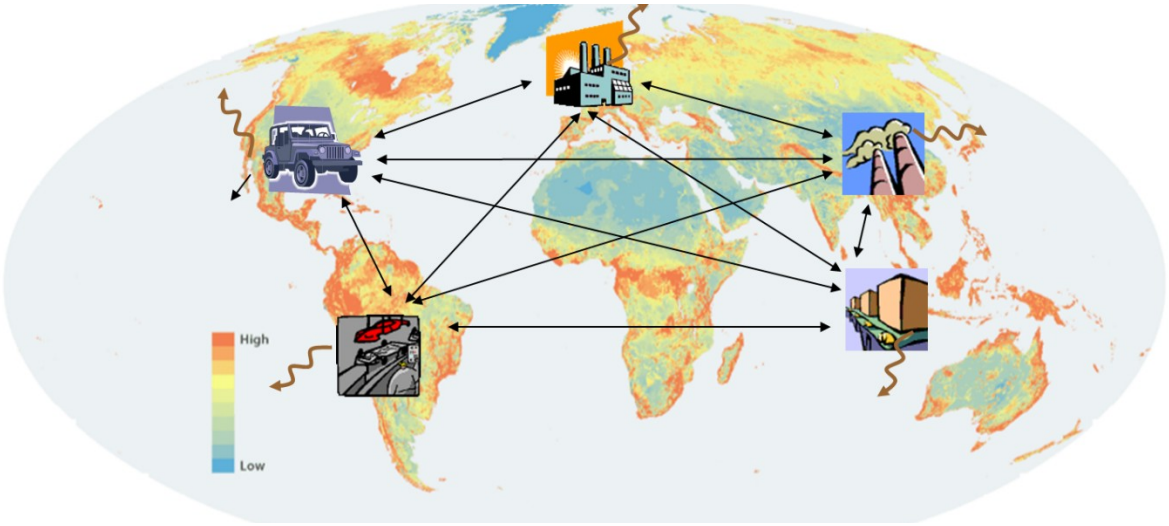
Advanced Environmentally-extended Input-Output Analysis

Course manual



May 27, 2022

Year	2022
Instructor(s)	Dr. Ranran Wang Dr. Oliver Taherzadeh Dr. Zhijie (Gloria) Li Dr. Glenn Aguilar Hernandez
Teaching assistants (TAs)	Maarten Schut (February 2022) Chia Wu Tan (March-June, 2022)
Language	English
Time and location	3rd quarter: • Tuesdays 13:15 – 15:00, Van Steenis F006 (lectures) • Tuesdays 15:20 – 17:00, Van Steenis F006 (exercises) 4th quarter: •Tuesday, 26 April, 13:15 – 17:00 GORL / 07 •Tuesday, 3 May, 13:15 – 17:00 GORLB / DM109 •Tuesday, 10 May, 13:15 – 17:00 STEEN / F102 •Tuesday, 17 May, 13:15 – 15:00 STEEN / F006 •Tuesday, 31 MAY, 13:15 – 15:00 STEEN / F006 •Tuesday, 14 June, 13:15 – 17:00 STEEN / F006
Online learning platform	BrightSpace: all course materials, announcements; Online lectures: MS Teams (meeting link embedded in BrightSpace weekly folder).
EC	10
Period	2nd Semester (Spring)
Hours of study	10 hours per week

Contents

1. General Information

1.1 Course description

In this course, students study advanced Environmentally-extended Input-Output Analysis (EEIOA), a standard methodology for assessing consumption-based environmental footprints (e.g., carbon footprints, water use embodied in trade, and indirect land use) and analyzing the production and consumption structures within one or across several economies.

The course is divided into two parts by a midterm exam. Built upon the EEIOA basics introduced in MAPP, the first part of the advanced course focuses on a more in-depth understanding of the IO tables and EEIOA calculation methods, including the use of detailed multi-regional input-output (MRIO) tables. The second part of the course introduces several advanced EEIOA analytical methods and how they are used for analyzing sustainability challenges, such as waste management, pollution haven and carbon leakage, and circular economy.

The course features a hands-on approach. Each lecture is accompanied by a 'working group' exercise session guided by teachers. In those sessions, students work on exercises designed based on the lecture. They also develop and apply python programming skills throughout the working group sessions.

The weekly study load is about 10 hours.

