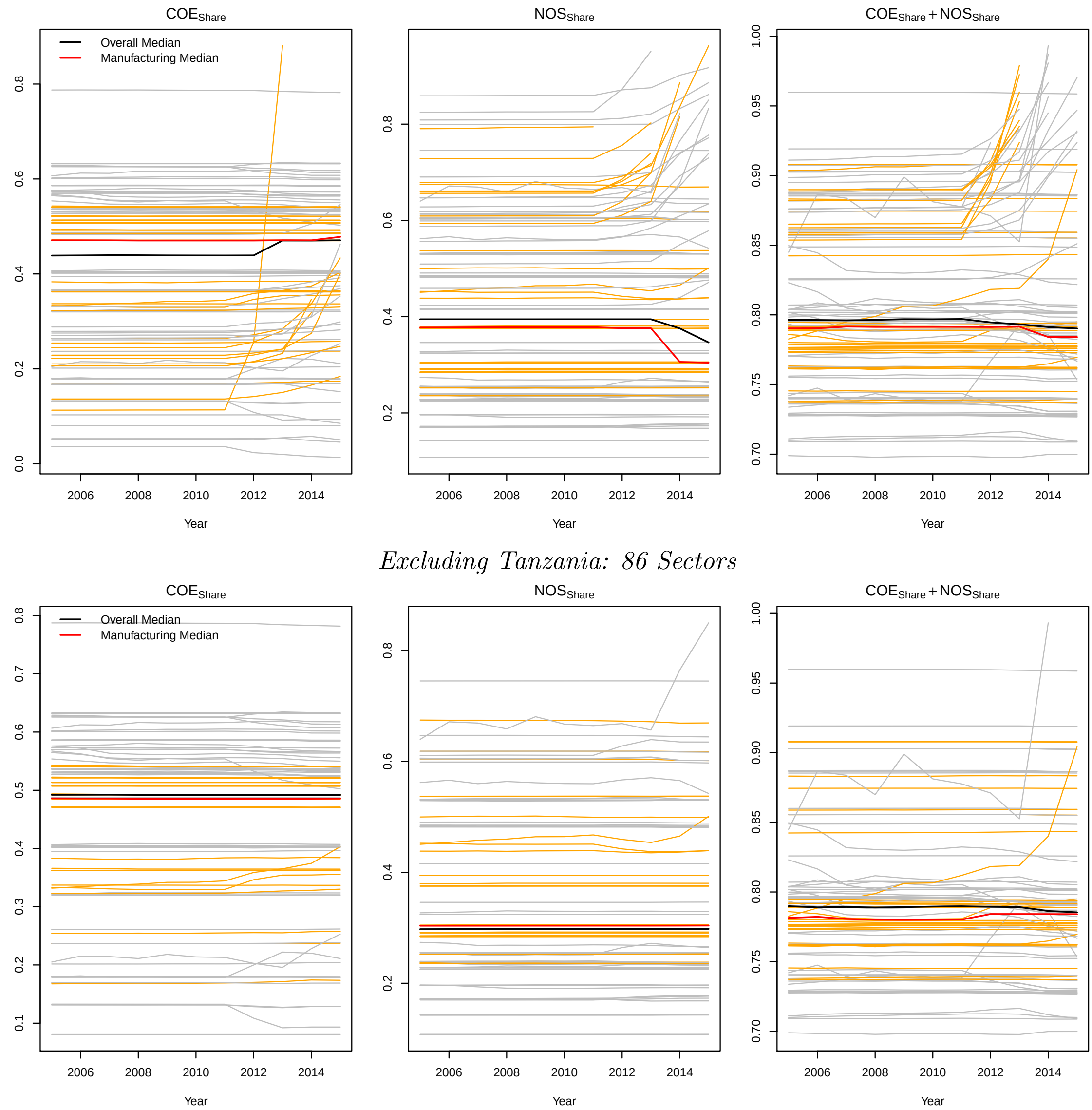
In addition to Table 12, Figure 32shows time series charts of the COE and NOS shares. It is evident that from 2012 onwards remarkable changes are taking place in a set of mostly Tanzanian sectors. Again concerns about data quality for Tanzania are paramout, and the lower part of Figure 32 excluding Tanzania shows much less anomalous behavior. The corresponding histograms in Figure 33 show that excluding Tanzania gets rid of some large values, particularly fro NOS, but does not change the distribution much.

