

# Global MRIOs – Which to use for what?

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# Which database to use for what?

## And what are the associated uncertainties?



- These questions were asked at
  - IIOA & ISIE conferences
  - Workshops at international organizations: OECD, ILO, UNECE, ...
  - Workshops on SDG assessments
  - ...
- GMRIO comparison and uncertainty paper exist, but focus on CBCA
- Aim of this presentation (is this needed as a paper in ESR?)
  - Which information should be included?
  - Which analysis should be included?

# Existing comparisons



- ESR 26(3)**
- Inomata, S., & Owen, A. (2014). Comparative Evaluation of MRIO Databases. *Economic Systems Research*, 26(3), 239–244. doi:10.1080/09535314.2014.940856
  - Stadler, K., Steen-Olsen, K., & Wood, R. (2014). the “Rest of the World” – Estimating the Economic Structure of Missing Regions in Global Multi-Regional Input–Output Tables. *Economic Systems Research*, 26(3), 303–326. doi:10.1080/09535314.2014.936831
  - Owen, A., Steen-Olsen, K., Barrett, J., Wiedmann, T., & Lenzen, M. (2014). A Structural Decomposition Approach To Comparing MRIO Databases. *Economic Systems Research*, 26(3), 262–283. doi:10.1080/09535314.2014.935299
  - Geschke, A., Wood, R., Kanemoto, K., Lenzen, M., & Moran, D. (2014). Investigating Alternative Approaches to Harmonising Multi-Regional Input–Output Data. *Economic Systems Research*, 26(3), 354–385. doi:10.1080/09535314.2014.937069
  - Moran, D., & Wood, R. (2014). Convergence Between the Eora, WIOD, EXIOBASE, and OpenEU's Consumption-Based Carbon Accounts. *Economic Systems Research*, 26(3), 245–261. doi:10.1080/09535314.2014.935298
  - Arto, I., Rueda-Cantucho, J. M., & Peters, G. P. (2014). Comparing the Gtap-Mrio and Wiod Databases for Carbon Footprint Analysis. *Economic Systems Research*, 26(3), 327–353. doi:10.1080/09535314.2014.939949
  - 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. doi:10.1080/09535314.2014.934325
  - Eisenmenger, N., Wiedenhofer, D., Schaffartzik, A., Giljum, S., Bruckner, M., Schandl, H., ... de Koning, A. (2016). Consumption-based material flow indicators – Comparing six ways of calculating the Austrian raw material consumption providing six results. *Ecological Economics*, 128, 177–186. doi:10.1016/j.ecolecon.2016.03.010
  - Steen-Olsen, K., Owen, A., Barrett, J., Guan, D., Hertwich, E. G., Lenzen, M., & Wiedmann, T. (2016). Accounting for value added embodied in trade and consumption: an intercomparison of global multiregional input–output databases. *Economic Systems Research*, 28(1), 78–94. doi:10.1080/09535314.2016.1141751
  - Owen, A., Wood, R., Barrett, J., & Evans, A. (2016). Explaining value chain differences in MRIO databases through structural path decomposition. *Economic Systems Research*, 28(2), 243–272. doi:10.1080/09535314.2015.1135309
  - Wieland, H., Giljum, S., Bruckner, M., Owen, A., & Wood, R. (2017). Structural production layer decomposition: a new method to measure differences between MRIO databases for footprint assessments. *Economic Systems Research*. doi:10.1080/09535314.2017.1350831
  - Owen, A. (2017). *Techniques for Evaluating the Differences in Multiregional Input-Output Databases: A Comparative Evaluation of CO2 Consumption-Based Accounts Calculated Using Eora, GTAP and WIOD*. Springer.
  - Tukker, A., de Koning, A., Owen, A., Lutter, S., Bruckner, M., Giljum, S., ... Hoekstra, R. (2018). Towards Robust, Authoritative Assessments of Environmental Impacts Embodied in Trade: Current State and Recommendations. *Journal of Industrial Ecology*. doi:10.1111/jiec.12716
  - OECD reports from International expert workshop on demand-based measures of material flows and resource productivity, September 2017.
  - Acosta, J., Saurat, M. & Schepelmann, P. (2017) Testing consistency of EXIOBASE and Eurostat datasets. Comparison of monetary economic data, physical data, socioeconomic data, intensities per unit output volume, and footprints based on Eurostat and EXIOBASE. EEA Project report Task 2.1.3d Sub-task 1. Project Manager Cathy Maguire.
  - Rodrigues, J., Moran, D. Wood, R. & Behrens, P. (2018) Uncertainty of Consumption-Based Carbon Accounts. *Environmental Science & Technology*. doi: 10.1021/acs.est.8b00632

# Approach



## 1. Focus on economic components

(to complement ongoing work on environmental and labour extensions)

## 2. Description of database development principles

Supplementary information of publications & questionnaire to database developers

## 3. Uncertainty analysis

- i. SNA main aggregates + development
- ii. Economic structures (IOTs/SUTs)
- iii. Trade

## 4. Recommendations

# Description of database components and development principles – questions to developers



- General information
  - Original purpose
  - Important during construction
  - Main applications
  - Coverage
  - Updates
  - Available formats (csv, R, mat)
- SUT / IOT data
  - SUT or IOT
  - Data sources
  - Annual initial estimate or extrapolation
- Other data
  - SNA data source + processing
  - Trade data source + processing
  - Re-exports
  - Non-residents
- Prices and valuation
  - Conversion to basic prices: when and how
  - Trade and transport margins
  - Exchange rate
  - Deflation method if pyp or constant
  - Limitations and uncertainties introduced into the data through conversions
- Gap filling and balancing
  - Balancing stages
  - Balancing techniques
  - Zeros remain zeros?
  - Estimation of missing data
  - Data for initial estimate = balancing constraints
  - What percentage (approximately) of all data points in your system is estimated?