1.2 Learning goals

After completing this course, students are expected to:

G1. Develop a **more in-depth understanding** of the IO tables and EEIOA from the EEIOA basics introduced in MAPP.

G2. Articulate the **advanced EEIOA techniques** introduced in the course and their applications in sustainability research and real-world decision-making.

G3. **Model, in Python**, and analyze the economic and environmental effects of production and consumption and potential policies across supply chains.

G4. **Develop and present** a quantitative study using EEIOA, interpreting its main results and potential limitations.

1.3 Pre-requisites

To take part in the course, students must have completed the MAPP course and are familiar with matrix calculations and basic Python programming.

Students can bring their laptops to the classes with Python installed. We strongly recommend using the anaconda package (https://www.anaconda.com/) as the python development environment. It's freely available for Windows, macOS, and Linux and comes with a code editor (Spyder). Likely you have been using the Anaconda package during the Earth System Science and Analysis course in Q1 of the academic year.

1.4 Attendance

Attendance of the lectures and working groups is not mandatory but strongly recommended.

Consultation hours are organized during the final group assignment, i.e., the integrated group assignment (IGA). The student teams (in their entirety) must attend the consultations because we want to follow your progress and catch problems early on.

Active participation during the working group sessions and the IGA is essential. The group will report each individual's contribution to the IGA.

1.5 Study load estimate

Item	Topic	Hours
Week 6-19		
Lectures; Guided individual or group exercises	• Plenary lectures • Working groups • Mid-term review • Final review	2 per week 2 per week 4 4
Self-study	• Pre-lecture prep • Post-lecture review	1-2 per week 4 per week
Examination	• Mid-term exam preparation • Mid-term exam	10 3
Week 20-24		
Group work	• Integrated group assignment	30
Consultation	• Report progress, Q&A	0.75

Total		10 per week

1.6 Contact Information of the teaching team

Name	Room	Contact information
Lecturers		
Dr. Ranran Wang	A3.24 (STEENIS)	r.wang@cml.leidenuniv.nl
Dr. Glenn A. Aguilar Hernandez	A3.16 (STEENIS)	g.a.aguilar@cml.leidenuniv.nl
Dr. Zhijie Li (Gloria)	A3.07 (STEENIS)	z.li@cml.leidenuniv.nl
Dr Oliver Taherzadeh	B2.17 (STEENIS)	o.a.taherzadeh@cml.leidenuniv.nl
Teaching assistants (TAs)		
Maarten Schut		schut1990@hotmail.com
Chia Wu Tan		c.w.tan@umail.leidenuniv.nl

2. Organization of the course

2.1 Teaching methods

We offer a mix of instruction methods to satisfy the course objectives and at the same time comply with the Dutch coronavirus measures.

Lectures (Weeks 6 –12 and 16-19)

Through 2 hours of lectures, each week, we present the key terminologies, concepts, and approaches of a new topic that is important in advanced EEIOA.

We welcome and encourage in-class interactions. Students may ask questions about learning objectives, understand the study materials, or clarify the requirements for exercises, exams, and projects. Teachers may ask questions to assess whether students are learning, are interested in the course content, or are simply paying attention.

Working Groups (Weeks 6 –12 and 16-19)

Following each lecture, students work on exercises to solidify the new information. The 45 min x 2 per week exercises consist of a series of dedicated assignments and Python programming practicals that the students work individually or in groups. The groups are randomly assigned each week.

Lecturers and TAs guide students during the WGs and answer procedural, theoretical, and programming questions and give hints when students get stuck. Each exercise question typically ends with a 5-10 minutes plenary recap and Q&A.

Mid-term Review (Week 14)

Before the mid-term review, students are expected to have worked through the mock exam questions. During the review session, the lecturers go through those questions and answer questions that the students may have while building connections between focal points covered in the first part of the course.

Integrated Group Assignment (IGA, Week 20-24)

For the IGA, students perform environmental input-output analysis with real-world data in groups. In the three weeks, each group is expected to formulate and conceptualize a research question around one of two real-world issues: BREXIT and national stimulus plans in a post COVID-19 world, perform the necessary EEIOA that integrate multiple concepts and techniques introduced in the course and be able to interpret and discuss the results.

At the beginning of Week 21, a 45-min meeting (‘consultation’) is scheduled for each group with the instructors (lecturers and TAs) to discuss the progress made and possible problems that the group ran into.

