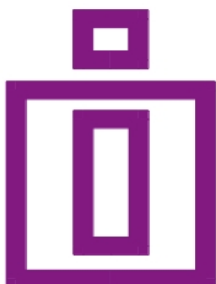# 29th IIOA Conference in ALGHERO, Sardinia, Italy

BOOK OF ABSTRACTS
AND LIST OF AUTHORS

25/Jun/2023 - 30/Jun/2023

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Land and Deforestation embodied in Trade: An Analysis for Brazilian Biomes

Topic: YSI and Development Programme - II - Discussant: Keisuke Nansai
Author: Damares Lopes AFONSO
Co-Authors: Fernando Salgueiro PEROBELLI, Weslem Rodrigues FARIA

Given the social and ecological importance of Brazilian biomes, which in addition to providing important environmental services on a global scale also contribute to the country's income generation in activities linked to agribusiness trade, the objective of this paper was to evaluate the agricultural land and deforestation content embodied in Brazilian trade, both at the intranational and international levels. To this end, an inter-regional input-output matrix was constructed, named MIP-Biomas, which has 47 regions, corresponding to the divisions of biomes in their respective Units of the Federation and 36 activities. The MIP-Biomas was built based on the matrix of the Instituto Brasileiro de Geografia e Estatística (IBGE) for the year 2015, considering the product-based technology and the Interregional Input-Output Adjustment System (IIOAS) method. This matrix also has the opening of the vector of exports to some of the main Brazilian trading partners, namely, the European Union, the United States, China and the rest of the world. Combining the monetary data from MIP-Biomas and physical data on direct agricultural land use and deforestation from satellite images Mapbiomas, indicators were constructed to measure agricultural land and deforestation content in intranational and international trade, separately. Among the results, it shows the pressure exerted by regions of the Mata Atlântica on land use and deforestation in the national territory, with land and deforestation displacement from the North to the South of the country, and a concentration of the impacts of the North and Northeast regions in their own territories. At the international level, the agricultural deforestation content from the Caatinga biome stands out. At the sectoral level, in both intranational and international trade, it is possible to verify the concentration of agricultural land and deforestation content in activities linked to the food sectors, highlighting proteins such as beef and its meats, milk and its derivatives, in addition to pork and poultry. It is emphasized that there are regional and sectorial variations in these results, as detailed in the paper. The results contribute to an evaluation of the origins and destinations of agricultural land use and deforestation in Brazilian trade and can serve as a basis for the formulation of national and international policies to fight deforestation and for a better allocation of land use.

Envisaging Economy-wide Context of Employment & Skills - Green Jobs in India

Topic: YSI and Development Programme - II - Discussant: Keisuke Nansai
Author: Ananya AJATASATRU
Co-Authors: Kakali MUKHOPADHYAY

The Indian economy is going through transformative changes both structurally and demographically. The country is currently progressing to the peak of its demographic window, with about 65% of the population being under the age of 35. This demographic shift is indicative of upcoming years with a surplus in working populous and low dependency ratio, presenting the premise for leapfrogging country's development. This premise is further bolstered with the country's commitments towards adopting sustainable avenues for greening the economy in the advent of impacts from climate change. The transition into a green economy requires both economic restructuring and shift in employment. Hence, at its core it is primarily a human capital issue, which requires significant investments in education, skill development and job creation.

The country has taken several steps towards harnessing the full potential of the demographic dividend from initiation a newly formed Ministry of Skill Development and Entrepreneurship to revamping the skill ecosystem with deeper partnerships between the industry and skilling institutions through Public Private Partnerships (PPPs) and the industry-led Sector Skill Councils for designing the skilling curriculums and standards. The formation of Skill Council for Green Jobs (SCGJ) under the National Skill Development Mission promoted by the Ministry of New and Renewable Energy (MNRE) and Confederation of Indian Industry (CII) marks a key development of addressing these challenges at both fronts.

Anticipating skill needs and changes in occupational structure of transitioning sectors is crucial for smooth transition to green economy. Furthermore, the aspects of greening the economy and green jobs are not only restricted to a group of exclusively classified "green" sectors. Rather within an economy most of the sectors have varied potential towards greening their processes, activities and outputs. Similarly, the concept of green jobs is multifaceted while certain job roles (such as Organic Grower, Solar PV technician, Electric Vehicle Assembler etc.) are foundational for shift towards greener economy and require significant training in relevant "green" skills to aid the economic restructuring and setup of green industries. There are job roles within the existing workforce which are supporting of greening, even though not exclusively classified for "green" skills training (such as construction workers, transport & logistics) but certain level of awareness and upskilling can aid in these cases.

In our study we assess the implications of certain key policies for decarbonization in Energy, Agriculture and Automotives sector on employment and workforce scenario of India. The use of an input output framework in this regard is of vital importance towards ascertaining the direct, indirect and induced job creation potential of these policy initiatives. The use of varying National Accounts for understanding the effects on labour market, arising from policy decisions, external shocks and rising demand; especially in context of green jobs has been widely recognized in various studies. Our study differs from several of the working papers on this theme through its exclusive focus on the occupational structure or classification in the context of economic activities pertained to core sector identified for green transition. Using the IOTT 2018-19, our study disaggregates both the exclusive green sectors from the parent sector such as Solar & Wind from Electricity sector as well as Electric Vehicle Manufacturing from Automotives. To explore the effects of various policy initiatives on the occupational structure of the economy, we have disaggregated labour groups in the SAM by building the concordance between the National Classification for Occupation (NCO) and National Industries Classification (NIC) from the unit level data of periodic labour force survey. Furthermore, we have exclusively introduced the green job roles introduced by the SCGJ and their recruitments to anticipate the training requirements in the upcoming years. Ascertaining the numbers of job created among the mentioned the earlier mentioned two groups (green & greening) of occupation is crucial to measuring the skill gap of transitioning to a greener economy, by enabling to determine the time period and quantum of trainees for effective skilling, upskilling or reskilling in the workforce of the country.

Brazilian trade pattern and its vulnerabilities: reflections based on the challenges imposed by the COVID-19 pandemic

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - II
Author: Tânia Moreira ALBERTI
Co-Authors: Vinicius A. VALE

The global economy and international trade have become increasingly structured around Global Value Chains. The production fragmentation has led to increases in the trade of intermediate goods, with the different stages of production taking place in many countries before reaching the final consumer. The global scale of the fragmented production became pronounced in the 2000s, with emerging economies taking on different roles in GVCs. These economies have become exporters of intermediate and final manufactured products, and large exporters of primary products, such as the case of Brazil.

The production shift from North to South accelerated in the 2000s and the production fragmentation has favored middle-income economies, increasing their shares in global export value added. With the trade growth in emerging economies, changes have also occurred in end markets, especially after the 2008-2009 economic recession.

Brazilian exports to China, for example, increased almost thirty times and Brazilian imports from China increased sixteen times between 2000 and 2010. This has raised concerns about the trade pattern since there is an export concentration on a few products, with about 70% of Brazilian exports composed of primary products or primary resource-based manufacturers. Further, Brazilian imports are concentrated in technology-intensive components and machinery.

Exported value added has increased from 1995 to 2011, but it is still low when compared to other countries. Moreover, Brazil's insertion in international trade and GVCs is considered peculiar, since it imports products with high technological content while undergoing deindustrialization, and concentrates its exports on basic.

Thus, Brazil has passed a period of increasing trade fragmentation, increasing its exports of basic products, taking advantage of a period of rising terms of trade. However, this period seems to have ended. Moreover, mistrust of global integrated production only increased after the Covid pandemic. Thus, the debate about over-reliance on certain sources of supply and the risks, trade restrictions, and interest in producing with less geographic dispersion increased.

The COVID-19 pandemic has become additional pressure on the already existing trade tensions. On the one hand, economies with natural resource-intensive exports could benefit from new export opportunities. On the other hand, efforts to diversify exports in these economies could be undermined.

Thus, this study aims to discuss Brazilian vulnerabilities in relation to value-added trade in the post-pandemic context and the weakening of world trade. We analyze the value added in Brazilian exports from 2000 to 2014 using the hypothetical extraction method (HEM) with data from the World Input-Output Database (WIOD).

The results show a strengthening of China as the destination of the value-added exported by Brazil to the detriment of the European Union and the United States over the period 2000 to 2014. The change in the destinations of exported value-added also meant a change in the sectoral composition of products exported by Brazil, with the value-added exported by Brazil

becoming more concentrated in products intensive in natural resources, especially in trade with China.

This change of destination and the change of product are evaluated in the context of the COVID-19 pandemic and the vulnerabilities to Brazilian trade are discussed. An important source of risk is the non-diversification of exported value-added, with a deepening on products intensive in natural resources. At the same time, there is a reduction in the value-added of manufactured products. The concentration in product and country exposes Brazil to shocks of external demand, variability of exported value, dependence, and specialization in products/markets with specific rules not always applicable to other markets, such as rules on the environment or labor market.

Thus, the study is a reflection on the risks for Brazilian trade, as part of the debate on the vulnerabilities of trade linked to GVCs in the post-pandemic scenario and the forecast of low growth in world trade and the weakening of fragmented trade.

Economic consequences of climatic changes in crop yields in water-abundant regions

Topic: Regional Input-Output Economics - I
Author: Grant Jordan ALLAN
Co-Authors: Gioele FIGUS

A concerning consequence of climate change is the impact that reduced rainfall and increased temperatures will have on agriculture yield. There is a growing literature showing the impact of changes in climate on output of the agricultural sectors, however the approaches used to date omit the wider consequences of these changes across the whole economy. Importantly, most studies are focussed on already water scarce countries. At the regional level, differences in economic structure will lead to a heterogenous direct economic exposure to climate changes, however the indirect exposure of regions to climate futures, taking into account interregional trade and intersectoral linkages, is less clear. We argue that even water abundant countries may experience severe impacts of climate change on agricultural yields, where regions that are crucial for agricultural production are more exposed to changes in climate.

Focussing on Scotland, we develop a micro-to-macro approach to investigate the consequences for the Scottish economy – using a CGE model with two regions – of projected changes in climate which are then linked to agricultural yields in each region. Whilst climate change may seem to be not a concern for a notoriously rainy country, starting from position of relative water abundance, Scotland is projected to see less rainfall and warmer temperatures over the coming decades as well as more weather extremes. Crucially, current projections show how the east side of the country, which is more populous and more agriculture intensive, is set to experience more frequent draughts especially in the growing season.

We begin by examining the historical relationship between rainfall and temperature with agricultural yields for four crop types (wheat, oats, winter barley and spring barley) using a simple econometric estimation. The estimated coefficients are combined with future climate projections for east and west Scotland to generate projections in agricultural yields.

Our final – macro – step introduces these via changes in productivity in the Agricultural sector into a two-region CGE model of West and East Scotland which captures the interconnectedness between regions through trade, and the system-wide consequences on output across sectors and

regions of Scotland.

The CGE model includes water as an implicit factor of production embodied in land using conventional production functions. A crucial feature of the Scottish economy is that rainfed land represents the vast majority of farmed land in the country. We consider two land types, rainfed and irrigated. These are supplied in fixed quantities.

The results from our historical crop yield analysis illustrate how agricultural climate during the growing season is critical for crop yields, with summer rainfall particularly damaging for oats and barley. Our CGE results show how sectors, and each region, are affected by the projections of changes in crop yields, under a no-mitigation case. Importantly, results from our simulations show how a proportionate reduction in agriculture productivity in East Scotland has detrimental impacts that are transmitted to West Scotland. The east-west channel propagates shocks more heavily than the west-east channel due to the location of Scottish farms. We end by discussing possible sector and policy actions in reducing the negative economic consequences of future climate projections including irrigation.

Economies vulnerability to import's restrictions: a supply-driven analysis

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - III
Author: Aleix ALTIMIRAS-MARTIN
Co-Authors: Joaquim J.M. GUILHOTO

Supply restrictions such as those induced by the covid-19 pandemic, or the war in Ukraine, have stressed the importance of international trade to economies. Specifically, certain imports have the potential to disrupt production and consumption. Such issues are pervasive across countries and can be sparked by restriction of many different products (e.g., food, energy, specialised electronic components, critical materials...). Hence, identifying and characterising such vulnerability is a priority to build resilient economies without losing the advantages brought by international trade for the nation's economic development and well-being.

The literature has already explored similar issues. At the domestic level, the Ghosh model has been used to study supply restriction. Unfortunately, the Ghosh model does not reflect the actual functioning of the economy since it considers primary inputs as independent. Thus, such exercises do not reveal the actual potential productive disruptions caused by import restrictions. More recent literature used (Global) Multi-Regional Input-Output Tables (G)MRIOTs to capture and decompose the different impacts of Global Value Chains (GVC). However, most analyses and indicators rely on demand-driven models and the Ghosh model. Thus, it is still difficult to fully assess the consequences of supply-restrictions.

Hence, currently, it is still not clear how specific import restrictions affect the productive capacity and structure of an economy, nor their impact on the country's value added (VA) and employment. It is unknown how each sector's imports may restrict the overall production and consumption of the country. Neither it is known the impacts on VA, employment, if specific import restrictions were to happen and cascade through the economy.

First, this paper uses a recently developed supply-driven model which consumes simultaneously all primary inputs, i.e., reflecting the actual functioning of the economy, to calculate different indicators and characterise a country's vulnerability to imports. The model is applied to OECD's

Inter-Country Input-Output (ICIO) tables to perform a comparative analysis. This method is especially suited to account for non-competitive imports, but variations of this methodology can also be applied to competitive imports. In particular, it is used to calculate production multipliers associated with every import to identify their respective capacity to disrupt domestic production, VA and employment.

Second, this paper aims to assess the structural effects that imports have on the domestic productive structure. In particular, a new method of hypothetical extraction of imports is developed and applied to a conventional IOT, revealing the "pure domestic" productive structure. The method extracts all flows associated to imports: i.e., imports accounted as primary inputs, their corresponding intermediate flow, and final outputs. Then, such a structure can be compared to the "conventional domestic" productive structure, which includes imports by default. In our case, we calculate the total backward linkages, and value-added and employment multipliers, using the Leontief model of the "pure domestic" and "conventional domestic" structures. We assess the differences in results from both structures to deepen the understanding on how imports affect the domestic economic structure.

The results allow researchers to: 1) identify the imports' supply restrictions with most economic impacts, in terms of total production, value-added and employment; and 2) identify how the domestic structure of economies is altered due to their own import needs, providing key information to internalise the production of imports.

Public Expenditure and GHG emissions in Brazil: A Structural Decomposition Analysis for the 2000-2019 period

Topic: Input-Output Modelling: Sustainable Production and Consumption Policies - II
Author: Marcio ALVARENGA JUNIOR
Co-Authors: Huascar Javier EGUINO, Lucas de Almeida Nogueira da COSTA, Patieene Alves PASSONI

Introduction

In the last two decades, primary public spending amounted, on average, to 30.6% of the Brazilian GDP. However, there is a great variation in the period not only in the scale of the public expenditure, but also in its composition. At least two major events resulted in important composition changes: (i) the Growth Acceleration Program, which resulted in the expansion of public investment after 2007, and (ii) the fiscal adjustment and the fiscal ceiling in the second half of the 2010s, which resulted in a sharp contraction of the discretionary expenditures.

To date, several studies have focused on the analysis of Brazilian public spending, seeking to answer a wide range of questions. The most frequent ones refer to the impact of public spending on economic cycles, public debt, inflation, and income distribution.

In a context of environmental crises, the analysis of Brazilian public spending has been gaining new contours. Several studies have been focusing on measuring and evaluating the quality of environmentally related public spending, especially those related to climate.

Nevertheless, the impact of public spending on greenhouse gas emissions is largely ignored in this debate given the methodological difficulties to estimate the emissions from public expenditure. Still knowing the public spending emission profile allows policy makers to design

policies to guide public investment and procurement to sectors, goods, services, and technologies with lower emission intensities. It important to highlight that greening public expenditure may result not only in the decarbonization of final goods and services, but also in important emission reduction throughout the entire production chain.

Research Questions:

Given the knowledge gap in this field, this paper aims at addressing the following research questions:

(i)   How much GHG emissions have been generated by the Brazilian public expenditure from 2000 to 2019?

(ii)   What is the pattern of GHG emissions (intensity, sectoral composition, etc.) from public expenditure in Brazil?

(iii)   What are the main drivers of changes in GHG emissions derived from the Brazilian public expenditure?

(iv)   Which policies can contribute to decarbonize the Brazilian public expenditure?

Objectives:

This paper aims at estimating GHG emissions from the Brazilian public expenditure between 2000 and 2019, identifying the elements behind their growth, and from there, recommending policies capable of decarbonizing public investment and consumption.

Data and methods:

The emissions by Brazilian public expenditure can be obtained from the multiplication of the vector of sectoral GHG emissions intensity (total emissions per unit of gross output), by the Leontief inverse matrix and the matrix of public expenditure, which includes government consumption and public investments.

The definition above represents an environmental extension of the canonical input-output model. The extended model presented here behaves in the same way and operates under the same hypotheses as the original model. However, data availability is a great challenge to carry out analysis like this, as the analysis proposed in this article requires:

(i)   Annual Input-Output tables (IOT).

(ii)   A vector of emission intensity per industry.

(iii)   A vector of public investment per industry.

Given the lack of official data on the topics mentioned above, this article integrates three estimated databases: the satellite accounts for GHG emissions, elaborated by Alvarenga, Costa and Young (2022), the IOT time series at constant prices, developed by Passoni and Freitas (2022), and the investment absorption matrices, developed by Miguez and Freitas (2021). The latter database allows us to estimate the public sector demand for the capital goods produced by each industry.

Furthermore, given the changes in the economic cycle, public investment trajectory, and productive structure over the last two decades, we decompose the public expenditure GHG emissions into:

(i)   Scale effect: emissions changes due to a variation in the level of the public expenditure.

(ii)   Composition effect: emissions changes due to a variation in the share of public investment and government consumption.
(iii)   Product mix effect: emission changes due to de sectoral distribution of the government expenditure.
(iv)   Technological effect: emission changes due to changes in total technical coefficients.
(v)   Trade pattern effect: emission changes due to changes in the proportion of imported inputs used in the production of public expenditure.
(vi)   Emission intensity effect: emissions changes due to changes in the sectoral emission per unit of gross output.

Novelty of the research:

To the authors' knowledge, this article is the first to measure and decomposing emissions derived from public spending. It is believed that the methodology proposed here can guide the estimation of emissions in other countries.

Research challenges for the future: panel discussion about Environment

Topic: 50th Anniversary of Leontief's Nobel Prize: Environment
Author: Guadalupe ARCE
Co-Authors: Shigemi KAGAWA, Albert E. STEENGE

Based on the seminal work: Wassily, Leontief (1970) "Environmental Repercussions and the Economic Structure: An Input-Output Approach", The Review of Economics and Statistics, 52(3): 262-271. Includes presentation of some archive materials and documents about this topic.

Climate change displacement responsibility along global production chains

Topic: Input-Output Analysis: Industrial Policies
Author: Guadalupe ARCE
Co-Authors: Ángela GARCíA-ALAMINOS, Mateo ORTIZ, Jorge E. ZAFRILLA

CO_2 emissions have exceeded the planet's boundaries in recent years. A map of national contributions to cumulative emissions of CO_2 could be helpful in allocating CO_2 atmospheric concentrations responsibilities to seek equal responsibility access to atmospheric commons (Hickel, 2020). The rise of globalization since the end of the 80s shows a rapid increase in developing countries' production-related emissions due to the rise of international trade exports from developing to developed countries (WTO, 2022). The net production emissions transfer from developed to developing countries increased rapidly from the beginning of the 90s until 2005. It has declined since 2006, with a maintained positive balance of 1.5 $GtCO_2$ per year (Wood et al., 2020). The resulting phenomenon of the increase in the carbon footprint responsibility of affluent economies must be considered when allocating the recent fast growth of atmospheric emissions concentration responsibilities.

Climate change is not only a matter of future generations. One of the current consequences of exceeding the planet's boundaries in terms of greenhouse gas emissions concentrations is the increase and stabilization of sudden weather-related events impacting human life along the

Earth. According to the data gathered by the Global Internal Displacement Database (GIDD) (IDMC, 2023), from 2008-2021, more than 24 million people were displaced inside the borders of their country because of severe climate-related events, with China, Philippines, Indonesia, Pakistan, or Bangladesh as the most hit countries. Several questions arise when examining the internal displacements regional patterns, in which emerging countries predominate. Is the Global South more prone to climate migration due to its sectoral structure's vulnerability? Considering the currently intricated global production chains and the magnitude of international trade, what is the role of the developed regions on the vulnerability suffered by emerging economies? Our work intends to address these questions by combining data on internal migrations, a vulnerability-to-climate-change index, and the input-output methodology.

On the one hand, using an environmentally extended MRIO model, this paper will allocate the observed climate change displacement responsibility from the GIDD among the consumer perspective cumulative emissions since the globalization boom in the early 90s. The method will allow us to evaluate the contribution of each country to the cumulative emissions generated since 1990.

On the other hand, we will analyze the influence of global trade on the vulnerability profile of the regions most affected by internal migration. First, we will identify among the countries with more internal climatic displacements in the GIDD those less prepared to adapt and more vulnerable to climate change based on the ND-GAIN score (ND-GAIN, 2023). This index summarizes a country's vulnerability to environmental challenges in combination with its readiness to implement adaptation actions. In terms of vulnerability, the index is disaggregated into several contributing factors, among which the so-called sensitivity factor -the extent to which a country is dependent upon a sector negatively affected by climate change- is considered. Therefore, the combination of the GIDD list of countries and types of disasters, and the ND-GAIN sensitivity score, will allow us to isolate the countries more vulnerable due to their sectoral structure.

After identifying these countries, we will explore how trade specialization has guided them to a more vulnerable situation. By using the detailed information provided by the MRIO models regarding international trade trends and production specialization processes in emerging economies, this paper will assess to what extent the way the global production chain shapes a country's production structure contributes to increasing the climate vulnerability of emerging economies. The environmentally extended MRIO model will be developed based on the GLORIA database, which provides a list of 160 countries plus four regions, and a time series covering 1990-2019 (Lenzen et al., 2021).

Uncertainty Propagation in EE-MRIO

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - IX
Author: Mohamed BADR
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Uncertainty Propagation in EE-MRIO - Abstract

Despite the prominent role of Multi-Regional Input Output models (MRIO) in sustainability analysis

and policy making, the role of uncertainty in MRIO modeling is not well understood. In the last years, there have been two main lines of research with regards to uncertainty in MRIO: The first analyzed the sensitivity of MRIO results regarding aggregation of sectors and regions, the second took a more general approach and analyzed uncertainty of results due to uncertainty in the raw data, often using Monte Carlo simulations. The effect of aggregation on consumption-based accounts of regions and sectors (aka footprints) has been well researched in MRIO literature, with the general conclusion being that increased sector and country resolution lead to more accurate footprint estimates. Within aggregation uncertainty literature, satellite accounts/ environmental extensions have been analyzed and include carbon, as well as material accounts. Monte Carlo simulations, as the second main line of research within MRIO uncertainty, has also been utilized. Among the findings of these studies is that MRIO uncertainty is generally maintained at acceptable levels. However, in contrast to uncertainty due to aggregation, the latter line of research is restricted to GHG (greenhouse gas) and does not analyze other environmental extensions. Linear error propagation in MRIO has not been as commonly used as aggregation-based methods or Monte Carlo in understanding uncertainty in MRIO. Thus, in this analysis, we use linear error propagation to understand the propagation of uncertainty from environmental stressors to the final footprint estimate, along with footprint sensitivity to stressor uncertainty. The research addresses two questions; 1) To what extent does error propagate from satellite extensions to regional footprint estimates? 2) Do footprints vary in their sensitivity to extension uncertainty? To answer these questions, we conduct an analysis assuming a constant relative standard deviation for several satellite accounts. We then calculate resulting consumption-based accounts (footprints) by coupling the standard MRIO calculations with a linear error propagation analysis. We used a set of satellite accounts which cover a wide variety of sector distribution: GHG and Employment, which are more or less evenly spread across sectors, contrasted by Water Consumption and Land Use which are restricted to certain (mostly agriculture) sectors. We confirm the analysis results with a "classical" Monte Carlo sensitivity analysis. EXIOBASE 3 (3.8.2) in the product-by-product classification for the base year 2019 was used for all analysis. The research utilizes HPC (high performance computing) clusters for the calculations. We find that the satellite extensions Land use and Water consumption propagate more uncertainty compared to Employment and GHG. We also find that regions with evenly distributed extensions, propagate less uncertainty to final footprint estimates. In general, footprints/CBA of extensions which are evenly distributed across sectors show less sensitivity to uncertainty of the underlying extension. Pymrio, the python package for MRIO calculations, was used for EE-MRIO calculations. On a more general scale, the research offers significant progress in the field of uncertainty in EE-MRIO which will aid researchers to better interpret footprint estimates of various products, and final demand vectors. Assuming a 0.1 relative standard deviation, we find the following mean relative standard deviation per footprint; Employment: 0.015, GHG: 0.018, Water consumption: 0.023, Land Use: 0.028. In other words, we find that accounts such as Water and Land are more sensitive to uncertainty given their sector-specific nature. The results were tested using an ANOVA (analysis of variance) test, as well as Tukey's HSD comparison of means, and in general, were found to be statistically significant.

Integrating developing countries into the global value chain: Compilation, Extensions, and Analysis of the ADB Multiregional Input-Output Database

Topic: Input-Output Analysis: Industrial Policies - I
Author: Faith BALISACAN
Co-Authors: Mahinthan Joseph MARIASINGHAM, Xue HAN

This paper focuses on the development of the Asian Development Bank's (ADB) Multiregional Input-Output (MRIO) tables and Digital Supply and Use Tables (DSUTs). These tables are a critical area of research as these are tools for analyzing the interdependencies of global production chains and assessing the potential impacts of policy interventions. In the compilation and regularly updating of the underlying national input-output tables and the integration of new economies to the database, the most significant challenges encountered are data availability and the capacity of national statistics offices (NSOs) to collect and compile the necessary data, particularly in developing countries where resources could be limited and constrained. As such, the ADB has been working towards providing technical assistance projects such as building the capacity of national statistical offices to collect, compile and/or improve the quality of their data. Moreover, these knowledge and support initiatives aim to strengthen the capacity of national statistics offices to undertake extensions to the multiregional table, such as the digital supply and use tables (DSUTs). Among these is the Japan Fund for Prosperous and Resilient Asia and the Pacific (JFPR) technical assistance, initiated by the ADB, to compile DSUTs for Indonesia, Viet Nam, Georgia, and Thailand.

The importance of continued efforts in developing MRIO and DSUTs cannot be overstated. Developing countries, in particular, can benefit greatly from the insights provided by the MRIOs and DSUTs. The ADB has been working continuously to address the challenges associated with compiling these tables, but more needs to be done to expand the coverage to more developing countries.

Blame the rich? Norwegian consumption-based accounts of household archetypes

Topic: Consumption-Based Accounts of Household Types
Author: Marta BALTRUSZEWICZ
Co-Authors: Kjartan STEEN-OLSEN

In the global effort to cut emissions of greenhouse gases, a key question is how the responsibility for the various emissions is to be distributed. Thus, understanding the various mechanisms through which human activities lead to emissions directly and indirectly and how different groups contribute to these is important.

Based on the Norwegian household consumption survey and additional physical data, we present six household archetypes that represent the footprints of the super-rich, high-income earners, and households in the lower income deciles. We use multi-regional input-output analysis combined with bottom-up approaches to calculate archetype footprints. In addition, we estimate the carbon footprint of private investments based on a novel approach taken by the World Inequality Database. In this approach, the full burden of the emissions associated with private investments is allocated to those with ownership interests in the investing entities.

Preliminary results indicate that when including contributions from private investments, the 1 % wealthiest Norwegian households have a carbon footprint of 155 tons CO2 equivalents on average. This is more than 6 times higher than the average Norwegian household at 25 tCO2e/hh. We produce results in cooperation with the non-profit organization "Future in our Hands", which employs this analysis to inform Norwegian net zero policies.

With this study, we hope to contribute to shaping the research on the carbon footprint of wealth and investment; and inform the research community about the lessons learned from the political process of working towards the reduction of the footprints of the wealthiest households.

Combining standard TiVA indicators towards a single exposure indicator

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - III
Author: Santacruz BANACLOCHE SáNCHEZ
Co-Authors: Pablo PINERO, José M. RUEDA-CANTUCHE

Developed by the European Commission, FIGARO stands for 'Full International and Global Accounts for Research in input-Output analysis' and comprises the EU inter-country supply, use and input-output tables (EU IC-SUIOTs). FIGARO tables are currently Eurostat's official statistics, available for the period 2010-2020 and produced in an annual basis. The Single Exposure Indicator combines two well-known TiVA indicators in a single and consistent format, to identify all key dependences in bilateral trade among partners. The novelty of this research relies on the data (FIGARO 64 industry-by-industry multi-regional input-output table for 45 countries plus 1 region) and methods (brand new TiVA indicator). Using the FIGARO database and the Single Exposure Indicator combined allows global value chains to be analysed providing interesting results to policy-makers, related to dependences, potential risks and vulnerabilities of countries at the industry level.

Crowding-out of Energy Consumption Using the Hefty Network of Trade-induced Spillover and Feedback Effects: A Structural Decomposition Analysis

Topic: YSI and Development Programme - III - Discussants: Sebastien Miroudot and Erik Dietzenbacher
Author: SUVAJIT BANERJEE

(1) The research question:
According to the Global Energy and CO2 Status Report, 2019, China, the USA and India stand top three positions for their total carbon-dioxide emissions in the year 2018 (IEA, 2019). Interestingly, China, the USA and India are also leading the trend in deploying the renewable energy generation capacity in the world (IEA, 2017).
Besides competing on the aspects of energy consumption, China, USA and India are also having an intense international trade relationship. Therefore, it would be of interest to examine how far these major carbon emitters as well as leading renewable energy deploying economies are contributing to the saving of each other's national energy use. This study theoretically explores how significantly international trade can reorder and help crowding-out the national energy use of the major carbon emitter trade partners and empirically analyses the implied economics of national energy governance by concentrating on the trade-induced spillover and feedback

effects.

(2)   The method used:

2.1.   Hybrid-units IRIO Framework: The study adopts a hybrid-units based input-output framework where the energy flows in the economy is measured in physical units (TJ) and the non-energy transactions are measured in value units (Millions of USD).

2.2.   Hierarchical Structural Decomposition Analysis (SDA): The study first conducts the SDA exercise of the increased aggregate energy use of top three world emitter economies. In the initial level, the contribution of the total energy requirement multiplier is decomposed into the contribution of changed energy-intensities and technological change represented by hybrid-Leontief multiplier. The study considers year 2012 as base year time-point '0' and of 2018 as final year time-point '1'. To avoid the hybrid-units related computational complications, the study also follows the suggestions proposed in Dietzenbacher and Stage (2006). In the subsequent levels of decompositions, the study is digging deeper into analysing all the contributing drivers decomposed at the initial level.