## **Bart Los**

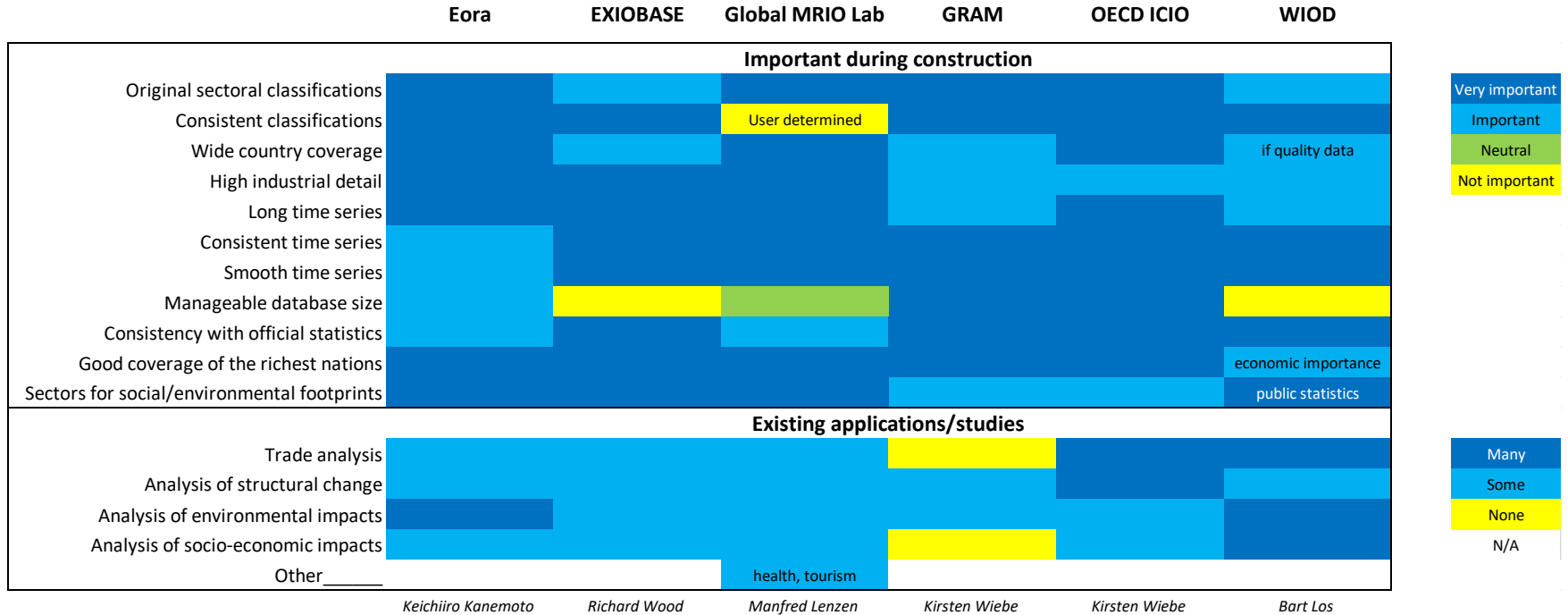
*“Any MRIO developer who would mention a percentage below 100% would provide a figure that is too low! GDP is an estimate and all numbers in National Accounts are estimates. So are SUTs and so are bilateral trade data.”*