At the end of Week 23, each group submit an IGA report and specify each individual’s contribution. Groups present their IGA works in Week 24.

Out-Of-Class Communication

Out-of-class communication is an important educational experience. We recommend that the students interact with the class, including the teachers and their fellow students, via the Discussion forum on BrightSpace. Students may also e-mail or schedule meetings with the teachers and TAs to inquire about course-related information, seek study advice, and share intellectual ideas.

2.2 Study materials

A list of study materials is provided (see Weekly program in this Manual). Almost all of them are available through the library or BrightSpace. The readings fall into two categories:

- MUST-READ: **study materials that will be part of the exam**. Be sure to study these before attending the lectures.
- RECOMMENDED READING: Articles, book chapters, newspaper articles, and videos that are interesting and provide more contexts for a particular topic of the course.

2.3 Schedule

Below you will find an overview of the schedule. Last-minute scheduling changes will be announced on BrightSpace, so please do read the announcements ☺

Week No.	Date	Content	Lecture	Working group	IGA consultation (Group #1-10)					Assessment date
					1-2	3-4	5-6	7-8	9-10	
6	February 8, 2022	Course introduction; IOT & National accounts	13:15-15:00	15:20-17:00						
7	February 15, 2022	Supply and Use Tables	13:15-15:00	15:20-17:00						
8	February 22, 2022	Two IO models	13:15-15:00	15:20-17:00						
9	March 1, 2022	Environmental footprint of nations	13:15-15:00	15:20-17:00						
10	March 8, 2022	EXIOBASE introduction	13:15-15:00	15:20-17:00						
11	March 15, 2022	MRIO semantic works	13:15-15:00	15:20-17:00						
12	March 22, 2022	Physical IO tables and analysis	13:15-15:00	15:20-17:00						
14	April 5, 2022	Mid-term exam prep Q&A	13:15-15:00							
15	April 12, 2022	Mid-term exam exam								13:15-16:15
16	April 19, 2022	Waste IOA	13:15-15:00	15:20-17:00						
17	April 26, 2022	Structural decomposition analysis	13:15-15:00	15:20-17:00						
	April 26, 2022	Midterm exam grades & feedback								16:00
18	May 3, 2022	Technology-adjusted CBA	13:15-15:00	15:20-17:00						
19	May 10, 2022	Circular economy	13:15-15:00	15:20-17:00						
20	May 17, 2022	IGA Q&A	13:15-15:00							
21	May 23, 2022	Group consultation (# 1,3,5,7,9)			9:00-9:45	10:00-10:45	11:00-11:45	14:00-14:45	15:00-15:45	
	May 24, 2022	Group consultation (# 2,4,6,8,10)								
22	May 31, 2022	IGA Q&A	13:15-15:00							
23	June 7, 2022	IGA Q&A (online)	13:15-15:00							
	June 10, 2022	IGA submission								17:00
24	June 14, 2022	IGA group presentation								13:15-17:00
25	June 21, 2022	1st midterm exam retake								13:15-16:15
26	June 24, 2022	IGA and final grades & feedback								17:00
28	July 4, 2022	1st retake grades & feedback								17:00
28	July 8, 2022	IGA revision due								17:00

2.4 Assessments

Assessment methods

The grading for this course consists of (weight in parentheses):

- 3-hr online, open-book mid-term exam, based on course materials in Weeks 6 – 12 (50%)
- IGA (50%)

At least a 'satisfactory' grade (5.5 out of 10) must be received for both the mid-term exam and the IGA to complete this course successfully. Those who receive an 'unsatisfactory' grade for the midterm exam can take a retake exam, and the retake is capped at 6.5. Those who fail the IGA have the opportunity to improve the report based on the instructors' feedback and resubmit a revised report for re-evaluation.

Examination and retake dates

- Mid-term exam: April 12 (Tuesday) 13:15-16:15, van Steenis F006.
- Mid-term exam retake: June 21 (Tuesday) 13:15 - 16:15, van Steeenis F102.
- IGA due: June 10 (Friday) by 17:00, upload IGA code, presentation slides, and the Method section to BrightSpace
- IGA revision due: July 8 (Friday), upload revised IGA report to BrightSpace

Regulation around exams

See the Onderwijs- en Examenregeling (OER)

Fraud and plagiarism

Fraud is the intentional action or inaction aimed at hindering the assessment of your knowledge, insight, and skills. Actions that can be regarded as fraud are, for example:

- personating (having someone else posing as you or you posing as someone else)
- plagiarism (handing in work that is not your own or not acknowledged as someone else's: e.g., copying a text from an information source (digital or paper) without mentioning the source or making a reference to it).