(3)   The data used:

The study uses the ADB-MRIO database at constant prices of 2010 for the years of 2018 and 2012 for constructing the three-country IRIO table consisting of China, India and the USA. For the non-energy sectors, the study extracted data from the energy-commodity balance tables and electricity profile tables of the United Nations Energy Statistics.

(4)   Novelty of the Research:

From the hierarchical SDA, the study found that China is both the biggest contributor to the potential interregional energy use and major driving economy to eliminate this scale-driven increased potential energy consumption. On the other hand, the USA found as the worst performer among the three countries in terms of generating dampening impact on the increased potential energy use and India is sharply increasing its energy consumption compared to China and the USA, although contributing to reducing the potential energy consumption to a smaller extent. To understand the roles of these economies and their driving forces the study further explored a couple of simulation-based exercises.

Assuming an 3-country emission-binding treaty, in simulation exercise 1 and 2, the USA and India are considered as the free-rider countries respectively and that the free-rider country does not initiate prudent energy-saving policies rather depends on the outsourcing of a proportion of its production activities required to facilitate the delivery of its unilaterally increased final demand. With a 50% increased final demand, the outsourcing of production from the free-rider country is empirically addressed.

Based on these simulations, the study substantiates that the USA in both the situations of being as a free-rider or a non-free-rider saves aggregate energy use of the three countries by outsourcing its production to China and India. On the other hand, China found serving to save energy usage of the outsourced energy requirement of India and the USA in the two simulation exercises. Here, India is found saving energy as a non-free-rider country, whereas fail to save energy from outsourcing as a free-rider. Therefore, this analysis portrays the comparative positions of these countries in terms of how far their aggregate emission is adjusted in the inter-country energy flows to govern the global volume of energy consumption to a substantial extent.

The study is the first of its kind where a comparative analysis is brought forth which yield the prudence of national energy-saving initiatives under an international emission-binding

agreement, while imprecating the external energy saving and energy decaying roles of international spillover and feedback effects on the national energy inventory to elaborate the roles of structurally decomposed drivers of increased energy use.

Analyzing climate change adaptation measures in Georgia

Topic: Input-Output Analyses and IO Modelling of Disasters - II
Author: Maximilian BANNING
Co-Authors: Christian LUTZ

We use a macroeconometric input-output model, e3.ge, that was specifically developed for this purpose, to analyze the socioeconomic impacts of various adaptation policies in the country of Georgia. Georgia's geographical location and natural conditions, ranging from complex mountainous landscape to the black sea coastal zone, contribute to a substantial vulnerability to climate change. There are several observable signs of climate change in Georgia during recent decades, among others increasing mean and extreme air temperatures, increased average annual precipitation, and changing rainfall patterns, increased frequency of droughts and hailstorms. These climate change effects are increasingly impacting people's lives and disrupting the Georgian economy.

The e3.ge model consists of three interlinked model parts. At the core of the economic model (1) is a Georgian input-output table. As no officially published table existed at the beginning of the project, one was derived from the available supply and use tables. 38 economic sectors are differentiated inside the model. Development and linkages of final demand components, such as household and government expenditures, or gross fixed capital formation is estimated econometrically using domestic data. Labor market data is also available from Georgia's National Statistical Office, distinguishing employment in 16 economic sectors and providing aggregated and averages wages. The energy module (2) consists of the energy balance. The energy consumption depicted in there is directly linked to individual sectors of the input-output table. The energy mix used as transformation input for the generation electricity can be found in there as well as exports and mainly imports of various energy carriers. Furthermore, energy-related emissions are calculated using national emission factors for several fossil energy carriers. The environment module (3) contains detailed economic information and data on climate change and adaptation options. Data on past damages from climate change cover extreme weather events. This damage data serves as a benchmark for the economic effects of climate change in Georgia and is projected to the future using data from extensive climate models.

Evaluation of adaptation measures is performed by conducting scenario analysis. A business-as-usual scenario is contrasted with a scenario that contains the negative impacts of climate change, and another scenario that contains both the impact from climate change and adaptation measures and their presumably positive impact, either by additional investment or by reduced damages.

Macroeconomic effects of adaptation measures in Georgia are overall positive. A higher gross domestic product (GDP), however, can result due to several factors and thus it is important to have a closer look on the underlying causes to evaluate individual measures. A positive GDP effect can be observed even in scenarios without adaptation for the years where damage occurs. Nevertheless, the so-called defensive spending on repairing, reconstruction and increased consumption behind the positive impact can be interpreted as inherently undesirable as the positive effect is due to the fact that damage has previously been caused by storms, heavy rains

or heatwaves. In contrast, adaptation to climate change ensures that, e.g. additional annual construction activity will also generate a positive GDP effect and, at the same time, damages caused by extreme weather events will be lower. This can be illustrated by the example of heatwaves: Buildings heat up and people are less productive; more energy is demanded for cooling reasons; more beverages are consumed; people experience health problems. While declining productivity has a negative impact on the economy, increased beverage consumption and increased demand for health services can have a positive economic impact. Analyzed extreme weather events also include strong wind and heavy precipitation while adaptation measures range from irrigation and windbreaks to infrastructural programs and coastline protection.

This model is the first macroeconometric model with input-output core applied in Georgia. It was developed together with the Georgian Ministry for Economy and Sustainable Development. All information and data entering the model were continuously discussed with additional stakeholders and national institutions, such as the Ministry for Environmental Protection and Agriculture, the National Bank of Georgia, and several NGOs. One objective of the project, that was fulfilled, was to rely on domestic data sources and only use international data where no other estimates are available. The model results will be now used in policy-making processes in Georgia to evaluate the economic effects under a bandwidth of climate change scenarios and adaptation options. They provide the quantitative background to decide upon effective policy instruments that lead to resilient economic develo

Heritage Tourism and Economic Development: An Input-Output Analysis for Minas Gerais, Brazil

Topic: YSI and Development Programme - V - Discussants: André Carrascal and Michael L. Lahr
Author: Arthur BAZOLLI ALVARENGA
Co-Authors: Cláudio Eurico Seibert Fernandes da SILVA, Elvira HELENA OLIVEIRA DE MEDEIROS, Fernando Salgueiro PEROBELLI, Filipe SANTIAGO DOS REIS

Considered one of the first Brazilian architectonic and cultural movements, the baroque style of Minas Gerais is a fundamental piece of the Brazilian identity. After efforts to value and promote it, the style has become one of the main Brazilian touristic products, symbolized by UNESCO's classification of sites in the cities of Ouro Preto, Congonhas, and Diamantina as World Cultural Heritage. Thus, tourism in baroque regions in Minas Gerais is nowadays an important part of the local economies. This article proposes to analyze the importance of tourism characteristic activities (TCAs) in these regions. To do so, we used the Brazilian 2018 I-O table and employment and export data to build a regionalized I-O for these regions under the Interregional Input Output Adjustment System (IIOAS) framework. This allows us to analyze the impacts of a hypothetical extraction of the TCAs through both interregional and intraregional lenses. Our results showed that the TCAs have a variable weight in local economies, ranging from 0.75 percent to 65 percent of the cities' Gross Value of Added (GVA) and averaging at 10 percent. Comparing the impacts of a simultaneous extraction with those of local extractions region by region, it was possible to identify as well that tourism activities have a relatively bigger impact on the local economies rather than on a regional scale, which points out to a modest interdependence in the supply chain of the baroque cities' touristic sector. In addition to providing an analysis of the tourism industry in the local economy of Minas Gerais which can further aid policy making, we also contribute to the literature by creating a novel regionalized setting with hypothetical extraction of a cross-sector industry, which was possible by estimating TCAs' shares in the I-O matrix sectors.

Towards a comprehensive and inclusive European Carbon Border Adjustment Mechanism

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - IV
Author: Timothe BEAUFILS

The European Union (EU) will implement a Carbon Border Adjustment Mechanism (CBAM) to reach its climate mitigation targets while avoiding carbon leakage. Under an EU CBAM regime, emissions caused by goods imported to the EU would be taxed based on the emissions their production generated elsewhere in the world. The EU CBAM may also entail export rebates, deducting the carbon price from the goods exported from the EU. Beyond EU producers and consumers, an EU CBAM would impact industries and final users in third countries through their direct and indirect trade dependence on the EU. Such international spillover of the EU climate policy could encourage other countries to adopt more stringent climate policies or retaliate against the EU CBAM. While most previous research focuses on the potential effect of an EU CBAM on the main EU trade partners, little is known about the exposure of middle- and low-income countries: we attempt to solve this gap by providing an assessment of the potential impacts of the EU CBAM at high regional resolution and exploring policy options to make an EU CBAM inclusive toward the most vulnerable nations.

Using spatially-detailed Multi-Regional Input-Output (MRIO) data (EORA 26) and a novel throughflow-based accounting framework, we evaluate different implementation options for the EU CBAM, based on various products and scope coverages. We propose a new approach to explore how an EU CBAM would channel the EU carbon price to third countries and quantify which countries would be the most affected. We find that, despite having few responsibilities in the current climate crisis, some low- and middle-income countries dependent on the EU for their exports would be disproportionally pressured by an EU CBAM, as a large share of their domestic emissions would be covered by the EU carbon price. We finally propose avenues to implement an inclusive recycling of the fiscal revenue of the EU CBAM toward vulnerable countries. We show that such a recycling scheme could make an EU CBAM more acceptable for the EU trade partners and foster increased climate cooperation, but it would require balancing between conflicting interests.

Economic impact of the social policy "Ingreso Mínimo Vital" in Spain: a multisectoral approach

Topic: Input-Output Modelling: Income Distribution Policies
Author: Luz Dary BELTRAN JAIMES
Co-Authors: Pilar CAMPOY-MUÑOZ, María C. DELGADO

In Spain, poverty and social exclusion are atypical in a country with a high-income level, reflecting the inability to generate better conditions and forcing us to think about the need to restructure current public policies. Therefore, migrating towards a social transformation would lead to achieving a real change with equity and economic development, but for this is necessary to implement structural measures that articulate the economic policy decisions taken at different levels.
The current indicators of poverty risk, inequality, low participation of wages in added value, and the gender wage gap reflect the great challenges in terms of social inclusion that must be faced as a result of a series of structural problems, labor market deficiencies, insufficient tax collection, and redistributive capacity, which are expected to have been accentuated after the pandemic.

Spain's economic and social recovery is conditioned to the resolution of these problems, highlighting the need to strengthen fiscal measures aimed at reinforcing growth capacity, fundamentally through the implementation of reforms in the benefits system and in the tax system that guarantee social inclusion. Therefore, these structural adjustment measures could help to recover macroeconomic stability, improve income distribution and implement better development strategies.

This inequality in Spain is accentuated by the low redistributive effect of the State's public policies compared to other European countries. Among the international recommendations has been to reinforce Spain's Income Guarantee System. In this way, the "Ingreso Mínimo Vital" (IMV) approved in 2020 reinforces the different models of minimum income policies that have been implemented with great disparity by the different autonomous communities.

The IMV was designed as a non-contributory Social Security economic benefit. Its main objective is to guarantee the full participation of all citizens in social and economic life, breaking the link between structural lack of resources and lack of access to opportunities in the labour, educational or social spheres. . In other words, IMV was defined to reduce poverty by ensuring a minimum standard of living for households when they lack other financial resources.

The above motivates this research, which aims to evaluate one of the last measures within the Spanish Income Guarantee Program IMV to achieve an inclusive society that strengthens social transformation and guarantees a regular economic income. For this, the impact generated by the IMV on the main macro magnitudes and household disposable income will be measured counterfactually through an Applied General Equilibrium Model. This will be calibrated based on a Social Accounting Matrix constructed for Spain with households disaggregated by income, gender, skill, and age groups, making it possible to detail the effects of the proposed measures on Spanish households. This research is novel because, so far, no research has evaluated the impact generated by the measure in question with the proposed approach, which is relevant for effective social policy programming.

To meet the objective, first, the impact scenario to be simulated is defined. For this purpose, the annual income ranges taken from the household budget survey used for the disaggregation by income decile in the SAM are used. To define the impact vector for the simulation scenario, the weight of each decile in the distribution of the IMV has been recalculated. Finally, for the disaggregation of households by gender, each income decile is weighted by gender based on the gender distribution of benefit recipients from social security data.

One of the results obtained is that, although the impact has been on the first four deciles, all households show increases in their disposable income. The greatest impact is found in the deciles to which the MVI transfers have been directed in the same proportion as they were targeted. In other words, the households that benefit most are those whose main income earner is a woman, except in the last two income deciles.

Multiregional Input-Output Tables for Swedish Regions - today and tomorrow

Topic: Regional Input-Output Economics - IV
Author: Mårten BERGLUND

In this article we describe an ongoing project at Statistics Sweden to develop a model for constructing multiregional input-output tables (MRIOTs) for Sweden. A prototype set of MRIOTs for 2018 has been constructed, which consists of 21 counties times 446 products, making up a table of 9366 x 9366 elements. The table was based on national data regionalised with the help of business surveys complemented by employment statistics, and interregional trade data from the commodity flow survey. In the next phase micro data from Statistics Sweden and Government agencies as the Swedish Transport Administration will be used to construct a bottom-up MRIOT.

The current project has also involved some novel analyses using the tables ranging from multilevel multiplier calculations to computations of value-added chains, and interregional freight and service trade. We have also constructed an environmental input-output model generating consumption-based GHG emissions per consuming county, i.e., carbon footprints for each county. This input-output model was coupled with data from the global MRIO database EXIOBASE to include imported emissions due to final consumption in Swedish counties.

Importing from developing countries: quantifying what is in it for them (and us)

Topic: Methodological and Statistical Challenges for Analyses of Integration of Developing Countries in Regional and Global Value Chains - II
Author: Timon I. BOHN
Co-Authors: Nieke AERTS, Tom NOTTEN, Khee Fung WONG

Development aid and trade facilitation often go hand in hand, but not much is known about how much low- and middle-income countries gain in terms of the value added and employment generated from their exports to countries like the Netherlands. Multi-regional input-output tables (MRIOs) provide valuable information on the value chain linkages. However, they generally do not cover all developing countries, and even where they do, there is a lack of product-level detail on what is being traded and more generally on how products exported by developing countries are used by the importer. A value-chain approach to measuring these trade flows can be useful for policymakers in creating development policy goals and may shed light on the fruits of development cooperation efforts.

In this paper we use the "single-country TiVA" concept to analyze trade from different developing countries to the Netherlands. The Netherlands is one of the world's largest donors of official development assistance as a share of its GNI. Dutch development aid might be targeted to promote exports to the Netherlands and/or exports of specific products/industries to the Netherlands. Our method allows to estimate the value added and employment involved, which is relevant for policy monitoring. We focus mostly on the exports of African countries. The region makes for an excellent case study given its importance in Dutch development aid efforts. More insights into the current trade patterns could also be useful in crafting new trade strategies with Africa. This has gained relevancy in light of the new EU-Africa strategy launched by the European Commission.

Our single-country TiVA approach involves linking Dutch micro data at the trader level to the General Business Registrar and then benchmarking to national input-output tables (Aerts et al., 2023). We distinguish between imports going to intermediate use (split by importing industry), imports for re-exports, and imports for final use. This data is available from 2015 to 2021 at industry by product by country level. Compared to a traditional IO-approach, this has the advantage that one has better quality (the Dutch IO-data has more detail, the trade data does not have to be balanced) and more detail (9000 products and about 20 services). It can also be timelier since one is not dependent on the complete MRIO but only on 2 national tables. The disadvantage is that one can only capture direct exports, not exports via the value chain/via other countries, as in the traditional IO-approach based on MRIOs.

The novel application is that we use these import estimates as a proxy of each countries' respective exports to the Netherlands. Next, we employ MRIOs and national IO-tables to compute the domestic value-added to gross export ratios at the sectoral level of developing countries that trade with the Netherlands. Then we combine these two sets of data: that is, we match data on import use derived from micro data linked to Dutch input-output tables to value-added (or employment) in export indicators of developing countries. This allows us to gain a comprehensive view into the export earnings - and where possible also employment generation - in developing countries that is embodied in the direct arm's length export to the Netherlands as well as their direct or indirect use by Dutch industries.

In the case of Africa this includes shedding light on how much different countries currently earn due to trade with the Netherlands. Note that while the reverse flows can also be important indicators in policy monitoring, e.g., Dutch exports to recipients of aid and the creation of new direct investment opportunities abroad, this paper focusses on exports of developing countries and how the corresponding imports are used in the Netherlands. In terms of import use, it could be that the Netherlands receives mainly imports for re-exports from certain countries, which has less of an impact on the Dutch economy and Dutch export earnings. In addition, policymakers are often interested to gain insights into the import of specific products by different industries and from specific countries. This paper provides value-chain based insights into these perspectives and further shows the evolution of value-added trade patterns since 2015 between different developing countries and the Netherlands. This once again shows how microdata can substantially enrich IO-analysis.

Exploring the structure of global value chains in European economic convergence

Topic: Input-Output Modelling: Trade and Global Value Chains Policies - II
Author: Lucía BOLEA
Co-Authors: Rosa DUARTE, Geoffrey J.D. HEWINGS, Sofía JIMÉNEZ

In recent decades, the role of globalization and the organization of production around global supply chains has become central in explaining the heterogeneity in the economic growth processes worldwide, also favoring an increasing connection between economically different and geographically distant countries and regions. Previous literature has focused on the consequences of globalization for the evolution of the convergence processes. Different authors find that, since the beginning of globalization, there has been a significant polarization of growth, promoting the articulation of a group of "advanced" areas in contrast to other areas that are "lagging behind." In the latter case, the opportunities for current and future development seem severely limited, generating important implications for European cohesion in the medium and

long term.

In this context, our paper aims to analyze to what extent the configuration of global value chains in Europe, and the way in which the regions have engaged in them (measured by the degree of specialization and position in the global value chains), has been a source of economic development of the regions and how this has contributed to the processes of income convergence in Europe. We are also interested in exploring the role of sectoral and interregional spillovers and the influence of the neighboring regions in these results, with different measurements of geographical, sectoral and functional distance.

Empirically, we use the last available version of the EUREGIO database. It covers the period 2000-2010 and it is constituted by 249 European regions (NUTS2 level) and 14 economic sectors by each region. While the full model documents 14 economic sectors, in a first analysis, we aggregate to a single sector as a prelude to more detailed information involving the multisector model in the second part of the paper. Indicators obtained from a multiregional and multectorial input-output model for the European regions are here combined with an econometric spatial analysis aiming at controlling for regional heterogeneity in the economic outcomes.

Our results suggest that the level of income is significant to explain the behavior of regions and their evolution in the last decade. In addition, our initial findings show that European regions that are more focused on the European productive chain and are in upstream positions of the chain, are those that present lower growth rates. However, the more globalized European regions, more open to global production chains and which are in more downstream positions, exhibit higher growth rates. Additionally, it seems that the urban, intermediate or rural character of the regions play a significant role, with the regions of the urban group characterized by lower growth rates, indicating a possible process of beta convergence.

This work attempts to shed light on the discussion of the consequences of globalization on the areas of economic integration and the effects of this phenomenon on bilateral trade flows between European regions. In addition, it tries to clarify if the European economies are really advancing at the same rate of growth, or if there are some lagging behind.
In our view, the results could contribute to clarify the economic state of the different European regions, as well as their levels of vulnerability to shocks. In addition, these results may influence the design of economic policies that should be focused on providing more opportunities to the regions that are lagging behind and which do not seem to matter as much.

Research challenges for the future: panel discussion about Innovation and Structural Change

Topic: 50th Anniversary of Leontief's Nobel Prize: Innovation and Structural Change
Author: Filippo BONTADINI
Co-Authors: Rosa DUARTE, Mònica SERRANO

Based on the Seminal work: Leontief, Wassily and Faye Duchin (1986) The Future Impact of Automation on Workers. New York: Oxford University Press.
Includes presentation of some archives materials and documents about this topic.

Nearshoring and Farsharing in Europe: implications for employment

Topic: The Reconfiguration of Global Value Chains in an Era of Growing Uncertainties
Author: Filippo BONTADINI
Co-Authors: Valentina MELICIANI, Maria SAVONA, Ariel Luis WIRKIERMAN

Several studies have recently investigated globalisation trends with particular attention to the reconfiguration of global value chains, in the light of a globalisation slowdown relative to the 'hyper-globalisation' era (1986-2008) (Piatanesi and Arauzo-Carod, 2019; Antràs, 2020), the Covid-19 pandemic (Baldwin and Evenett, 2020) and the war in Ukraine. However, empirical evidence on the employment impact of the reconfiguration of global value chains (GVCs) within and across regional areas is still missing.

This paper documents recent trends in the geographical distribution of value added across Global Value Chains (GVCs) and its relationship with employment in Europe. Our main research questions are: how has the geographical distribution of value added sourced by European GVCs and supplied by European industries changed in recent decades? What have been the implications of these changes for European employment?

In order to study the evolution of GVC and their impact on employment, this paper applies (and further refines) well-established input-output methodology (Foster-McGregor and Stehrer, 2013; Timmer et al., 2014; Los et al., 2015) to the – recently released – OECD Inter- Country Input-Output (ICIO) 2021 dataset, covering the 1995-2018 period.

In particular, using measures developed by Los et. al (2015) we look at where value chains in each region draw value-added contributions from and whether this comes from within (i.e. the Regional Foreign Value Added Share) or outside (i.e. the Global Foreign Value Added Share) a country's region. However, we complement this approach by introducing an output destination perspective: we look at the final destination of domestic value added and whether it contributes to value chains reaching completion within (i.e. Regional Foreign Subsystem Share) or outside (i.e. Global Foreign Subsystem Share) a country's region.

Hence, a key novelty of our research lies in jointly considering a sector in terms of its backward (i.e. vertical) input linkages and its forward (i.e. horizontal) output linkages. By combining a value chain and country-industry analytical perspectives, we find two concurrent processes setting Europe's participation in GVCs apart from other two macro-regions, Asia-Pacific and the Americas. On the one hand, European value chains have increased the share of value added they import from within Europe – which amounts to nearshoring – while, on the other, European country-industries have increased the share of value added they provide to extra-European value chains – which we refer to as farsharing.

Finally, our econometric analysis finds that nearshoring has a positive effect on employment in the country of completion, while in contrast farsharing shows no significant relationship with employment. We discuss these novel findings in light of the recent policy debate around nearshoring, highlighting the complexity of this phenomenon and the breadth of its implications for Europe.

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Impacts of the electric vehicle penetration in Spain: A dynamic EV-aware CGE model

Topic: Input-Output Analysis: Energy Policies
Author: Yolanda BRAVO RODíGUEZ
Co-Authors: Cristina SARASA, Rosa DUARTE

The European Green Deal aims to achieve the carbon neutrality in Europe for 2050. The transportation sector is an important contributor for this objective, where the efforts are focused on the electrification of the vehicle fleet. This electrification strategy involves an important conversion of the traditional automotive sector. The change in the powertrain from well-known combustion engines to electric motors and batteries brings new industries to the sector and a different distribution of imports and exports. The supply chain is highly affected due to the origin of raw materials and know-how of components of the electric powertrain. In this context, the aim of the present work is to analyse the impact of a massive penetration of electric vehicles with a dynamic approach up to the year 2050. To do it, a dynamic electric-vehicles (EV)-aware computable general equilibrium (CGE) model has been developed for the evaluation. This EV-aware CGE model is defined for the whole economy, establishing differences between Spain, rest of Europe and rest of the world. The case of Spain has been analysed isolated since this country is specifically sensitive to automotive industry change due the impact in its economy, given the fact that the automotive sector represents a significant percentage of the GDP. Moreover, most of the automotive sector in Spain is focused on manufacturing but there is no major technological centres so the risk can be more severe when analysing a change in the supply chain. The EV-aware CGE model designed reflects the behaviour and interactions of the economic agents (consumers, producers and public sector) so it is possible to measure direct and indirect effects of changes in behaviour of the agents and different economic policies. As a novelty, the dynamic EV-aware CGE model implements the selection of inputs for the production of electric vehicles, considering the necessary components of the production chain of the traditional automotive industry, and substitution by electric components, through elasticities of substitution. This extension works both on the production side and on the consumption side. The structures have been disaggregated in levels reaching the key sectors where the modifications are applied. The EXIOBASE database has been used as input data for the EV-aware CGE model for the year 2016, which presents a detailed number of sectors and environmental extensions, so it

enables to take the appropriate activities under the production chain of interest. In particular for this work, the aggregation of sectors has been done according to the most relevant production chains and business for mobility. CGE models have been applied in the literature for the evaluation of this change in different regions of the world. However, there is not extensive work on the subject, and what is more, this work presents an extended horizon up to 2050 defining future scenarios and focused on regions where the traditional automotive sector has a significant weight in the overall economy. The scenarios simulated combine the change in demand by the main stakeholders, and also by fiscal policies that can be applied to promote the change. Additionally, we study the infrastructures required to address the development and accessibility of a network of public access for the supply of electric recharging points to enable the penetration of the most efficient and cleanest technologies in means of transport, as well as the development of measures to promote private access infrastructures for electric recharging in homes.

What drives the changes in the labour compensation share? A Global Input-Output analysis

Topic: Input-Output Theory and Methodology - I
Author: Gabriel BRONDINO
Co-Authors: Davide VILLANI

There is growing research documenting a decrease in the income share of labour compensation over the past years, especially in advanced economies. Despite this growing interest, the discussion regarding the drivers of this process is still open. Specialised scholars point to several factors behind this process, such as technical progress, offshoring, growing market concentration and weakening workers' bargaining power. This paper contributes to this literature by focusing on the manufacturing sector of six Western economies (France, Germany, Italy, Japan, the United Kingdom, and the United States) over the period 2000-2014.

Using a Global Input-Output Model, we compute the domestic labour compensation share of a country's final demand. Different from conventional industry-level analysis, this makes it possible to account for all the direct and indirect, domestic and imported steps of the production chain. Hence, the labour share of income estimated in such a way includes wages paid at all domestic stages to produce and sell finished products.

We restate the labour share as a function of three components: [i] the total (domestic and foreign) labour content per unit of final production (or global vertically integrated labour coefficient); [ii] the ratio of domestic to total employment induced by final demand; and [iii] the average domestic unit wage. Finally, we develop a structural decomposition analysis to assess the contribution of each factor to the evolution of the labour share of income in the six countries analysed. The change in component [i] is deemed as the contribution of technical progress, the change in component [ii] as the contribution of offshoring, and changes in component [iii] reflect the role of domestic labour costs. The latter can be further decomposed to assess the role of unit wage growth and the role of domestic labour reallocation.

We focus on manufacturing sectors because it is where offshoring operated more intensively (based on WIOD data, the income induced by final external demand in manufacturing production was around 47% in 2014, while in primary and service activities, it was 16.4 and 12.5%, respectively).

The dataset employed is the World Input-Output Database (WIOD) project (release 2016). This database allows the decomposition at constant prices and, thus, eliminates price effects from the analysis. This feature is important, especially for computing changes in the total labour content per unit of final production.

The proposal is novel with respect to the literature in several aspects. First, the measure of technical change is different, based on changes in physical labour productivity rather than more conventional estimates (e.g., TFP). Second, most of the existing research is based on aggregate or industry-level econometric studies. Instead, this paper looks at vertically integrated sectors (which within a global IO model can be conceived as 'global value chains'). Furthermore, econometric studies do not provide an accurate accounting decomposition as input-output analysis does. Finally, and related to the previous point, the additive decomposition can consider the effects of structural change on domestic labour costs.

Regional Value Chains at subnational level. An application to Santa Fe, Argentina.

Topic: Regional Input-Output Economics - I
Author: Gabriel BRONDINO
Co-Authors: Hernan Alejandro ROITBARG, Francisco LEIVA, Joaquin LUCERO

In recent decades, supply chain research has evolved significantly worldwide. Both internationally and nationally, countries have made significant progress in generating knowledge and policies directed at specific sectors, based on their better understanding of current production dynamics. In this sense, in Argentina, the investigation of production chains has also grown in recent years, especially with regard to understanding the chains of extraction of natural resources and their first processing, such as agriculture and food production.

The subnational dimension of the phenomenon has also grown worldwide, yet there is still little evidence of this in the country. However, studying it is essential, as it provides important information for decision-making, identifies relevant linkages for the subnational economy, improves the efficiency of industrial policies, and detects possible supply problems at the subnational level. This is especially important in light of the limited resources available to lower levels of government.

In other words, this research aims to assess the effectiveness of methods for studying the shapes of value chains at a subnational level, the pertinent connections, and the best ways to formulate demand and supply policies at the subnational level in Argentina.

In the research we work on this theme and focus on Santa Fe. Santa Fe province is one of the most important regions of Argentina in terms of agricultural and industrial production. Responsible for 5.4% of the country's total employment, it is consolidated within service activities, at the same time the sector is responsible for most of the provincial invoicing. The productive profile of the province is identified with a large proportion of services of low technological content with some relevance to high productivity activities and the presence of research and development, along with a secondary sector occupying a less relevant place for the local fabric. Although there are studies for particular industries such as the dairy sector, metallurgical industry and the manufacturing of agricultural machinery, there is no systematic and consistent study of all of them. In particular, this study focuses on the main regional chains of the province of Santa Fe in 2018, and the attempt to systematize them in integrated work.

The proposed methodology uses a regional Input-Output Matrix to study value chains at the sub-national level. We "regionalise" the national input-output matrix applying the simple location quotient method. The national input-output matrix is estimated by the OECD for 2018. The quotients are computed employing employment data from the household survey of the national statistics institute.

Second, we employ an indirect method to estimate the final demand vector as the difference between gross output and total intermediate demand. The vector of gross output is estimated by ECLAC and the Ministry of Economy of Argentina. Total intermediate demand is computed by multiplying the estimated regional matrix to the gross output vector

The results provide valuable insights into the potential for developing the region, highlighting strategic vectors around manufacturing, despite the province's limited industrial network. Despite the province's service-oriented productive profile, there is a diversity of sectors when it comes to characterizing their degree of integration. In particular, there are strongly integrated manufacturing and service sectors in the centre of the province, with a preponderance of integrated services such as the research and development sector. In the south, there are strongly integrated primary, secondary, and tertiary sectors, most of which are manufacturing sectors such as the manufacture of metals and chemical products.
Overall, this research contributes to a more comprehensive understanding of regional economic dynamics in developing countries and demonstrates the potential of innovative methodologies to overcome data limitations.