# Global MRIOs (GMRIOS)



	#Cou	# ind/ prod	years	Original purpose/philosophy	Regular Update	Info
Eora / Eora26	190	1-500	1990-2016	Include all countries of the world and as many extensions as possible. Make construction process as automatized as possible.	Yes	<a href="http://www.worldmrio.com">http://www.worldmrio.com</a>
EXIOBASE 1,2,3	44+5	163x200	1995-2016	Provide detailed and robust analysis of links between production and consumption, with a main focus on environmental impacts and natural resource use. <i>Richard Wood</i>	Yes	<a href="http://exiobase.eu">http://exiobase.eu</a>
Global MRIO Lab	All	flexible	As long as possible	The global MRIO Lab <b>breaks with all MRIO construction tradition</b> in that it does away with a fixed regional and sectoral structure, but instead uses a very detailed root classification to <b>enable the construction of virtually any MRIO database</b> the user wants. In addition, it offers i) long time series, ii) homogeneous and inhomogeneous classifications, iii) standard deviation tables, iv) nested international/subnational tables, v) <b>timeliness</b> with lags of less than 2 years (= UN SNA Main Aggregates database lag). <i>Manfred Lenzen</i>	Yes	<a href="https://ielab.info/">https://ielab.info/</a>
GRAM	63	48x48	1995-2010	Estimate (in 2009/2010) emissions embodied in Austria's consumption, given available official statistics (IOTs, trade, emissions) and a good representation of European countries and their main trading partners. Analysis of consumption-based climate mitigation policies (DG CLIMA).	No	<a href="https://www.gws-os.com/de/index.php/energy-and-climate/models/model-details/gram.html">https://www.gws-os.com/de/index.php/energy-and-climate/models/model-details/gram.html</a>
GTAP-MRIO	140	57x57	Some years between 1990-2011	First estimation of consumption-based emissions and emissions embodied in trade, environmental footprinting originating from the LCA perspective	Maybe	<a href="https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4140">https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4140</a>
OECD ICIO	62, 64 64	34x34 36x36	1995-2011 2010-2014	Trade in Value Added "Flows of goods and services within these global production chains are not always reflected in conventional measures of international trade. TIVA indicators are designed to better inform policy makers by providing new insights into the commercial relations between nations." Best possible adherence to national statistics according to international standards and in discussion with country delegates.	Yes	<a href="http://oe.cd/icio">http://oe.cd/icio</a> <a href="http://oe.cd/tiva">http://oe.cd/tiva</a> <a href="http://oe.cd/io-co2">http://oe.cd/io-co2</a>
WIOD	40+1 43+1	35x35 56x56	1995-2011 2000-2014	The main of the project was to <b>construct a time series of quantitative descriptions of the world economy</b> , in which the roles of countries and industries could be analyzed. The data should be based on <b>official and publicly available</b> data only and the construction process should <b>be transparent and replicable</b> . Finally, the data should be made accessible for free to everyone interested, in a manageable and intuitive format. <i>Bart Los</i>	Yes	<a href="http://www.wiod.org">http://www.wiod.org</a>

# Global MRIOs



# GMRIO uncertainty analysis



- i. SNA main aggregates + development
- ii. Economic structures
- iii. Trade

What to use as basis? Problem: there is no single harmonized database. Which is the reason for the differences between the databases as, in the end, they are all based on COMTRADE, but then take different routes to get to their trade, e.g. OECD STAN BTDIxE or CEPII BACI. What about service trade?

**National statistical offices do not publish uncertainty estimates for SUTs/IOTs**





Table 4. Reduction on Global CBCA When the Uncertainty of Top 20 Data Elements Is Eliminated, Assuming the Mean Is the True Value<sup>a</sup>

rank	block	source region	source sector	destination region	destination sector	Ind. (%)	Cum. (%)
1	IndEm	RoWorld	Electricity			19.95	80.05
2	IndEm	Russia	Electricity			9.04	71.01
3	IndEm	China	Electric eq.			9.13	61.87
4	Scale			USA		6.83	55.05
5	Techn.	China	Electricity		Electricity	8.25	46.80
6	Comp.			China	Electricity	8.03	38.76
7	IntTrade	RoWorld		RoWorld	Transport	5.34	33.42
8	IndEm	Russia	Oil			5.18	28.24
9	Techn.	India	Electricity		Transport	4.71	23.53
10	IntTrade	China		China	Electric eq.	4.23	19.30
11	Techn.	RoWorld	Transport		Transport	3.22	16.08
12	IndEm	China	Construction			3.41	12.67
13	Comp.			RoWorld	Other serv.	2.90	9.77
14	IntTrade	China		China	Mining	2.65	7.12
15	Techn.	USA	Electricity		Fuel/trade	2.40	4.72
16	IndEm	RoWorld	Construction			2.81	1.91
17	IndEm	Canada	Oil			1.31	0.61
18	Techn.	Russia	Transport		Oil	0.42	0.19
19	Techn.	USA	Oil		Communicat	0.14	0.05
20	IntTrade	France		RoWorld	Transport eq.	0.04	0.01

Table 5. List of Acronyms of Data Blocks

	short	long
1	Scale	scale
2	Comp	composition
3	Tech	technology
5	FinTr	trade in final goods
6	IntTr	trade in intermediate goods
7	HHEm	household emissions
8	IndEm	industry emissions

<sup>a</sup>The key of data block acronyms is reported in Table 5. Ind = individual; Cum = cumulative.

