Explaining value chain differences in MRIO databases through structural path decomposition

1.1 Aggregating to common classifications

In order to make quantitative comparisons between two matrices using techniques such as matrix difference statistics, structural decomposition analysis (SDA) and structural path decomposition analysis (SPD), we require the two matrices to be of the same dimensions. This means that the matrices must contain the same number of regions and sectors and be presented in the same order. The Eora, GTAP and WIOD MRIO databases vary in their country and sectoral coverage and where GTAP and WIOD use SIOT structures, Eora has a mix of SUT and SIOT regions. This study proposes the use of a classification structure containing only those regions groupings and sector groupings that are common to all the MRIO databases in the study. These aggregated versions of the Eora, GTAP and WIOD databases are constructed using a system of concordance matrices.

1.2 The common classification system

The common classification (CC), is designed to be common to Eora, GTAP and WIOD and also to EXIOBASE. Countries that are common to each database are preserved in the classification system and any country that appears in one database and not others is aggregated to a “Rest of the World” (RoW) region. This leaves a system with 40 countries and one aggregated RoW region (see Table 2.1).

Table 2.1: Common Classification region aggregation showing the region’s position in the original database

#	CODE	Region Name	Eora	GTAP	WIOD
1	AUS	Australia	10	1	1
2	AUT	Austria	11	49	2
3	BEL	Belgium	18	50	3
4	BLG	Bulgaria	29	78	4
5	BRA	Brazil	26	32	5
6	CAN	Canada	34	26	6
7	CHN	China	40	4	7
8	CYP	Cyprus	46	51	8

9	CZE	Czech Republic	47	52	9
10	DEU	Germany	66	57	10
11	DNK	Denmark	51	53	11
12	ESP	Spain	157	71	12
13	EST	Estonia	58	54	13
14	FIN	Finland	61	55	14
15	FRA	France	62	56	15
16	GBR	Great Britain and N.I.	177	73	16
17	GRC	Greece	68	58	17
18	HUN	Hungary	77	59	18
19	IDN	Indonesia	80	12	19
20	IND	India	79	21	20
21	IRW	Ireland	83	60	21
22	ITA	Italy	85	61	22
23	JPN	Japan	87	6	23
24	KOR	Korea	156	7	24
25	LTU	Lithuania	100	63	25
26	LUX	Luxembourg	101	64	26
27	LVA	Latvia	94	62	27
28	MEX	Mexico	111	28	28
29	MLT	Malta	108	65	29
30	NLD	Netherlands	121	66	30
31	POL	Poland	137	67	31
32	PRT	Portugal	138	68	32
33	ROU	Romania	140	81	33
34	RUS	Russia	141	82	34
35	SVK	Slovakia	152	69	35
36	SVN	Slovenia	153	70	36
37	SWE	Sweden	162	72	37
38	TUR	Turkey	173	99	38
39	TWN	Taiwan	165	9	39
40	USA	USA	180	27	40
41	RoW	Rest of World	Sum of all other regions	Sum of all other regions	41

Sectors are treated similarly undergoing a process of progressive aggregations until there is an identical sector structure in each database. The CC has 17 sectors. The nature of the system of aggregation means that for each sector in the CC, there is usually at least one MRIO database where the sector is a one-to-one mapping—see Table 2.2. This direct mapping is important for understanding the effects of aggregation (Steen-Olsen et al., 2014).