Open-source implementation of the IPCC guidelines for national greenhouse gas inventories: and its contribution in developing a global input-output database

Topic: Advances in Open Source Software for Input-Output Compilation, Analysis and Quantitative Impact Assessment
Author: Maik BUDZINSKI

Open-source software is becoming more and more important for reproduceable scientific work. Also, in the field of Input-Output Economics and Industrial Ecology ongoing efforts have been made to provide open science infrastructures.

Several input-output (IO) datasets have been published under open-source license, e.g. EXIOBASE3, WIOD. The development of those datasets requires detailed and comprehensive data. Many data transformation steps are involved. However, if publicly available as open source, usually only the final IO dataset is provided. The code for data collection, data cleaning and data calibration is mostly not provided.

Within the "getting the data right" project (https://www.en.plan.aau.dk/getting-the-data-right/) we develop a global IO database to calculate consequential carbon footprints. All data and code shall be published under open-source licenses. The database aims to include at least more than 1000 activities and products per region. Furthermore, several (monetary and physical) layers shall be provided.

When developing global IO datasets with high product and geographical resolution, a major challenge is to retrieve data. To address the challenge of increasing product resolution, one way

we follow is to develop parametrized tools. These tools shall determine inventories for different production and waste treatment activities, which are then used by other steps of the IO dataset development workflow (e.g., balancing).

One of the tools is a python package for the implementation of the IPCC guidelines for national greenhouse gas inventories (https://www.ipcc-nggip.iges.or.jp/public/2019rf/index.html).

These guidelines provide equations and default data that can be used to carry out country-based greenhouse gas inventories, considering different production and treatment activities as well as the characteristics of the produced (treated) commodity. The guidelines cover the greenhouse gas (GHG) relevant areas Energy, Industrial Processes, Agriculture, and Waste. Furthermore, sequences (tier 1, tier 2 and tier 3) define the order on how to apply the equations to calculate the GHG inventory. The three tiers differ in the level of detail, with tier 1 as default method and tier 3 as most detailed method. This also affects the requirements for data collection, when applying the guidelines. Tier 1 sequences calculate GHG inventories based on generic country data (e.g., population) and other default parameters, whereas tier 3 sequences require detailed information on the applied technologies of a country.

The python package is an ongoing project. The aim of the package is to allow users:
- To determine GHG inventories for production and treatment activities
- To carry out uncertainty analysis
- To submit own data

The implementation of the volume Waste has been finalized. Uncertainty in data can be considered by analytical error propagation and Monte-Carlo simulation. Its application for IO database developments would allow the differentiation of the following waste treatment activities:
- 2 biogenic waste treatment activities,
- 10 waste incineration activities,
- 8 solid waste disposal activities, and
- 24 wastewater treatment activities.

A differentiation of waste types would be possible in the following manner:
- 23 solid waste types,
- 1 type of domestic wastewater, and
- 18 types of wastewaters based on the industry.

To make use of this package in the development of the project´s global IO dataset, data shall be collected for the base year and for different countries, fulfilling the requirements of tier 1 and, if possible, tier 2 methods.

Future efforts shall also be put in the implementation of the three remaining volumes Energy, Industrial Processes, and Agriculture.

Non-survey regionalization with commodity balance and the gravity model

Topic: Regional Input-Output Economics - III
Author: Mattia CAI

Very few National Statistical Offices produce survey-based input-output (IO) data with subnational ('regional') resolution. Regional analysts have debated ways of getting around this problem for several decades now, giving rise to a sizable and constantly expanding literature on IO regionalization.

The greatest challenge in this area is represented by an almost complete lack of official data on interregional trade. Accordingly, one line of research has focused on estimating bilateral trade between the regions of a country from existing data sources. These approaches are often cumbersome to implement, as they either rely on information that is noisy and incomplete (freight transport data) or require datasets that are only available under special circumstances (e.g. ad-hoc surveys, pre-existing regional IO tables) (Többen 2017, Zheng at al. 2022).
Conversely, a large family of ('non-survey') techniques attempt to construct single-region IO models without having to estimate bilateral trade flows. For example, location quotient (LQ) methods derive the IO coefficients of a regional model by tweaking those of the country as whole. Even though their theoretical foundations and empirical performance have sometimes been called into question (Hermannsson 2016, Lamonica and Chelli 2018), LQs are very popular in applications thanks to their computational simplicity and minimal data requirements (Buendía et al. 2022, Flegg et al. 2021, Kwon and Choi 2023).

Another popular non-survey approach builds on the fundamental fact that in an input-output table total supply must match total use. Hence, commodity balance (CB) methods seek to work out interregional trade as a balancing item after all other components of the regional IO table (e.g., output, intermediate and final use) have been estimated (e.g. combining national IO and regional accounting data). In terms of minimum data requirements CB techniques are comparable with LQs, but they provide a more intuitive way of incorporating any additional information that may be available. The main drawback is that they yield estimates of net trade but cannot distinguish between imports and exports, although some workarounds have been proposed (Kronenberg 2009).

As many modern applications of IO analysis require multiregional models (e.g. greenhouse gas emission accounting and trade in value added analysis), non-survey regionalization methods are increasingly being generalized to accommodate multiple regions. Still, this tends to require additional assumptions whose relationship with the original single-region setup is not always transparent. Also, ensuring accounting consistency across regions often involves additional balancing steps, as a result of which these techniques are no longer as convenient as their original single-region version (Többen and Kronenberg 2015, Jahn 2017).

This paper reports on the author's efforts to develop a general procedure for constructing multiregional IO databases at the subnational level that would score well on the following three broad criteria. Firstly, it should rely on data that are routinely available from national statistical offices (e.g. national and regional accounts) but be flexible enough to accommodate any relevant additional data. Secondly, it should be based on a coherent set of standard theoretical assumptions. Thirdly, to the extent possible it should retain the ease of use of traditional non-survey approaches.

In practice, our approach can be described as combining the CB method with a doubly constrained gravity (DCG) model of interregional trade. Effectively, the DCG model is used to blow up the net trade estimates computed by CB regionalization into a full set of bilateral flows, thus separating imports from exports.

We start by defining an origin-destination matrix of interregional trade for each product (or industry) of the IO accounts. Its entries are unobserved but assumed to follow a gravity equation. Under very general conditions, this trade matrix can be recovered from just three pieces of information: 1. Bilateral interregional distances; 2. the (product-or industry-specific) distance elasticity of trade; 3. the row and column totals of the trade matrix itself. If estimates of these quantities are available, the trade matrix can indeed be estimated via a standard application of the RAS algorithm (Cai 2021). In applications, distance data are easy to obtain. Also, theory-backed distance elasticity estimates can be constructed using standard econometrics on widely available datasets, e.g., international trade data (Cai 2022). As for the last piece of the puzzle – the trade matrix's marginal totals – this paper shows that they emerge naturally when the CB method is applied region by region. Besides, those trade flow estimates balance the multi-regional system by construction, so that there is no need for further balancing.

The approach is demonstrated using a case study of Italy.

Life-cycle CO2 and Air Pollutant Emission Assessment of China's Cement Industry under Planetary Boundaries

Topic: Input-Output Analysis: Industrial Policies and Prices
Author: Xingrui CAI

China is the world's largest cement producer and consumer, contributing 58% of the world's total cement production in 2020. The cement industry in China is associated with 4–5% of China's total energy production and contributes 10–15% of national total CO_2 emissions, ranking second only to the power industry, and also significant air pollutant discharges such as SO_2, NO_x and particulate matter (PM). Since China's energy and environmental policies for the cement industry usually focus on specific energy/environment effects and a single manufacturing process, this study described the cradle-to-gate lifecycle covariation relationship of these effects and analyzed the potential transgression magnitude to related planetary boundaries to assist in designing low carbon and pollution industrial transition in Chinese cement industry. The multi-regional decomposition analysis model, the LMDI decomposition, and the SDA method were employed to identify the driving factors such as energy intensity, manufacturing technology, economic structure, intermediate demand and structure, and total demand. We found that the Chinese cement industry not only causes massive emissions directly but also imposes environmental burdens on other sectors through up- and downstream supply chains, especially in eastern and central regions. Scope 1 and 2 emissions decreased sharply for CO_2, SO_2, and PM thanks to stricter environmental regulations, but Scope 3 emissions of CO_2 increased by approximately 30%, contributed by energy intensity and economic structural change. Although total emissions basically presented decline trends, several national and regional planetary boundaries might be transgressed under downscaling principles based on population, and gross value added. This work improves our understanding of lifecycle carbon emissions and pollution and related total environmental burden in terms of planetary boundaries, thus offering references for the implementation of energy conservation and environment policies in the Chinese cement industry.

Distributional impacts of long-term renewable power policies: a multi-regional analysis for Brazil until 2050

Topic: Input-Output Modelling: Energy Policies - I
Author: Lilia CAIADO COELHO BELTRAO COUTO
Co-Authors: Tiago DINIZ

Assessing the scale of green jobs and the socioeconomic effects of the energy transition is relevant and timely, while clear, comparable methodologies are still scarce. The discussion around just transitions, and the extent to which renewable energy creates more positive socioeconomic impacts than fossil fuels, increasingly attracts policymakers' and researchers' attention. However, data constraints, particularly in developing economies, expose a relevant gap in providing quantitative evidence for such discussions. Existing input-output tables are usually aggregated into activities irrespectively of technology or Greenhouse gas emission profile.

In this paper, we propose a replicable data triangulation approach to disaggregate the electricity sector into renewable and non-renewable generation sources in input-output tables applied to the case of Brazil, using the latest input-output data of the country, for 2015, energy generation statistics for the same year, mainly the National Energy Balance and the Statistical Yearbook of Electricity. Then, we calibrate a multi-regional recursive-dynamic CGE model with the resulting dataset and assess the distributional impacts of long-term renewable electricity capacity expansion scenarios through a soft-link with three energy-system models.

The research question of this paper is: what are the regional distributional implications of different electricity capacity expansion mixes up to 2050 resulting from different energy and climate policies for the electricity sector in Brazil? The novelty is that this is the first known research to assess long-term multi-regional distributional impacts of renewable electricity policies in an emerging or developing economy apart from China.

Brazil has relied on hydropower for the last decades, but climate change has impacted rainfall regimes, causing long droughts and higher hydrological risks. Moreover, most remaining hydropower potential lies in the Amazon region and is unlikely to be exploited due to socio-environmental regulation. Hence, Brazil must increase non-hydro renewable technologies for its electricity mix to remain renewable in the long run. Notably, the least developed region of Brazil, the Northeast (NE), concentrates most of the Brazilian territory's potential for wind and solar generation. Hence, there is a great potential for Brazil to use renewable energy policies to reduce regional inequalities.

The model used is the TERM-BR E15 model - a multi-region recursive dynamic computable general equilibrium model for Brazil with the electricity sector disaggregated into nine sources and the transmission and distribution sector. The TERM-BR E15 belongs to TERM models family, described in literature such as Horridge (2011) and Horridge et. al. (2005), and follows TERM-BR 10 (Diniz, 2019). The model distinguishes ten different labour grades by wage level, and ten different household income bands.

As a Baseline, we use the Brazilian official National Energy Plan 2050 scenario in which hydropower is the main source and a higher share of fossil-fuels remains until 2050. By its turn, wind and solar are limited to 50GW each, in terms of total installed capacity from 2020 to 2050. On the other hand, renewable policy scenarios were built considering (i) net zero economy-wide emissions by 2050 and (ii) the inclusion of the highest possible share of wind and solar PV in the electricity mix by 2050. The following table summarizes the main aspects of those scenarios.

Modelling results have indicated that scenarios with higher shares of non-hydro renewable electricity in the mix create a demand for higher-skilled labour nationally. However, multi-objective policies are necessary to create a migration from lower skills toward higher skilled jobs in the NE region. It is visible from the results that the NE is the greatest winner in terms of job creation of the process of renewable electricity capacity expansion. Across all scenarios and wage levels, employment increased relative to the baseline in the Northeast region. This shows that a renewable pathway is not only feasible but would create more jobs in Brazil's poorest region than a less-renewable pathway. However, most regions apart from the NE experience negative employment impacts in the policy scenarios, counterbalanced by the Northeast, indicating regional trade-offs.

In the renewable policy scenarios, the NE is the only region where real wage grows above the baseline and therefore the NE region it attracts workforce. Historically, however, the Northeast workers have migrated in search for better opportunities in the SE region, where wage levels are higher. The Northeast region is also the clear winner in terms of household consumption in policy scenarios. Household consumption gains are equal across income bands in this region, particularly in the case of electricity capacity expansion scenario (ii).

Disparities in consumption patterns and carbon footprints driven by increasing female-headed households in Europe

Topic: Gender Issues in Input-Output Analysis: New Challenges and New Perspectives - I
Author: Elena CALVO CALVO
Co-Authors: Rosa DUARTE, Cristina SARASA

A good understanding of household carbon emissions is key for the design of climate mitigation strategies. Traditionally, households were characterized by a breadwinning man and a woman whose role was mainly associated with household chores and did not contribute directly to the family income. In other words, until the last quarter of the twentieth century, almost all household income was earned by the man and the cases in which the woman also contributed, were mainly because there was the economic need to do so, for example, in families with little income or because of the unemployment of the man. Several changes along history, however, have brought us today, to a moment in history characterized by women being more educated than men and in which they play a major role in the economy. To fully understand the novelty of this approach, we should first understand the novelty of women being the main earners of their families.

Thus, we are now more likely to find families in which women earn more than their husbands, a trend that has been increasing over the last few decades. Although this evolution has been increasingly studied, its main implications are significantly understudied. In order for us to better understand the impacts of this change in women´s roles, this paper attempts, firstly, to gather the history of what has brought us this far, so that women are more educated and significantly more integrated in the labor markets than before. Second, to analyze the repercussions of such changes in terms of consumption patterns and pollution footprints. How do household consumption patterns change as the gender of their main earner changes, and how does their environmental footprint change, are some of the questions we attempt to answer.

In this paper, we aim to analyze the impact that the increasing number of female headed households has over the consumption patterns in Europe and, thus, over their carbon footprints.

Moreover, we also consider the income, the age and the educational attainment of the main earner of the household to quantify not only the footprints of an increasing number of female-headed households in Europe, but also that associated with an ageing population as well as with populations with higher levels of education. Understanding what have led us to this point matters as much as how this impacts the economic performance of countries today and how it will in the future, for instance, through this impacts on environmental outcomes.

For this purpose, the Household Budget Survey (HSB) for the year 2015 have been used to link the Household Member Data to the Household Data in order to collect the individual characteristics of the main earner of each household. Then, the consumption coefficients by commodity for each type of household have been calculated to apply them to the consumption vector of the multiregional and multisectoral input output tables (MRIO) available in EXIOBASE. This allows us to calculate the direct and the indirect (embodied) carbon emissions driven by each type of EU household by quintile, gender, age and education of the main earner. Thus, we can quantify the carbon footprint of each group of households using the environmental account available in EXIOBASE. To our knowledge, is the first time that such extensive analysis of the footprint of households by the gender, the age and the educational attainment of the main earner has been done so far for Europe.

In short, this analysis shows us the impacts that not only the increasing number of female-headed households have over the economic performance and the environmental footprints of the European Countries, but also the impacts of an ageing population that attain higher and higher levels of education as the time goes. Next, the relation that may exist between such footprints and households' characteristics, such as the gender of their main earner, will be studied using econometric models, for the current research to serve as a stronger basis for policy recommendation, as well as a guideline for the consecution of the Sustainable Development Goals (SDGs) proposed by the United Nations (UN).

Research challenges for the future: panel discussion about Growth and Development

Topic: 50th Anniversary of Leontief's Nobel Prize: Growth and Development
Author: Andre CARRASCAL-INCERA
Co-Authors: Heinz KURZ, Bart LOS

Based on the seminal work: Wassily, Leontief (1953) "Dynamic Analysis" in Studies in the Structure of the American Economy, edited by W. Leontief et al. New York: Oxford University Press. Includes presentation of some archive materials and documents about this topic.

Exploring the deep roots of interregional inequality: Spatial income distribution in the European regions

Topic: Income Distribution in Input-Output: Applications of Miyazawa's Model
Author: Andre CARRASCAL-INCERA
Co-Authors: Geoffrey J.D. HEWINGS

In recent years, there has been a growing awareness of the negative consequences of interregional inequalities, especially about left-behind places worldwide (Rodriguez-Pose, 2018). In particular, this affects some European countries such as the UK, France, Belgium and Denmark,

which are more geographically unbalanced today than some decades ago, experiencing an accumulation of income dominated by metropolitan and central areas. These extreme interregional inequalities appear as a result of complex interrelationships between the effects of economic geography and modern production processes in a globalised context. In this paper, the EUREGIO database (Thissen et al., 2018) is used to compare the income distribution structure in 2000 and 2010. By means of an extended multiregional Input-Output model, we explore the structural roots of these inequalities in the European regions, offering results for interregional inequality within and between countries, and their impacts across the multiregional system. These models highlight the systemic contribution and structure of income interdependence, revealing important asymmetries that would remain hidden otherwise.

Industrial strategies to reduce interregional inequalities in Europe: An alternative Miyazawa approach

Topic: Income Distribution in Input-Output: Applications of Miyazawa's Model
Author: Andre CARRASCAL-INCERA
Co-Authors: Albert E. STEENGE, Mònica SERRANO, Geoffrey J.D. HEWINGS

The trend of decreasing income disparities between regions has come to a halt. Since the 1980s, there has been a consistent and persistent level of economic imbalances within European countries, with some countries such as the UK, Sweden, Belgium, and France experiencing widening gaps not seen since World War II. These interregional inequalities are crucial to understanding the phenomena of "revenge of the places that do not matter" (Rodriguez-Pose, 2018) and "economies of discontent" (Dijkstra et al., 2020) in Europe.

In this paper, we aim to evaluate which sectors contribute to the persistent uneven distribution of income across different European economies, while also identifying industries that have the potential to decrease income inequalities. By utilizing an alternative approach to solving the Miyazawa Input-Output model (Steenge et al., 2020), we explicitly demonstrate the relative distribution of income among various household groups by region, enabling us to analyze changes over time. This can assist policymakers in devising industrial policies aimed at reducing spatial income inequalities, such as the "levelling up" policy in the UK.

Industrialization and Economic Diversification – Keys to Unlocking the Full Potential of the AfCFTA – A Case Study for Central Africa

Topic: Methodological and Statistical Challenges for Analyses of Integration of Developing Countries in Regional and Global Value Chains - II
Author: Caitlyn CARRICO
Co-Authors: Simon MEVEL, Jean Luc Mastaki NAMEGABE, Stephen Njuguna KARINGI

While natural resource abundance can provide opportunities for economic growth, natural resource dependency is often associated with stagnated growth. Within the African continent, the level of dependence on natural resources and, inversely, the level of economic diversification is variable across regions. Measuring output across subregions from the GTAP Database, Central Africa is the subregion with the highest production dependence on extraction, accounting for 26% of total output, compared with an average of 10% across the rest of the continent. Further, manufacturing output is the lowest amongst subregions, accounting for 14% of total output, in contrast to an average of 25% across all other subregions.

On 29 September 2017, Central African member states adopted the Douala Consensus, committing to spurring economic diversification through industrialization and trade, with the aim to increase subregional production of higher-value products. In parallel, all Central African member states ratified the African Continental Free Trade Area (AfCFTA), under which free trade began on 1 January 2021. The AfCFTA is a key opportunity for Central African governments to build upon regional integration strategies, aligning their national trade strategies as well as industrial strategies, to enhance intra-regional trade as well as trade with continental partners. However, only by achieving the objectives of the Douala Consensus will Central African states be able to unlock the full potential of the AfCFTA.

In this paper, we assess the impact of economic diversification and industrialization in combination with the implementation of the AfCFTA for Central Africa with a Computable General Equilibrium (CGE) model. Several CGE studies have analyzed the AfCFTA at the continental level, including the European Commission, the World Bank, the IMF, UNCTAD, and UNECA. Ekobena et al. (2021) specifically analyze the effects of the AfCFTA on Central Africa, presenting macro-level findings at the country level for Cameroon, the Central African Republic, the Democratic Republic of Congo, Gabon and Chad. The present paper expands upon this field of research with the ambition to be the most comprehensive CGE model study of AfCFTA implementation in Central Africa to-date. We implement a new GTAP Database version with increased coverage for members of the Economic Community of Central African States (ECCAS) based on our continent-wide project for official IO data collection to expand GTAP Database coverage in Africa. Further, in the CGE model, we innovate by simulating both trade policy as well as economic diversification and industrialization plans.

We implement the GTAP Model, a CGE model with up to 65 sectors for each of the 141 countries and regions in the corresponding GTAP Database, compiled from national IO tables. In our paper, we exploit the aforementioned new GTAP Database, featuring updated IO data for Cameroon as well as newly introduced IO data for Chad, the Congo, Gabon, Equatorial Guinea, and the Central African Republic. Data for Rwanda is already in the standard release of the GTAP Database version 10, and data collection for Burundi has been completed under this project. Data collection for the Democratic Republic of Congo, Angola, and São Tomé and Principe is underway in a sub-regional initiative of the continental project collecting official IO tables and national statistics to expand both GTAP and TiVA Databases for Central Africa.

We implement the following sequential simulations (a combination not previously exploited) in the GTAP Model to simulate the AfCFTA in combination with economic diversification and industrialization plans: (1) tariff removal, (2) non-tariff barrier reduction, (3) manufacturing growth, and (4) services growth. Simulations (3) and (4), which are linked to exogenous structural change, are implemented via calibration of primary factor efficiency as well as the intensification of intermediate demand. We additionally explore calibrating import sourcing preferences.

Preliminary results from the AfCFTA simulation demonstrate overall increases in trade among ECCAS member countries across all products, except for extraction products which decrease. Trade between ECCAS members and the rest of the continent increases across all products. Extra-continental trade decreases. The most important increases in trade for ECCAS as a subregion occur for heavy and light manufacturing as well as processed food. While the largest current increases in trade for the ECCAS subregion represent import substitution (Rest of World imports replaced by Rest of Africa imports), structural change simulations illustrating the implementation of economic diversification and industrialization plans are anticipated to increase trade within the ECCAS subregion as well as boost exports to the rest of the continent.

What if Brazilians reduce their beef consumption?

Topic: Input-Output Modelling: Sustainable Production and Consumption Policies - I
Author: Terciane SABADINI CARVALHO
Co-Authors: Luciana PARZIANELLO

In favor of sustainability, a dietary change is urgent. Beef, among all foods, has the greatest environmental impact. Brazil is one of the largest consumers, on par with developed countries, and most of its GHG emissions are related to deforestation and agriculture. This article projects economic and environmental impacts of a beef consumption reduction by households preference changes. A dynamic interregional Computable General Equilibrium model for regions of the Brazilian economy is used. It has a land use change module and allows for substitution between different foods in its theoretical structure. The results show that a 40% reduction in beef consumption could contribute to avoid a 63,297 km² area of deforestation and would have a virtually zero impact on the national GDP by 2050.

The economic impact of the tourism sector on the overall Italian economy: An Input-Output Approach following Satellite Accounts schemes

Topic: Input-Output Accounts - II
Author: Samuele CESARINI
Co-Authors: Fabrizio ANTOLINI, Giorgio GARAU

Defining the tourism sector is a challenging task, as its economic activities are spread across different kinds of activity including service, industry, and agriculture. It makes it more difficult to estimate the contribution of tourism to the gross domestic product (GDP). Despite this, satellite accounting is the usual instrument to determine the spread of tourism across various economic activities and then, its contribution to the final value-added production. However, the complexity of measuring tourism spending, as characterized by satellite accounting, may lead to evident differences in estimating the contribution of tourism to the domestic value-added, as compared to other statistical surveys. Since the approach utilized in satellite accounts to measure tourism contribution to GDP is tourism expenditure, first, it is important to consider which aggregate is considered in the Italian satellite accounts framework. In addition, the relationship between tourism and other economic sectors is not fully understood since tourism is not identified as a separate industry in the country's input-output tables. This study aims to address this issue by examining the discrepancies in data related to tourism spending and analysing the connections between the tourism sector and other sectors of the economy, using an input-output approach. More analytically, the paper aims at comparing the expenditure figure of the Italian satellite accounts with that estimated by the Italian household expenditure survey using microdata released by Italian National Institute (ISTAT). Further, in determining the impact of tourism on the overall economy following the I-O approach was necessary to make a new classification considering tourism as a single sector of economic activity. To do this, the economic activities of the tourism industry – as defined in satellite accounting – were aggregated in the I-O tables called tourism sector, weighing the original economic activities by applying the tourism coefficients of satellite accounting. To this end, it was used the latest Input-Output scheme published by ISTAT for the year 2019. To estimate the total impact of tourism on employment, income, and production through the calculation of multipliers, it was needed to calculate preliminary technical coefficients for the tourism sector. Finally, the study presents forward and backward linkage coefficients to illustrate how changes in the tourism sector's value-added would affect the

production, employment, and income of the entire national economy. Although the input-output scheme may not be up to date enough to analyse the rapidly changing economic system, it is still the most effective tool for understanding the level of sectoral interdependence, even for a sector as tourism that is difficult to define. This study highlights first the importance of analysing tourism spending and using sources that can determine different economic effects on GDP. Then, by using the input-output scheme and introducing the tourism sector, it was possible to estimate its relationships with other sectors of the economy. This could be useful for economic policy planning. Indeed, policymakers will be able to measure the impact of policies that support the tourism industry, such as assistance for tourism-related businesses, which affect and indirectly supports the production of other sectors.

Research challenges for the future: panel discussion about International Trade

Topic: 50th Anniversary of Leontief's Nobel Prize: International Trade
Author: Quanrun CHEN
Co-Authors: Sebastien MIROUDOT, Erik DIETZENBACHER

Based on the seminal work: Wassily, Leontief (1953) "Domestic Production and Foreign Trade; The American Capital Position Re-Examined", Proceedings of the American Philosophical Society, 97(4): 332-349. Includes presentation of some archive materials and documents about this topic.

Accounting for Global Production of Exports: A Unified Framework

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - III
Author: Quanrun CHEN

The contributions of participants in the global production of exports are important concerns of trade analysts and policy makers. This paper aims to construct a unified framework with sound theoretical foundation for measuring global production of exports. The framework harmonizes export decomposition at all levels and embraces a broad range of global-value-chain indicators. World export decomposition analyses show that the supply-side diversification of China's export production structure is lower than the demand-side. The suppliers mainly concentrate in east Asia area, with a shift from Japan and Chinese Taipei to Korea. The purchasers spread over relatively broad regions, with a shift from the United States and Korea to Mexico and Vietnam.

Incremental Market-Oriented Reforms, Industrial Policies and Economic Growth in China

Topic: Input-Output Analysis: Industrial Policies and Prices
Author: Rongjie CHEN
Co-Authors: Chen LIN, Xiangyu XU

(1) The research question: Since China's reform and openness in 1978, it has adopted incremental rather than radical market-oriented reforms. Compared to radical market-oriented reforms, adopting incremental market-oriented reforms could accumulate experience, and avoid the risk of overall failures, and a rapid distortion in income distribution. China's rapid growth has proved that the way of incremental market-oriented reforms is successful. Incremental

market-oriented reforms mean taking reforms in some sectors firstly, and then the other sectors. For China, incremental market-oriented reforms have been implemented in downstream sectors before upstream sectors. On the contrary, China taking industrial policies to support the development of upstream over downstream sectors. So, China has adopted the policy combination of market-oriented reform in the downstream and industrial policy in the upstream sector. There are two questions this paper tries to answer, the first one is how this policy combination affects economic growth in China. The other question is whether this combination is the most suitable for China, what if China takes the policy combination of market-oriented reform in upstream and industrial policy in downstream sectors.

(2) The method used: this paper studies the above questions theoretically and empirically. On one hand, we extend the production network model developed by Liu (2019) and apply this model to analyze how the position of the sector in the production chain affects the effect of market-oriented reform and industrial policy. On the other hand, we estimate the effect of China's actual policy combination, which is market-oriented reform in downstream and industrial policy in upstream sectors. After that, we also construct three counterfactual facts of market-oriented reform in downstream and industrial policy in downstream sectors, market-oriented reform in upstream and industrial policy in upstream sectors, and market-oriented reform in upstream and industrial policy in downstream sectors. Comparing the effect of actual policy combinations with three counterfactual policy combinations, we can find which policy combination would increase China's economic growth the most.

(3) The data used: this paper has two main data sources. The first one is firm data called the Annual Survey of Industrial Firms for the period 1998-2007, which is collected by the National Bureau of Statistics (NBS). This data includes all industrial firms that are either state-owned firms or non-state firms with sales above 5 million RMB. With this firm data, we estimate the firm's markup to measure the intensity of market-oriented reform across sectors in different years. Annual Survey of Industrial Firms also includes the information on the subsidy received from the government in each firm, which could be viewed as the support by industrial policy.
The second data used in this paper is the Input-output table in China. To match the firm data, we use the Input-output table in 1997 and 2007 to measure the linkage across sectors. The input-output table in 1997 contains 124 sectors, and the input-output table in 2007 contains 135 sectors. In order to match these two input-output tables, we decompose and merge sectors in input-output tables. Finally, we get two input-output tables containing 107 sectors.

(4) The novelty of the research: there is two-strand literature related to our paper mainly, the first one is about the equilibrium model with production network, and the second one is about China's market-oriented reform and industrial policy. Compared to the existing literature about the equilibrium model with production network, this paper is applied research, we applied this model to study an interesting and important question in China. We also extend this model to analyze how the position of the production chain would affect the effect of markup decreasing. This research is also closely related to studies on the effects of market-oriented reform or key industrial policies in China. However, existing literature tends to discuss the economic impact of incremental market-oriented reforms and key industrial policies separately, and the conclusions are mixed. While the incremental market-oriented reforms and key industrial policies both have obvious sector characteristics. Incremental market-oriented reforms have been implemented in downstream sectors before upstream sectors, whereas industrial policies have primarily supported the development of upstream over downstream sectors. We combine these two policies together and analyze how the interaction of these two policies affects the economic growth in China. Then, we construct a counterfactual analysis to explore whether these policies' combination is best for China. What we find provides a new perspective to understanding the

rapid economic growth in China.