# Acosta et al. (2017)

## Testing consistency of EXIOBASE and Eurostat data

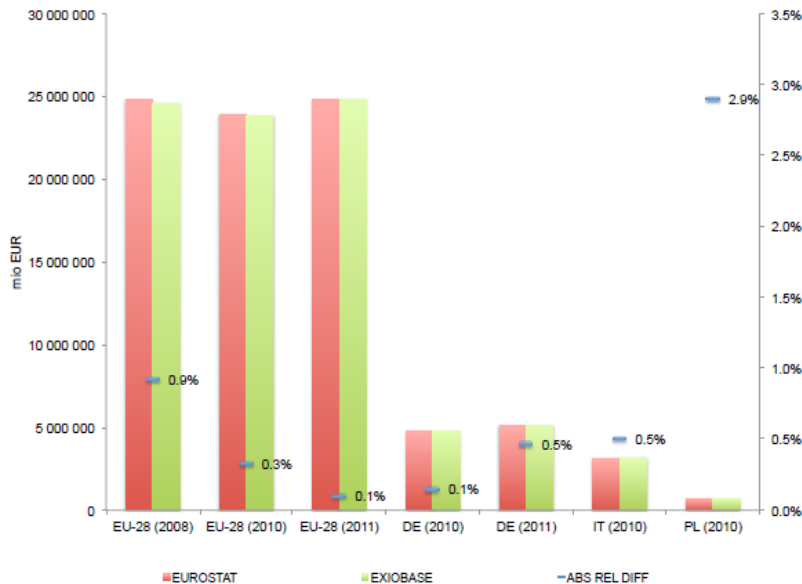


Figure 7: Comparison of total output volumes

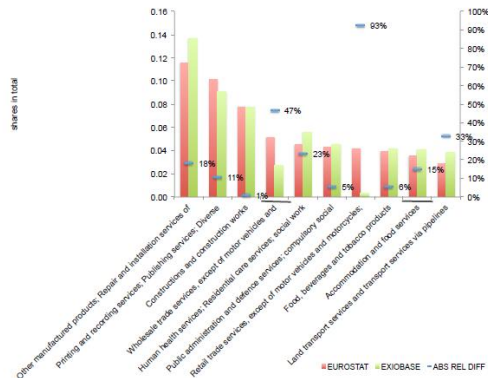


Figure 13: Comparison of output volume structure for the top ten Eurostat product groups, Italy, 2010

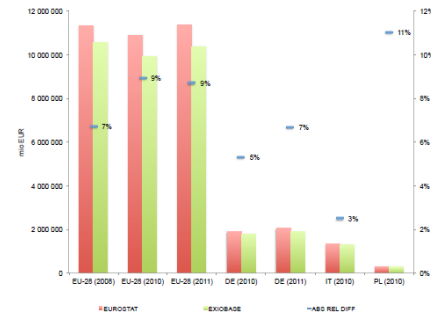


Figure 15: Comparison of total intermediary use

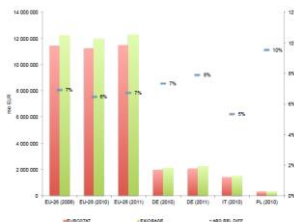


Figure 16: Comparison of domestic final use

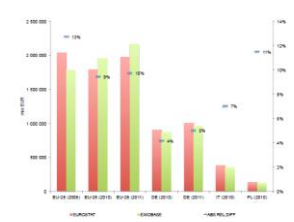


Figure 17: Comparison of total exports

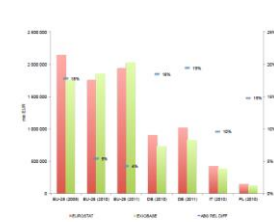


Figure 18: Comparison of total imports

# First steps to GMRIO uncertainty analysis

## Macroeconomic indicators



- 1. Benchmark** Relative values in the official international statistics
- 2. SNA main aggregates** calculated from databases relative to UN SNA main aggregates
- 3. Correlation coefficients** by country of main aggregates over time (levels and growth rates)

### %% SNA main aggregates

- % 1 'Final consumption expenditure'
- % 2 'Household consumption expenditure (including NPSH)'
- % 3 'General government final consumption expenditure'
- % 4 'Gross capital formation'
- % 5 'Exports of goods and services'
- % 6 'Imports of goods and services'
- % 7 'Gross Domestic Product (GDP)'
- % 8 'VA Agriculture, hunting, forestry, fishing (ISIC A-B)'
- % 9 'VA Mining, Manufacturing, Utilities (ISIC C-E)'
- %10 'VA Manufacturing (ISIC D)'
- %11 'VA Construction (ISIC F)'
- %12 'VA Wholesale, retail trade, restaurants and hotels (ISIC G-H)'
- %13 'VA Transport, storage and communication (ISIC I)'
- %14 'VA Other Activities (ISIC J-P)'
- %15 'VA Total'

### Databases in alphabetical order

1. Eora26 v199.82
2. EXIOBASE v3.6
3. OECD ICIO2015
4. WIOD v2013.413

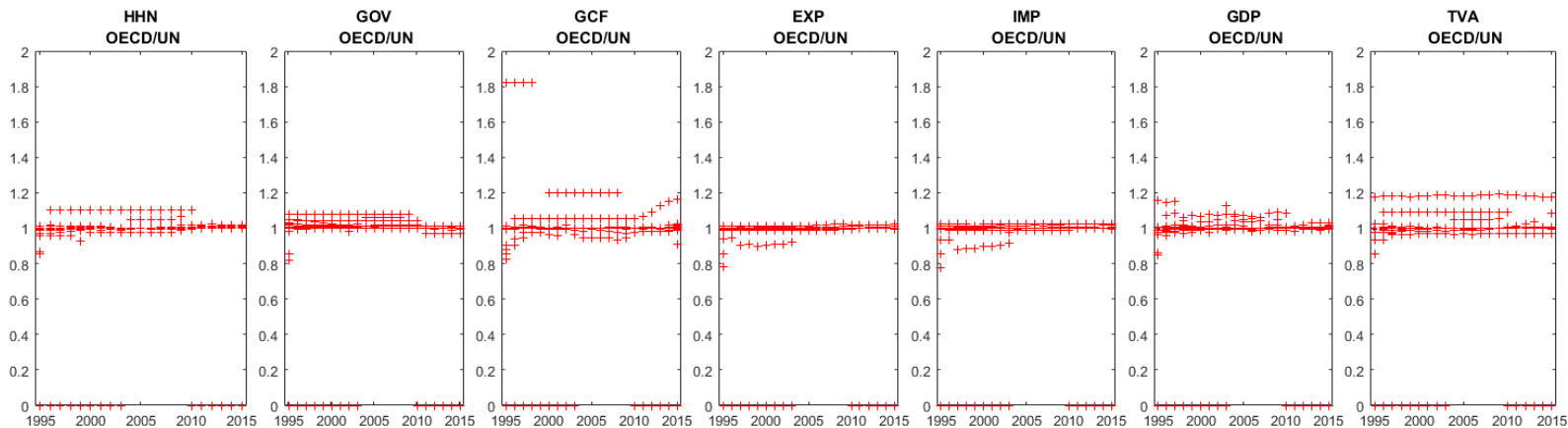
(Updated versions can be considered, if made available)