Table 2.2: Common Classification sector aggregation (adapted from (Steen-Olsen et al., 2014)) showing the sectors to be combined

#	Code	Sector Name	Eora26	GTAP	WIOD
1	AGRI	Agriculture, forestry, hunting and fisheries	1-2	1-14	1
2	MINQ	Mining and quarrying	3	15-18	2
3	FOOD	Food products, beverages and tobacco	4	19-26	3
4	CLTH	Textiles, leather and wearing apparel	5	27-29	4-5
5	WOOD	Wood, paper and publishing	6	30-31	6-7
6	PETC	Petroleum, chemical and non-metal mineral products	7	32-34	8-11
7	METP	Metal and metal products	8	35-37	12
8	ELMA	Electrical equipment and machinery	9	40-41	13-14
9	TREQ	Transport equipment	10	38-39	15
10	MANF	Manufacturing and recycling	11-12	42	16
11	ELGW	Electricity, gas and water	13	43-45	17
12	CNST	Construction	14	46	18
13	TRAD	Trade	15-18	47	19-22
14	TRNS	Transport	19	48-50	23-26
15	POST	Post and telecommunications	20	51	27
16	BSNS	Financial intermediation and business activities	21	52-54, 57	28-30
17	PAEH	Public administration, education, health, recreational and other services	22-26	55-56	31-35

Table 2.2 shows the aggregation for Eora26, the homogenised version of Eora, where each region has a common set of 26 sectors. In the full version of Eora, used in this study, the number of sectors per region ranges from 511 to 26. Each of these region specific classifications maps to the 26 sectors in a many-to-one mapping. The second aggregated classification system takes each combination of MRIO pairs and finds the common classification for that unique pair.

The SPD described in sections 3 requires the MRIO to be in an SIOT format. This means that second versions of the CC for pairs involving Eora have to be constructed in an SIOT format. Section 0 explains how the SUT parts of the Eora database were converted to SIOTs.

1.3 Using concordance matrices

Once the CC has been established, binary concordance matrices are used to map each original MRIO database table to an aggregated version. If $\mathbf{Z_0}$, $\mathbf{Y_0}$ and $\mathbf{e_0}$ are the original transaction matrix, final demand matrix and production emissions vector respectively, the concordance matrices $\mathbf{C_{01}}$ and $\mathbf{C_{01}^r}$ can be used to transform the original elements to their aggregated counterparts $\mathbf{Z_1}$, $\mathbf{Y_1}$ and $\mathbf{e_1}$ as follows:

$$\mathbf{Z_1} = \mathbf{C'_{01}} \mathbf{Z_0} \mathbf{C_{01}} \tag{2.1}$$

$$\mathbf{Y_1} = \mathbf{C'_{01}} \mathbf{Y_0} \mathbf{C_{01}^r} \tag{2.2}$$

$$\mathbf{e_1} = \mathbf{e_0} \mathbf{C_{01}} \tag{2.3}$$

(Steen-Olsen et al., 2014)

$\mathbf{C_{01}^r}$ is the concordance matrix mapping the original set of regions to the new set of regions. $\mathbf{C_{01}}$ is the concordance matrix that maps the full table to the new table.

2. Databases and emissions extensions used in this study

Table 2.1 shows the database versions and emissions data chosen for use in this study. The versions of Eora, EXIOBASE, GTAP and WIOD are those that were available after July 2015

Table 2.1: Database versions and emissions used in this study

MRIO	version	emissions
Eora	199.74	CO_2 from fuel burning
EXIOBASE	2.2.0	CO_2
GTAP	V7.1	CO_2
WIOD	May 2012	CO_2

3. Further SPD results

Table 3.1: Characteristics of the 100 largest paths differences for each MRIO database pairing

Characteristic	Eora	EXIOBASE	
Overall sum of top 100 path differences (net difference) (MtCO2)	2,144		
Contribution to net difference by database ($MtCO_2$)	3,462	-1,318	**Contribution to gross difference**
Sum of path differences by size ($MtCO_2$)			
500<x	1,225	0	26%
100<x≤500	927	-112	22%
50<x≤100	398	-315	15%
20<x≤50	573	-622	25%
x≤20	339	-270	13%
Sum of path differences by path order ($MtCO_2$)			
0	2,477	-516	63%
1	960	-694	35%
2	25	-108	3%
3	0	0	0%
Sum of path differences by source region ($MtCO_2$)			
USA	1,696	-375	43%
China	744	-471	25%
Russia	389	-275	14%
India	194	-36	5%
Other	438	-162	13%
Sum of path differences by source industry ($MtCO_2$)			
Electricity, gas and water	535	-537	22%
Transport	1,709	-23	36%
Construction	987	0	21%
Petroleum, chemicals and other non-metallic minerals	14	-98	2%
Other	218	-662	18%