If a case of fraud and/or plagiarism is detected, the student and the Board of Examiners will be informed.

3. **Weekly program**

3.1 Week 6 Course introduction; IOT & National accounts

Lecture

We cover two topics in the first lecture. We start with an overview of the advanced EEIOA course. We briefly go through the course schedule, the learning objectives, and the assessments, which are introduced in detail in this course manual. We also present the teaching crew of the course.

The second topic, also the first of the eleven content lectures of the course, is an introduction to IO tables' connections to national accounts (NA). We start with a critical review of the NA variables in the IO tables. These concepts are fundamental to EEIOA and thus the later lectures. We then focus on the IO-based understanding of GDP (gross domestic product), one of the most influential economic development metrics.

Working group

In this first working group, you will get first-hand experience with NAs underlying the IO tables by collecting, plotting, and analyzing national accounts data from eurostat. You can use any graphing tools for this exercise, but a template will be made available in Excel for ease of use. The objectives of this working group are:

- Collect, compile and analyze national accounts data from the eurostat database
- Understand and apply the three approaches of GDP calculation
- Interpret the components of GDP for different sectors of the economy

Study materials

MUST READ

Before the lecture

- This manual 😊

After the lecture

- System of National Accounts 2008: Chapter 1 Introduction **A.** What is the System of National Accounts *(one page only; to get a formal, high-level understanding of what SNA is and is for)*

RECOMMENDED STUDY MATERIALS

- Leontief's "magnificent machine" and other contributions to applied economics
- Book: Replacing GDP by 2030
- Video: Beyond GDP: what we have accomplished so far

3.2 Week 7 Supply and use tables

Lecture

As an integral part of national accounts, supply and use tables (SUT) offer the underlying data to construct IOTs and MRIOTs. In this second lecture, after a short recap of related concepts from Week 1, we introduce the basic structure of the supply and use table, including the supply table, the use table, and the three fundamental identities in the balancing process.

We then further discuss the compilation of SUT, and important concepts involved, e.g., valuation. We explain the transformation from SUT to IOT and explore the strength of SUTs.

Working group

In this working group, we will take the SUT from one region/nation as an example to explore the snapshot of the economy as a whole and its industry composition. The objectives of the working group are:

- Understand the structure of supply and use tables
- Practice and interpret the industry aggregation/disaggregation in SUT
- Interpret the structural changes of supply/use in a given time period

Study materials

MUST READ

Before the lecture

- Video: What are Supply And Use Tables? (very short video: 4.5 mins)
- Handbook on Supply and Use Tables and Input-Output Tables with Extensions and Applications: Chapter 2 B Overview of SUTs, p23-35.

RECOMMENDED READINGS

- Eurostat Manual of Supply, Use and Input-Output Tables (This is not a thin book. But the instructions are straightforward to follow and understand. It can be your go-to book when you have SUT-related questions!)

3.3 Week 8 Two IO models: Demand-pull v. Cost-push

Lecture

In this lecture, we first quickly review the Leontief demand-pull model, which reveals the direct and indirect repercussions of ***a change*** in final demand, and the Leontief matrix and the power series approximation. We then introduce the Leontief cost-push model, also known as the price model. It quantifies how changes in costs and thus prices of the upstream sector(s) are propagated downstream the supply chain, affecting the costs and prices of industries across the economy. Lastly, after a brief introduction of the Ghosh inverse and Ghosh model, we look at various ways to measure a sector's of interindustry linkage.