Carbon tax design and revenue recycling in line with national redistribution policy and global justice principles

Topic: Input-Output Analysis: Income Distribution Policies - II
Author: Xiangjie CHEN
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Carbon taxation is regarded as an essential tool for curbing carbon emissions but can be regressive, in the worst case increases poverty, and moreover lacks universal acceptance among the public and policymakers. Recycling the tax revenue raised to vulnerable households is a promising solution to this issue. However, little is known about the best strategy for designing such a policy at the global level. By using an environmentally extended global multiregional input-output approach based on the Global Trade Analysis Project, a highly detailed expenditure database and data on coverage of social assistance programs, this paper investigates the effectiveness of various carbon taxation methods and revenue recycling mechanisms in reducing poverty and inequality between and within countries. We find that the policy mix with the highest poverty reduction potential is implementing a consumption tax with higher tax rates on luxury goods and recycling revenue through the expanded social assistance systems during the COVID-19 pandemic. While differentiating tax rates across goods within countries is advantageous, the average tax level across countries is best kept uniform since it potentially offers governments in low- and middle-income countries more financial capacity to support the poor. Furthermore, collecting a global climate fund from developed countries and redistributing it to developing countries based on poverty headcounts can further significantly reduce poverty and inequality within and between countries. However, substantial improvements in social assistance systems are urgently needed to further unlock the poverty-reduction potential of revenue recycling, particularly in Sub-Saharan African countries. Also, recycling carbon tax revenues to combat poverty and inequality will inhibit the emission reduction effect of carbon taxation in the short term, necessitating additional mitigation efforts in other areas.

'Made in the World': Measuring the Productivity of Global Value Chains

Topic: YSI and Development Programme - III - Discussants: Sebastien Miroudot and Erik Dietzenbacher
Author: Wenyin CHENG
Co-Authors: Bo MENG, Yuning GAO, Shang-jin WEI, Kyoji FUKAO

Given the rise of global value chains (GVCs) over the past two decades, the "made in" label, typical of manufactured goods, which attributes them to a specific economy, has become an archaic symbol of a bygone era as most manufactured goods are now "made in the world." As an additional approach to the traditional Jorgenson's accounting method based on the sectoral total factor productivity (TFP), this paper aims to measure GVC-based TFP by explicitly considering intermediate inputs as an endogenous variable.

Based on the theoretical derivations, simulations, and a recursive approach, we first clarify the distinction between the Domar- and Leontief-based GVC TFP. We further point out the knife-edge feature of Domar aggregation based on the sectoral TFP, as well as the "missing productivity" of

the conventional approach based on the share-weighted sectoral TFP or aggregate production function. Finally, we unify the Domar- and Leontief-based GVC TFP within Jorgenson's accounting framework and decompose it into five parts. Using the world input–output database, we show that the new GVC TFP helps better understand the nature and structure of international fragmentation production (e.g., snake vs. spider) and the evolution of global resource allocations.

We aim to contribute to productivity accounting theory in the following three ways: (1) We clarify the gap between the Domar- and Leontief-based GVC TFPs, which remains ambiguous in the literature; however, understanding the differences is critical to comprehending the relationship between sectoral TFP and GVC TFP, and also the micro-foundations of aggregate TFP. Domar aggregation based on sectoral TFP has been a widely used way of calculating aggregate TFP in the literature. However, few scholars have noticed that Domar approach can also be used to analyze GVC TFP, and the difference between Domar-based GVC TFP and Leontief-based GVC TFP remains unclear.

(2) We integrate GVC TFP into the accounting framework of Jorgenson and provide a symmetrical interpretation of GVC TFP as the traditional Jorgenson's accounting method based on sectoral TFP. Jorgenson provides a classical framework for decomposing aggregate sectoral TFP growth. Based on this framework, APF-based APG (Solow type) and PPF-based APG (Jorgenson type) can be decomposed into different components with value chain connections.

(3) We point out the knife-edge feature of PPF-based APG (with Domar aggregation based on sectoral TFP). In other words, PPF-based APG is valid only in a closed economy. When it comes to the national TFP in an open economy, it fails to capture the foreign value chains in a proper way. Furthermore, we figure out the "missing productivity" of conventional approach based on share-weighted sectoral TFP or aggregate production function, because of their failure in solving the endogeneity issue.

Besides the theoretical findings above, we also have some interesting empirical findings. For example, anti-globalization does more harm for developing countries than developed countries in terms of GVC TFP growth and the foreign contribution to GVC TFP. The contribution from China grows dramatically to the GVC TFP of the U.S. and Japan. Furthermore, in terms of the sector of computer, electronic and optical products, China, rather than India or Russia, where final goods are produced, is better for promoting global productivity.

In sum, this paper answers not only "which country, where final goods are produced, is better for promoting global productivity?", but "which country contributes more to the international competitiveness of a specific country?" These are all significant issues for the development of the world and a country.

Mounting Nutritional and Environmental Pressures of the Global Food Loss and Waste Calls for Urgent Policy Action

Topic: Economics of Food Systems - II
Author: Maksym G. CHEPELIEV
Co-Authors: Alessandro GATTO

Global food losses and waste (FLW) lie at the core of the transition to a more secure and sustainable food system. FLW generated along global food supply chains (FSC) contribute to climate change and natural resources depletion, threatening economic stability and endangering

our path toward global food security. Tackling global FLW in line with United Nations' Sustainable Development Goal (UN-SDG) 12.3 requires quantifying the magnitude, composition, and geographical location of lost and discarded foods, outlining where policy interventions may provide the highest socioeconomic and environmental benefits. Today, three significant barriers hinder the development of consistent policies for tackling FLW.

The first barrier is represented by the lack of harmonized global FLW estimates. As no reliable global measurement is available, most adopted estimates from Food and Agriculture Organization are considered broadly inconsistent but remain widely used in relevant studies illustrating significant gaps in the availability of data. On top of data limitations, a second barrier is generated by the presence of conflicting methodologies adopted to quantify FLW. Methodologies computing FLW estimates are circumscribed to the accounting agent's behavior and/or providing a consistent representation of physical biomass flows along global FSC. Technical studies rely on detailed physical mass flows to derive FLW amounts, but often ignore socioeconomic drivers of FLW, neglecting stakeholders' interactions and value-chain dynamics. In a globalized food system, changing actors' interactions and trade along global FSC affect demand for biomass, influencing spatial availability and composition of non-primary foods. As most available studies rely on poor global trade data, flows of traded biomass are often misrepresented but remain crucial for tracing food from farm to fork and accurately defining FLW along global FSC. Finally, a third barrier lies in the absence of a multidisciplinary framework able to address wide-ranging challenges around FLW. Currently, as available studies lack a consistent cross-check analysis between FLW and net/gross food intakes, no effective guidelines for nutritional security are provided. Several studies link FLW estimates with nutritional losses but report no information on how food and nutritional intakes are affected by FLW along the FSC. Expanding the nutritional analysis on FLW requires tracing flows of nutrients along global supply chains in order to quantify where interventions can best contribute to global food security. Additionally, as FLW and nutritional security directly link to the environment, a framework capable of merging nutritional analyses and embedded environmental footprint allows for defining policies from a broader multidisciplinary perspective.

In this paper, we attempt to address the main barriers and limitations of available FLW studies, compiling an up-to-date global FLW database based on a food supply-chain perspective. We align with the United Nations defining FLW as "food (including inedible parts) lost or discarded along the food supply chain, comprising pre-harvest losses, and excluding food diverted to animal feed, seed or to other non-food material uses such as bio-based products''. Adopting a multidisciplinary approach, we merge technical and economic modeling of FLW to capture physical flows of lost or discarded food biomass along each stage of global FSC. Building on a recent development that incorporates physical and nutritional flows in a global economic framework, we define country-level gross food and nutritional supply across stages of global FSC, matching estimates provided in the FAO Food-Balance-Sheets (FBS). We collect from the literature the best available estimates on shares of lost and discarded foods along FSC remaining consistent with our definition of FLW. We merge the FLW estimates with gross food and nutrient supply to quantify net food and nutritional intakes. With this, we explore county-level FLW developments across a ten-year time frame (2004-2014), using the Global Trade Analysis Project (GTAP) multi-region input-output (MRIO) framework. We quantify the magnitude, composition, geographical location, and nutritional contents of FLW, accounting for the economic interactions of the food system and global food trade. Finally, we integrate additional data on land use, water use, and greenhouse gas (GHG) emissions globally, quantifying the environmental footprint embedded in FLW generation along the FSC. Our analysis aims to bridge knowledge gaps on global FLW developments, providing an innovative link to nutritional security and environmental impacts. We aim to further embed FLW in the multidisciplinary framework of the Sustainable Development

Goals, assisting future policies on FLW reduction and circularity.

The War in Ukraine Disrupts Agricultural Value Chains, but Trade Policy Measures Can Mitigate the Impacts

Topic: Input-Output Modelling: Trade and Global Value Chains Policies - II
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Co-Authors: Maryla MALISZEWSKA, Maria Filipa SEARA E PEREIRA

On 24 February 2022, Russia launched an unprovoked attack on Ukraine, invading its territory on multiple fronts, including from neighboring Belarus. The ongoing war has disrupted global supplies of many essential commodities, with agricultural products, food, fertilizers, and energy at the top of the list. As Ukraine and Russia are major exporters of these essential goods, supply disruptions and associated price spikes are being severely felt across the globe.

Earlier studies have provided valuable contributions toward better understanding the implications of the war for agricultural commodity markets and food security while proposing specific measures to ease the adverse impacts. However, several important points have not been properly addressed in the literature. First, while rich in qualitative discussions, the existing literature lacks a detailed quantification of the potential implications of the war on the agricultural trade and value chains for the countries/regions around the globe. Second, most of the earlier studies that focused on the topic of agricultural/food-related implications of the war in Ukraine have not explicitly considered a broader context of sanctions, climate impacts, and trade restrictions that shapes the impacts of the war on the agricultural sector. Finally, the discussion of the potential policy responses to the food crises caused by the war has been primarily of a qualitative nature.

To explore the impacts of the Russian invasion of Ukraine on the global agricultural trade and value chains, we link a Global Trade Analysis Project (GTAP) global multi-region input-output (MRIO) database with the ENVISAGE computable general equilibrium (CGE) model, which distinguishes agent-based demand for imports by region of origin. We also incorporate a recently developed GTAP nutritional module into the assessment framework. The model represents the global economy with 23 aggregate regions/countries and 25 sectors. To capture the impacts of the war and implications of other ongoing market disruptions, a number of commodity- and country-specific shocks are considered: (a) agricultural supply shocks in Ukraine, Russia, and Belarus due to direct impacts of the war, with the implementation of a 35 percent supply shock for crops in Ukraine, and in line with the USDA forecast; (b) Change in crop yields due to weather conditions in 2022 following a comparison of the USDA yield forecasts between the spring and winter; (c) observed restrictions (bans or export taxes) implemented by countries around the world during 2022; (d) disruptions to fertilizer commodity markets, such as an increase in the price of imported fertilizer; (e) restrictions on fossil fuel imports from Russia by EU and other countries, and a downward shift in the global fossil fuel supply by the OPEC; (f) other trade-related sanctions imposed on Russia.

In addition to the shocks listed above, which are expected to have negative implications for agricultural value chains and food supply, we are exploring a set of policy responses that countries could implement to alleviate the adverse impacts of the ongoing disruptions. These include the following: (a) trade liberalization measures, which assume an elimination of import tariffs on agricultural primary and processed commodities, and (b) implementation of the trade facilitation measures (TFMs).

Our analysis provides several crucial policy insights. First, when analyzing the impacts of agricultural market disruptions, such as from the war in Ukraine, it is important to consider a broad context of the ongoing policies, climate impacts, and market disruptions. As we show, in many cases, the latter substantially exacerbates the direct impacts of the war. Second, with rapidly increasing food prices, some countries have started imposing agricultural trade restrictions to protect domestic consumers. Our results suggest that such actions should be avoided, as they only further jeopardize global food security. Third, the consequences of the war in Ukraine have already put disproportionate pressure on lower-income households in developing countries, who spend a large share of their budget on food and energy. Buffering the impacts on poor households via targeted support measures, such as direct lump-sum payments, is a crucial step to ease the burden on the most vulnerable. Finally, the analysis shows that the implementation of trade facilitation measures and the reduction of import tariffs on agricultural and food commodities could mitigate the impacts of the war by boosting agricultural trade and increasing overall food availability.

Implications of the Green and Sustainable Transition in Economic Structure: Analyzing the Evolution of the Complexity of the German Economy

Topic: Input-Output Modelling: Energy Policies - III
Author: Ana Luiza Maria Guimarães COELHO

This paper quantifies and analyzes the effects of green and sustainable transition as the path of development in the economic structure. We pay special attention to the Germany case. The energy transition is a concept that involves promoting important changes in some strategic economic sectors: energy, transport, and IT. In this context, the economic structure of some countries has been subject to policies that react to national, regional e and international goals. Among the countries that make the most effort to reach these goals are the European countries, particularly Germany. In recent years, german policies promoted important changes in its energy sectors. Those changes affect how those sectors are integrated and their importance for the whole german economy and the regional European economy. In other words, structural changes are happening in the German economic structure due to sustainable transition (Denholm et al., 2010; IRENA (International Renewable Energy Agency), 2017; Schmidt and Sewerin, 2017).

Empirically, measuring structural changes in the input-output framework is a challenge. The input-output table estimations reflect not only structural factors of how the economic sectors are connected but also short-term shocks and fluctuations. The last creates noise in the data, which implies undesirable trends for any measure built directly on such tables. In this case, it becomes tough to analyze the structural information contained in the data (Bullard and Sebald, 1977; Lahr and Dietzenbacher, 2001; Linden and Dietzenbacher, 2000; Miller and Blair, 2009; Sonis et al., 2000; Thakur, 2008). To deal with that, we propose using Markov Chains; in special, we use the steady-state properties. Markov Chains have been applied to input-output literature to analyze world input-output tables. They consist of a method to compute system risk (sensibility), to identify key sectors for the economic system, the level of fragmentation and specialization of the world economy, and also to analyze the conditions of the equilibrium of the system (Kostoska et al., 2020; Moosavi and Isacchini, 2017; Riane and David, 2022).

Differently from those works, we use Markov Chain methods to investigate the evolution of only one economy. We analyze the german economic structure from 1995 to 2018, building stochastic matrixes. To work with Stochastic Absorbing Markov Chains, we modified input-output tables

regarding the import and export column; and added value and final demand columns. In this way, we ensured a closed system and continued with the ability to analyze the external impact caused by changes in german structure or the opposite. We assume that the steady state of each matrix represents the equilibrium state after n periods when there was any structural change. Therefore changes in economic structure represent changes in the equilibrium state. Some measures or indicators computed based on the equilibrium transition matrix will show ruptures in its time series or a very characteristic path after a structural change. In the context of this paper, it implies that some of the measures will show a specific behavior over time based on the changes occurring in the german economy's energy sectors. In particular, from it, we can also identify the measures that reflect more structural changes and those that are more affected by short-term fluctuations. We use as a control the time series of some macroeconomic variables.

Besides the use of the traditional indicators proposed in the literature (Aroche-Reyes, 2002; Dietzenbacher, 1992; Miller and Blair, 2009; Morillas and Díaz, 2008; Oosterhaven and Stelder, 2002; Sonis et al., 2000) and sectors statistics, we also define a complex index as Hidalgo and Hausmann (2009). The complex index calculates the complexity of each sector's sales and purchase structures, considering the weight of each transaction and the sector's connectivity inside the economy. We use data available from the OCDE and EuroStat between 1995 and 2018 on German input-output tables, and employment, international trade, and technological development statistics (e.g., employees, labor cost, wages, import, export, tax subsidies to innovation, patents, and R&D spending by sector).

Preview results show that among the indicators used, the complex index and indirect multipliers are the most relevant indicators in explaining the evolution of the economic structure. There is no rupture in the evolution of the global complexity index, which is expected for a developed economy. However, the complexity in the energy sector changes and is positively correlated to technological development.

The GTAP-MRIO version 11 Data Base and Environmental Extensions

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - VIII
Author: Erwin CORONG

The global economy is increasingly organized along value chains which involve production stages being performed in different countries, with intermediate inputs crossing borders multiple times (Koopman et al., 2014). This global fragmentation of production along with deepening economic integration efforts since the 1990s, resulted in 70% of current global trade being associated with value chains (OECD, 2020). Understanding the economic and trade implications of global value chains (GVCs) has become an important research agenda since the early 2000s (Hummels et al. (2001); Baldwin (2011); Baldwin and Venables (2013); Backer and Miroudot (2013); (Koopman et al., 2014); Kowalski et al. (2015); Blanchard et al. (2016)). The preferred method for GVC analysis relies on multi-regional input-output (MRIO) frameworks. An MRIO harmonizes input-output (IO) tables for multiple regions and links trade flows directly from producers or firms in each region to importing firms (hence, GVCs) and consumers in other regions.

In this paper, we provide an overview of the GTAP Multi-Region Input Output (GTAP-MRIO) version 11 Data Base. While the Standard GTAP Data Base accounts for bilateral trade for each product, it assumes that domestic agents in each economy have the same mix of imports from different countries. To address this, the GTAP-MRIO extends the standard GTAP version 11 Data Base

(Aguiar et al., 2023) by additionally distinguishing bilateral trade and tariff flows by agents or so-called end-users, namely: firms, private household, government and investors. To construct the GTAP-MRIO, we use the International Trade Centre's (ITC) MAcMap database and the United Nations Statistics Division (UNSD) 6-digit Harmonized System (HS) to Broad Economic Categories (BEC) concordances to System of National Accounts (SNA) end-use framework and the GTAP Center's HS to GTAP concordances. We then aggregate over GTAP commodities, the trade and tariff data by end-users in MAcMap and consequently use these to disaggregate their associated flows in the standard GTAP Data Base. Finally, we employ constrained optimization procedures to ensure that the GTAP-MRIO trade and tariff flows, when summed over end-users, aggregate back to the trade and tariff flows in the standard GTAP Data Base.

In this paper, we also present the various environmental indicators—e.g., greenhouse gas emissions (CO_2, Methane, N_2O, F-gas) and air pollution— that can be calculated using the GTAP-MRIO Data Base. Finally, we illustrate the novelty of using the GTAP-MRIO Data Base as input to the GTAP-MRIO model to conduct policy simulations within a general equilibrium framework, thereby allowing us to capture not only the nuances of agent-specific trade patterns and the degree by which bilateral tariffs differ across agents or end-users, but also to trace the environment emissions/footprint associated with international trade policy changes.

GVC positioning of countries and income inequality: A global empirical assessment

Topic: The Reconfiguration of Global Value Chains in an Era of Growing Uncertainties
Author: Andrea COVERI
Co-Authors: Elena PAGLIALUNGA, Antonello ZANFEI

A growing literature has stressed that the geographical dispersion of production and the subsequent rise of global value chains (GVCs) are associated with important social and economic disparities across countries. In fact, several contributions have shed light on the uneven distribution of value captured by economies and their different opportunities to upgrade from low to higher knowledge-intensive activities along GVCs.

However, systematic empirical evidence on the distributional consequences of GVCs within countries has so far been rather limited. In this work, we take a step forward in the direction of filling this gap by providing a global empirical assessment of the GVC-inequality nexus. Our analysis is performed on a sample including more than 100 countries over the period 2003-2018 and contributes to the extant literature in the following three respects.

First, we use indicators of trade in GVCs based on Multi-Regional Input-Output tables in order to empirically assess the heterogeneous impact of different forms of participation in GVCs on within-country income inequality for both developed and developing economies.

Second, we combine information on the GVC position of countries based on input-output tables with detailed data on inward foreign direct investments (FDIs), which include information on the value chain activities they are aimed to perform. Cross-border capital flows have represented indeed a key driver of the international fragmentation of production and have largely contributed to the involvement of low- and middle-income countries in GVCs. This allows us to complement analyses on the impact of trade in GVCs on income inequality with evidence on the value chain activities in which countries are involved.

Third, we introduce and compute a measure of "functional diversification in FDI" – namely an indicator which captures the ability of countries to attract FDIs in a more diversified set of economic activities – in order to investigate the role played by the diversification of economies in terms of value chain functions in affecting their level of income inequality. Our research hypothesis is that higher GVC participation of economies combined with greater functional diversification – as opposed to hyper-specialization –can have a beneficial effect on income distribution within countries by enabling economies to expand their production matrix and foster a more inclusive development. In fact, while performing a limited set of activities in GVCs would merely reduce the variety of capabilities that they have, a greater functional diversification can sustain a larger and increasingly diverse set of skills, therefore promoting a more even distributional outcome.

By jointly considering both FDI and trade modes of countries' involvement in GVCs, our empirical analysis therefore allows: (a) to distinguish the distributional impact of more captive or hierarchical type of governance of GVCs from that resulting from firms' international outsourcing strategies (which greatly fuels trade in intermediate inputs within GVCs); (b) to better control for the omitted variable bias that might arise when failing to include both these forms of countries' involvement in GVCs.

Our preliminary results show that (i) the association between trade in GVC and income inequality is conditioned by the GVC position of countries in terms of backward to forward GVC linkages and by their level of economic development; (ii) countries attracting a larger share of FDIs in the upstream and downstream value chain functions report lower income inequality, while the opposite emerges for economies drawing mainly FDIs in production functions; (iii) countries characterized by a greater functional diversification in FDI exhibit a more equal distribution of income, which appears consistent with the hypothesis that a larger mix of value-adding activities an economy carries out allows to expand the learning opportunities and occupational choices for its workers and is conducive to a more inclusive development.

Simplifying gravity equations to embed regions within world input-output models

Topic: Input-Output Theory and Methodology - V
Author: Fernando DE LA TORRE CUEVAS
Co-Authors: Michael L. LAHR

Multiregional input-output (MRIO) models provide better maps of economic structure. They yield detailed mappings of structural relationships among different industries and economies than do single-region models. If models can be considered a sort of mapping of reality, then it follows that we should be able to attain better findings as our models better reflect actual human and environmental interaction across space and sectors (our maps become more accurate).

But a lack of viable trade data within nations deters the inclusion of subnational regional economies in global MRIO models. This inconvenience has encouraged scholars and practitioners to produce clever solutions ameliorating the usual problem of data scarcity. We identify in literature three main tools that deal with this problem. Import/export weights appear as the more meticulous approach, yet the more data demanding too. It relies on detailed information on regional imports/exports by sector and country origin/destination, which is seldom available. Gravity models are one way to estimate trade flows when information on trade is minimally available (if at all) and distance (or travel time) is an important consideration. However, their

accuracy is improvable and relies on parameters that cannot be set a priori. Finally biproportional balancing techniques (e.g.: RAS) are useful ensuring MRIO coherency but cannot compensate for badly posed initial estimates.

To facilitate more-ready development of such multiscale MRIO models, in this paper we identify a gravity model simplification with minimal data requirements that generates reasonable estimates of region-to-abroad trade. We illustrate the approach by spatially disaggregating two hypothetically constructed countries: one built upon small and open economies (Belgium, Luxembourg and the Netherlands); other combining big and less trade-oriented economies (France, Germany and Italy). We embed these regions within FIGARO global MRIO model and contrast estimates against true published data. Our results suggest that it is possible to reduce information requirements and still produce relatively accurate multiscale MRIO models. Feedback effects and spillovers are also well captured.

A space-industry econometric filter: The A matrix as a measure of industry proximity

Topic: Regional Input-Output Economics - III
Author: Fernando DE LA TORRE CUEVAS
Co-Authors: Michael L. LAHR

Subnational economic development has at least three dimensions: time, space, and industry. Time is required for economies to develop following a sequence that goes from entrepreneurial discovery— either private, public or combined— towards structural change. Space is less obvious, but fundamental to regional science. Spatial interactions may influence economic development in two different directions. On the one hand, proximity favours interactions among agents yielding more intense economic and knowledge exchanges. On the other hand, capabilities sustaining economic development are not necessarily deployed and contained within strict regional boundaries. Regions influence each other by means of spatial spillovers effects caused by investments, trade, consumerism, commuting behaviour, etc. Analogously, inter-industry connections are also likely to facilitate exchanges between firms and territories. They can be expressed in input-output (IO) analysis parlance or supply chains in the field of logistics. Other industry-based agglomeration economies can also attach, springing up as other establishments and/or people locate within the same spatial sphere.

IO spillovers account both for spatial and industrial interactions affecting a region´s economic performance. They are typically calculated as the to the column sum of the Leontief inverse matrix excluding the entries of the region to be analysed. Hence, their measurement requires interregional IO tables to be available. Unfortunately, interregional IO models are seldom published on regular basis by statistical institutions. Their geographical coverage is also limited. IO and econometrics have a long-lasting and fertile collaboration record. Econometrics can be used to overcome practical limitations in IO analysis, such as data scarcity. In this vein, we propose a way to circumvent the described inconvenience. We present a slight modification of the space-industry filter as developed by Tian (2014) and applied by Tian, Gottlieb, and Goetz (2020). This way, we calculate estimates for spatial, interindustry spillover effects using an aggregated (e.g.: national) IO table, which is much more likely to be available, combined with a regression model. We account for cross-effects between spatial and industrial structures too. In essence, our point is to evaluate if national IO coefficients can be used as weighting factors in regression analysis.

To test our findings, we present a modest empirical application predicated upon the 53 shires of Galicia (NW Spain). We describe variations in value-added and productivity between 2010 and 2018 for 12 different sectors. As explanatory variables we consider agglomeration economies —location, urbanization and diversification—; average firm size; and market potential. We then include our space-industry filter in the model. To account for spatial structures, we use a distance measure between regions as an approximation to transportation costs. To account for industrial structure, we aggregate the 2011 survey-based Galician symmetric IO table into the mentioned 12 industries. The goal is to examine to what extent the inclusion of our spatial and industrial spillover measures improves the explanatory power of the model. Results will be reported considering both backward and forward linkages between industries.

Compilation of investment matrix as an integrated part of the SUT framework for Estonia

Topic: Compilation of National Supply, Use and Input-Output Tables
Author: Iljen DEDEGKAJEVA

This paper answers to the following question: why do we need to compile gross fixed capital formation (GFCF) or investment matrix every year? Statistics Estonia compiles the GFCF matrix within the supply and use framework since 2000. The paper discusses the main sources and the methods of estimation of GFCF. An overview of dimensions by type of assets, by kind of activities and by products is given. Procedure of GFCF estimates in current prices, valuation aspects, methodological adjustments, balancing and integration into GDP are described in detail. This paper also gives an overview of the estimating GFCF in the previous years' prices, i.e. deflation methods, availability of price information used for deflation, level of product detail, split into domestic and imported components of GFCF. Some challenges of GFCF matrix compilation in practice is discussed.

At the territorial roots of global processes: the heterogeneous participation of regions in Global Value Chains

Topic: Regional Input-Output Economics - III
Author: Roberto DELLISANTI
Co-Authors: Roberta CAPELLO, Giovanni PERUCCA

During the past decades, an unprecedented wave of globalization caused the emergence of Global Value Chains (GVCs) and GVCs-related research. This stream of research mostly focused on the national dimension, provided relevant insights of the participation of national economies to the globally fragmentated production processes. Despite this evidence, very little is known about the participation of regional economies to GVCs.

The poor evidence on the regional participation to GVCs is due to two elements, one conceptual and one empirical. On the one hand, the phenomenon has been conceptualized as driven by the comparative advantage of countries, in which the regional dimension had no role to play. On the other hand, data limitation has always represented a threat to regional studies that started to emerge only recently, when regional-level data on GVCs became available (Thissen et al., 2018).

The regional dimension, on the contrary, is an important aspect to analyse. The participation to a GVC by a country is not spatially homogeneous. It provides growth opportunities to regions at

detriment to others, according to the way regions participate in the GVCs. For this reason, the paper is interested in going to the territorial roots of GVCs, identifying and mapping the different modes with which regions participate to GVCs ad to highlight which local characteristics are associated to a more rewarding position in GVCs.

Based on regional matrices of trade in value added (Thissen et al., 2018), two indicators are built for 258 European regions. The first one measures the regional intensity of participation in GVCs, the second captures what regions gain in terms of local value added by such participation. Put together, four modes of participation to a GVCs emerge. Through a multinomial model, the major regional characteristics of competitiveness, economic specialization and urban/rural structure will be associated to each of the four modes. This evidence will shed light on the determinants of the positioning of European regions in GVC, capturing the value they are able to produce in global processes.

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Regional competitive opportunities, fossil fuel cost changes and the role of decarbonization

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - I
Author: Sacha DEN NIJS
Co-Authors: Mark THISSEN

In this paper we analyze the competitive opportunities and threats to industries in different regions of fossil fuel cost changes and how decarbonization may affect these opportunities and threats. The last few years, during but also after COVID-19 pandemic waves and lockdowns, large fluctuations in energy prices are observed. Global political changes, like the war in Ukraine, are expected to also induce large shocks to fossil fuel prices. Meanwhile, decarbonization efforts and the resulting change in the energy system will affect international trade patterns in energy: less fossil fuels are required and renewable energy can be produced locally, reducing dependency (Scholten et al., 2020). This affects regional economies in particular as these may not have their own fossil fuel supply locally. The increasing need for regions and countries to decarbonize implies that energy demand and supply should fundamentally change. Various studies have tried to investigate the regional economic effects of this impending transition as increasingly policy makers are concerned about the distributional aspects of such climate policies. For example, Alves Dias et al. (2018) and Kapetaki et al. (2020) study EU coal regions and employment effects of phasing out coal mining. Here, we are concerned with the competitive position of regions and how such a transition could change this position - potentially providing a region with more opportunities. Instead of focusing directly on energy markets, energy demand and supply changes, we investigate the global value chain and the indirect use of energy within those chains.

Thus, this papers investigates two research questions: first, which industries in what regions are most sensitive in terms of their competitive position to changes in fossil fuel prices, such as gas, coal and oil, for example due to world-wide shocks like COVID-19. Second, and more interestingly, we consider how possible future changes in the electricity mix and energy usage that are the result of climate policy and decarbonization strategies may affect the regional competitive opportunities and threats of changes in fossil fuel prices. The first follows previous work of

Miernyk (1976) and Polenske (1979), applying a similar method to investigate the cost pass-through of energy through the supply chain using an input-output price model. The second research question makes use of an adaptation of the model where we introduce marginal effects on the technological coefficients, to further investigate this sensitivity. To investigate the effects of these fossil cost changes, we use the measure of revealed competition developed in Los et al. (2016) combined with value chain analysis using marginal prices as used in Thissen et al. (2020). We extend this approach by introducing marginal prices on technological change and substitution between energy types, thereby creating the possibility of analyzing the effect of decarbonization strategies on the competitive opportunities and threats. Such an approach gives the opportunity to derive more general conclusions than those that rely on a few specific ad hoc scenarios. Meanwhile, decarbonization may present opportunities for various regions and industries to decrease this sensitivity, which can result in policy recommendations that support decarbonizing faster to reduce the regional sensitivity of possibly world-wide global energy price shocks.

As stated above, a Leontief input-output price model based on multi-regional input-output tables on an EU NUTS 2 level from Thissen et al. (2018) is used. In addition, we make use of various data sources, such as IEA energy data and BACI trade data, to disaggregate the energy sector in the supply and use tables. This way, we construct a multi-regional input-output table including detail on fossil fuel usage across sectors and regions, which is still consistent with national level Eurostat FIGARO tables. Various regional level data sources are used to be consistent with regional energy supply. This provides us with a new regional input-output table through which we can trace the fossil energy sources through the value chain.