Sum of path differences by Leontief element ($MtCO_2$)			
$\mathbf{f}$	3,274	-1,398	45%
$\mathbf{x}^{-1}$	868	-869	17%
$\mathbf{A}$	416	-433	8%
y	1,668	-1,382	30%
Characteristic	**Eora**	**GTAP**	
Overall sum of top 100 path differences (net difference) (MtCO2)	2,479		
Contribution to net difference by database ($MtCO_2$)	3,863	-1,384	**Contribution to gross difference**
Sum of path differences by size ($MtCO_2$)			
500<x	1,854	0	35%
100<x≤500	488	-568	20%
50<x≤100	456	-233	13%
20<x≤50	627	-295	18%
x≤20	439	-289	14%
Sum of path differences by path order ($MtCO_2$)			
0	2,944	-560	67%
1	906	-625	29%
2	13	-188	4%
3	0	-12	0%
Sum of path differences by source region ($MtCO_2$)			
USA	2,075	-385	47%
China	792	-452	24%
Russia	303	-286	11%
India	272	-171	8%
Other	422	-91	10%
Sum of path differences by source industry ($MtCO_2$)			
Electricity, gas and water	1,213	-1,138	45%
Transport	1,023	-74	21%
Construction	997	0	19%
Petroleum, chemicals and other non-metallic minerals	95	-66	3%
Other	531	-105	12%
Sum of path differences by Leontief element ($MtCO_2$)			
$\mathbf{f}$	2,930	-688	30%
$\mathbf{x}^{-1}$	2,174	-915	26%
$\mathbf{A}$	423	-982	12%
y	1,763	-2,203	33%
Characteristic	**Eora**	**WIOD**	
Overall sum of top 100 path differences (net difference) (MtCO2)	2,511		
Contribution to net difference by database ($MtCO_2$)	3,778	-1,267	**Contribution to gross difference**
Sum of path differences by size ($MtCO_2$)			
500<x	1,256	0	25%
100<x≤500	1,010	-124	22%
50<x≤100	528	-344	17%
20<x≤50	672	-452	22%
x≤20	312	-348	13%
Sum of path differences by path order ($MtCO_2$)			
0	2,690	-604	65%

1	1,048	-563	32%
2	40	-101	3%
3	0	0	0%
Sum of path differences by source region ($MtCO_2$)			
USA	1,792	-338	42%
China	870	-404	25%
Russia	424	-321	15%
India	229	-52	6%
Other	464	-152	12%
Sum of path differences by source industry ($MtCO_2$)			
Electricity, gas and water	781	-408	24%
Transport	1,756	0	35%
Construction	1,012	0	20%
Petroleum, chemicals and other non-metallic minerals	23	-293	6%
Other	206	-566	15%
Sum of path differences by Leontief element ($MtCO_2$)			
$\mathbf{f}$	3,413	-1,283	43%
$\mathbf{x}^{-1}$	1,029	-895	18%
$\mathbf{A}$	436	-292	7%
$\boldsymbol{y}$	1,808	-1,705	32%