### Potential additions

1. Global MRIO Lab
2. GRAM
3. GTAP-MRIO
4. Extended EXIOBASE

# 1. Benchmark

## Official international statistics



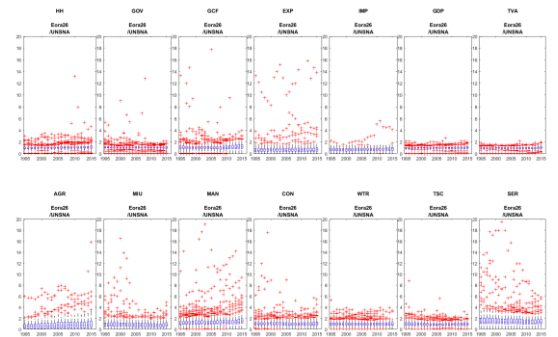
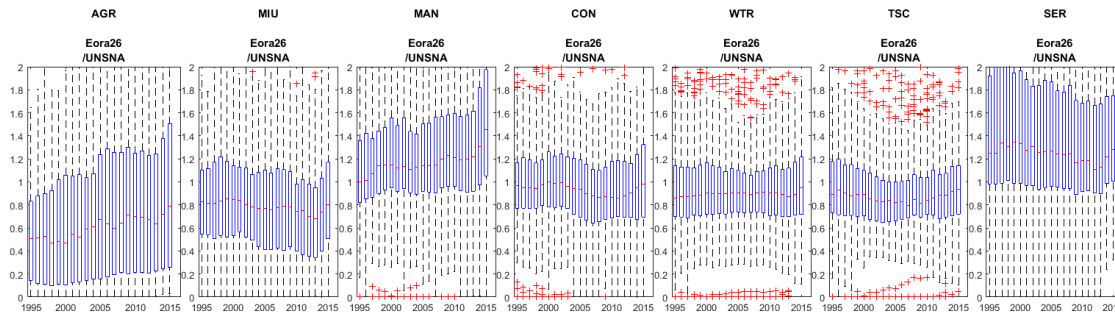
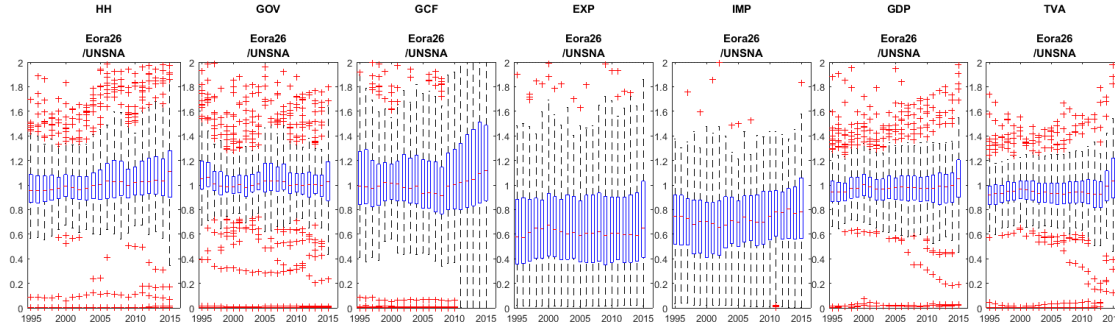
OECD SNA main aggregates relative to UN SNA main aggregates for 44 countries