Studying the Netherlands, first results indicate that the competitive position of the low-technology industry sector is most sensitive to fossil energy price shocks. As expected, fossil energy price increases in the own sector has the largest negative effect on regional price competitiveness. An increase in the fossil energy price in other sectors in the EU has a negative effect on the competitiveness of this sector in most Dutch regions, whereas this is not the case for non-EU price increases. This suggest that outside of the EU, increases in fossil prices result in higher prices for competitors but not for the Dutch regions, increasing the regional price competitiveness. When input prices down-stream, within the EU, increase, this affects the regional price competitiveness negatively.

Resource scarcity, circular economy and the energy rebound: a macro-evolutionary Input-Output model

Topic: YSI and Development Programme - IV - Discussants: Bart Los and Rosa Duarte
Author: Lorenzo DI DOMENICO
Co-Authors: Marco RABERTO, Karolina SAFARZYNSKA

In this paper, we propose an Agent-Based Stock-Flow Consistent model combined with an Input-Output structure of production. In the model, heterogeneous firms interact in the energy, material, capital and consumption markets. Materials for production of consumer goods can be manufactured using non-renewable or recycled resources. We examine the conditions under which the circular economy emerges through market mechanisms, as well as it can be a source of the rebound effect. An important novelty of our approach is that recycling and mining sectors employ different types of capital for production. Capital firms constantly engage in innovations to improve their technological features. This way we endogenize changes in technological coefficients of the Input-Output tables and we include time-consuming and long-term factor substitutability. We show that sectoral interdependencies along the value chain can render the

energy rebound effect due to the circular economy (CE) even if energy intensity of the recycling process is lower compared to mining. Finally, we assess the role of different macroeconomic policies, namely mission-oriented innovation policies (MOIPs) and environmental taxation in fostering the CE transition, while mitigating the rebound effect. We find that the combination of MOIPs and active fiscal policy is the most effective in promoting the circular economy, preserving employment and ensuring a sustainable growth path.

The essentials of Leontief (1953) Domestic Production and Foreign Trade; The American Capital Position Re-Examined

Topic: 50th Anniversary of Leontief's Nobel Prize: International Trade
Author: Erik DIETZENBACHER

Based on the seminal work: Wassily, Leontief (1953) "Domestic Production and Foreign Trade; The American Capital Position Re-Examined", Proceedings of the American Philosophical Society, 97(4): 332-349. Includes presentation of some archive materials and documents about this topic.

From the roots to the present: input-output contributions in Innovation and Structural Change

Topic: 50th Anniversary of Leontief's Nobel Prize: Innovation and Structural Change
Author: Rosa DUARTE

Based on the Seminal work: Leontief, Wassily and Faye Duchin (1986) The Future Impact of Automation on Workers. New York: Oxford University Press.
Includes presentation of some archives materials and documents about this topic.

Gender polarization and gender inequality in globalized economies: recent insights from a MRIO perspective

Topic: Gender issues in Input-Output Analysis: New challenges and new perspectives - II
Author: Rosa DUARTE
Co-Authors: Cristina SARASA, Mònica SERRANO

Economic literature has extensively documented the skill-biased technical change in advanced economies showing a "U" shape skill-labour demand distribution, meaning employment polarization. Thus, the increase in the upper and bottom tails of the skill-labour demand distributions and the significant reduction in the medium skill categories of workers have involved significant consequences on wages and income distribution linked to the technical change and the development of ICT technologies in the eighties and nineties of the last century. The contribution to this process of the involvement of countries and regions in global value chains has been less explored and, significantly, the potential implications of the skill-labour distribution by gender remain largely unexplored in the literature. Moreover, recent studies in feminist economics highlight the relevance of sectoral feminization or horizontal segregation in the persistence of gender gaps. Both facts suggest a relationship between employment polarization and gender dimension, which is closely related with the sectoral composition of the economy, the specialization patterns and the drivers of growth.

This paper goes deeper into these questions, approaching from a multisectoral and multiregional perspective, the implications of recent economic trends on gender polarization and gender inequality. More specifically, the European economy has experienced important changes in labour markets in the last decades, and particularly from the irruption of the international economic crisis in 2008 and the subsequent recovery processes to the most recent crises associated to the COVID pandemic and the international instability. These changes affect the employment distribution among sectors and countries. The internationalization of supply chains has also contributed to the current configuration of sectoral structures, employment attribution to sectors and occupations and, in consequence, to gender gaps. The distribution has been unequal among countries, finding certain patterns of regional-sectoral specialization with effects on labour composition.

The incidence of economic crisis has been also largely different by age groups, affecting notably to young and elder employees. Interesting gender differences can be found by age and skill groups, which help to understand the current nature of European pay gender gaps.

In this paper, we provide evidence on the evolution of these indicators, as well as the structural, technological and specialization factors underlying. We particularly focus the analysis on the effect of the stylized facts found on the persistence of gender gaps and gender pay inequality.

Methodologically, we depart from a multisectoral and multiregional input-output (MRIO) model to develop several indexes accounting for employment polarization, gender dimensions, gender pay gap and structural change in Europe and in a group of advanced economies. The relationships of these indexes with the performance of countries and sectors in GVCs, country specialization, and economic closeness are empirically tested by way of econometric analysis.

Our results point at a type of gender polarization, with different characteristics than those observed for the US economy in previous decades, with heterogeneous composition by countries and regions in Europe (Northern, Mediterranean, central Europe), age groups and sectors. Our preliminary results also provide some evidence of the relationship between these factors and the country specialization and export orientation over the period studied.

How should governments respond to energy shocks? A horse-race approach to compare the impacts of energy policies designed to counteract energy shocks.

Topic: Input-Output Modelling: Energy Policies - II
Author: Geoffroy DUPARC-PORTIER

Energy shocks are an important and topical issue in modern economies. By reducing production capacities, they can lead to increasing consumer prices and other consequences such as stagflation. In turn, energy shocks may reduce overall welfare. As the price of energy increases, the value of savings erodes and real wages decrease, these shocks may exacerbate inequality. This is since households, already struggling with energy poverty, may need to spend an even larger proportion of their incomes on increasingly expensive energy.

Although history suggests that energy shocks often trigger economic downturns, governments have devised tools to reduce their economic and societal costs. These tools have been used to tackle the current cost-of-living crisis across Europe and include: targeted energy price subsidies to low income household groups and untargeted energy price subsidies, energy bill support to

firms as well as targeted and untargeted income subsidies to household.

Although extensive research exists investigating the impacts of various energy policies, few authors compare these fiscal policy measures on a like-for-like basis. It is however crucial to investigate the implications of these policies using a harmonized framework as it allows for clear comparisons of the outcomes of each policy. Hence, in this paper, I shed light on the strengths and benefits of a set of fiscal policy measures used by governments facing energy shocks. Motivated by the current fiscal policy measures implemented across Europe, I evaluate three sets of fiscal policies. These are: targeted and untargeted energy price subsidies to lower income households; firm energy price subsidies and general energy price subsidies to all agents and targeted and untargeted income subsidies to households.

To compare the fiscal policy measures, I develop a dynamic two-region Computable General Equilibrium model of Germany and the rest of the EU calibrated on Eurostat's Figaro data. Both Germany and the rest of the EU are endogenous regions whereas the rest of the world is assumed to be exogeous in the model. Households are dissagregated into net income quintiles using experimental data from Eurostat "icw_res_01". Households are differentiated by their level of capital ownership, firm ownership, and sectoral consumption. Labour market dynamics are captured through a wage curve and non-energy sectors operate in perfectly competitive markets. Energy sectors have an oligopoly structure with profits being re-allocated disproportiantely to richer households. Production is captured through a multi-level structure where intermediate goods are aggregated through CES nests following the Armington assumption and combined with capital and labour to form final production. Other agents in the model are the rest of the world and the government sector.

I introduce a permanent exogenous foreign energy price shock and measure its aggregate, sectoral and distributional implications using the CGE model. Following this, I introduce the set of putative fiscal policies to counteract the shock and evaluate their effects. To compare the putative policies, I assume that governments are endowed with an additional debt financed budget in the first year. This debt must be reimbursed in the following periods. This budget is used for one of the policies allowing for a comparison of the key outcomes of each of the policies given the same initial budget. A windfall tax scenario is also introduced in which increases in energy firm profits are taxed to raise further government revenue in the period following the shock.

Following the introduction of the energy price shock, I find a long run reduction in real GDP with energy intensive sectors being impacted more negatively than other sectors. I also find increasing prices with energy prices puts upward pressure on non-energy prices as well as increasing inequality. The increasing inequality is a consequence of the larger household energy consumption share of lower income households. Inequality is further increased due to richer households holding more capital and collecting profits from the energy firms.

In general, the results of the paper suggest that fiscal policy makers face a trade-off between efficiency and equality for demand-side fiscal policy interventions. I find that targeted price subsidies and windfall tax funding are the most effective ways to reduce the inequality effects of the energy price shock. Firm price subsidies and General price subsidies are more effective at helping the economy rebound following the shock. Income subsidies are found to be much less effective than the other policies.

In the full paper, I will discuss the methodological decisions both modelling and policy implementation in more detail. I will also provide more discussion on the key results and

interpretation of each of the policies.

Artificial Intelligence Driven Solutions for Complex Targets: Multi-Objective Evolutionary Algorithms coupled with SAM-Based Modelling

Topic: Economics of Food Systems - I
Author: Andrea K. EL MELIGI
Co-Authors: Mohammed BASHEER, Valeria FERREIRA, Victor NECHIFOR

This study explores the potential for coupling Multi-Objective Evolutionary Algorithms (MOEA) with a SAM-based modelling framework to search for model parameters that minimize tradeoffs between conflicting objectives. Inspired by biological evolution, the MOEA uses metaheuristics to find non-dominated Pareto-optimal solutions. The algorithms iterate with simulators to learn and find efficient solutions that are approximately on the Pareto Front (defined by the multiple objectives). MOEA can assist in designing policy options based on the minimum possible tradeoffs to be visualized without pre-determining specific policy preferences. The research couples MOEA with a SAM-based model for Cameroon's economy. It explores policies related to final demand that optimize outcomes across different indicators. The resulting performance metrics, such as income inequality index, jobs created, and emissions are visualized to combine optimal sustainability policies for the proposed case study.

Cluster Analysis of the Effects of Trade Restrictions on the EU Food System: A SAM Multiplier Approach

Topic: Economics of Food Systems - II
Author: Andrea K. EL MELIGI
Co-Authors: Ana Isabel SANJUáN LóPEZ, George PHILIPPIDIS

This paper investigates the potential impact of a reduction in imported marketable goods on the food system, focusing on the resilience and vulnerability of different clusters to potential spillover effects. To achieve this, the 2015 BioSAM database is used to conduct a comprehensive analysis of the impact of changes in the food system, including the assessment of potential effects on different sectors. At this purpose, the COMEXT trade database is employed to identify products that may be affected by trade restrictions, which will help in defining the scale of changes. By employing different SAM multipliers, the aim is to provide a more nuanced understanding of the resilience and vulnerability of different clusters in the food system across EU countries. The statistical analysis will be conducted to formally identify clusters and test for structural differences, with a specific focus on the impact of trade restrictions between Ukraine and Russia.

Income inequality and globalization: new evidence from a sectoral perspective

Topic: Input-Output Analysis: Income Distribution Policies - II
Author: Adrian ESPINOSA-GRACIA
Co-Authors: Rosa DUARTE, Sofía JIMÉNEZ

The intensification of globalization processes that has taken place since the 1990s brough about several implications, among which the international fragmentation of production and its configuration along Global Value Chains (GVCs) should be highlighted. As this has affected how global value added is distributed, both within and between countries, these processes might have influenced the recent trends observed in global income inequality.

Recent studies have addressed these relationships between intra- and inter-country inequalities and countries' involvement in GVCs, although those have only been studied at a country/region level. Indeed, these conclude that measures of integration into GVCs (such as participation and position) are related to measures of inequality within countries (usually, Gini indexes) and between countries (indexes of convergence/divergence). Furthermore, the relations to position measures are quadratic, adjusting to the 'smile curve hypothesis', in the sense that value added tends to concentrate in the tails of the chains, and so differential behaviors between upstream/downstream and intermediate positions appear.

As was already commented, this has been done mainly at country level. At sectoral level, previous research has focused on the impact of sectoral diversification/concentration on inequality. These works find that diversified/concentrated productive structures indeed affect income distribution, with results varying depending on countries' levels of development or income.

In this context, we aim to deepen in the relationship between inequality and involvement in GVCs, analyzing how different patterns of trade affect could affect income inequality. Thus is, we want to answer questions such as: How does a higher number of suppliers affect a country's social outcomes, both internally and in respect with other countries? Does occupying central positions in the global networks have an impact on intra-country inequality? How does exports sectoral specialization affect inequality indicators, and which sectors are more determinants?

For achieving our purpose, we are using the latest release of OECD's Inter-Country Input-Output (ICIO) tables, which covers 66 countries and 45 industries for the period 1995-2018. To find these relationships, we construct a panel. We use the tables to calculate two indicators of country's involvement in GVCs, which are participation (a country-sector share of value added embodied in exports over global value added embodied) and position (which, in turn, indicates the 'upstreamness' of the vertical specialization of a country or, in other words, if its production of intermediate inputs is focused on primary or in final goods, a longer distance to final demand meaning a higher upstreamness). Besides, a set of institutional variables highly related to income inequality are used as controls in the panel: these are unemployment rates, enrollment rates in tertiary education, Foreign Direct Investment, Corruption control indexes, Patents, and urban population (all from World Bank). Besides, two sets of dummies variables are included as controls: a time dummy for controlling the 2008 crisis, and a dummy for geographical areas for controlling for spatial effects (and also for levels of development of different areas).

Nonetheless, the novelty of this paper is in the study of these relations to the sectoral anatomies of countries/regions. For doing this, using the input-output tables, we calculate several indicators for measuring different productive structures, such as Herfindahl indexes of sector/country

concentration, sectoral participation, or measures of economic complexity associated to technological capabilities. These will be used to determine which are the strategic sectors that might have influenced the evolution of social inequality in relation to countries' engagement in GVCs.

Finally, some indicators of inequality must be calculated to be used as endogenous variables in our model. As measures of intra-country inequality, we calculate Gini indexes and income concentration from World Inequality Database. These can be complemented with existing measures of inequality and poverty from the Luxembourg Income Study and Poverty and Inequality Platform from the World Bank (these measures including, namely, Atkinson indexes, relative income ratios, relative poverty rates, etc.). Concerning inter-country measures, we calculate ratios of value added per capita to global value added, in order to account for convergence or divergence processes through a linear transformation of these formula.

In short, we hope to contribute to the research line that studies relations between income inequality and globalization by taking into account the sectoral dimension, which we consider to be a key determinant of countries' social outcomes, but has been left out of the existing literature at the moment, to the best of the authors' kn

Assessing the Labour, Income and Carbon Footprint on the Global Tourism Sector

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - VI
Author: Futu FATURAY
Co-Authors: Lintje SIE, Ya-Yen SUN, Wanru ZHOU

The tourism industry has rebounded from the COVID-19 pandemic. While the rapid growth of tourism can have a positive impact on the economy through GDP and employment, it also poses a danger to global warming due to its carbon-intensive nature. This research article aims to examine the nexus between employment, GDP, and carbon emissions for tourism activities at a global scale. The study employs the GLORIA multi-region input-output table to analyze the economic, social, and environmental impact of tourism for more than 160 countries. Data from various sources, including carbon emissions data, UN World Tourism Organization tourism statistics, and economic indicators between 2009 and 2019, were utilized to assess the historical performance of the tourism sector. Based on this, we further simulate the tourism impact on the national economy and environment in the post-COVID period. We provide the trajectory of tourism's significance in generating GDP and supporting employment while pointing out the possible emissions burdens on the national ambition to achieve net-zero by 2050.

Measuring global market power for the agricultural industry with input-output data

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - IV
Author: Esteban FERNANDEZ-VAZQUEZ
Co-Authors: Adrian Maarten RODRIGUEZ DEL VALLE DEN OUDEN

The study of market power in the primary food industry is of high interest to policymakers seeking to help develop poorer countries, due to its potential source to create market inefficiencies and hamper economic development. Recent papers have provided ample empirical

evidence, that market power around the world has been increasing nearly continuously since the 1980's. Nevertheless, due to the availability of firm-level data, most research is constrained to analyzing the firms of More Developed Countries with a particular focus on manufacturing and service sectors. This paper proposes to remedy this gap in the literature by using aggregate data contained within the Eora Input-Output Tables and a procedure based on Generalized Maximum Entropy to provide estimates of the markup for the Primary Foods industry (defined as the agriculture, hunting and fishing industries) for up to 188 countries in the world. We document a large heterogeneity based on a country's income level classification, with poorer countries having progressively higher markups. Furthermore, measures of globalization are seen to both significantly impact markups negatively (reducing them).

The snowball effect in a globalized economy. The contribution of different sources of inflation

Topic: Inflation and Supply Chain Adaptation in Dynamic Interindustry Modelling
Author: Tommaso FERRARESI
Co-Authors: Rossella BARDAZZI, Leonardo GHEZZI

Whereas usually either neglected by the rising literature on global value chains (e.g., Koopman et al., 2014), or narrowly focused on the economic impact of disasters highly concentrated in space (Okuyama et al. 2004, Avelino and Hewings, 2019; Koks and Thissen, 2016; Inoue & Todo, 2019), the investigation of the generalized effects of bottlenecks in production networks due to supply shocks has blossomed in the very last years.

Such a renewed interest has been spurred by the global impact of recent events which have been threatening the functioning of international production networks. First, the unfolding of the COVID-19 crisis since 2020 through 2021 and 2022 has contributed to globally impair production (Reissl et al., 2022 a,b; Meier and Pinto, 2020; Inoue and Todo, 2020; Pichler et al., 2020), as documented by the Global Supply Pressure Index estimated by Benigno et al. (2022). Second, the energy crisis fuelled by the Ukraine crisis, complemented by the sharp increase in the demand of goods in the United States in the wake of the COVID-19 crisis, gave rise to sharp increase of inflation in most of the world economies (Weber et al., 2022; OECD, 2022). Finally, the spread and the intensity of climate change induced disasters have sharply increased over time (Coronese et al., 2019), threatening the production of the goods most vulnerable to climate change at the global level.

To explore this issue empirically, we use a Bilateral Trade Model (BTM) developed at INFORUM (Interindustry Forecasting at the University of Maryland) and a system of national models. We have built an original dataset of bilateral trade flows built using UN Comtrade data combined with national accounts and sectoral data for all economies included in the system. As described in Bardazzi and Ghezzi (2018, 2022), this modelling approach also considers the effects through the relative prices of commodities while in most of the literature the demand side is the main channel to evaluate the economic consequences of a shock. This effect is endogenized in estimating and forecasting bilateral trade shares: the latter are not assumed constant as a change in international demand generates pressures on prices and affects the relative competitiveness between countries. Moreover, our model allows a change in the global demand as countries adjust to international prices through changes in output, input and import substitution, and export diversion. A high level of disaggregation of trade flows is particularly useful to fully capture the complex interrelations between economies. In this linking system, both the flows of commodities produced in country i and consumed in country j and also domestic prices in country

j are affected by (i) changes in the import-to-domestic-purchase ratio in country j; (ii) changes in the share of country i in country j's imports; (iii) changes in the level of output of both countries.

We run the international system of models under different scenarios to calculate the impact of different sources of inflation. Considering the main features of this model, the overall linking system of BTM and the national multisectoral models allow to estimate direct and indirect feedbacks between the economies through international trade flows.

The novelty of our approach is twofold. On the one hand, integrating data and models from different sources, it allows to geographically pin down shocks to the production of goods, which are then transmitted to industries from all around the world, taking into account of the peculiarities of the production systems of different countries. Secondly, adopting a simulation methodology able to disentangle supply and demand effects, it allows to assess the intensity of different factors at work in pushing the inflation dynamics. Each national economy possibly adjusts to the variation in relative prices through a change in demand, an import substitution from other sources or with domestic production depending on the relative price competitiveness on domestic and international markets. These adjustments are modelled with the simultaneous solution of the real and nominal sides of the models, taking into account the feedback from trade substitution on IO linkages directly in the dual IO equations which include also the endogenous estimation of several final demand and value added components. These feedbacks represent a way to factor in resilience in the simulation of a shock which propagates through international markets and it's an outstanding feature of this modelling approach.

SAMs as a tool for conducting quantitative investigation in tourism

Topic: Input-Output Theory and Methodology - IV
Author: Guido FERRARI
Co-Authors: Yan Yun ZHAO

SAMs as extensions of I-O tables are widely used for economic systems comprehensive analysis using Impact Multiplier Models IMM) and via CGE models.

In this paper, IMM will be used to quantitatively investigate tourism sector, to analyse the structure of the economic system and the role of tourism and its effect on the whole system through the estimation of impact multiplier coefficients.

The data used is represented by a (51x51) accounts and (38x38) branches SAM for China jointly elaborated at the Shanxii University of Finance and Economics (SXUFE) and at the Department of Statistics of the University of Florence.

The research will analyse for the first time the impact of tourism on productive structure of the Chinese economic system, and the multiplicative impact of exogenous demand for tourism services on the endogenous accounts (branches), particularly on the manufacturing ones, after having identified the endogenous accounts and the exogenous one.

The results will provide information for government policy decisions.

A Structural Decomposition Analysis of the evolution of the Wage Share in Developed and Developing Economies

Topic: Input-Output Analysis: Income Distribution Policies - I
Author: José Bruno FEVEREIRO

The decline of the Wage Share and increased inequality since the 1980's has drawn significant attention in both academic and policy circles, with the literature pointing to a variety of causes such as technical change, loss of bargaining power by workers in a globalised economy. This papers seek to contribute to this literature by analysing the key structural drivers of the evolution of the Wage Share by means of an additive Structural Decomposition Analysis (SDA) of the Wage Share, building on the multiplicative SDA developed by Dietzenbacher (2004). The changes in the wage share is decomposed into five main contributing factors: (i) changes in real wage; (ii) changes in value added per worker; (iii) changes in the direct labour input coefficients; (iv) changes in the intermediate input coefficients; (v) changes in the final demand. While the first two factors represent income distribution dynamics within sectors (shift-effects), the other three factors relate to changes in the economic structure (share-effects), which reflect technological changes in the productive structure and in final demand composition. Analysis is developed for G7 economies and six developing countries (China, India, Indonesia, Brazil, Mexico and Turkey) between 2000-2014, using the WIOD database.

The evolution of the Wage Share across developed and developing economies has differed considerably. However, the results from the SDA reveal some interesting patterns. In developed countries the main driving factors in the change in wages shares is the distributive conflict occurring within sectors, with real wages increasing slower than value added per worker in countries such as USA, Germany and Japan, However, in countries like Italy, France and Canada real wages have increased faster than value added per worker, on average. In developing economies changes in the productive structure of the economy, such as the changes in composition of intermediate and final demand, have pushed the aggregate wage share downwards, specially in China and India; while real wages have increased faster than value added per worker contributing to an increase in the overall Wage Share, with the notable exception of Mexico.

Economic resilience to changes in Covid-19 driven tourism demand: an ex-post modelling contribution

Topic: Input-Output Analyses and Input-Output Modelling of Disasters - I
Author: Gioele FIGUS
Co-Authors: Grant Jordan ALLAN

The focus of this paper is the measurement of resilience of tourism-facing industries following the COVID-19 pandemic. Tourism activities across the world have been massively impacted by COVID-19, with the economic consequences propagating beyond the narrowly defined tourism industry to other economic activities. Several studies have used multi-sectoral economic models such as Input Output (IO) and Computable General Equilibrium (CGE) to capture the whole-economy impact of reduced tourism activities for various economies around the world. In parallel to these modelling applications, a significant strand of research since the start of 2020 has examined the changes in tourism activity during the COVID-19 period, including the development of metrics of "tourism resilience".

A common approach in the tourism resilience literature is to quantify resilience as the degree to which tourism activities have returned to their pre-pandemic capacity, measured as a percentage. A key issue is that the measures of resilience found from such studies aggregate the result of a combination of both the ability of tourism-facing activities to continue to operate despite public health measures in place during COVID restrictions - for example by increasing distancing, more frequent sanitisation, inputs substitution - and the policies and interventions that have fostered resilience through mitigation, such as finding new products and markets.

This paper brings conceptual insights from the resilience literature on the whole economy modelling of natural disasters to the tourism literature and illustrates how – for an observed change in tourists' accommodation spending during 2020 in Scotland – Input-Output (IO) and Computable General Equilibrium (CGE) models can be used to describe situations where different elements of resilience are introduced in a controlled setting.

The basic idea is that incorporating different modelling assumptions and behavioural responses into economic models can generate – for the same change in tourism spending - different tourism activity and whole economy outcomes for resilience. Our paper shows that the analyst's choice of model and its specification can rule out possible resilience responses, which can lead to an underestimation the degree of resilience in an economy. The extreme case of hypothetical extraction in an IO system reflects a situation where essentially no resilience is present in the system and establishes a maximum business interruption scenario. Demand driven IO modelling assumes that inputs are used in fixed proportions and are linearly related to output. Hence, these models cannot capture the ability of industries to reorganise their supply chain and select cost minimising inputs but can consider the ability of hotels to gradually reopen (at reduced capacity) for certain periods of the year. CGE models can capture input substitution following an economic shock through price sensitivity behaviour. By calibrating a set of IO and CGE models for Scotland on a common 2019 Input Output table, and using data on reduced demand for accommodation in 2020, we demonstrate how increasing the degree of endogenous responsiveness of economic models can help to explain broad categories of resilience. By comparing the change in the accommodation industry gross value added estimated by our different models with the maximum business interruption case we are able to calculate a measure for resilience for each model.

An additional novelty of the paper is that we use data on the actual changes in gross value added in the accommodation industry in Scotland in 2020 to assess the performance of the IO and CGE models in predicting the impact of the shock to accommodation. We find that in most cases economic models tend to over-estimate the impacts of a demand shock to the accommodation sector. However, the performance of the models improves when flexibility is introduced in the model specifications to account for potential resilience strategies such as input substitution. We find that our CGE model explains about 80% of the variation in gross value added in the Scottish accommodation sector in 2020. This sheds important light on the selection and use of models for exploring the sector and economy-wide impacts of tourism shocks.

Curve shapes and parameters in FLQ regional modelling: some alternative approaches

Topic: Input-Output Theory and Methodology - V
Author: Anthony T. FLEGG
Co-Authors: Xesús PEREIRA, Napoleón Guillermo SáNCHEZ CHóEZ, Fernando DE LA TORRE CUEVAS, Timo TOHMO

In this paper, we propose a novel way of implementing the FLQ (Flegg's location quotient) approach to the regionalization of national input-output tables. Although the FLQ formula often yields the most accurate results of the pure LQ-based methods, the need to specify values of the unknown parameter δ in this formula presents an obstacle to its implementation. A possible solution is to use the FLQ+ method, which employs a modified cross-entropy method, along with a regression model, to estimate values of δ specific to both region and country. Here we develop a fresh approach to the use of the FLQ that substantially simplifies its application, while simultaneously enhancing its performance. As before, sectoral outputs (or employment) are the only regional data required. We focus on how regional size, R, is incorporated in the FLQ formula and simplify the way in which R affects the allowance made for imports from other regions. We call this new formula the reformulated FLQ or RFLQ. We also show how the unknown parameter in this formula can be estimated using readily available data. We test our proposal using the 2005 and 2015 Korean survey-based regional IO datasets. We contrast our estimates with survey-based values and compare results with those from several well-known techniques. Furthermore, we examine two different information scenarios: with and without industry-specific information. The results suggest that one can produce regional IO tables with similar or even better accuracy without using unknown parameters.

Policy strategies to tackle rebound effects: A comparative analysis

Topic: Input-Output Modelling: Energy Policies - I
Author: Jaume FREIRE-GONZáLEZ
Co-Authors: MUN Sing HO

Promoting energy efficiency is generally assumed to be an effective strategy to reduce energy use and tackle climate change. However, an extensive literature has shown that rebound effects reduce its effectiveness and can even be counterproductive. We show how a more complex policy strategy, with coordinated measures, could provide the desired results by offsetting energy and carbon rebound effects.

Along with the energy-efficiency improvement, we establish and analyze the implementation of six different scenarios or policy strategies: (1) energy efficiency promotion with no additional policies or measures, (2) energy efficiency plus carbon taxes, (3) energy efficiency plus energy production taxes, (4) energy efficiency plus ETS, (5) energy efficiency plus energy conservation in households, and (6) energy efficiency plus a shift to services consumption in households. These are 3 market-based and two behavioral strategies suggested in previous works including van den Bergh (2011, 2015), Santarius (2012), Freire-González and Puig-Ventosa (2015) and Font Vivanco et al. (2016a).

These policies are assessed using an economy–energy–environment dynamic Computable General Equilibrium (CGE) model developed for Catalonia, and compared in economic, energy, and environmental terms. The simulations show that all the strategies tested are able to offset

rebounds at a low cost, with a proper design. All of them improve GDP in relation to the no-efficiency improvement base case. If tax revenues from the parallel policies are used to encourage investment, the long-term effect on GDP may even be positive.

This is the first study, to the best of our knowledge, to assess the potential effectiveness and economic impact of a set of different instruments in avoiding rebound effects and compare them within the same framework.

Mitigating Baumol's cost disease in a stock-flow consistent framework

Topic: Recent Developments in Stock-Flow Consistent Input-Output Modelling - I
Author: Ben GALLANT
Co-Authors: Tim JACKSON

Baumol's cost disease (or the 'Baumol effect') is an economic theory explaining the price divergence between high- and low-labour productivity growth sectors (the fast and slow sector, respectively). The Baumol effect is the result of wage growth in the fast sector transferring to the slow sector where it results in higher labour costs and therefore higher prices, which raises potential problems for a post-growth economy. This paper seeks to explore whether Baumol's cost disease presents a barrier to the stability of a post-growth economy. Specifically, we explore whether policy intervention can be used to mitigate the impacts of the cost disease in a post-growth context.

In order to explore the dynamics and mutability of the cost disease effect in a post-growth context, we have developed a Stock-Flow Consistent Input-Output (SFC-IO) model FALSTAFF 2.B as presented in Jackson, Gallant and Mair (2023). The model has been partially parameterised to approximate the UK economy by Gallant (2022) using data from the UK national accounts and EU KLEMS database. The input-output component of the model, which was introduced through the authors previous work (Gallant, 2022; Jackson, Gallant and Mair, 2023), represents a novel addition to the cost disease literature.