Characteristic	EXIOBASE	GTAP	Contribution to gross difference
Overall sum of top 100 path differences (net difference) (MtCO2)	335		
Contribution to net difference by database ($MtCO_2$)	1,921	-1,566	
Sum of path differences by size ($MtCO_2$)			
500<x	0	0	0%
100<x≤500	589	-583	34%
50<x≤100	321	-206	15%
20<x≤50	628	-513	33%
x≤20	383	-264	19%
Sum of path differences by path order ($MtCO_2$)			
0	1,169	-837	58%
1	618	-534	33%
2	120	-171	8%
3	14	-25	1%
Sum of path differences by source region ($MtCO_2$)			
USA	1,022	-592	46%
China	368	-355	21%
Russia	62	-121	5%
India	106	-162	8%
Other	363	-336	20%
Sum of path differences by source industry ($MtCO_2$)			
Electricity, gas and water	903	-798	49%
Transport	23	-757	22%
Construction	72	0	2%
Petroleum, chemicals and other non-metallic minerals	118	0	3%
Other	806	-11	23%
Sum of path differences by Leontief element ($MtCO_2$)			
$\mathbf{f}$	1,035	-696	26%
$\mathbf{x}^{-1}$	1,294	-814	31%
$\mathbf{A}$	616	-769	21%

y	579	-890	22%
Characteristic	**EXIOBASE**	**WIOD**	
Overall sum of top 100 path differences (net difference) (MtCO2)	373		
Contribution to net difference by database ($MtCO_2$)	1,052	-680	**Contribution to gross difference**
Sum of path differences by size ($MtCO_2$)			
500<x	0	0	0%
100<x≤500	126	0	7%
50<x≤100	128	82	12%
20<x≤50	383	-183	33%
x≤20	415	-415	48%
Sum of path differences by path order ($MtCO_2$)			
0	539	-444	57%
1	454	-183	38%
2	59	-82	5%
3	0	0	0%
Sum of path differences by source region ($MtCO_2$)			
USA	350	-18	31%
China	323	-135	26%
Russia	38	-89	7%
India	106	-102	12%
Other	236	-174	24%
Sum of path differences by source industry ($MtCO_2$)			
Electricity, gas and water	593	-173	44%
Transport	119	-22	8%
Construction	29	0	2%
Petroleum, chemicals and other non-metallic minerals	9	-168	10%
Other	303	-318	36%
Sum of path differences by Leontief element ($MtCO_2$)			
$\mathbf{f}$	727	458	35%
$\mathbf{x}^{-1}$	452	450	26%
$\mathbf{A}$	300	160	13%
y	416	455	25%
Characteristic	**GTAP**	**WIOD**	
Overall sum of top 100 path differences (net difference) (MtCO2)	100		
Contribution to net difference by database ($MtCO_2$)	1,868	-1,768	**Contribution to gross difference**
Sum of path differences by size ($MtCO_2$)			
500<x	0	0	0%
100<x≤500	767	-662	39%
50<x≤100	240	-121	10%
20<x≤50	579	-555	31%
x≤20	281	-430	20%
Sum of path differences by path order ($MtCO_2$)			
0	1,033	-1,227	62%
1	671	-466	31%
2	153	-59	6%
3	11	-15	1%
Sum of path differences by source region ($MtCO_2$)			

USA	702	-971	46%
China	431	-233	18%
Russia	155	-102	7%
India	215	-105	9%
Other	364	-357	20%
Sum of path differences by source industry ($MtCO_2$)			
Electricity, gas and water	1,059	-692	48%
Transport	793	793	22%
Construction	0	0	0%
Petroleum, chemicals and other non-metallic minerals	0	-281	8%
Other	15	-795	22%
Sum of path differences by Leontief element ($MtCO_2$)			
$\mathbf{f}$	857	-980	27%
$\mathbf{x}^{-1}$	525	-1,442	29%
$\mathbf{A}$	912	-348	19%
$\boldsymbol{y}$	1,118	-544	25%

4. References

Steen-Olsen, K., Owen, A., Hertwich, E. G., & Lenzen, M. (2014). Effects of Sector Aggregation on CO2 Multipliers in Multiregional Input–Output Analyses. *Economic Systems Research*, *26*(3), 284–302. http://doi.org/10.1080/09535314.2014.934325,