Working group

In this working group, we use simple EEIOA tables describing a 5-sector economy to conduct demand-pull and cost-push EEIOA analysis in Python. Before the lecture, please also try the Python warm-up exercise in BrightSpace. The objectives of this working group are:

- Conduct EEIOA calculations using python programming
- Better understand the differences between the demand-pull and cost-push models introduced in the lecture

Study materials

MUST READ

Before the lecture

- MAPP EEIOA slides
- United Nations, Handbook of Input-Output Table Compilation and Analysis:
    - Chapter 1 Basic Input-Output Symmetric Model (SIOT)

After the lecture

- Miller and Blair. Input-Output Analysis: Foundations and Extensions (Second edition):
    - 2.6 The Price Model

RECOMMENDED READINGS

- Miller and Blair. Input-Output Analysis: Foundations and Extensions (Second edition):
    - 12.1 Overview of the Leontief and Ghosh Quantity and Price Models
    - 12.2 Linkage Measures
    - 12.3 Classification of Backward and Forward Linkage Results

3.4 Week 9 Environmental footprints of the nations

Lecture

Based on the MRIO lectures in MAPP, this lecture zoom into the unique analytical niche of MRIO tables and models, introducing how the economic and environmental implications of nations' consumption and international trade are framed conceptually (e.g., displacement or outsourcing) and quantified.

We also introduce and compare the widely-used MRIO databases.

Working group

The exercise includes two parts. The first part aims to reinforce the understanding of the MRIO structure using an example of a simplified international supply chain. The second part is through python programming. Based on an 8-sector 3-region MRIO table (2015 global economy), environmental footprints and emissions embodied in trade (import and export) will be calculated in Python. The objectives of this working group are:

- Review and better understand the structure of MRIO
- Perform MRIO calculations in Python

Study materials

MUST READ

Before the lecture

- MAPP EEIOA slides related to MRIO

After the lecture

- Weinzettel, J., et al. (2011). Footprint Family Technical Report: Integration into MRIO model, OPEN: EU: 2.2 Environmentally extended input-output analysis – a general concept (page 7-14)

RECOMMENDED READINGS

- Peters, G. P., et al. (2011). "Constructing an Environmentally-Extended Multi-Regional Input-Output Table Using the GTAP Database." Economic Systems Research 23(2): 131-152.
- Wiedmann, T., et al. (2011). "Quo Vadis MRIO? Methodological, data and institutional requirements for multi-region input-output analysis." Ecological Economics 70(11): 1937-1945.

3.5 Week 10 Introduction to EXIOBASE

Lecture

EXIOBASE has been one of the widely used MRIO databases providing extensive satellite accounts information. EXIOBAS (3.4 or other later versions) will be used as the primary dataset for IGA. In this lecture, we first introduce the main features of EXIOBASE (e.g., sectoral, country, and satellite accounts specifications, downloads, etc.). We then go through the Pythons codes prepared to load EXIOBASE data and a few examples illustrating the use of the data for MRIO analyses.

Working group

The objectives of the working group are:

- Use EXIOBASE in a Python environment
- Develop a code using Pandas

MUST READ

Before the lecture

- Stadler K, R. Wood, T. Bulavskaya, C.J. Sodersten, M. Simas, S. Schmidt, A. Usubiaga, J. Acosta-Fernandez, J. Kuenen, M. Bruckner, S. Giljum, S. Lutter, S. Merciai, J.H. Schmidt, M.C. Theurl, C. Plutzar, T. Kastner, M. Eisenmenger, K. Erb, A. de Koning, A. Tukker (2018) EXIOBASE 3: Developing a Time Series of Detailed Environmentally Extended Multi-Regional Input-Output Tables, Journal of Industrial Ecology 22(3)502-515. DOI: 10.1111/jiec.12715

3.6 Week 11 MRIO semantic works

Lecture

In this lecture, we discuss seminal MRIO studies that have been foundational to environmental footprinting's technical and empirical development. The literature covers a broad range of footprint indicators, i.e., carbon, water, material, land, and footprint 'family' made up of multiple indicators. The core methods adopted in the literature have been largely covered in our previous lectures. As such, here we learn about how the methods were implemented in scientific studies to investigate important sustainability questions as well as the crucial findings and policy implications revealed by those semantic works.

Working group

In the working group, we use the EXIOBASE data to reproduce some of the key results presented in three semantic works in Python. The objectives of this working group are:

- Understand and explain the main results from EEIOA studies
- Perform an MRIO analysis in Python using EXIOBASE

Study materials

MUST READ

Before the lecture

- Wood, R., Stadler, K., Simas, M., Bulavskaya, T., Giljum, S., Lutter, S., & Tukker, A. (2018). Growth in Environmental Footprints and Environmental Impacts Embodied in Trade: Resource Efficiency Indicators from EXIOBASE3. Journal of Industrial Ecology, 22(3), 553–562. https://doi.org/10.1111/jiec.12735

After the lecture

- Hertwich, E. G. and G. P. Peters (2009). "Carbon Footprint of Nations: A Global, Trade-Linked Analysis." Environmental Science & Technology 43(16): 6414-6420.
- Tukker, A., et al. (2016). "Environmental and resource footprints in a global context: Europe's structural deficit in resource endowments." Global Environmental Change 40: 171-181.