Calculate median line properly using all sectors?

Figure 32: Time Series of COE and NOS Shares

Full Sample: 108 Sectors

Excluding Tanzania: 86 Sectors



Compared to Figure 31, the distributions shown in Figure 33 are also much less regular and all appear to be multi-modal.

Because of the insufficiencies of the data, special care is taken in these sections to ensure robustness of the results.

Figure 33: Histograms of COE and NOS Shares

Full Sample: 108 Sectors

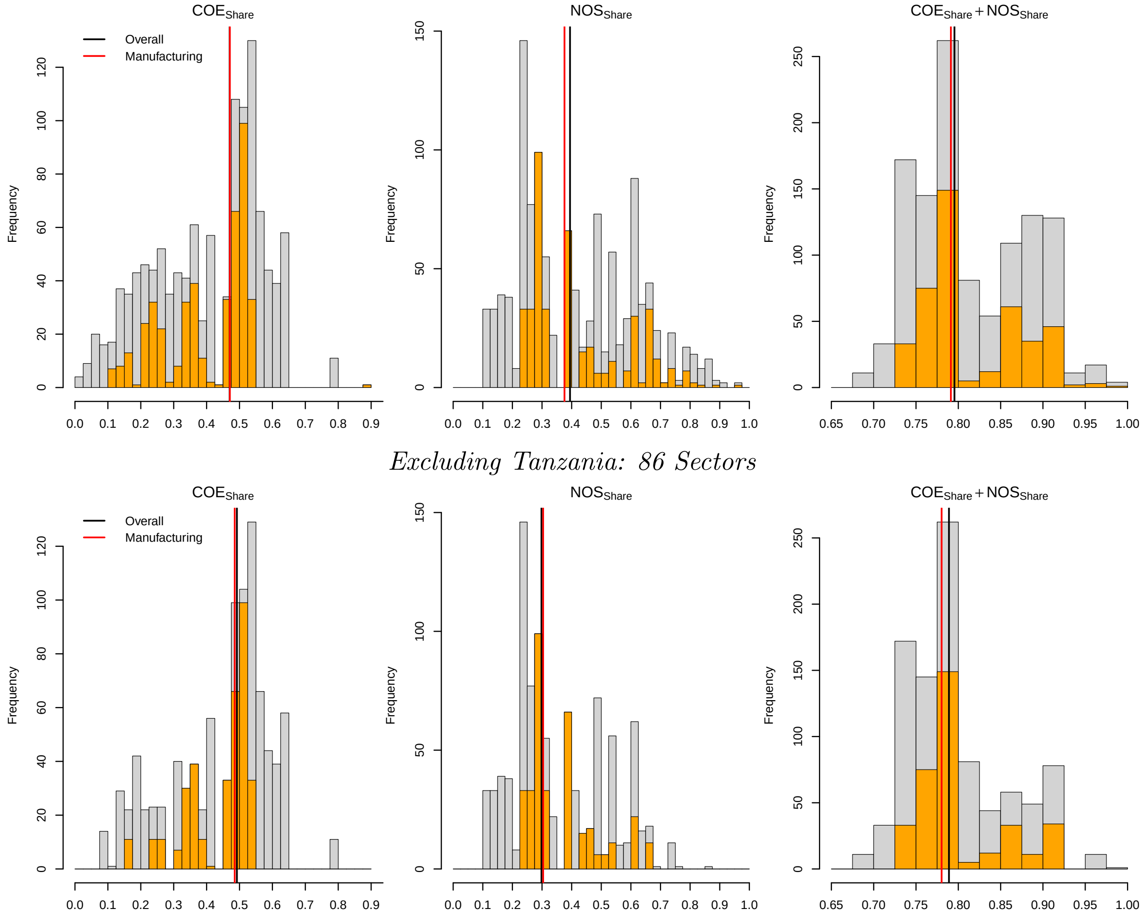


Table 13: Share-Share

	Dependent variable:								
	COE_S			NOS_S			COE_NOS_S		
	OLS	*robust linear*	*MM-type linear*	*OLS*	*robust linear*	*MM-type linear*	*OLS*	*robust linear*	*MM-type linear*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I2E	0.165**	0.002***	0.001***	0.561*	0.003***	0.001***	0.726*	0.005***	0.002***
	(0.082)	(0.0005)	(0.0003)	(0.312)	(0.0005)	(0.0002)	(0.394)	(0.001)	(0.0003)
L1.I2E	−0.090	0.001***	0.001**	−0.306	0.002***	0.0005*	−0.396	0.004***	0.001***
	(0.085)	(0.0005)	(0.0003)	(0.323)	(0.0005)	(0.0002)	(0.407)	(0.001)	(0.0004)
L2.I2E	−0.062	0.003***	0.001*	−0.173	0.004***	0.0004	−0.235	0.005***	0.001**
	(0.080)	(0.0004)	(0.0003)	(0.302)	(0.0005)	(0.0003)	(0.381)	(0.001)	(0.0004)
E2R	−0.015	−0.002***	−0.001**	0.010	−0.003***	−0.001***	−0.005	−0.005***	−0.002***
	(0.139)	(0.001)	(0.0005)	(0.525)	(0.001)	(0.0004)	(0.663)	(0.001)	(0.001)
L1.E2R	−0.055	−0.001	−0.0003	−0.184	0.0001	−0.0001	−0.239	−0.001	−0.001
	(0.135)	(0.001)	(0.0004)	(0.513)	(0.001)	(0.0004)	(0.647)	(0.001)	(0.001)
L2.E2R	0.115	−0.001**	−0.001	0.304	0.001	0.0002	0.420	−0.001	−0.001
	(0.107)	(0.001)	(0.0004)	(0.406)	(0.001)	(0.0003)	(0.512)	(0.001)	(0.0004)
Constant	−0.0001	−0.00004***	−0.00002***	0.001	−0.00000	0.00000	0.001	−0.0001***	−0.00004***
	(0.002)	(0.00001)	(0.00001)	(0.008)	(0.00001)	(0.00001)	(0.010)	(0.00002)	(0.00001)
Observations	864	864	864	864	864	864	864	864	864