We evaluate three potential mitigation policies, the most successful of which is a sales tax that we name the Cost Disease Tax (CDT). The CDT is a hypothetical sales tax levied on high labour productivity growth industries, the proceeds of which are used to subsidise low labour productivity growth industries. Within the conceptual modelling framework, the CDT is able to fully eliminate the cost disease effect in several different post-growth scenarios. This paper contributes to the ecological and post-Keynesian economics literatures as well as the existing body of work exploring Baumol's cost disease. The CDT is the first attempt to test the mutability of the cost disease effect and has implications for a range of sustainability challenges including: environmental taxation (Hardt et al., 2021), post-growth economics (Jackson, 2017) and pro-environmental consumption practices (Baumol et al., 2012).

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Measuring the Industry Relocation at the Macro-level

Topic: Input-Output Analysis: Industrial Policies
Author: Xiang GAO
Co-Authors: Geoffrey J.D. HEWINGS, Cuihong YANG

In recent years, the COVID-19 pandemic and the consequential disruption in the GVCs, the increasing geopolitical tensions and uncertainties (e.g., the Russia-Ukraine war and the Brexit), the rising trade protectionism (e.g., the US-China trade war), and the associated policies have strongly stimulated the global industry relocation in a reverse direction. As a result, the transformation of global and national industry relocation has been prompted in the recent past, and how it is and will be transformed has become an increasingly important question, drawing a great deal of interest among economists, policymakers, entrepreneurs, and the public. A proper discussion of that requires first and foremost an appropriate measure of industry relocation, which, to date, has been relatively poorly developed (see next section for more details). Thus, this paper has proposed a systematic approach to measuring the magnitude of industry relocation at the macro-level, drawing on data assembled in the inter-country/ inter-regional input-output tables and associated models. The approach overcomes the biases from the existing industry relocation measures, and thus, advances the toolset for capturing the evolution of production location.

In the empirical section, using the new measure, the paper investigated how the global and China's national industry relocation evolved from 2002 to 2017. The empirical findings show that Jones & Kierzkowski's (2005) hypothesis that "the production activities are more dispersed worldwide, while simultaneously agglomerated nationally" is only held during 2002-2007. However, after the shock of the global financial crisis in 2008, the premise of Jones & Kierzkowski's (2005) hypothesis has been challenged, and the patterns of industry relocation have changed. The dispersion pattern in global industry relocation weakened during 2012-2017. Meanwhile, within China, industry relocation experienced a transformation from slight agglomeration to dispersion. Such an evolution was a dominant feature of the technology-intensive industries, which is the most representative industry for the GVCs.

Measuring Trade Balance and Competitiveness under the Perspective of Income Flow through Global Value Chain

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - V
Author: Yuning GAO
Co-Authors: Bo MENG, Meichen ZHANG, Jiabai YE

The current misunderstanding of trade imbalance is mainly caused by the inconsistency between the assumptions of traditional trade statistics and modern trade based on global value chains. While traditional trade statistics are premised on goods crossing their own borders, in the era of global value chains, goods crossing borders is no longer a necessary condition for trade realization. The factory-less manufacturing method of multinational enterprises and the sales method of entering other countries' markets through foreign direct investment have become typical features and prevalent phenomena of global value chain trade. In view of this, this paper follows a new concept of "Trade in Factor Income ", that exports are defined as the exporter's factor income used to meet importer's final demand, based on the characteristics of global value chains. This paper constructs a long series global input-output model based on the OECD's AMNE-ICIO database that takes into account firm heterogeneity and a bilateral FDI stock database covering 20 sectors in 35 countries. It further decomposes factor income in value added formation, forms a new measure of bilateral trade balance accounting, and re-estimates the trade balance and competitiveness of main economies from 2005 to 2018. The scientific measurement of bilateral trade between main economies is important for resolving bilateral trade disputes, comprehensively assessing the true extent to the benefits from trade and promoting bilateral trade cooperation.

The Impact of the Pandemic and War on Surplus Redistribution Mechanisms: A Sectoral Analysis of France and Italy

Topic: Input-Output Analysis: Income Distribution Policies - I
Author: Giorgio GARAU
Co-Authors: Andrea K. EL MELIGI

The past three years have witnessed two rare events, the pandemic and the Ukrainian war, which have had significant impacts on the redistribution of surplus. Although both events were exceptional, they affected the surplus redistribution mechanisms differently. The pandemic has raised concerns about globalization processes, leading to a redefinition of global value chains. Conversely, the war has had devastating effects on populations, non-compliance with international laws, and cost inflation, similar to the oil crises of the 1970s. Interestingly, while production systems have scaled back in response to the pandemic, online sales, and the procurement of vaccines and medicines have grown exponentially on a global scale. In contrast, the war has caused certain goods, such as energy, agriculture, and electronics, to become scarce, causing problems in value chains and our daily lives.

This paper aims to investigate the period between 2010 and 2019, corresponding to the interval between the 2008 crisis and the 2019 breakdown, to better understand the relationships between productive sectors and economic agents in France and Italy. Using the Input-Output Tables (IOT) at current and constant prices produced by the respective national statistical systems, we will analyze how the pandemic and the war could affect distributional rules, using Fontela's (1989) and Garau's (1996) methods. Fontela's model establishes the distributional rule of productivity gain in the input-output context, while Garau's proposed model identifies a measure of surplus,

called purchasing power transfer (PPT), which accounts for the extra-profit conditions resulting from rental positions held by agents (Market Surplus).

By analyzing the Total Factor Productivity Surplus (TFPS) and Market Surplus measures, policymakers can understand the degree of non-competitiveness in different markets and the impact of the pandemic and the war on sectoral redistribution mechanisms. Limiting market surplus situations and eliminating barriers that protect specific sectors can prevent hindrances to the full revival of the economy. Although the pandemic and the war have global effects, this paper emphasizes the importance of studying redistribution mechanisms at the sectoral level. Understanding sectoral relations can help create a more equitable redistribution of the benefits of economic growth and identify the mechanisms and rules necessary to counteract the observed global issues.

Disentangling social impacts in global value chains through structural path analysis: the case of forced labour in the cotton industry

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - IV
Author: Ángela GARCíA-ALAMINOS
Co-Authors: Jorge E. ZAFRILLA, Fabio MONSALVE

This analysis proposes an analytical method to trace the precise pathways through which impacts from a specific origin are disseminated worldwide and embodied in high-income nations' consumption. Our methodological approach is based on a multi-regional input-output model developed using Exiobase data for 2019 (Stadler et al., 2021). The model is extended with the Structural Analysis Path (SPA) methodology, which allows us to trace and quantify the critical interactions in the impacts' dissemination process from their origin until reaching their destination as final demand in a specific industry and region. The SPA method is explored both in gross and net terms as complementary perspectives to disentangle the complexity of global value chains, which is the main contribution of our approach. The net assessment accounts just for interindustry transactions, whereas the gross analysis considers all steps of the value chain, even those occurring at an intraindustry level.

In this work, we analyze a case study to expose the features of this proposal, which focuses on assessing the global reach of forced labour in the cotton industry in China and India, the two leading worldwide cotton producers. Forced labour in the cotton industry in Asia is a matter of interest since it is a core issue in the fashion industry's sustainability debate. Cotton cropping is a labour-intensive activity often performed by vulnerable collectives, like migrants, children or women in the case of India (Singh, 2017) or ethnic minorities in the case of China (Lehr, 2020). Based on Exiobase and the International Labour Organization data, China and India are estimated to use approximately 31,900 and 55,300 forced labour workers in this activity, respectively. In addition, textile global value chains are intricate and complex, making it hard to trace the negative social impacts linked to them. Therefore, a deeper understanding of how the responsibility of workers' exploitation spreads to developed nations is necessary to shed light on the social sustainability debate.

Although this kind of forced labour seems to be a regional affair, our results show that more than a high share of these forced workers are attributed to the European Union and the United States consumption, respectively, with apparel, footwear, and textiles as key goods embodying these workers. However, other relevant industries, such as machinery, motor vehicles, and furniture,

also incorporate forced labour from the Chinese and Indian cotton industries in their value chains. After analyzing the specific paths of dissemination linked to the fashion demand of the European Union and the United States, our key findings show the predominant role of the Chinese textile industry in most paths given the high number of intrasectoral transformations inside this sector.

We also prove that forced labour in the Chinese and Indian cotton industries is even more distant to the final consumer than usual unskilled labour, which is an additional obstacle to its traceability. The bulk of this indecent labour appears in two to four stages of production before finalizing the good, which is far enough to hinder traceability.

Different patterns arise when looking at other employment indicators in the fashion value chain: while value-added and high-skill labour are mainly concentrated in short paths in the developed countries of destination, medium- and low-skilled labour are mainly imported from longer paths crossing emerging economies.

It was better when it was worse. Or not? The impact of deglobalizing value chains

Topic: The Reconfiguration of Global Value Chains in an Era of Growing Uncertainties
Author: Raffaele GIAMMETTI
Co-Authors: Nadia GARBELLINI, Ariel Luis WIRKIERMAN

Globalization is under attack (van Bergeijk, 2019). Systemic events like the US-China trade war, Brexit, Covid-19, and the recent Russia-Ukraine conflict have compromised the functioning of global value chains (GVCs) and catapulted the risk issue in global supply chains to the top of policy agendas. Some authors have seen an opportunity from shortening GVCs to increase the resilience of domestic production systems (Gereffi, 2020). Others warned that turning away from the internationalization of production may harm firms' productivity and innovation dynamics (Miroudot, 2020).

However, beyond the debate on the pros and cons of decoupling from GVCs (Coveri et al. 2020), there is broad agreement that GVCs may experience a persistent shift in the near deglobalized future (Antràs, 2020). The impact such changes would have on the economy and the geography of the global production network is still understudied. This paper aims to fill the gap by evaluating the economic impact of three different deglobalization scenarios.

The contribution of this work is twofold. First, we measure how a return to a less globalized production network would impact the world economy. Second, focusing on the European region, we evaluate how the European single market (ESM) would respond to two opposite deglobalization policies: (i) the European (EU) strategic autonomy, simulated by a full regionalization of trade flows; (ii) the hyper-globalization of ESM countries' trade flows.

Measuring the impact of deglobalization is a challenging issue. There are several questions that are difficult to answer. What is deglobalization? How will it manifest? Which countries and sectors will it affect? Therefore, the first effort we must make is on definitions.

A natural way to imagine deglobalization is to think about a retreat from globalization. Although even the concept of globalization is complex and multifaceted (Livesey, 2018), there is a broad consensus around the definition of globalization as the rise in international flows of intermediate goods and services (Hummels et al. 1998). Thus, in our first attempt to model deglobalization, we

imagine a reduction in the trade of intermediates on a global level. More specifically, in the first scenario, we turn back the clock on globalization to measure how today's value-added would change if it could be produced with the past's production schemes and trade patterns.

In the second and third scenarios, we focus on the European region and model a selective deglobalization, i.e. a decoupling from global value chains generated by two alternative trade policies implemented by ESM countries. More specifically, in the second scenario, we imagine a complete regionalization of the ESM. In this hypothetical world, the imports of intermediate inputs from extra-ESM countries are replaced by intra-ESM inputs. The third scenario models the opposite situation: the hyper-globalization of ESM countries. Here, we imagine that intra-ESM intermediate flows are completely replaced by extra-ESM inputs.

We model the three scenarios by employing the hypothetical extraction method and some of its extensions (Dietzenbacher and Lahr, 2013; Dietzenbacher et al., 2019) as this is a standard input-output tool widely used in the recent GVCs literature for studying how the value-added of a sector, a region, or a country, changes following the perturbation of the input requirements matrix (Los et al., 2017; Chen et al., 2018; Giammetti et al., 2020; Giammetti et al., 2022).

The scenario analysis is calibrated using the 2021 edition of the OECD Inter-Country Input-Output (ICIO) Tables (OECD, 2021). This dataset covers 45 industries classified by the International Standard Industrial Classification Revision 4 (ISIC Rev. 4), in 65 countries plus a region called "Rest of the World", for the period 1995–2018.

Our results show that deglobalization generates winners and losers. Specifically, the analysis suggests that encouraging and promoting globalization (van Bergeijk, 2018) has proved to be a double-edged sword for developed economies. The Western world is the loser of globalization. These findings add useful elements to the debate on the shift of anti-globalization movements from developing to developed countries, and, more generally, to the advance of political deglobalization - Trump's protectionist agenda, Brexit, the rise of nationalist parties in Europe (see James, 2018).

From micro to meso to macro and back: combining agent-based-modeling and input-output analysis

Topic: Agent-Based Modeling and Input-Output Analysis - I
Author: Raffaele GIAMMETTI
Co-Authors: Mauro GALLEGATI, Simone LANDINI

This paper discusses the limitations of a static and asymptotic approach used in standard input-output models and in the recent strand of literature on production networks (Acemoglu et al., 2012; Carvalho and Tahbaz-Salehi, 2019) to investigate the influence of the topology of input-output networks on the transmission of shocks and the build-up of macroeconomic volatility.

We present a micro-founded dynamic model in which aggregate volatility materializes in a genuinely dynamic sense and shock emergence and propagation are endogenous processes. This is accomplished through the use of agent-based modeling, which simulates the interactions of boundedly rational and heterogeneous entities in order to produce out-of-equilibrium dynamics. The model takes into consideration the endogenous production of shocks, disequilibrium, and aggregate volatility, as well as processes of convergence toward equilibrium.

We employ computational methods. We numerically apply our model and use Monte-Carlo simulations to examine its characteristics. This is how agent-based algorithmic economics typically operates (see LeBaron and Tesfatsion, 2008). However, the hybrid character of our model is a significant innovation. As is typical in the agent-based literature, some of the dynamics are defined by behavioral rules and local interactions. Other dynamics are defined in a more axiomatic manner by assuming some kind of efficiency, and they are then implemented as solutions to linear programs. This enables us to abstract away from the specifics of processes whose time scale or magnitude are below those of interest in the model, thereby lowering the number of free parameters (this perspective on time scales is akin to the one leading to subscale parameterization in climate modeling, see Edwards, 2010). However, this strategy requires resolving significant and challenging network optimization issues. As a result, it brings up the problem of computational capacity in the context of agent-based computational economics for the first time that we are aware of. Even though none of the simulations presented in this paper involve a sizable number of industries or businesses, they all needed months of computation time.

Unlike most ABM approaches, our model is fully calibrated. Specifically, the model is based on micro and macro data from national accounts, sector accounts, input–output tables, government statistics, census data, and business demography data. The model parameters are either taken directly from data or are calculated from national accounting identities.

The results confirm the influence of the topology of the production network on aggregate volatility and establish a strong connection between disequilibrium and aggregate volatility, which is absent in input-output and standard production network models.

Our model also identifies financial constraints as an endogenous route to disequilibrium, which impairs the local functioning of markets and generates endogenously micro-economic shocks from which aggregate volatility can emerge. The presence of credit networks and the positive feedback between financial fragility and financial constraints foster the propagation of financial shocks (Delli Gatti et al., 2010; Battiston et al., 2012).

The paper contributes to the literature on the origins of aggregate fluctuations (Bak et al. 1993; Gabaix, 2011) by grounding existing results on the non-diversification of shocks in a dynamical setting with heterogeneous interacting agents and allowing for the endogenous generation and propagation of shocks via bankruptcies, defaults and network-based financial accelerator mechanisms. The presence of credit networks and the positive feedback between financial fragility and financial constraints foster the propagation of financial shocks.

Assessing the carbon footprint inequality of Colombian households

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - X
Author: Enrique GILLES
Co-Authors: Fabio MONSALVE

This paper analyzes the relationship between income and carbon footprint using Colombian data from a Household Budget Survey and an environmentally-extended multi-regional input-output model. The results show that the income-elasticity of carbon footprint in Colombia is high, indicating that absent correcting policies and/or profound lifestyle and consumer behavior changes the country's economic growth process will lead to a significant increase in carbon

emissions which can have severe environmental and social consequences. The paper highlights the need for urgent action to reduce carbon emissions and promote sustainable development, providing valuable insights which can inform policies in Colombia and other developing countries.

Developments and Challenges in Producing UK Supply and Use Tables

Topic: Compilation of National Supply, Use and Input-Output Tables
Author: Peter Anthony GITTINS

Before high quality Input Output tables, we must have high quality estimates of Supply and Use. Balancing the three measures of GDP (production, income, and expenditure) is done annually through supply and use tables. Generally in the UK, the most recent 3 or 4 years are fully balanced, and earlier years are adjusted to accommodate methods and data improvements. However, in 2019 supply and use tables were rebalanced back to 1997 to incorporate significant method and data changes, and in 2014 a similar full rebalance took place as part of moving to the ESA 2010 accounting standards.

In the supply and use tables, production data are confronted with income data at industry level, and with expenditure data at product level. In the UK, we have a subdivision to 114*114 industries/products. In the industry dimension, production data (based predominantly on surveys run by the Office for National Statistics) and income data (based predominantly on tax records) are confronted to balance Gross Value Added estimates. In the product dimension, the production data is confronted with expenditure data (from multiple administrative and surveys sources) to balance supply and demand. Each of the national accounts identities involved has its own strengths and weaknesses which vary (according to source data) from industry to industry and product to product.

The paper will discuss data source strengths and weaknesses across the three measures of GDP (including some reflections on recent globalisation work). There will be a focus on microdata and other improvements, particularly in the production data (for example introducing new purchases survey data). There will also be reflections on the difficulties in large scale rebalancing such as in 2014/2019. The presentation will be largely qualitative. However, there will be some illustrative examples of the difficulties in balancing the data. There will also be some quantification of the scale of change introduced in 2019 and subsequent years as a result of other methodological improvements.

Finally, the paper will look at balanced GDP estimates for 2020. This will explore some of the difficulties encountered in producing balanced supply and use estimates in a year of unprecedented social and economic change. That will include impacts on compilation processes, source data, and links to wider developments in national accounts during the pandemic.

This is an update and resubmission of the paper accepted for the 28th Conference that had to be withdrawn due to personal circumstances.

MARIO: a versatile and user-friendly software for building Input-Output models

Topic: Advances in Open Source Software for Input-Output Compilation, Analysis and Quantitative Impact Assessment
Author: Nicolò GOLINUCCI
Co-Authors: Mohammad Amin TAHAVORI, Lorenzo RINALDI, Matteo Vincenzo ROCCO, Emanuela COLOMBO

Input-Output models create comprehensive and coherent descriptions of the interdependencies between different sectors through a quantitative representation of the flows of goods and services in an economy. The formulation of Input-Output models allows a modeler to assess the effects of changes in the demand or supply of goods and services on the economy and to identify their key consequences on environmental, social, and economic aspects. Models such as these are essential for understanding the complex interactions within an economy and for planning and implementing policies. The development of a tool that can easily set the scope and detail of an IO model and automate the most common input-output modelling procedures would greatly simplify the rigorous application of these methods.

MARIO (Multi-Regional Analysis of Regions through Input-Output) is a framework to build Input-Output models, designed to evaluate the economic and environmental impacts of different scenarios with a scale and database agnostic approach where any kind of input-output tables ranging from a single region to multi-region, monetary, or hybrid, and input-output or supply and use can be adopted. MARIO key features include automatic parsing of different available databases, automatic calculation of different tables, intuitive Application Program Interface (API) for changing an existing database through adding a new flow or sector to the tables, database aggregation, and scenario creation through shock analysis. Through the separation of mathematical complexities of input-output models and databases, MARIO provides an efficient tool to input-output modelers to focus on their analysis (problem-specific) rather than performing recursive mathematical operations of input-output models. MARIO API is designed to be used by users with little experienced and knowledge of Python programming language as well as experienced Python users.

To build an input-output model using MARIO, an input-output database needs to be parsed at the first step. MARIO has different parsing functionalities where different available input-output tables like EXIOBASE (different versions such as monetary and hybrid and IO and SUT versions), EORA (single-region and multi-region), and EUROSTAT can be imported, and the missing table will be calculated in a one-line command. When dealing with non-structured tables, MARIO can read a specific table from excel, csv, or text files. Implementing any changes to an existing database, including aggregation, adding a new sector, flow, or satellite account, as well as building different scenarios through shock implementation, can be done through an automatically generated excel interface where the modeler needs to fill the necessary data for the change while, for more complex and programmatic uses, the Python interface of MARIO can be utilized. Moreover, MARIO's built-in functionalities allow interactive analysis of the model outcomes through some routine visualizations. The newly generated or updated input-output database in MARIO, can be saved in different formats (such as excel, csv, or text files) while generating a metadata file that is capable of tracking down all the operations and changes performed on the original database.

MARIO is an open-source software that can be freely accessed, used, modified, and distributed by anyone, taking the advantage of open-source scientific software philosophy of contributing to higher transparency and flexibility, while allowing researchers to collaborate and build upon

existing work, resulting in faster and more efficient scenting progress.

Expanding the supply and use framework: from technologies to needs

Topic: Input-Output Theory and Methodology - II
Author: Nicolò GOLINUCCI
Co-Authors: Matteo Vincenzo ROCCO

The ongoing transition to sustainable energy implies the need to expand the portfolio of renewable energy technologies. The large availability of renewable energy sources represents a great opportunity to produce low-carbon energy services. However, many technical barriers have hindered the large-scale deployment of low-carbon energy technologies. The need to decarbonise society while meeting all its needs is one of the greatest and most complex scientific challenges of this and the next decades. The use of models that combine the expertise of engineers and economists, such as those offered by industrial ecology and, in particular, input-output analysis, is a valuable approach. However, transformations such as the sustainable energy transition require the introduction of new types of machinery, interventions or, more generally, innovations in the way inputs are transformed into outputs. Such technologies are usually introduced to meet a specific need - usually already met by an existing solution - with the promise of reducing operational impacts. Among the various approaches to input-output analysis, the supply and use framework is an important starting point for mapping new supply chains and exploring different market share scenarios. However, supply and use frameworks only allow a partial and not explicit representation of such aspects of the economic system.

The Technology-Activities-Commodity-Need (TACN) framework, presented in this paper, extends the traditional supply and use tables by allowing the two crucial missing pieces of the economic system (i.e. technologies and needs) to be represented. The framework is applied in the context of a large-scale development of a specific technology for the conversion of marine energy into electricity, and the economic, environmental and social impacts associated with the introduction and operation of a new dedicated supply chain are analysed.

The aim of the TACN framework is to allow a wide range of models to be represented within the accountability principles clearly defined by supply and use tables.

The technology level and the need level are introduced to overcome the lack of representation of two crucial aspects of modelling. On the technology side, the concept of installed capacity is not usually present in supply and use tables. In fact, the level of activity is usually recorded without considering the maximum level of output theoretically possible from each of them. Taking this into account in meso-economic models would allow for the accounting of unused capacity. Let's take the example of chip production or lithium extraction: both are constrained by a lack of productive capacity (i.e., the installed capacity of these specific activities in modelling terms). Knowing the capacity rate of each industrial activity could provide valuable information to better manage supply chain disruptions.

On the needs side, the concept of needs that can be satisfied by different commodities allows competition between activities. It can be seen as the functional unit in demand. From a meso-economic point of view, it would be possible to introduce a new level of accounting that takes into account not only "what" is consumed, but also "why" it is consumed, thus broadening the attribution of final consumption (e.g., 90% of the final consumption of methane by Italians is

attributed to heating and 10% to hot sanitary water). Let's take the example of energy demand: every year we demand heating in our homes in winter, regardless of whether this heating comes from heat pumps, which consume the good electricity, or from gas boilers, which consume the good methane. Explicitly consider the level of needs allows for a greater competitiveness in scenarios considering multiple technologies.

A demonstrative application in this context allowed for the analysis of the large-scale deployment of devices capable of converting sea energy into electricity by expanding EXIOBASE with a new sector built using specific case-specific data.

Building AfCIOT and TiVA Indicators in Africa in Support of AfCFTA

Topic: Methodological and Statistical Challenges for Analyses of Integration of Developing Countries in Regional and Global Value Chains - I
Author: Xiaoning GONG
Co-Authors: Eleanor Carys Jerram KEEBLE, David Gbetongninougbo BOKO, Ana DEVEZA

A key part of transforming Africa over the next decade is trade. The signature of the African Continental Free Trade Area (AfCFTA) agreement constitutes an expression of interest from African countries in boosting intra-African trade and increasing participation in Global Value Chains (GVCs). For Africa to maximize the benefit of this, the focus should be on developing an integrated, complementary, and strengthened African value chain. Trade in Value Added (TiVA) provides new statistical insights useful for tracking the progress toward this goal and helps evaluate industries for countries' specialization and industrialization policies.

While the inter-country input-output (ICIO) tables and sets of TiVA indicators developed by the OECD have been recognized as the best practices, only three of the 54 African economies are included in the global database (Morocco, South Africa, and Tunisia). Africa is also the only region that has no ICIO yet. Nonetheless, 63% of African countries already compile SUTs, which represents an opportunity for building a continental ICIO.

The African Continental Input-Output Table (AfCIOT) is a product in development that results from a partnership between WTO, OECD, and UNECA. Its strength lies in the dedicated capacity and expertise to access updated SUTs and national accounts from National Statistical Offices (NSOs), conduct research, and fill data gaps within the specificities of the African context. AfCIOT currently incorporates data from 15 countries and the rest of the world, while the target is the entire continent.

Statistical and methodological challenges surround the low quality and availability of underlying data. Timing, quality, and detail of SUTs and external data availability vary significantly between countries. The accuracy of trade and economic flows is low; large informal markets exist; there is a lack of digital capturing of many market transactions; and data regarding trade in services is hard to find if not non-existent. In developing the AfCIOT we are trying to solve these with innovative econometric calibration methods and modern data science techniques.

For now, various assumptions and estimation techniques to standardize and integrate African SUTs have been made and applied in building AfCIOT, such as:
• Use of data science techniques to make correspondence between local definitions and international industry and product classifications.
• Simple arithmetic addition and division to standardize Member States' SUTs.

- Model D fixed sales assumption to transform SUT to IOT.
- Use of the supply table at basic prices and use proportions to construct the use table at basic prices.
- Accepted estimation strategy for distributing imports to construct the imports use table.
- An uplift based on GVA by industry to convert the SUTs to dollars and the same years.
- For the Rest of the World, we have started to incorporate the major trading partners of Africa, such as the USA and China.

This is at the very early stage of building AfCIOT. Efforts are made on two fronts: On one hand, we will learn and adopt all the best practices by other experts in model building to set up the framework and testify that the goal is achievable. On the other hand, we will work closely with the Member States in a phased approach to strengthen the quality and timely availability of the required key macroeconomic data, such as SUTs, national accounts, and external trade statistics, which will, in turn, improve the quality and accuracy of the input data and resulting outcomes of AfCIOT.

Assessing the Distributional Effects of Maritime Spatial Planning Policies in Galicia, Spain: A Social Augmented Matrix Approach

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - IV
Author: Andres GONZALEZ
Co-Authors: Xesús PEREIRA

In recent years, there has been growing interest in studying the impacts of maritime spatial planning policies, which aim to sustainably manage the use of marine space. While several studies have been conducted on this topic, input-output tables have been commonly used to understand the socioeconomic impacts of these policies. However, previous studies have not adequately explored the distributional effects among the various actors involved in different economies.

To address this research gap, we have constructed a Social Augmented Matrix (SAM) for the Galician region of Spain, which serves as a valuable tool for assessing the impact of maritime spatial planning policies on the economy. Our SAM is based on an input matrix that decomposes the fisheries sector into 14 sub-sectors, enabling us to capture the nuances of the industry and its impact on different actors.

Building on this SAM, we have focused on studying two key channels through which MSP policies affect the wider economy: changes in household income and changes in the output of affected factors.

To conduct our study, we have used the 2018 Galician Input-Output Framework, developed by the Galician Statistical Institute (IGE). We have also obtained the distribution of wages by educational level from the 2018 Wage Structure Survey, published by the National Statistical Institute (INE). Additionally, we have used information from the Household Budget Survey (INE) to determine the distribution of households by income level. Finally, we have analyzed fiscal aggregates using the public sector database (BADESPE), compiled by the Institute for Fiscal Studies (IEF).

As mentioned earlier, our study aims to assess the impact of maritime spatial planning policies by enhancing the analysis of distributional effects and nuanced multipliers through a SAM. By doing

so, we seek to contribute to the current discourse on maritime spatial management and assist policymakers in making informed decisions that promote sustainable economic growth and social welfare.

Main Drivers of Carbon Emissions across the World: Does the Level of Development Matter?

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - I
Author: Srishti GOYAL
Co-Authors: Maria LLOP

Efforts to reduce GHG emissions began with the first COP in 1995 and led to the Paris Agreement at COP 21. This study examines the main drivers of carbon emissions based on the development status of countries between 1995 and 2018. The paper outlines two scenarios: (i) a country whose development status remains unchanged (either developed or developing), and (ii) a country that transitions from developing to developed status. It identifies the key drivers of carbon emissions in each scenario and provide relevant policy recommendations. Using SDA and OECD ICIO tables, the findings are expected to contribute to a better understanding of the complex relationship between development and carbon emissions, and inform more effective strategies for mitigating climate change.

Burden of the global energy price crisis on households

Topic: Input-Output Analysis: Energy Policies - III
Author: Yuru GUAN
Co-Authors: Jin YAN, Yuli SHAN, Klaus HUBACEK

Energy markets have tightened since the COVID-19 pandemic, and the situation was exacerbated considerably following the Russia–Ukraine conflict in late February 2022, contributing to a global energy crisis. This crisis has pushed a number of economies into recession, caused higher inflation, and put painful cost-of-living pressures on households around the world. High energy prices impose cost burdens on households in two ways. On the one hand, fuel price rises directly increase household fuel bills (for example, for heating and cooling, cooking, and mobility). On the other hand, energy and fossil feedstock inputs needed for the production of goods and services for final household consumption will lead to higher prices of household-expenditure items. Due to the unequal distribution of income, reflected in different household consumption patterns, surging energy prices could affect households in very different ways. Unaffordable costs of energy and other necessities would push vulnerable populations into energy poverty and even extreme poverty. Understanding how global energy prices are transmitted to households through global supply chains and how they are affected is crucial for effective and equitable policy design.

This paper provides a detailed assessment of the energy price shock on households and highlights the disparities of direct and indirect energy burden across different expenditure groups. We bridge a global multi-regional input–output database with detailed household-expenditure data to model the direct and indirect impacts of increased energy prices on households with different consumption patterns. We distinguish between 201 expenditure groups in 116 different countries, covering 87.4% of the global population, with a focus on developing countries.