RECOMMENDED READINGS

- Wiedmann, T., & Lenzen, M. (2018). Environmental and social footprints of international trade. Nature Geoscience, 11(5), 314-321.

3.7 Week 12 Physical IO tables

Lecture

Guest lecturer Dr. Stefano Merciai, who pioneered the development of global physical input-output tables, will introduce the leading IO development. He will present the novel structure of the physical IO tables both theoretically and with examples. He will also illustrate the physical tables' novel contributions to IOA's sustainability research application.

Working group

The objectives for the working group are:

- Explain the structure of PIOTs/HIOTs
- Perform a balance check for PIOTs/HIOTs
- Create a Sankey diagram using PIOTs/HIOTs data in Python

Study materials

MUST READ

Before the lecture

- Aguilar-Hernandez, G. A., Sigüenza-Sanchez, C. P., Donati, F., Merciai, S., Schmidt, J., Rodrigues, J. F., & Tukker, A. (2019). The circularity gap of nations: A multiregional analysis of waste generation, recovery, and stock depletion in 2011. Resources, Conservation and Recycling, 151, 104452.

After the lecture

- Merciai, S., & Schmidt, J. (2018). Methodology for the construction of global multi-regional hybrid supply and use tables for the EXIOBASE v3 database. Journal of Industrial Ecology, 22(3), 516-531.

3.8 Week 14 Mid-term review

In this review session, we take a step back and synthesize what has been introduced in the first part of the course. Before coming to the review session, students can submit specific questions they want to ask and address at the review session and **must have finished the mock exam questions**. At the review session, we discuss the solution to each sample question and address the questions submitted by students. We will try to connect the concepts, methods, and/or models introduced in the course so far.

3.9 Week 15 Mid-term exam

The mid-term exam is based on the first part of the course from Week 6 to Week 12. The exam is composed of short-answer and essay questions. It will be open-book and last for max. three hours. A grade of 5.5 (out of 10) or higher is considered satisfactory, i.e., a pass. The mid-term exam accounts for 50% of the course's final grade.

The mid-term exam is meant to help you identify areas that need more work and prepare you for the next part of the course, where more advanced EEIOA techniques are introduced. It also serves as an indication of how well you've been doing so that you can adjust your study methods for the rest of the semester.

3.10 Week 16 Waste IO

Lecture

We introduce the waste input-output model developed by Drs. Shinichiro Nakamura and Yasushi Kondo in this lecture. The waste IO model augments the monetary input-output model with physical waste flows and waste management service sectors, making it suitable for analyzing waste and waste management activities. We also look at some applications of the waste IO model. are shown.

Working group

The objectives of the working group are:

- Understand the structure of a WIOT
- Build a WIO model in Python
- Analyze data from a WIO model

Study materials

MUST READ

After the lecture

- Nakamura, S. & Y. Kondo (2002) Input-Output Analysis of Waste Management, Journal of Industrial Ecology 6(1)39-61 DOI: https://doi.org/10.1162/108819802320971632.

RECOMMENDED READINGS

- Nakamura, S., K. Nakajima, Y. Kondo, & T. Nagasaka (2007) The Waste Input-Output Approach to Materials Flow Analysis Concepts and Application to Base Metals. Journal of Industrial Ecology 11(4)50-63 DOI: https://doi.org/10.1162/jiec.2007.1290

3.11 Week 17 Structural decomposition analysis

Lecture

Decomposition analysis offers a means to quantify the importance of various components in an "explanation" of some observed economic/environmental intervention change. It's a technique that can be applied to all kinds of models, but we'll focus on the input-output model. We focus on studying the structural decomposition considering its unique connection with IO tables.

Working group

- Write a structural decomposition analysis python program that recreates the values in Table 13.1 of Miller & Blair
- Write an LMDI decomposition python program that decomposes the kaya identity following the example shown on the slides.