R^2	0.008		0.048	0.006		0.051	0.006		0.116
Adjusted R^2	0.001		0.042	−0.001		0.044	−0.001		0.110
Residual Std. Error	0.053	0.0002	0.0002	0.199	0.0002	0.0001	0.251	0.0003	0.0002
F Statistic	1.170			0.835			0.902		

Note: *p<0.1; **p<0.05; ***p<0.01

Table 14: Log Share - Log Share

	Dependent variable:								
	COE_S			NOS_S			COE_NOS_S		
	OLS	*robust linear*	*MM-type linear*	*OLS*	*robust linear*	*MM-type linear*	*OLS*	*robust linear*	*MM-type linear*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I2E	0.022	0.001***	0.001***	0.011	0.001***	0.001***	0.014	0.001***	0.001***
	(0.024)	(0.0003)	(0.0002)	(0.022)	(0.0003)	(0.0002)	(0.022)	(0.0002)	(0.0001)
L1.I2E	0.004	0.001**	0.0004**	0.023	0.001***	0.0004**	0.021	0.001***	0.0004***
	(0.025)	(0.0003)	(0.0002)	(0.023)	(0.0003)	(0.0002)	(0.023)	(0.0002)	(0.0001)
L2.I2E	0.039*	0.001***	0.0002	0.040*	0.002***	0.0001	0.041**	0.001***	0.0001
	(0.023)	(0.0002)	(0.0002)	(0.021)	(0.0003)	(0.0002)	(0.020)	(0.0002)	(0.0001)
E2R	−0.091***	−0.001***	−0.00002	−0.059***	−0.001***	0.00003	−0.064***	−0.001***	0.0001
	(0.015)	(0.0002)	(0.0001)	(0.014)	(0.0002)	(0.0001)	(0.014)	(0.0001)	(0.0001)
L1.E2R	−0.082***	−0.0004**	−0.0002	−0.069***	0.0002	−0.0002	−0.071***	−0.0003***	−0.0002**
	(0.016)	(0.0002)	(0.0002)	(0.015)	(0.0002)	(0.0002)	(0.015)	(0.0001)	(0.0001)
L2.E2R	−0.031**	−0.001***	−0.001***	−0.035**	0.001***	−0.0001	−0.033**	−0.0004***	−0.0004***
	(0.015)	(0.0002)	(0.0002)	(0.013)	(0.0002)	(0.0002)	(0.013)	(0.0001)	(0.0001)
Constant	−0.002	−0.0001***	−0.00004**	0.003	0.00002	0.00000	0.002	−0.0001***	−0.00003***
	(0.002)	(0.00003)	(0.00002)	(0.002)	(0.00003)	(0.00002)	(0.002)	(0.00002)	(0.00001)
Observations	855	855	855	855	855	855	855	855	855
R^2	0.074		0.082	0.058		0.055	0.064		0.131
Adjusted R^2	0.067		0.076	0.051		0.049	0.058		0.125
Residual Std. Error	0.061	0.0005	0.0004	0.057	0.001	0.0004	0.055	0.0003	0.0003
F Statistic	11.275***			8.628***			9.689***		