# 2.1 Eora26 v199.82

## relative to UNSNA main aggregates



189 countries

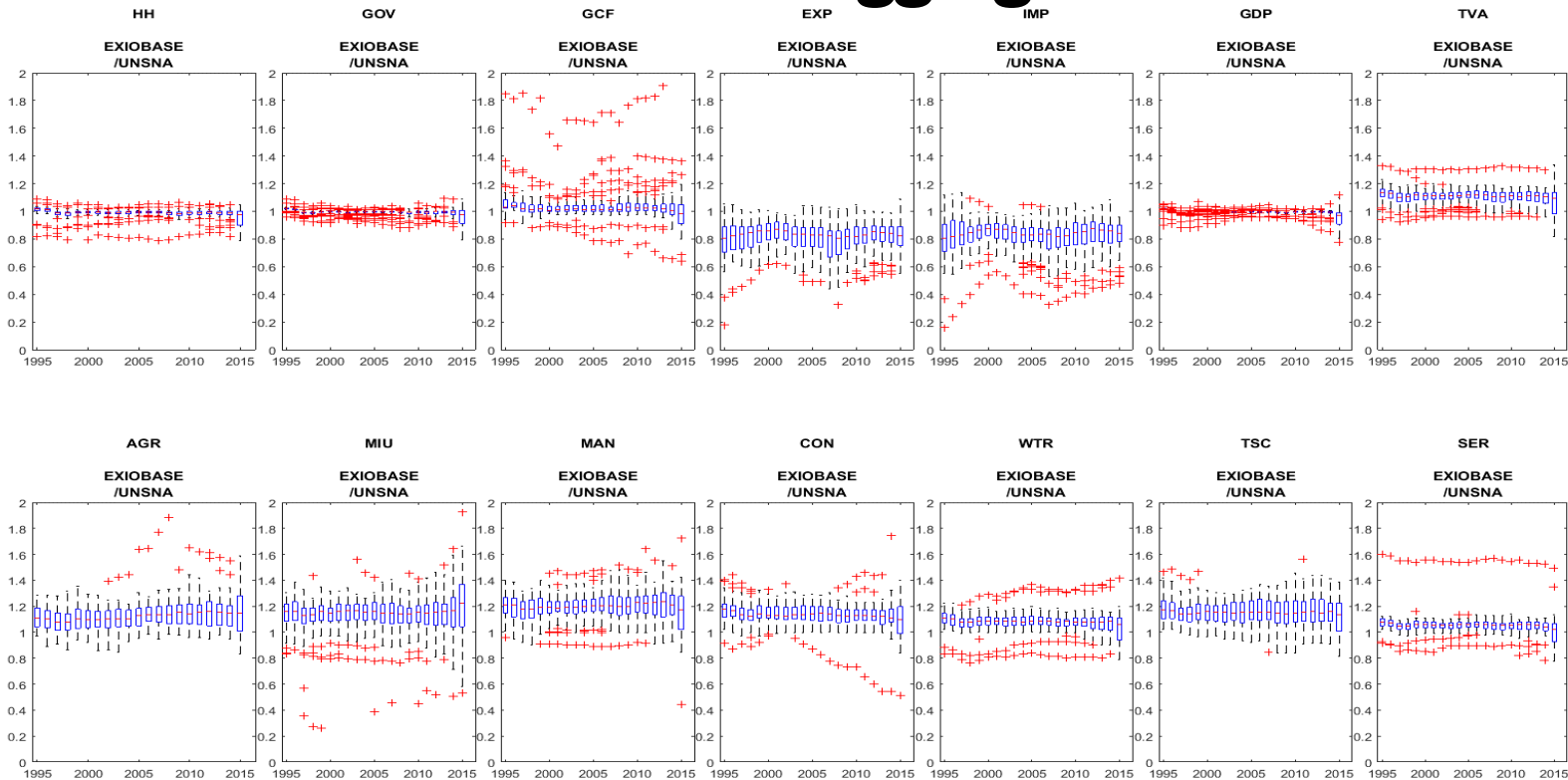


# 2.2 EXIOBASE v3.6

## relative to UNSNA main aggregates



44 countries + 5 RoWs

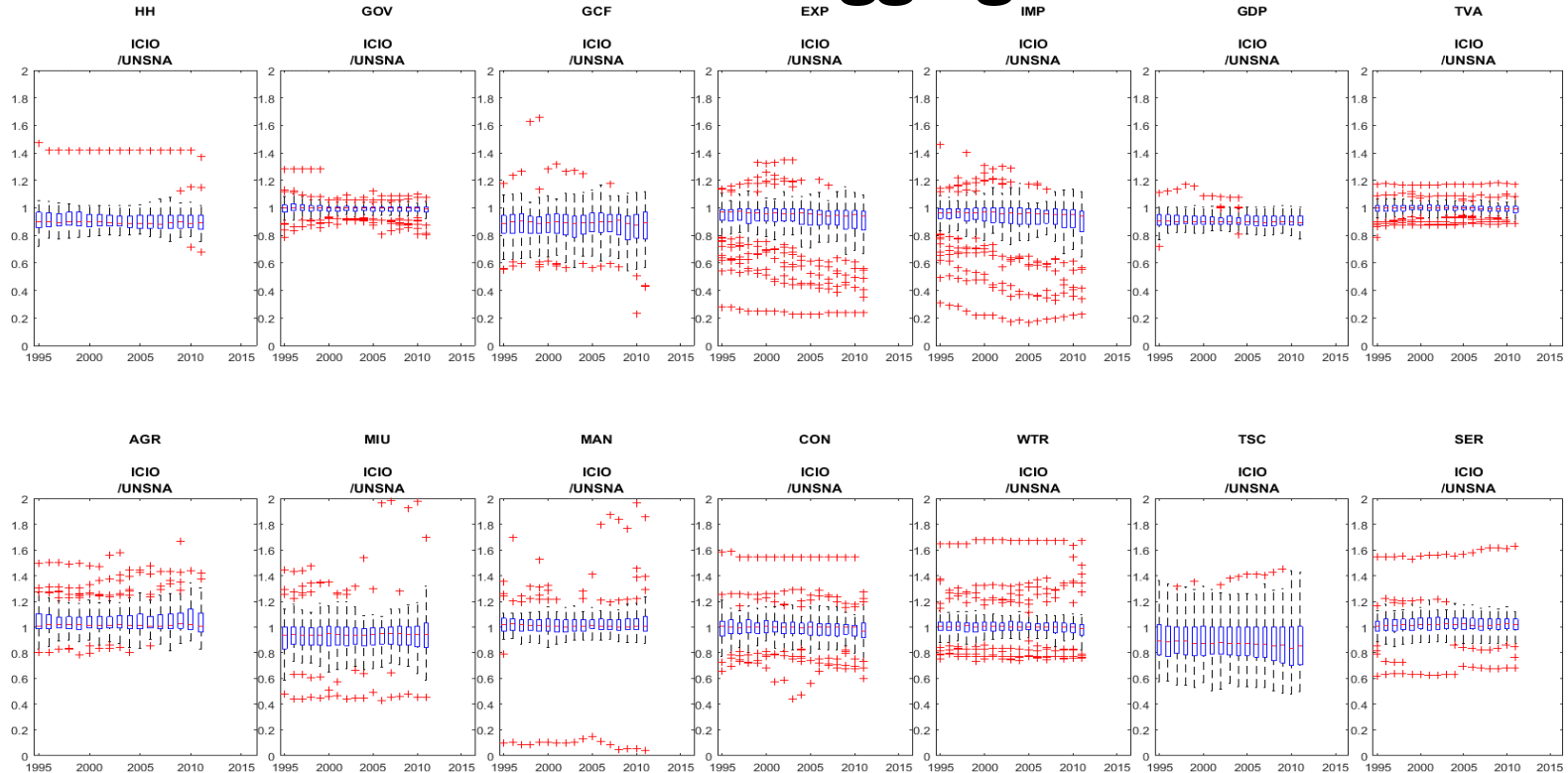


# 2.3 ICIO v2015

## relative to UNSNA main aggregates



62 countries + RoW

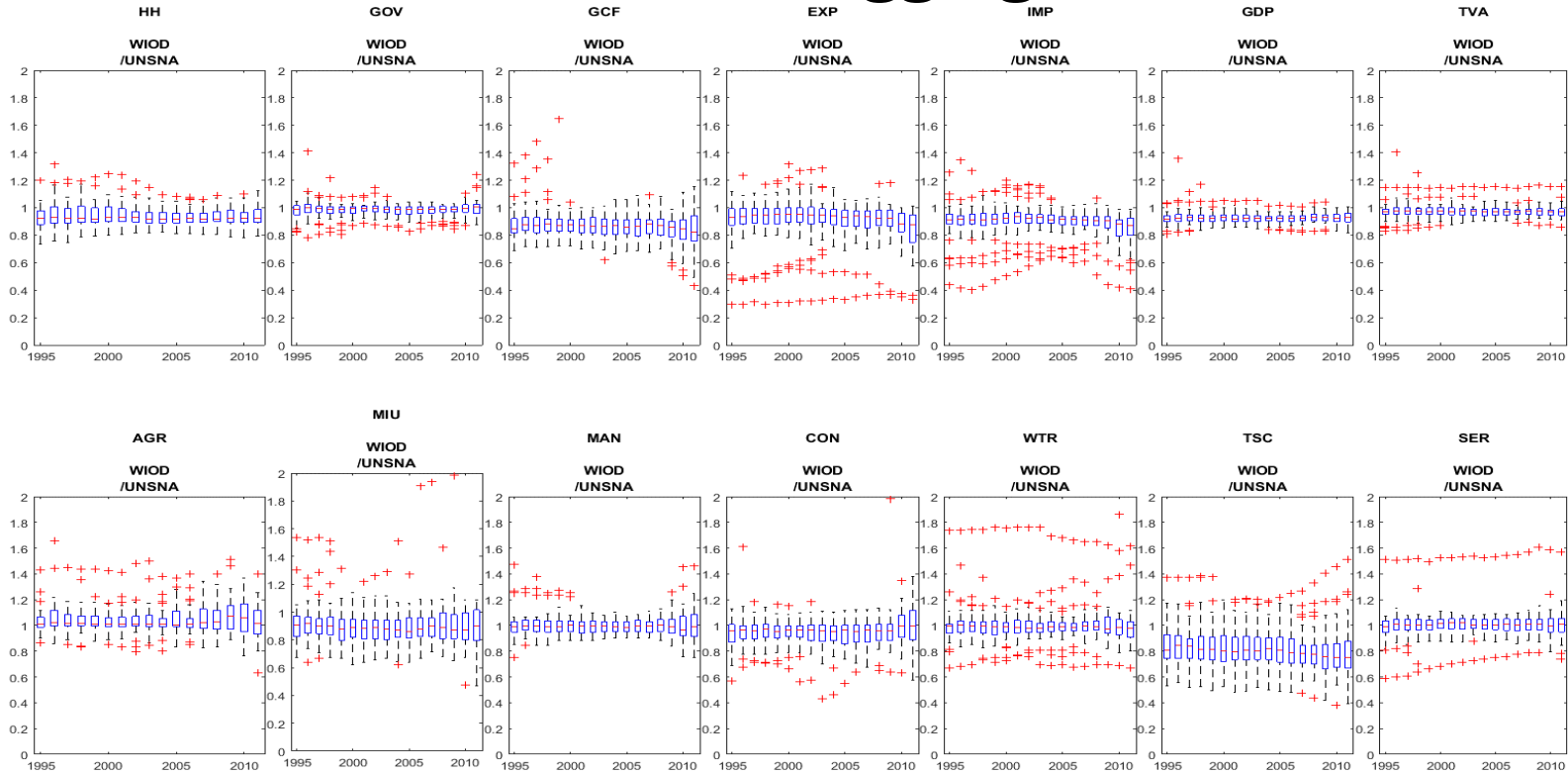


# 2.4 WIOD v2013.413



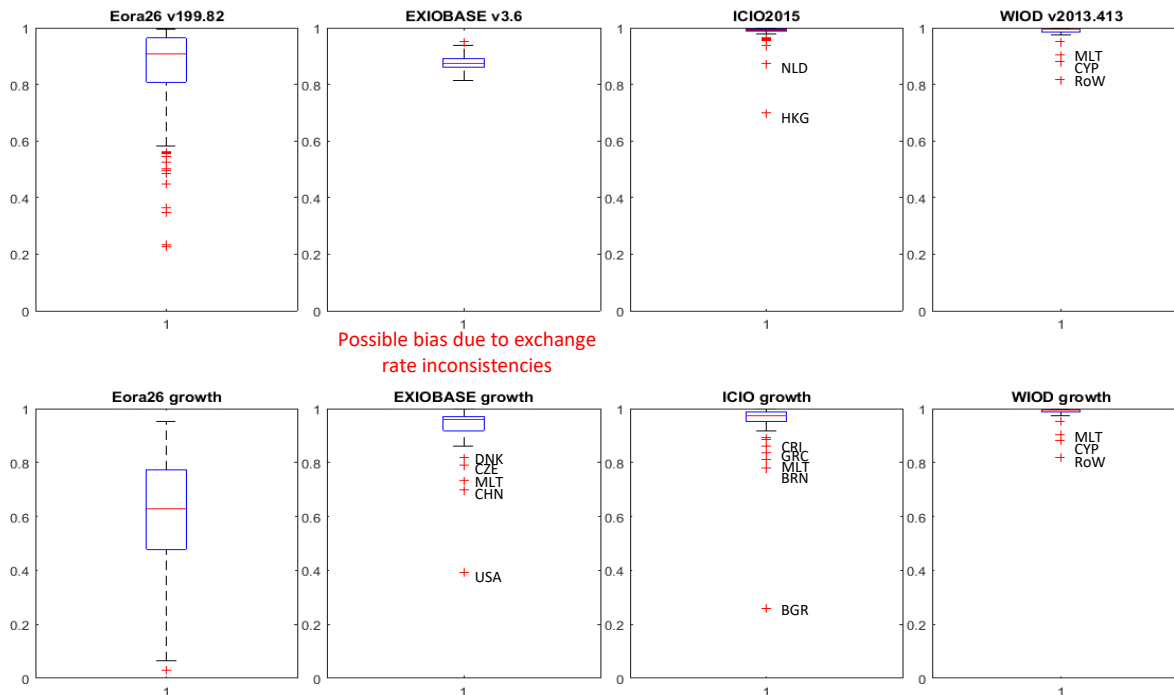
## relative to UNSNA main aggregates

40 countries + RoW





# 3. Correlation coefficients of economic structure SNA main aggregates over time by country



- % 1 'Final consumption expenditure'
- % 2 'Household consumption expenditure (including NPSH)'
- % 3 'General government final consumption expenditure'
- % 4 'Gross capital formation'
- % 5 'Exports of goods and services'
- % 6 'Imports of goods and services'
- % 7 'Gross Domestic Product (GDP)'
- % 8 'VA Agriculture, hunting, forestry, fishing (ISIC A-B)'