On the basis of a set of energy price scenarios, we show that total energy costs of households would increase by 62.6–112.9%, contributing to a 2.7–4.8% increase in household expenditures. Direct energy costs contributed 15.0–29.6% of additional costs, while indirect costs contributed 44.8–83.4%. Households' indirect energy costs increased considerably more than their direct energy costs. The energy cost burdens across household groups vary due to differences in supply chain structure, consumption patterns and energy needs. Comparing across countries, households in central Asian countries are most affected in terms of total energy cost, and sub-Saharan African countries are most affected in terms of total energy cost burden rate. Wealthier households tend to have heavier burden rates of energy costs in low-income countries, whereas poorer households tend to have higher rates in high-income countries. Wealthier groups tend to have higher energy costs on goods and services with high value added, while poorer households tend to spend more on meeting daily needs such as food and direct energy. Under the cost-of-living pressures, an additional 78 million–141 million people will potentially be pushed into extreme poverty.

At this juncture, protecting vulnerable households should be a clear priority. Targeted energy assistance can help vulnerable households during this crisis. We emphasize support for increased costs of necessities, especially for food. It is worth noting that short-term policies addressing the cost-of-living crisis must be in line with climate-mitigation goals and other long-term sustainable development commitments. This unprecedented global energy crisis should come as a reminder that an energy system highly reliant on fossil fuels perpetuates energy-security risks and accelerates climate change. These emphasize the urgency to realize diversified energy sources and develop a more secure, diverse, reliable, and independent energy system by accelerating the clean energy transition for all countries. We call for more attention to countries that have been severely affected by this crisis. Multilateral action is critical to address potential energy transition bottlenecks and alleviate inequalities in access to affordable energy for households worldwide.

The overwhelming disadvantages of Index Decomposition Analysis compared to Structural Decomposition Analysis in Environmental studies

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - IX
Author: Zeus GUEVARA
Co-Authors: Sofia Teives HENRIQUES

Decomposition analysis is a methodology that identifies the driving factors of changes in performance variables of an economic system. It has been broadly applied to environmental studies since the 1970s and is now a widely recognized tool for environmental planning and policy. There are two conventional decomposition approaches: Index (IDA) and Structural Decomposition Analysis (SDA), whose main differences rely on their theoretical foundations and input data. While IDA is based on the theory of index numbers and needs time series of sectoral data, SDA is based on input-output analysis and hence requires input-output data. As both SDA and IDA are theoretically sound, in practice, the selection between them has mainly relied on the "type" of data at hand (e.g., IDA-fit historical data are broadly available), under the assumption that results should, in theory, be similar. This has led to a large dominance of IDA environmental studies despite it being recognized that SDA provides more detailed results. Some authors have evaluated both techniques in the same case study (e.g., Guevara, 2015, Stachura, 2018, Wang et al., 2017, and Wei et al., 2021) and found significant differences between IDA and SDA results that could lead to contradicting conclusions. However, they did not specify which of them is better; as previously explained, both techniques are correct in theory. Such a conclusion cannot

be made based on theory alone. Instead, it should be recognized that the characteristics of the decomposition model of the analyzed variable and the quality and aggregation of input data are as important as the theoretical foundations. This work demonstrates that when these two later aspects are also taken into account in the selection of decomposition technique for a given study, the SDA should be preferred. To do so, we rely on two existing decomposition studies of environmental variables: an SDA study of energy decoupling in Portugal and an IDA study of decarbonization in the UK. We reproduce each study with the other decomposition technique. First, we developed an IDA study of energy decoupling, in which we varied the data aggregation level while respecting the foundations of the decomposition model of the analyzed variable of the original study. Second, we develop an SDA study with a novel decarbonization model that better mimics the energy processes that occur in the economy with the same data quality as the original study. The comparison of these four studies shows that the IDA presents significant problems with data aggregation and model inconsistencies which can lead to opposite conclusions in the interpretation of decomposition results. For example, IDA shows that energy efficiency policies could have had a negative performance in 2004-2006 despite structural changes in the production system being more likely to have caused that effect. Also, IDA could make paying lower attention to household consumption patterns on decarbonization than to industrial energy intensity. Even though data aggregation issues affect both techniques, the SDA is more resilient against different levels of data aggregation. Moreover, SDA is more consistent with the physical processes that environmental flows experience in the economy. In addition, the characteristic of SDA models allows for better accounting of the limitations of the study. These results confirm that SDA is superior to IDA and more resilient to common general decomposition drawbacks. Even the IDA can provide erroneous conclusions regarding factor effects. Hence, IDA should only be used when structuring data as an input-output system is impossible. However, recent developments in environmental input-output analysis (namely the physical supply and use tables and the multifactor energy input-output model) allow structuring almost any environmental data as an input-output system, reducing the instances when SDA cannot be used.

IMF Multi-Analytical Regional Input-Output (IMF-MARIO) Database

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - VIII
Author: Joaquim J.M. GUILHOTO
Co-Authors: Gregory Max LEGOFF, Achille PEGOUE, Maria BORGA, Erich H STRASSNER

Input-output tables represent a unique source of information to understand the sale and purchase relationships between producers and consumers within an economy and their interconnection with: a) environment - emissions of CO_2 and other pollutants, use of land, natural resources, energy, etc.; b) employment - by gender, age, income group, qualification, green activities, etc.; c) tax gaps and income distribution; d) Trade in Value Added (TiVA), and so on. Given the IMF's new priority areas for surveillance, including climate change and gender, as well as its traditional surveillance and policy formulation, extending domestic input-output tables to an IMF Multi-Regional Input-Output (MRIO) model would constitute a powerful analytical tool, and source of harmonized granular data, for many IMF Departments, member economies, academia, and researches institutes, to better understand the inter-relationships between economies; their role in global value chains; the implications of their production, consumption, and investment activities for climate change; and their economic and social development. It would also help improve the data and conceptual consistency across individual economies' input-output tables and could also be used to develop or improve Supply-Use Tables (SUTs) for those economies with limited use of the SUT framework in estimation of GDP by the production approach. To fulfill this goal, the IMF is developing the Multi-Analytical Regional Input-Output (IMF-MARIO) database, a

new database which will take advantage of already available data from different global input-output tables initiatives; statistical offices; international organizations, including official source data collected by the IMF from its member countries, giving the IMF the advantage of early, and sometimes exclusive, access to a broader set of official statistics, which will reduce the amount of missing data faced in the estimation of MRIOs.

Over the past decade or so, different initiatives were conducted to estimate global MRIOs, with the main ones being the OECD Inter-Country Input-Output Tables (ICIO), the University of Groningen World Input-Output Database (WIOD), the IDE-JETRO's international input-output tables, the University of Sydney EORA and GLORIA databases, the Eurostat FIGARO database, the EXIOBASE database, the University of Purdue GTAP-MRIO, the Asian Development Bank (ADB) MRIO, the ECLAC MRIO, and the recently launched EMERGING.

Some of these MRIO databases use information from previous databases in their estimation. In this way, the different databases are sharing data among themselves in a way to improve estimation and to decrease costs and time of their estimation; this process may also lead to a better convergence of results from these different databases in the future. Following this observed trend, the initial estimation of the IMF-MARIO also draws from information already available in selected MRIOs.

Given the estimation complexity, it is proposed a methodological solution to allow flexibility and speed, it consists in breaking down the IMF-MARIO estimation process into 5 major blocks: 1) SNA constraints for the economy as a whole; 2) Output, value added, tax, subsidies, and final demand components broken down by commodities and industries; 3) Technical coefficients for intermediate consumption and final demand; 4) International trade; and 5) Estimation of the IMF-MARIO components based on data from the 4 previous blocks. Despite the blocks interdependence, the blocks work is organized in such a way to allow that the data gathering and the work in each block can take place in parallel.

Moreover, the new proposed framework for the IMF-MARIO estimation will be flexible enough to make it possible to: a) replace the initial databases used in the estimation process by other better databases or source data; b) add new databases; c) nowcast and forecast the estimation based on IMF macroeconomic projections; and d) obtain yearly and quarterly estimation of this database.

Regarding the IMF-MARIO scope, an important step in the estimation is the definition of countries, commodities, and industries, as this choice will impact the estimation, the results, and the future use of the model. Despite being possible to change the number of components of these 3 key variables, experience shows that changing their definition usually is not so straightforward, and it is highly demanding in time and resources. As such, the estimation considers a more granular definition of economies, to include all IMF member economies and the main commodities and industries associated with trade, consumption, emissions, and energy.

The resulting IMF-MARIO database consists of: a) harmonized national SUTs at purchasers' and basic prices; b) tables for trade and transportation margins, taxes and subsidies; c) IMF-MARUT (Multi-Analytical Regional Use Table) at basic prices; and d) IMF-MARIO at basic prices.

The Role of R&D Investment in Global Value Chains: Insights from BEA's TiVA Statistics

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - VI
Author: Jiemin GUO
Co-Authors: Ledia GUCI, Thomas F HOWELLS

Research and Development (R&D) is a crucial driver of economic growth, enabling companies to develop new technologies, products, and services that increase productivity and competitiveness. However, less attention has been paid to R&D impacts on domestic production across industries, especially the role that R&D plays in facilitating domestic engagement in global value chains. The Bureau of Economic Analysis (BEA) recently published statistics on Trade in Value Added (TiVA), providing insights into the importance of R&D activities in the global economy and their contribution to domestic production. This research paper aims to analyze TiVA measurements and Supply and Use Tables (SUTs) to identify the critical role of R&D investment in the global value chains of the United States. Specifically, this paper highlights that R&D investment plays a vital role in US exports by interacting with non-R&D industries, contributing to the competitiveness of the US in the global market. The findings demonstrate the importance of continued investment in R&D to maintain the US position in global value chains. The paper concludes by discussing the future roles of R&D investment in shaping the global economy and its significance for fostering innovation and technological advancements. Overall, this research provides insights into the essential role of R&D investment in the US economy and its impact on globalization across all industries.

Mexico, towards the energy transition? The possibilities of success of Mexico's current energy policy

Topic: Input-Output Analysis: Energy Policies - IV
Author: David Silva GUTIERREZ
Co-Authors: Zeus GUEVARA, Juan Roberto VARGAS, Zeus Salvador Hernández VELEROS

Mexico, towards the energy transition? The possibilities of success of Mexico's current energy policy

The need to lessen the impacts of climate change calls for energy alternatives based on clean energies that facilitate the energy transition. In Mexico, the new government shares this vision and considers it urgent to achieve the national energy transition within the framework of the Energy and Climate Change Program, one of the Strategic National Programs that are part of the government's development strategy.

To achieve this objective, it is necessary to consider that on the one hand, the national energy demand has increased significantly during the decade of the 2000s and is mainly satisfied with hydrocarbons, generating a dependence on fossil fuels that is significantly higher than that of the world, with 85% and 55% respectively (BP, 2022: 9); and on the other hand, that the Mexican State historically controls and exploits a sector of clear strategic character key to national macroeconomic stability in terms of exchange rate and public budget, which represents an opportunity in the long term to promote the change towards national energy transition (IEA, 2020).

Therefore, this paper aims to analyze the current national energy policy with the objective of

understanding and assessing the possibilities of achieving this energy transition process and its impact on the energy sector and the national economy. Specifically, we analyze the impact that a change in the national energy matrix with greater use of renewable energies would have on the energy sector and the national economy in terms of GDP, employment, and level of CO2 emissions.

This exercise is carried out with a multifactor input-output methodology, which will allow us to build scenarios and systematically understand with precision and depth the impact of these policies and identify opportunities for improvement and success of the policies implemented. Under this modeling framework, we will build scenarios to understand the possible structural changes in the Mexican economy and the oil and gas sector caused by the change of the energy matrix towards one with greater use of renewable energies. In a novel way, this model considers the economic transactions of all activities and processes that create value linked to the production and consumption of oil and gas products, including the activities of the conventional hydrocarbon value chain; and allows us to adequately map all the value chains in supply and provision and the energy sector, and to understand the economic, environmental and social impact of public policies and identify possible changes about their implementation.

The results suggest that the use of renewable energies in the energy matrix would generate a limited impact in terms of economic growth and employment in the national economy and a decrease in the level of CO2 emissions. Based on these results, we put forward some energy policy recommendations for government policymakers to increase the chances of success of the current energy policy.

The Impact of Carbon Prices on Trade via Global Value Chains

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - XI
Author: Arash HABIBI

This paper investigates the effects of the differences in carbon prices between source sectors domestically and abroad to study whether higher carbon prices in domestic sources have shifted demand to sources abroad. Using carbon pricing data, input-output database, and by applying the structural gravity model, we find evidence of carbon leakage in the country of final demand. The novelty of this analysis is the employment of a dataset that covers fuel excise taxes, carbon taxes, and emission trading systems. The dataset also considers the exemptions given to various sectors to prevent carbon leakage. Emission trading schemes (ETS) and carbon taxes contribute to a small share of total carbon prices. The share becomes even smaller after accounting for ETS-related exemptions. The previous works have missed the significant contribution of fuel excise taxes to carbon prices.

Macro-economic impacts of low-carbon infrastructure investments in France

Topic: Input-Output Modelling: Sustainable Production and Consumption Policies - I
Author: Meriem HAMDI-CHERIF
Co-Authors: Paul MALLIET, Frederic REYNES

See long abstract uploaded

A brief introduction of ADB MRIO and Digital Supply and Use Table

Topic: Methodological and Statistical Challenges for Analyses of Integration of Developing Countries in Regional and Global Value Chains - II
Author: Xue HAN
Co-Authors: Faith BALISACAN

The development of Multi-Regional Input-Output (MRIO) tables and Digital Supply Use Tables (DSUTs) by the Asian Development Bank (ADB) is a critical area of research and development in the field of economics. These tables serve as essential tools for policymakers and researchers to analyze the interdependencies of global production chains and assess the potential impacts of policy interventions. In this paper, we discuss the challenges involved in compiling these tables, the initiatives undertaken by the ADB to address these challenges, and the importance of continued efforts in developing MRIO and DSUTs. One of the significant challenges in compiling MRIO and DSUTs is the lack of data availability, particularly in developing countries. To overcome this challenge, the ADB has been working to build the capacity of national statistical offices in developing countries to collect and compile data. The ADB has also been providing technical assistance to improve the quality of data. These efforts have been successful in expanding the coverage of MRIO and DSUTs to more developing countries. Another challenge in compiling MRIO and DSUTs is the need to enhance the quality of data. This is particularly important for developing countries where the quality of data can be limited due to resource constraints and other factors. The ADB has been providing technical assistance to national statistical offices to enhance the quality of data. This includes developing guidelines and standards for data collection and improving the capacity of staff in statistical offices. In addition to these challenges, there is also a need to strengthen the capacity of national statistical offices to analyze segments of their economic statistics. This is important because the MRIO and DSUTs are derived from economic statistics and are only as accurate as the underlying data. Therefore, it is critical to ensure that the data used to compile MRIO and DSUTs is of high quality and accurate. To address these challenges, the ADB has been implementing several initiatives. One such initiative is the Japan Fund for Prosperous and Resilient Asia and the Pacific (JFPR) knowledge support and technical assistance program. The program aims to provide technical assistance to Indonesia, Vietnam, and Georgia to compile DSUTs, which are essential tools for analyzing the interdependencies of global production chains. The program is also providing training and capacity building to staff in national statistical offices to enhance the quality of data and analyze segments of their economic statistics. This initiative is significant because it demonstrates the commitment of the ADB to developing MRIO and DSUTs and promoting economic growth and poverty reduction in developing countries. The development of MRIO and DSUTs has important implications for policymakers, particularly in developing countries. These tables can help policymakers understand the complex interdependencies of global production chains and identify potential vulnerabilities in their economies in the context of digital transformation. For example, the COVID-19 pandemic has highlighted the vulnerabilities of global production chains and the need for policymakers to understand the potential impacts of disruptions in these chains. MRIO and DSUTs can provide policymakers with the necessary information to design policies that promote economic growth and reduce poverty. The importance of continued efforts in developing MRIO and DSUTs cannot be overstated. Developing countries, in particular, can benefit greatly from the insights provided by MRIO and DSUTs. The ADB has been working to address the challenges associated with compiling these tables, but more needs to be done to expand the coverage of MRIO and DSUTs to more developing countries.

The role of material flow indicators in reducing carbon emissions in Japan

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - XI
Author: Sho HATA
Co-Authors: Kenichi NAKAJIMA, Keisuke NANSAI

In Japan, improvements in material flow indicators (MFIs) have helped facilitate the transition to a more sustainable material-cycle society. However, it is uncertain whether further improvements in MFIs would contribute significantly to Japan's journey toward carbon neutrality. We developed the structural decomposition analysis that identifies the key change drivers in MFIs and carbon footprints. Our results reveal that while changes in the supply chain and fixed capital formation led to improvements in two MFIs (resource productivity and material circularity), these same changes also resulted in an increase in emissions. To address this conflict, producers need to recognize the nexus between material consumption and carbon emissions and manage both in an integrated manner.

An Electricity Big Data Application of the Sequential Interindustry Model – The Case of Chongqing

Topic: Input-Output Theory and Methodology - VI
Author: Kehan HE
Co-Authors: Zhifu MI

Regression emerges as a powerful econometric tool. However, it often overlooks the underlying economic theories. Good integration and compromise between the two are hard to find in the current literature. Here in this research, we propose an algorithm based on a variation of the Input–Output (IO) model, the sequential interindustry model (SIM), to introduce time domain into IO modelling. Using the electricity consumption data of Chongqing municipality of China as a proxy for economic activities, we quantitatively analysed its chronological interactions among industrial sectors. We discovered that changes in demand consumption induce unproportionally larger demand variations in other sectors. It serves as quantitative evidence for the chronological economic multiplier effect.

Energy transition and regional distribution in Europe: A new MRIO modelling approach

Topic: Input-Output Analysis: Energy Policies - II
Author: Katharina HEMBACH-STUNDEN
Co-Authors: Maximilian BANNING, Britta STÖVER, Johannes TöBBEN, Philip ULRICH

Cohesion policy as part of the European Union's (EU's) regional policy is the EU's main investment policy. The goals of the EU's cohesion policy are job creation, improved business competitiveness, economic growth, improved quality of life and sustainable development on top of the reduction of disparities between regions. Since 2001, the EU's cohesion policy supported economic growth in less developed regions. Especially, eastern regions have been catching up with the rest of the EU and the gap of the GDP per capita has decreased substantially. Despite this convergence, several middle-income and less developed regions, mostly located in the southern EU, struggle to recover from the economic and financial crisis in 2008 and face

stagnating or even declining economic developments. Overall, capital metropolitan regions outperform other, more rural regions.

In the future, the clean energy transition will have substantial impacts on the EU's economic growth. As stated in the European Green Deal, the EU's greenhouse gas emissions should be reduced by 55% by 2030 and carbon neutrality is the EU's goal for 2050. To reach carbon neutrality the transition to renewable energy (RE) technologies as main energy sources is inevitable. However, an EU-wide clean energy transition is challenged by the disparities between and within the 27 member states. Therefore, the new EU cohesion policy supports the transformation of the economy through investments in key sectors like RE, recycling, renovation, and ecosystem services. Yet, the uneven regional distribution of these key sectors might manifest or widen regional disparities. In addition, heavy industries need to reduce their emissions and the regions in which they are located might be adversely affected by the clean energy transition. Thus, the social impact of the transition will differ between regions and is likely higher in less developed areas.

In a recent study, Maucorps et al. (2022) examined general growth potentials and regional readiness for the digital and green transition of the EU's NUTS-2 regions based on a scoring approach applied to five key factors of economic growth (human capital, innovation, investment, institutions and infrastructure). The authors find that the EU faces a danger of rising imbalances and increasing disparities, since especially urban regions located mostly in the European centre show high growth potential and high levels of readiness, whereas rural, agricultural, and mining regions show low levels of digital and green readiness combined with a low growth potential. The investments necessary to support the transition to a carbon neutrality are an opportunity for economic growth while at the same time the necessary structural changes impose risks for new regional disparities.

To our knowledge, the potential effects of investments in RE technologies and their operation on cohesion in the EU have not been thoroughly examined yet. Previous studies have concentrated on the regional impacts of the energy transition in single member states of the EU. Ulrich et al. (2022), for example, compare the macroeconomic developments in ten scenarios of energy system transformation in Germany and find that especially in northern and eastern German states, where wind and PV capacities are high, the energy transition is expected to enhance economic growth. The dependence on employment in the coal industry varies greatly across the EU. The employment vulnerability is higher in Central European countries like Poland, Bulgaria and Czech Republic than in Western Europe, and thus these countries face much higher costs associated with a transition to RE. An analysis based on the RHOMOLO-IO modelling framework concludes that 215,000 jobs in the EU can potentially be affected by the shift away from coal (Mandras et al. 2019; Kochanek 2021).

To fill these knowledge gaps, we analyse the impact of the clean energy transition on EU cohesion based on a multiregional input-output (MRIO) modelling approach that takes various impact channels of investments in RE technologies, their regional distribution, the economic structural differences of the NUTS-2 regions and their interrelations through local-to-global value chains into account. We develop a new database that consists of two components: firstly, the economic structure of the EU's NUTS2 regions, and interregional as well as international trade dependencies are mapped by MRIO tables from the EUREGIO database. Secondly, since the sectoral resolution of the MRIO tables is low, especially in the energy sector, we combine them with detailed survey based cost structures of the production and operation of eight of the most important RE technologies (wind, hydropower, PV, CSP, biomass, biogas and geothermal). Overall, we shed light on possible synergies and trade-offs between the clean energy transition

and cohesion amongst and within the regions of the 27 EU member states.

Environmental and Energy Efficiency of Eco-Friendly Vehicles with Renewable Energy: A Life Cycle Analysis

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - VI
Author: Shunichi HIENUKI

Using hydrogen and electricity from renewable energy sources is crucial for achieving a low-carbon and decarbonized society through sustainable mobility systems. However, the immediate decarbonization of energy sources is not feasible, and the introduction of fuel cell vehicles (FCVs) and electric vehicles (EVs) requires the use of hydrogen and electricity generated by fossil fuels. Therefore, a quantitative analysis assessing the improvements in environmental and energy efficiency that can be achieved through the diffusion of FCVs, EVs, and other eco-friendly vehicles is necessary, along with the decarbonization of energy sources. This study aimed to analyze the energy consumption and greenhouse gas (GHG) emissions of eco-friendly vehicles, including FCVs, EVs, hybrid electric vehicles (HEVs), and gasoline vehicles (GVs) throughout their life cycles, and determine their potential contributions to improving environmental and energy efficiency if they become prevalent in society in future.

This study involved four steps, including system boundary setting, information collection of target systems, sector extension of input-output tables, and input–output analysis:

1. The life cycle of each eco-friendly vehicle system was divided into five stages: system construction (including equipment manufacturing), fuel production, fuel transportation, fuel supply facilities (hydrogen stations or gas stations), vehicle production, and vehicle utilization. The system's functional unit was set at 8,500 cars driving 100,000 km over 10 years.

2. The relevant information was collected and organized based solely on published reports and papers, and the prices, technical levels, and social situations from 2020 to 2025 were assumed. The equipment required for hydrogen energy production was limited to that required for naphtha reforming from existing refinery equipment. Gas stations, which are already used extensively, were assumed to only require renewal of facilities to comply with current regulations. This estimation did not include EV-charging facilities, which are small-scale and decentralized facilities. The vehicle-manufacturing costs for HEVs and GVs were assumed to be in the same weight category as FCVs.

3. Since there is no sector in the existing input–output table that can accurately simulate vehicle and power generation systems, an input coefficient table was created by extending the 11 sectors related to each system. The Japanese Input–Output Table, which forms the basis for this compilation, consists of approximately 395 sectors.

4. Lastly, input–output analysis was performed under these conditions.

This study presents the results of the GHG emissions of the FCV, EV, HEV, and GV systems over their entire life cycles. The estimated GHG emissions per kilometer were 0.34 kg for FCV, 0.24 kg for EV, 0.22 kg for HEV, and 0.48 kg for GV. Regarding the characteristics of each lifecycle stage, the share of emissions from vehicle manufacturing is higher for newer technologies, with FCVs, EVs, HEVs, and GVs accounting for 65%, 50%, 41%, and 34% of emissions, respectively. EVs have the highest GHG emissions from fuel production at approximately 48%, followed by FCVs at

approximately 20% and GVs and HEVs at approximately 12%. Additionally, fuel-supply facilities (hydrogen and gas stations) account for approximately 7% of the total FCV, GV, and HEV emissions, with the impacts of hydrogen stations and gas stations being attributed to electricity consumption from pressure boosting and cooling, and electricity consumption from lighting and other equipment, respectively.

Next, the GHG emissions were estimated if all the energy required for driving was derived from renewable electricity. Specifically, we envisioned a system in which FCVs convert electricity generated by wind power into hydrogen through the electrolysis of water, while EVs directly charge the electricity generated by wind power. Consequently, the FCV emission was 0.29 kg-CO2eq. per km, which represents a 15% reduction compared to the emissions of the naphtha reforming system. Emissions from manufacturing and constructing wind power facilities and water electrolyzers were twice as high as those from naphtha reforming; however, the impact was a reduction of approximately 90% in emissions from fuel production. Conversely, the EV emission was 0.13 kg-CO2eq. per km, representing a reduction of more than 40%. In other words, while FCVs powered by renewable hydrogen may compete against EVs powered by grid electricity, the advantage of EVs powered by renewable-energy-derived electricity remains unchanged. However, because FCVs with renewable energy hydrogen exhibit approximately 30% less emission than GVs of similar weight, they should be introduced in areas where they can take advantage of the characteristics of the FCV system, such as short filling time and cruising range.

Measuring regional Global Value Chain integration in the UK: A bottom-up approach for better regional statistics

Topic: Input-Output Modelling: Trade and Global Value Chains Policies - II
Author: Peter HORVáT
Co-Authors: Juergen AMANN

Openness to trade has long been a crucial driver of economic prosperity. The advent of modern communication technologies and declining trade costs has transformed its nature in recent decades and led to the increasing fragmentation of production processes and a higher degree of economic connectivity at the global level. This dynamic, where production processes are spread over multiple countries and firms, gives rise to global value chains (GVCs) (Los, Timmer and de Vries, 2015). Significant progress has been made in measuring regional integration in GVCs at the national level with the development of Multi-Regional Input-Output tables (MRIOs) such as OECD's Inter-Country Input-Output tables (ICIO) underpinning the OECD's Trade in Value Added (TiVA), thereby enabling an extensive GVC-related analysis of economic structures since the early 2010s. On the sub-national front, the most prominent efforts utilise a top-down approach to regionalise ICIOs, such as by Ivanova, Kancs and Thissen (2019), who regionalising input-output data from the World Input-Output Database (WIOD) for EU economies. Despite their usefulness, top-down approaches typically require more extensive model-based assumptions while offering lower accuracy in adequately quantifying regional economic activities than bottom-up approaches. Notwithstanding the strong evidence of the critical regional impacts of globalisation, the use of bottom-up approaches to shed light on the complex nature of economic integration has been limited to a selected group of countries and initiatives because of the extensive data requirement of this approach.

In this paper, we address the issue of regionalisation by introducing a novel framework to create regional Supply-Use and Input-Output tables for the UK following a bottom-up approach. The level of regional disaggregation follows the TL2 classification, which allows us to measure economic

activity based on UK microdata for 12 separate UK regions.

Our work expands on the current literature by providing the first implementation of a bottom-up approach to creating regional Supply and Use tables for the UK at a level of disaggregation not addressed by earlier works, as we capture interregional trade between the nine English TL2 regions and the devolved nations of Northern Ireland, Scotland, and Wales by employing novel interregional trade data. Building on granular microdata for the year 2019, our research provides new measures and analysis of regional GVC participation in the UK economy consistent with National Account statistics.

In the analytical work of the paper, we propose a set of regional indicators to identify the economic performance of UK regions along multiple lines, including the degree of regional integration in regional, national, and global production chains of goods and services, as well as regional forward and backward linkages which we contrast with their national counterparts.

Lastly, we provide a general technical description and guidance on how to derive regional statistics beyond the case of the UK. We do so by elaborating on typical data constraints and potential solutions to remedy these issues when creating bottom-up Supply and Use tables that remain relevant in a general country context. The methodological discussion in our paper also covers practical applications of regional Supply and Use tables and their integration into the ICIO framework and the creation of the sub-national TiVA indicators.

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CO2 emissions recuction potential from passenger vehicles in road network complexity in Japan

Topic: Input-Output Analysis: Energy Policies
Author: Chisato HOSOSHIMA
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The Intergovernmental Panel on Climate Change (IPCC) reported that greenhouse gas (GHG) emissions should be reduced by 43% in 2030 and 84% in 2050, compared to 2019 levels in order to limit average temperature increase to 1.5 degrees Celsius. Japan ranks fifth in the world in GHG emissions in 2019, therefore a decarbonization policy in Japan could have a significant impact in limiting the average temperature increase. The Japanese government has pledged to reduce GHG emissions by 46% from 2013 levels by 2030 and to achieve carbon neutrality by 2050.

In particular, the transportation sector accounts for 17.7% of Japan's total CO_2 emissions in FY2020, with 45.7% of these emissions from private passenger cars. Therefore, emissions from passenger cars cannot be ignored. In order to realize decarbonization, it is essential to understand the relationship between urban structure, transportation, and CO_2 emissions. Urban structure affects urban transportation, and that urban transportation causes

transportation-related CO_2 emissions. However, there has been no detailed CO_2 emissions analysis of urban transportation in Japan as a whole, considering the difference characteristics of urban structures in different regions, nor have there been rigorous estimates of CO_2 emissions from Japan's road network at the city level.

To the best of our knowledge, this study is the first attempt to not only estimate CO_2 emissions from passenger vehicles in road network complexity in Japan in 2015 but also forecast the vehicle emissions in 2030. Specially, we complied a comprehensive cities database in Japan in 2015 including urban agglomeration (i.e., population density in persons per km2), transportation infrastructure development (i.e., number of bus stops per capita), aging structure (i.e., percentage of households with household members aged 65 years old and over), job opportunity (i.e., percentage of people working in its own city), urban economy (i.e., average price of residential land in JPY per m2), and urban traffic (i.e., traffic volume of passenger vehicles in road network complexity in a city). Based on the dataset covering 1523 cities of Japan, we conducted a cross-sectional regression analysis and estimated the impact of urban structure (urban agglomeration, transportation infrastructure development, aging structure, worker environment, and urban economy) on urban traffic at city level.

The traffic volume of a specific city estimated by the specified regression model was further used to estimate CO_2 emissions caused by driving passenger cars as well as idling i.e., when the engine is running while the car is stopped. In estimating the vehicle emissions in a city, we considered the differences in the penetration of next-generation vehicles (i.e., hybrid vehicles, plug-in hybrid vehicles, electric vehicles, and fuel cell vehicles) and conventional gasoline vehicles) and traffic congestions across cities. It should be noted that the fuel efficiency differs across the vehicle types. In addition, we considered different fuel efficiencies of driving on general roads and highways, respectively.