Study materials

MUST READ

After the lecture

- Minx et al. (2011) A "Carbonizing Dragon": China's Fast Growing CO2 Emissions. DOI: 10.1021/es201497m. Also study the supporting info of this paper.

RECOMMENDED READINGS

- Ang (2016) A Simple Guide to LMDI Decomposition Analysis.
- Levinson, A. (2009). "Technology, International Trade, and Pollution from US Manufacturing." American Economic Review 99(5): 2177-2192.

3.12 Week 18 Technology-adjusted CBA

Lecture

Consumption-based analysis (CBA) of EEIOA plays a unique role in greenhouse gas (GHG) accounting in the context of climate change mitigation. Conventional CBA approaches are criticized for not crediting countries for cleaning up their export industries and punishing some types of trade that could contribute to more carbon-efficient production worldwide. As such, some improved carbon accounting methods have been proposed in recent years. They attempt to address the technology differences in import and export sectors and thereby allow a 'more correct' evaluation of how national policy changes affect total global emissions. In this lecture, we take a detailed look at the technology adjustments proposed in the improved methods and discuss the underlying assumptions.

Working group

In this working group, we use EXIOBASE data to assess emissions embodied in trade with and without the technology adjustments method proposed in Kander et al. (2015).

Study materials

After the lecture

- Kander, A., et al. (2015). "National greenhouse-gas accounting for effective climate policy on international trade." Nature Climate Change 5(5): 431-435.
- Xu, Z., Li, Y., Chau, S. N., Dietz, T., Li, C., Wan, L., ... & Liu, J. (2020). Impacts of international trade on global sustainable development. Nature Sustainability, 3(11), 964-971.

RECOMMENDED READINGS

- Hertwich, E. G. and R. Wood (2018). "The growing importance of scope 3 greenhouse gas emissions from industry." Environmental Research Letters 13(10): 104013.
- Huang, Y. A., et al. (2009). "The role of input-output analysis for the screening of corporate carbon footprints." Economic Systems Research 21(3): 217-242.

3.13 Week 19 Modeling circularity interventions

Lecture

A transition towards a circular economy is a crucial aspect to enable climate change targets in the upcoming decade. In this lecture, we will explore the concept of circular economy from a macro-level perspective, focusing on how circular economy strategies have been assessed through EEIOA. Furthermore, we will discuss how we can apply EEIOA to analyze circularity interventions and provide insights on what are the potential macroeconomic, social, and environmental implications of a circularity transition.

Working group

The objectives of the working group are:

- Calculate circularity metrics (e.g., circularity gap) from IOTs
- Develop and apply functions in Python

Study materials

MUST READ

- Aguilar-Hernandez, G. A., Sigüenza-Sanchez, C. P., Donati, F., Rodrigues, J. F., & Tukker, A. (2018). Assessing circularity interventions: a review of EEIOA-based studies. Journal of Economic Structures, 7(1), 1-24.
- Donati, F., Aguilar-Hernandez, G. A., Sigüenza-Sánchez, C. P., de Koning, A., Rodrigues, J. F., & Tukker, A. (2020). Modeling the circular economy in environmentally extended input-output tables: Methods, software and case study. Resources, Conservation and Recycling, 152, 104508.

RECOMMENDED READINGS

- Re-cap: Aguilar-Hernandez, G. A., Sigüenza-Sanchez, C. P., Donati, F., Merciai, S., Schmidt, J., Rodrigues, J. F., & Tukker, A. (2019). The circularity gap of nations: A multiregional analysis of waste generation, recovery, and stock depletion in 2011. Resources, Conservation and Recycling, 151, 104452.
- Wiebe, K. S., Harsdorff, M., Montt, G., Simas, M. S., & Wood, R. (2019). Global circular economy scenario in a multiregional input-output framework. Environmental science & technology, 53(11), 6362-6373.

3.14 Weeks 20-24 IGA

This assignment tests your ability to perform the EEIOA approaches learned throughout the advanced method course with real-world data through Python programming. You are expected to formulate and conceptualize a research question around one of the two topics: BREXIT and national stimulus plans in a post COVID-19 world, perform the appropriate EEIOA that builds upon and integrates multiple concepts and techniques introduced in the course and be able to interpret and discuss the results. You will use the real-world MRIO data from EXIOBASE 3-monetary for this assignment. It's possible to choose another topic - please consult with the course coordinator.