Note: *p<0.1; **p<0.05; ***p<0.01

Table 15: Log Level - Share

	Dependent variable:								
	log_COE			log_NOS			log_COE_NOS		
	OLS	*robust linear*	*MM-type linear*	*OLS*	*robust linear*	*MM-type linear*	*OLS*	*robust linear*	*MM-type linear*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I2E	−0.077	−0.049	0.053	−0.203	−0.142	−0.030	−0.176	−0.133	−0.021
	(0.281)	(0.140)	(0.132)	(0.257)	(0.137)	(0.131)	(0.261)	(0.137)	(0.131)
L1.I2E	−1.488***	−0.555***	−0.305**	−1.402***	−0.580***	−0.338**	−1.414***	−0.570***	−0.330**
	(0.290)	(0.145)	(0.137)	(0.265)	(0.141)	(0.135)	(0.270)	(0.141)	(0.135)
L2.I2E	−1.288***	−0.458***	−0.195	−1.203***	−0.458***	−0.214	−1.221***	−0.457***	−0.210
	(0.272)	(0.135)	(0.134)	(0.248)	(0.132)	(0.132)	(0.252)	(0.132)	(0.132)
E2R	0.817*	1.219***	1.265***	0.916**	1.240***	1.274***	0.900**	1.251***	1.287***
	(0.473)	(0.236)	(0.232)	(0.432)	(0.230)	(0.229)	(0.439)	(0.230)	(0.229)
L1.E2R	0.208	0.747***	0.935***	0.272	0.729***	0.901***	0.262	0.726***	0.898***
	(0.461)	(0.230)	(0.213)	(0.422)	(0.225)	(0.211)	(0.429)	(0.224)	(0.211)
L2.E2R	1.255***	0.965***	0.972***	1.189***	0.965***	0.976***	1.205***	0.954***	0.962***
	(0.365)	(0.182)	(0.175)	(0.334)	(0.178)	(0.173)	(0.340)	(0.178)	(0.172)
Constant	0.064***	0.077***	0.081***	0.069***	0.079***	0.081***	0.068***	0.078***	0.081***
	(0.007)	(0.004)	(0.003)	(0.006)	(0.003)	(0.003)	(0.007)	(0.003)	(0.003)
Observations	864	864	864	864	864	864	864	864	864
R^2	0.097		0.117	0.108		0.122	0.106		0.121
Adjusted R^2	0.091		0.111	0.101		0.116	0.099		0.115
Residual Std. Error	0.179	0.085	0.083	0.164	0.083	0.083	0.166	0.083	0.082
F Statistic	15.361***			17.225***			16.855***		