- % 9 'VA Mining, Manufacturing, Utilities (ISIC C-E)'
- % 10 'VA Manufacturing (ISIC D)'
- % 11 'VA Construction (ISIC F)'
- % 12 'VA Wholesale, retail trade, restaurants and hotels (ISIC G-H)'
- % 13 'VA Transport, storage and communication (ISIC I)'
- % 14 'VA Other Activities (ISIC J-P)'



# Observations

- Good representation of economic structures as described by SNA main aggregates
- Despite large amount of data processing involved, for most indicators: 50% of country observations within 10% deviation
- The more countries, the higher the spread
- Generally lower imports and exports than in SNA
  - Price concept
  - Allocation of trade and transport margins
  - Re-exports



# Possible next steps

- List of «recommended to read» articles that document the development of the databases
- Summarize main commonalities and differences of approaches
- Identify the main differences in the data sources used
- Uncertainty analysis: Matrix difference statistics
  - MRIO input coefficients & original data, e.g. EUROSTAT, USBEA, etc.
  - Pre- and post-balanced tables
  - Trade & original data



# Global MRIOs – which to use for what?

- Beware of the original purpose
- Consider what was important during the construction process
- Beware of the data that is estimated from estimated data
  - For some countries IOTs/SUTs simply do not exist
  - For most countries, the industry/product resolution in official statistics is low
  - «Always aggregate at least two levels from your analysis when showing results»  
(Angela Höh, DESTATIS, at IO Workshop in Bremen, March 2018)
- Consider effects of price and exchange rate conversions



# Question for discussion

- Is this interesting? Is this needed?
- What other information should to be included?
- Is this a valid approach to uncertainty estimation? Does it increase or decrease the confidence in the CBA results?



# Thank you!

For more information

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