Students will form the IGA groups based on their preferences.

The consultation meeting (see 'Schedule') will take place in person.

Deliverables:

- June 10 at 17:00 (deadline): Upload a description of the methods and data used in the analysis (i.e., the Methods section in an EEIOA report/journal article), the python script, and the presentation slides (the final version to be used in the presentation on June 14) to Brightspace/Assignments
- June 14: Presentations (see 'Schedule' for further information); 20 minutes per group (15 min presentation + 5 min Q&A).

Grading criteria

Contribution of the IGA to final grade: 50%

Eight grading criteria (grade 0-10) with equal weight:

1) **Motivation and literature review**

Your topic should be related to the materials covered in the course, and you should refer to scientific publications.

- ≤5: Relation to course unclear and/or no publication cited
- 6: Relation to course clear with a few publications cited, a weak link between the literature review and identified knowledge gap
- 7-8: Relation to course clear, clear knowledge gap identified, well-based in state-of-the-art academic literature with detailed referencing
- 9-10: Relation to course clear and referencing to the point, adequate and perfect, literature review leads to an original knowledge gap definition, displaying critical awareness of ongoing debates

2) **Research question and approach**

You are expected to formulate a research question that follows logically from the literature review and research objective. The approach should fit t within the scope of the course.

- ≤5: Research question and/or approach unclear or unrelated to EEIOA

- 6: Research question follows knowledge gap and research objective but approaches inappropriate or unrelated to EEIOA
- 7-8: Well-formulated research question, meets knowledge gap and research objective, and is related to EEIOA
- 9-10: Original and convincing research question firmly based on knowledge gap and research objective and is related to EEIOA

3) Data sources & processing

In the assignment, you are expected to obtain and use real-world data, correctly reference and describe them, and describe the steps required for their transformation.

- ≤5: Data sources or processing steps inappropriate to address the research question
- 6: Data sources and processing steps appropriate to address the research question
- 7-8: Data sources and processing steps appropriate to address the research question, sources and processes are well referenced and described
- 9-10: Data sources and processing steps appropriate to address the research question, sources and methods are well referenced and described, with a critical discussion on data requirements and alternative sources and some form of validation performed (i.e., comparison of data with external sources, or internal consistency check)

4) Analytical method

In the assignment, you are expected to apply techniques and concepts learned in the course and correctly describe them.

- ≤5: Analytical method inappropriate to address the research question
- 6: Analytical method appropriate to address the research question
- 7-8: Analytical method appropriate to address the research question and described with clarity
- 9-10: Advanced analytical method is appropriately applied to address the research question and described with clarity, showing critical awareness of underlying assumptions

5) Results

You are expected to report and interpret your main findings in the assignment. Tables and figures are helpful to present results.

- ≤5: Results do not answer the research question
- 6: Results answer the research question
- 7-8: Results answer the research question with clarity with some comparisons to existing knowledge in the literature and policy implications discussions

- 9-10: Results answer the research question with clarity, and a sound discussion of policy relevance is presented, critically contrasting the results with existing understanding revealed by the literature

6) Scientific rigor

You are expected to make systematic and consistent use of units, terminology, and notation throughout the presentation.

- ≤5: Use of units, terminology, or notation frequently inconsistent with conventions
- 6: Use of units, terminology, or notation mainly consistent with conventions
- 7-8: Use of units, terminology, or notation consistent with conventions
- 9-10: Use of units, terminology, or notation consistent with conventions and care given to details (e.g., the choice of decimal cases in results relative to that of source data)

7) Analysis layout and presentation

You are expected to present the analyses logically and communicate the results clearly.

- ≤5: Fragmented, no or weak line of reasoning
- 6: Straightforward line of reasoning
- 7-8 Convincing line of reasoning, purposeful (i.e., with good reasons) use of figures or tables
- 9-10: Outstanding reporting clarity, appealing visualizations are used purposefully and effectively to highlight the reasoning and critical messages of the results.

8) Quality of code

The code submitted should correspond to the report's material and follow good programming practices.

- ≤5: Connection with source data, processing, and results presented in the report unclear
- 6: Connection with source data and results presented in the report clear
- 7-8: Connection with source data, processing, and results presented in the report clear
- 9-10: Connection with source data, processing, and results reported in the report clear, and code clear, with sectioning and comments