Note: *p<0.1; **p<0.05; ***p<0.01

Table 16: Log Level - Log Share

	Dependent variable:								
	COE			NOS			COE_NOS		
	OLS	*robust linear*	*MM-type linear*	*OLS*	*robust linear*	*MM-type linear*	*OLS*	*robust linear*	*MM-type linear*
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
I2E	0.028	0.063*	0.079**	0.011	0.049	0.070**	0.015	0.051	0.071**
	(0.072)	(0.035)	(0.032)	(0.066)	(0.034)	(0.032)	(0.067)	(0.034)	(0.032)
L1.I2E	−0.175**	−0.060	−0.032	−0.158**	−0.058	−0.034	−0.160**	−0.058	−0.034
	(0.076)	(0.037)	(0.034)	(0.070)	(0.036)	(0.034)	(0.071)	(0.036)	(0.034)
L2.I2E	−0.026	0.009	0.026	−0.023	0.009	0.027	−0.023	0.008	0.026
	(0.068)	(0.033)	(0.031)	(0.062)	(0.032)	(0.031)	(0.063)	(0.032)	(0.031)
E2R	0.084*	0.099***	0.089***	0.111***	0.138***	0.116***	0.106***	0.136***	0.113***
	(0.044)	(0.021)	(0.022)	(0.040)	(0.021)	(0.021)	(0.040)	(0.021)	(0.022)
L1.E2R	0.129***	0.135***	0.146***	0.129***	0.139***	0.182***	0.129***	0.133***	0.168***
	(0.046)	(0.022)	(0.027)	(0.042)	(0.022)	(0.028)	(0.042)	(0.022)	(0.028)
L2.E2R	0.200***	0.201***	0.197***	0.183***	0.201***	0.198***	0.188***	0.199***	0.195***
	(0.042)	(0.020)	(0.028)	(0.038)	(0.020)	(0.028)	(0.039)	(0.020)	(0.028)
Constant	0.050***	0.070***	0.075***	0.055***	0.072***	0.077***	0.054***	0.072***	0.076***
	(0.007)	(0.003)	(0.003)	(0.007)	(0.003)	(0.003)	(0.007)	(0.003)	(0.003)
Observations	861	861	861	861	861	861	861	861	861
R^2	0.050		0.116	0.056		0.147	0.055		0.135
Adjusted R^2	0.043		0.109	0.049		0.141	0.048		0.129
Residual Std. Error	0.183	0.078	0.083	0.168	0.078	0.082	0.171	0.079	0.082
F Statistic	7.468***			8.410***			8.238***		
Note:							*p<0.1; **p<0.05; ***p<0.01		

5.3 GVC Integration and Export Diversification

Another potential benefit of GVC integration is that it potentially increases the diversity and range of exported products, which may have pro-competitive effects on the economy that eventually foster growth. One idea for country-level analysis could be to compute an index of concentration such as the Herfindahl-Hirshman (HH) Index over the range of exported products and see whether it increases with GVC integretion and/or is correlated with growth. The HH index is computed by expressing the exports of sector i as a share s_i of total country exports E, and then calculating the sum of the squares of the shares.

$$HH_E = \sum_{i=0}^{k} s_i^2. \tag{21}$$

See if HH index is correlated with growth... do a mediation analysis? See your M&S II class.

Table 17:

	Dependent variable:							
	HIN		Dlog(HIN)	D(HIN)	HIN_DVA		Dlog(HIN_DVA)	D(HIN_DVA)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
log(i2e)	−0.045				−0.012			
	(0.028)				(0.021)			
I2E		−0.171				−0.050		
		(0.141)				(0.128)		
log(Exports)	0.051	0.0001						
	(0.045)	(0.020)						
Dlog(i2e)			−0.464				0.033	
			(0.676)				(0.458)	
D(I2E)				−0.084				0.032
				(0.214)				(0.218)
Dlog(Exports)			0.508	0.001				
			(0.968)	(0.033)				
log(DVA_Exports)					0.003	−0.013		
					(0.040)	(0.021)		
Dlog(DVA_Exports)							−0.141	−0.009
							(0.715)	(0.036)
Constant	−0.083	0.095	−0.030	−0.003	0.174	0.241	−0.034	−0.003
	(0.271)	(0.216)	(0.059)	(0.004)	(0.275)	(0.231)	(0.057)	(0.005)
Observations	11	11	10	10	11	11	10	10
R^2	0.469	0.407	0.072	0.027	0.252	0.235	0.009	0.009
Adjusted R^2	0.336	0.259	−0.193	−0.251	0.065	0.043	−0.274	−0.274
Residual Std. Error	0.009	0.009	0.161	0.012	0.010	0.010	0.155	0.013
F Statistic	3.536*	2.745	0.271	0.097	1.348	1.226	0.032	0.032
Note:								*p<0.1; **p<0.05; ***p<0.01

5.4 GVC Integration and Export Competitiveness

A third idea is proposed by Foster 2015 drawing on ..., to obtain a measure of which products are globally competitive, and then investigate whether increased GVC integration shifts the composition of exports towards more globally competitive products...

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