For transportation-related CO_2 reduction policies of each city by 2030, we set the following three scenarios: (I) reducing not only CO_2 emission factor for power generation by 48 to 69% but also reducing CO_2 emission factor for hydrogen refining by 71%, (II) increasing fuel efficiencies in km per liter of all vehicle types by 32%, and (III) increasing the penetrations of hybrid vehicles, plug-in hybrid vehicles, electric vehicles, and fuel cell vehicles by 40%, 7%, 20%, and 3%, respectively. The Embodied Energy and Emissions Intensity Data for Japan Using Input-Output Tables (3EID) was used to estimate the additional CO_2 emissions induced by the next-generation vehicles promotion policy in each city.

The results from the scenario (I) shows that the CO_2 emission intensity reduction targets of power generation and hydrogen refining under the current penetrations of the next-generation vehicles would have a small effect of 1.6% decrease in the total vehicle emissions in the Japanese cities in 2030. On the other hand, we found that the vehicle emissions would considerably be reduced by 37% under the scenario (III) of promoting the use of next-generation vehicles by 2030. Furthermore, the results show that by implementing all the three policies (I), (II), and (III), CO_2 emissions from passenger cars are expected to be reduced by 55.5% from 2015 to 2030. This indicates that although the spread of next-generation vehicles is the most effective in reducing CO_2 emissions in the road networks, technological improvements such as improved fuel efficiency of vehicles are also essential in obtaining the additional CO_2 reductions. The detailed city level results show that if the above three scenarios are attained in the Japanese cities in 2030, the passenger vehicle emissions could be reduced by 46% from 2013 levels by 2030.

Spatial analysis connects excess water pollution discharge, industrial production, and consumption at the sectoral level

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - IV
Author: Siyu HOU
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Linking of 'consumption-industrial production-surface water deterioration' is essential for industrialised economies to understand the mechanism of industrial water pollution. However, such a connection may mislead policy decisions if sectoral details are lacking. This study investigated excess pollution discharge from 11,094 industrial enterprises comprising 22 economic sectors through setting discharge thresholds on 1,338 water function zones in Jiangsu Province, the most industrialised province in China. We further evaluated the contribution of final consumption in Chinese provinces to excess pollution discharge in Jiangsu via a national multi-region input-output table. Notably, despite typically heavy polluting sectors contributing the maximum excess pollution discharge, high-tech manufacturing sectors had a higher level of risk for excess pollution discharge. This was attributed to the spatial agglomeration of these sectors, with enterprises typically located in industrial parks. The increasing final consumption of specific sectors in both Jiangsu and other provinces may further drive excess pollution discharge in Jiangsu.

Has servitization reduced the embodied carbon emissions of manufacturing export trade?

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - VII
Author: Yongming HUANG
Co-Authors: Suppakorn KHONKHLONG, Zebo KULDASHEVA, Xin LI, Changwei LIU, Yanan ZHANG

Manufacturing servitization, which introduces elements of the service industry to enhance the manufacturing structure, is increasingly being proposed as a carbon-reduction solution. However, the impact of rising service inputs on the embodied carbon emissions (ECE) of exports from the manufacturing sector has not been sufficiently investigated. This study departs from existing work by empirically examining the effect of manufacturing servitization on ECE in exports using a multi-way fixed-effect model and three-dimensional panel data from 18 manufacturing industries in 38 countries from 2000 to 2014. The results show that input servitization significantly reduces the carbon emissions embodied in manufacturing export trade. Furthermore, manufacturing servitization has a greater effect on reducing ECE in exports in developed countries (pollution-intensive industries) than in developing countries (non-pollution-intensive industries). While using the mediating effect model, the mechanism analysis shows that input servitization reduces ECE in manufacturing exports primarily through productivity improvement, energy substitution, and global value chain effects. Finally, we find that input servitization and the ECE from manufacturing exports exhibits nonlinear characteristics with changes in technological and economic development levels. The study's findings highlight the importance of promoting deeper integration of service elements and manufacturing production processes in achieving the goal of global sustainable development.

CO2 Emission Hotspot Anlysis in the Supply Chain Complexity for Wooden Houses in Japan

Topic: Input-Output Modelling: Industrial Policies
Author: Seiya IMADA
Co-Authors: Shigemi KAGAWA, Keitaro MAENO

Buildings (e.g., houses, apartment buildings) are essential to people's lives, but these building have a significant impact on climate change and other environmental issues. For example, CO_2 emissions induced by each country construction actives and the electricity and heat consumption accounted for 19% of total CO_2 emissions induced by world's economic activities. In addition, 94% of CO_2 emissions induced by final demand in the global construction sector come from the supply chain. Therefore, reducing CO_2 emissions from the supply chain is important to mitigate the CO_2 emission load of the construction sector. To reduce CO_2 emissions from the supply chain, it needs to identify the CO_2 emission hotspots in the supply chain. Several previous studies identified CO_2 emission hotspots throughout the construction sector, including civil engineering (e.g., dam, tunnel construction) and housing. However, these studies didn't only focus on the housing supply chain structure. Therefore, this study identified CO_2 emission hotspots in the supply chain structure of wooden house, which account for 90% of detached houses in Japan.

This study used the following methodology. (1) We used environmentally extended input-output analysis to estimate CO_2 emissions from wooden house's supply chain in 2015. (2) We used Unit Structure Model to estimate the supply chain structure of a wooden house. (3) We estimated Create an adjacency matrix weighted by CO_2 emissions for the wooden house supply chain structure. (4) We applied cluster analysis to the adjacency matrix to identify CO_2 emission hotspots.

To decide functional unit of housing, we used data on the total floor area of wooden house from 2018 to 2021, as published by the Ministry of Land, Infrastructure, Transport and Tourism. We defined a house with a total floor area of 119 m2 as an average wooden house. We used data on the direct CO_2 emission intensity, as published by National Institute for Environmental Studies. Also, we used on the input-output table in 2015, as published by Ministry of Internal Affairs and Communications.

This study revealed three results. (1) Direct and indirect CO_2 emissions for the construction of one average wooden house in 2015, were 38t-CO_2. (2) Top 10 clusters accounted for 30% of wooden house's carbon footprint. (3) In particular, clusters related to steelmaking (Pig iron, Crude steel, Cast iron pipes and tubes, Cast and forged materials sector) and clusters related to cement products (Gravel and quarrying, Crushed stones, Cement, Ready mixed concrete, Cement products sector) accounted for 60% of CO_2 emissions from cluster.

These results indicate that in order to reduce the carbon footprint of wooden houses, it is significant to reduce CO_2 emissions from two clusters. Most of steel products and cement products are used by constructing wooden houses are used as foundation of the house. It is significant for house builder to promote renovation and remodeling vacant wooden house (2.4 million units) in Japan. This is because, renovation and remodeling enable house builder to reuse foundation of the house and to reduce CO_2 emissions from producing foundation (i.e., CO_2 emissions from top2 clusters).

Consumption and production footprints in the EU; a comparison of different accounting approaches to national greenhouse gas emissions

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - I
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In order to reduce the national contribution to global warming, national climate policies typically focus on reducing greenhouse gas (GHG) emissions domestically. Apart from addressing direct emissions of companies and consumers, opportunities to reduce emissions abroad through companies' and consumers' supply chains have started to receive more attention from policy makers. To measure the impact of their supply chain policies, policy makers need indicators at the national level. Footprint analysis integrates supply chain emissions into such useful indicators. However, the well-known consumption footprint only partially addresses foreign emissions by accounting for supply chain emissions from production for domestic final demand. In this paper, we show that by using so-called production footprints foreign emissions related to production for exports can be captured as well. These production footprints have received little attention in the scientific literature until now.

Environmentally extended multi-regional input-output (EE-MRIO) analysis provides various emission accounting approaches that include supply chain emissions by re-allocating industry emissions across countries in different ways. Based on the production-based emissions, which reflect the direct emissions of all producers in a country, an EE-MRIO model enables the calculation of consumption-based and final production-based emissions that account for the emissions related to domestic final demand and domestic production for all final demand, respectively. Consumption and production footprints can be seen as extensions of these accounting approaches. Consumption footprints include the consumption-based emissions extended by consumer direct emissions that are not included in the transactions in an MRIO table. The production footprint extends the final production-based accounting approach by also considering supply chain emissions from production for intermediate exports, as well as from production for final exports and domestic final demand. Production footprints therewith consider all imports from industries regardless of the final destination of their production.

In this paper, we illustrate the different accounting approaches, including footprints, by analysing GHG emissions related to consumption and production in all 27 countries of the European Union (EU) for the year 2015. We used the OECD Inter-Country Input-Output (ICIO) tables extended with GHG emission data from Eurostat and additional data sources for non-EU countries to populate the MRIO model to perform the calculations. Our analysis reveals that different accounting methods lead to rather similar rankings of EU countries in terms of their emissions. Countries in north-western Europe show large GHG emissions per capita, while countries in eastern Europe show the largest emissions per 1000 euro of GDP regardless of the accounting approach used. A comparison of accounting approaches within countries shows that the production footprint was larger than the consumption footprint in all EU countries except two of the largest, France and Italy. These two countries have relatively large direct emissions from consumers compared to other EU countries. Furthermore, consumption and production footprints identify different industries as main contributors to total emissions per country. An analysis that focuses only on consumption footprints and not on production footprints misses between 22% and 69% of the GHG emissions associated with imports. This complements the consumption and production footprints as national indicators of consumer and company supply chain emissions, capturing all imports from a country.

As different accounting approaches lead to different insights, we recommend that policy makers consider consumption and production footprints side by side together with production-based emissions, as they may lead to different reduction opportunities.

Firm-level Propagation of the Effect of the Disruption of International Trade through Domestic Supply Chains

Topic: Agent-Based Modeling and Input-Output Analysis - I
Author: Hiroyasu INOUE

The risk of disruption to global supply chains is rising because of the increasing frequency of pandemics and natural disasters and deteriorating geopolitical stability, threatening the sustainability of global supply chains. This study simulates how the disruption of imports from various regions affects the total production of Japanese firms. We particularly incorporate the propagation of the economic effect through domestic supply chains using data on more than one million firms and four million supply chain ties. We find that the negative effect of the disruption of intermediate imports grows exponentially as its duration and level increase because of downstream propagation. In addition, the propagation of the economic effect is substantially affected by the network topology of importers, such as the number of importers (affected nodes) and their upstreamness in supply chains, but not necessarily by their centrality. Furthermore, the negative effect of import disruption can be mitigated by the reorganisation of domestic supply chains, even when conducted only among network neighbours. Our findings highlight the differences between the propagation of economic effects through supply chains and the diffusion of information and behaviours through social networks and provide important policy and managerial implications for the achievement of more sustainable global supply chains.

Modelling energy transition risks and opportunities in an SFC-IO model.

Topic: Input-Output Modelling: Energy Policies - III
Author: Andrew JACKSON
Co-Authors: Tim JACKSON

Limiting global temperature increases to 1.5°C will necessitate a transition away from fossil fuels and towards a net zero carbon energy system. While such a transition is necessary to avoid the catastrophic effects of climate change, it might also lead to a number of transition risks and transition opportunities. For example, a reduction in the demand for fossil fuels could lead to the stranding of fossil fuel related assets, reductions in the market value of fossil fuel firms, and defaults on fossil fuel firm debts. If large enough, these negative impacts could have (via their impacts on banks and financial markets) serious negative repercussions for the rest of the economy. In addition, a transition to net zero carbon energy system may lead to a decline in the energy return on energy invested (EROI) of the energy sector. Declines in EROI are likely to lead to increases in energy prices and so the general price level, which are in turn likely to negatively affect economic activity. On the other hand, the large levels of investment required for the transition are likely to lead to significant increases in demand and so employment and output. Crucially, each of these risks and opportunities are likely to affect the different sectors and industries that make up the economy in different ways.

Despite the fact the macroeconomic, sectoral and financial implications of a transition to net zero are not well understood, to date only a small number of models exist that attempt to simulate the potential economic effects of different types of energy transitions. The majority of these models, however, do not include a financial sector or financial assets, and instead focus purely on the 'real' side of the economy. In addition, to our knowledge none of these models are able to simulate how the potential benefits of an energy transition (increases in employment and output due to an increase in green investment) are likely to interact with all the different potential risks (asset stranding, loan defaults, changes in equity market values, and reductions in EROI) along different transition pathways, or how sectoral specific impacts might feedback and affect other sectors and the broader economy. As such, the modelling of how asset stranding, changes in EROI, increases in green investment (and how that investment is financed) might affect the financial and real sides of the economy (and how these impacts might feedback and interact with each other) remains something of a gap in the literature.

In order to address this gap, this paper presents a stock-flow consistent (SFC) model with an integrated input-output (IO) model for the study of the economic and financial impacts of energy transitions, with a particular focus on energy investment, investment financing, capital asset stranding, changes in EROI, and sectoral impacts. The model consists of a household sector, a government sector, a banking sector, an external sector 10 non-energy firm sectors (Agriculture, Production, Construction, Distribution, transport, hotels and restaurants, Information and communication, Financial and insurance, Real estate, Professional and support activities, Government, health & education, Other services) and 6 energy sectors (oil, gas, wind, bioenergy, hydrogen, nuclear). Novel or semi-novel aspects of the model include multiple firm sectors and goods types, the integration of an input-output model and an almost ideal demand system into the larger SFC model, firms that produce distinct capital vintages which last for a given number of periods and have endogenously determined levels of labour productivity and material goods inputs, the endogenisation of firms' markups based on target profit rates, and the tracking of individual loans and loan repayments (with loan defaults that affect the bank's capital position and so its lending rates).

We use this model to investigate the economic impacts of different types of transitions to a low carbon economy. Particular focus is placed on the interactions between changes in EROI, fossil fuel firm asset stranding and financial transition risks (i.e. loans defaults and asset prices changes on financial markets), changes in investment and investment financing, and interactions between these factors and the different sectors that make up the economy.

An agent-based modeling approach for real-world economic systems: calibration with a Social Accounting Matrix of Spain

Topic: Agent-Based Modeling and Input-Output Analysis - II
Author: Martin JARAIZ
Co-Authors: Ruth PINACHO

The global economy is one of today's major challenges, with increasing relevance in recent decades. A frequent observation by policy makers is the lack of tools that help at least to understand, if not predict, economic crises. Currently, macroeconomic modeling is dominated by Dynamic Stochastic General Equilibrium (DSGE) models. The limitations of DSGE in coping with the complexity of today's global economy are often recognized and are the subject of intense research to find possible solutions. As an alternative or complement to DSGE, the last two decades have seen the rise of agent-based models (ABM). An attractive feature of ABM is that it

can model very complex systems because it is a bottom-up approach that can describe the specific behavior of heterogeneous agents. The main obstacle, however, is the large number of parameters that need to be known or calibrated. To enable the use of ABM with data from the real-world economy, this paper describes an agent-based macroeconomic modeling approach that can read a Social Accounting Matrix (SAM) and deploy from scratch an economic system (labor, activity sectors operating as firms, a central bank, the government, external sectors...) whose structure and activity produce a SAM with values very close to those of the actual SAM snapshot. This approach paves the way for unleashing the expected high performance of ABM models to deal with the complexities of current global macroeconomics, including other layers of interest like ecology, epidemiology, or social networks among others.

The regional smile curves and their role in the European value chains

Topic: Input-Output Analysis: Employment Policies
Author: Sofía JIMÉNEZ
Co-Authors: Lucía BOLEA, Rosa DUARTE

The increasing role of global value chains (GVCs) and their impact in the international trade have significantly changed the nature and structure of global production processes. Tow concepts arise around GVCs; participation and position. Previous literature has study the impact of these variables, that show the evolvement of countries in GVCs, on economic development. They find lineal relations showing that both are positively correlated with economic development. In this context, the concept of "smile curves" has gained importance in recent years and has been widely analyzed in case studies of relevant firms. The concept of the smile curve was first proposed around 1996 by Stan Shih. Shih (1996) observed that in the personal computer industry, both ends of the value chain command higher values added to the product than the middle part of the value chain. Thus, if this phenomenon is presented in a graph, the resulting curve appears in the shape of smile (Meng et al., 2020). In other words, authors find a u-shaped relationship between GDP growth and position, showing that companies can benefit from an upstream position.

Up to now, there are some works at more macro level that investigated the phenomenon of smile curves at the sectoral or country level using real data for cross-country analysis, obtaining results in favor of this relation. However, in this framework, relatively little attention has been directed so far to the regional (sub-national) dimension. In this line, this paper aims to study whether the "smile curves" also keeps for all the European regions or, on the contrary, if it depends on other structural and economic factors. That is, whether we can find clusters of countries in function of this relation.

Empirically, we focus on a set of NUTS2 European regions of the database EUREGIO for the period 2000 to 2010. Using econometrics techniques, we relate value added and compensation of employees with position. To calculate position, we follow the measure of upstreamness proposed by Antràs et al. (2013), showing the higher is its value, the more upstream a region is. That is, it is more focus on the production of intermediate products.

Our empirical results show a non-lineal relation, particularly concave, between position and value added, which is the opposite to previous findings at national level. We should note that most part of regions are situated in the increasing part. After that we clustered the sample in function of the economic development of these regions, getting four different groups of regions and finding

important differences between them. Indeed, only in one of the four clusters we obtain the "smile curve" (convex relation) and corresponds to the one formed by high-income regions (for instance Inner London, Madrid, or Cataluña, among others). Controlling by other factors such as the productive structure, our findings suggest that, depending on factors such as the degree of participation in the GVCs or the specialization in high-technology industries, the gains and losses vary significantly. Finally, these results confirm the hypothesis of the growing gap between countries and regions due to the recent globalization process, situating the design of economic policies more focused on reducing these differences.

Achieving a decent living in emerging economies challenges national reductions goals

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - VIII
Author: Huo JINGWEN

Emerging economies face major challenges in improving their living standards for large population groups while stabilizing carbon emissions. We construct a new global MRIO model (EMERGING), focusing on all 208 emerging economies, to quantify emissions for achieving decent living standard (DLS). The results show that emerging economies in Asia and Africa will need more carbon space to achieve DLS compared with other regions, especially in mobility and electricity. The total emissions in the emerging economies to meet living standards (LS) of the USA is comparable to these of DLS. For more than half of the emerging economies that have emission reduction policies, the expected emission increments for DLS are larger than the emission reductions in their national emission mitigation targets.

CBAM ready trade: Assessing socio economic impacts of process choice for decarbonisation under the evolving global trade dynamics for India

Topic:
Author: Surabhi JOSHI
Co-Authors: Kakali MUKHOPADHYAY

The implementation of Carbon Border Adjustment Mechanism (CBAM) by the European Union (EU) has significant implications for developing countries like India, which have important exports in the "harder to abate" sectors of iron and steel and cement. The EU's CBAM proposal aims to level the playing field for EU producers against imports from countries with less strict climate policies, by putting a carbon price on imported goods based on their embedded emissions.

To avoid paying the CBAM, Indian producers of iron and steel and cement would need to make their exports CBAM-ready, which means reducing the carbon intensity of their products. However, this is challenging as these sectors are highly energy-intensive and emissions from these sectors are mainly from the combustion of fossil fuels, which are deeply embedded in their production processes.

India has already committed to add 500 GW combined solar and wind capacity by 2030 however, an increasingly cleaner grid does not directly translate into product decarbonisation for these sectors. This research evaluates direct and indirect economic and environmental impacts of three alternative strategies for CBAM readiness under the background of ongoing energy transitions in

India

1.   Investments in technology switch towards low carbon manufacturing process in cement and Iron & Steel sector thereby minimising embodied emissions from manufacturing process. This involves creating a technology block for switch to i) electric arc furnaces for iron and steel sector ii) dynamic batch production for cement manufacturing for maximising variable renewable energy input in the sector . The data has been procured from Industry sources for the technology switch

2.   Adjusting embodied emission from Iron & Steel and cement industry by trading through proposed National Carbon Market with trading EScerts (Energy saving certificates)

3.   CBAM based tax adjustment with revenue recycle as international transfers for mitigation support in India, primarily modelled in terms of efforts for carbon sink creation

The cumulative impacts of these alternatives are evaluated using E3-India, an integrated macro econometric regional simulation model for India. The model couples accounting framework of the economy at subnational level with balances for energy and environmental emission. The model also provides a non-linear interaction (two-way feedback) between the economy, energy demand/supply, and environmental emissions. The short- and long-term behavioural changes are captured through econometric equations and the impacts is simulated till 2030. An array of economic indicators including change in sector output, employment and income effects for rural and urban households are evaluated for the three alternatives along with change in embodied carbon emissions for the three alternatives. Further direct and indirect impacts of decarbonisation in Iron & steel and cement sectors on emission profiles of key economic sectors by 2035 is also evaluated. The preliminary runs reveal that without specific sectoral interventions for decarbonisation in Iron & steel and cement industries the high renewable trajectory for India will elicit selective increase in carbon emission by over 2.5 million Tons by 2030 from these 'harder to abate' sectors alone.

There is ongoing research and debate on the potential impacts of Carbon Border Adjustment Mechanism (CBAM) on developing countries. Some argue that CBAM could lead to a significant reduction in emissions globally, benefiting all countries in the long run. Others warn that CBAM could exacerbate existing inequalities in the global economy, particularly if it is not implemented in a way that takes into account the different capacities and development trajectories of countries. This research provides an initial guidance on socio economic impacts of process choice for decarbonisation under the changing global dynamics of trade for developing countries like India thus creating a space to negotiate better on international platforms.

From the roots to the present: input-output contributions in Environment

Topic: 50th Anniversary of Leontief's Nobel Prize: Environment
Author: Shigemi KAGAWA

Based on the seminal work: Wassily, Leontief (1970) "Environmental Repercussions and the Economic Structure: An Input-Output Approach", The Review of Economics and Statistics, 52(3): 262-271. Includes presentation of some archive materials and documents about this topic.

Extensive loss of forest and non-forest natural land covers driven by global agricultural supply chains

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - VIII
Author: Siyi KAN
Co-Authors: Nana DENG, Jing MENG, Heran ZHENG

Intact forest landscapes (IFLs) have exceptional conservation value considering the range of ecosystem services they deliver, like regulating climate and harboring biodiversity. The continued loss of unfragmented IFLs despite numerous global conservation initiatives indicates the need for improved knowledge of proximate and underlying drivers. Attention has focused on agriculture as a primary cause of deforestation. However, non-agricultural activities like logging, mining, or road clearing also compromise the ecological value of intact forests and sometimes precede and enable agricultural encroachment. Therefore, we focus on IFL loss (including deforestation, forest degradation and fragmentation) caused by various economic activities and investigate the influence of global consumption and trade via the multi-regional input-output model. For IFL loss associated with the 2014 world economy, over 60% was related to final consumption of non-agricultural products. More than one-third of IFL loss was linked to export, primarily from Russia, Canada, and tropical regions to mainland China, the EU, and the United States. Of IFL loss associated with export, 51% and 26% was directly caused by logging and mining or energy extraction, respectively. The dispersed nature of IFL loss drivers and their indirect links to individual final consumers call for stronger government engagement and supply chain interventions.

Achieving Fair and Effective Emission Reductions: The Impact of Rebound Effects on Emissions of UK Households

Topic: Consumption-Based Accounts of Household Types
Author: Lena KILIAN
Co-Authors: Anne OWEN, Andy NEWING, Diana IVANOVA

To limit global warming to 1.5 degrees Celsius, urgent and radical reductions in greenhouse gas emissions are needed. Recent years have seen an increased interest in demand-side mitigation approaches as a means to reduce global greenhouse gas emissions and to meet national and international climate targets. Understanding consumption-based emissions can contribute to designing policy aimed at reducing greenhouse gas emissions globally. Indeed, research shows the need for population-targeted policy, to ensure effectiveness and to avoid further increasing social inequalities. For instance, although higher income is frequently seen as a key driver for higher consumption-based emissions, economic emission reduction policies, such as carbon taxes, often disproportionately affect lower income households. In addition, existing research showcases the need to pay attention to rebound effects, as emission reductions in one area of consumption can be tied to increases in other areas. To address assess how product-level emissions from different social cohorts are impacted by external shocks, this research studies emission changes following the 2007/08 economic crisis and the 2020 COVID-19 lockdowns. The recent release of 2020 data makes such an analysis possible for the first time. This analysis allows us to investigate the impacts of income changes and other restrictions on the emission patterns of different households, to compare levels of carbon inequality before and after these events, as well as the differences in rebound effects. Although these events disrupted wellbeing and increased inequalities and, therefore, do not provide a suitable blueprint for climate policy, they highlight the drastic impact behaviour change can have on emissions and can provide a

lesson for how climate policy can be more just and effective.

To estimate subnational consumption-based greenhouse gas emissions we use data from the UK's multi-regional input-output model, as well as from the Living Costs and Food Survey, an annual household expenditure survey conducted by the UK's Office for National Statistics. The Living Costs and Food Survey surveys 4,000 to 6,000 UK households each year. In addition to full, product-level expenditure profiles, this survey contains additional demographic information, including the income, age, and gender of each household member.

To date, we find significant (p<0.05) differences in the relationships between income and emissions of some age and income groups, as well as substantial descriptive differences between how age and income groups are impacted at a product-level. For instance, younger age groups show larger rebound effects of flight emissions, while older age groups show increased home energy emissions with reductions in other categories. Further analysis will investigate these differences statistically.

Importantly, our preliminary analysis also shows that despite existing levels of carbon inequality, particularly across income groups, substantial emission reductions are needed for all social cohorts assessed to meet global climate targets. However, to avoid further increasing existing inequalities and to reduce the impact of rebound effects we propose interventions targeted at specific social cohorts. While an income reduction may reduce emissions of high-income households, increased access to high quality housing and public services may help reduce emissions of low-income households, whose emissions are already decoupled from income.

Monetary policy evaluation using international financial input-output table for the United States, Euro area and Japan.

Topic: Input-Output Theory and Methodology - IV
Author: Jiyoung KIM
Co-Authors: Satoru HAGINO

This study evaluates the authorities' monetary policies on a "from-whom-to-whom" basis for international flow-of-funds tables and using the input–output (IO) analysis method. In general, the central bank decides on its monetary policy in order to achieve sustainable economic growth, while maintaining the value of the currency. This is managed by the amount of money, interest rate, price, and so on. For example, the Federal Reserve conducts the nation's monetary policy to promote maximum employment, stable prices, and moderate long-term interest rates in the United State economy. The U.S. economy has played a major role in globalization due to the petro-dollar (the U.S. dollar) being the world's reserve currency for well over 70 years. Therefore, not only for the domestic economy, but also the world economy can be affected by monetary policy of the U.S.

In this paper, we analyze how the monetary policies of the U.S. influences domestic sectors and foreign countries. For this purpose, we compile "from-whom-to-whom" financial stock tables for the U.S., Euro area and Japan, and combine these tables to generate a three-area international "from-whom-to-whom" financial stock table (in other words, international financial IO table). In order to analyze the monetary policies of the central bank, net induced investments and net induced savings are calculated and decomposed applying IO analysis method.

Some previous researches have constructed and analyzed international flows of funds. For

example, Tsujimura and Tsujimura (2008, 2009, 2010, 2011) constructed tables for financial transactions among multiple countries. Zhang (2005, 2009, 2015), Zhang and Zhao (2019), Hagino and Kim (2021) built global flow of funds models comprising the financial instruments of major countries. Schumacher (2019) analyzed intercountry credit and savings to evaluate the effects of credit defaults. However, its analyzing methods are not sufficiently developed yet. This research will contribute to expand applications for the international financial IO table.

A Methodology for Estimating Labour Impacts of Low Carbon Growth Pathways

Topic: Input-Output Analysis: Employment Policies
Author: Joan Shilpa KIRAN
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Authors: Joan Shilpa Kiran and Tejal Kanitkar
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Large-scale and rapid reductions in global fossil fuel use are required to meet the temperature goals set by the Paris Agreement 2015. Inadequate reductions in emissions in the pre-Paris Agreement period have led to a rapidly shrinking global carbon budget, and even developing countries with very low contributions to historical emissions and low income and developmental levels are now under pressure to rapidly decarbonize from already low levels of carbonization across their economies. Forgoing the use of fossil fuels can impact the entire economy based on a country's national circumstances, production processes, resource and technological availability, and labour dependencies. Nevertheless, it is often argued in the literature that forgoing fossil fuels and undertaking low-carbon or carbon-free development constitutes an 'opportunity' rather than a hardship. However, this potential and/or trade-off is never adequately quantified, especially for developing countries. Conversation on just transitions must cover all aspects of the transition from fossil fuel use, or foregoing the use of a particular fuel despite its domestic availability, i.e., the impact on energy security, costs, supply chains, labour, investments, and on the economy as a whole. In this paper, we attempt to address a part of this question and quantify the impacts of forgoing the use of coal on economic output and labour in India.

Coal is one of the core sectors of the Indian economy accounting for ~65% of its total primary energy supply in 2021 (Government of India, 2022). Its contribution to the total GDP in 2015-16 was ~1% (Chadda & Sivamani, 2022). It is also a highly labour-intensive sector, employing more than 0.3 million workers in government-owned mines alone (Government of India, 2020). However, the renewable energy (RE) sector is currently less labour-intensive with employment limited to short-term jobs in downstream activities such as construction, installation etc.

In this paper, we propose a methodology to quantify the impacts of low-carbon development or fuel substitution on economic output, wage bills and employment for India. We use an Input-Output (IO) model to estimate the impacts on total economic output, and changes in patterns of labour absorption, of a reduction in coal-based power generation and a commensurate increase in RE-based power generation. We use the recently released hybrid IO table for India for 2015-16 developed by Chadda & Sivamani (2022). We demonstrate the methodology using a scenario for a 20% shift from coal to RE-based power generation for the year 2030. The potential gains and losses in terms of wages and jobs are then assessed for this scenario.

The novelty of the study is that it attempts to bridge a gap in the literature. Studies assessing the effect of low carbon development mostly focus on impacts on the fossil fuel sector alone and fail to capture the economy-wide impacts. Other studies which project plausible employment generation from the RE sector do not quantify potential job losses and whether RE sector employment can abate the labour impacts of phasing down of fossil fuels.

While we illustrate a methodology to assess the impacts of low-carbon development for India, we emphasize here that this is not an argument against low-carbon development. It is unarguable that we need urgent global climate action and for countries of the Global South, the impacts of climate change are likely to be much higher due to higher vulnerability and low resilience (IPCC, 2022). However, we must be cognizant of the impacts of climate action as well. Indeed, the United Nations Framework Convention on Climate Change (UNFCCC) itself recognizes the importance of assessing the "impacts of response measures" implemented to address climate change. It is important for India and other developing countries to assess the potential impacts of implementing mitigation measures to then enable a policy environment to address these, to ensure just and equitable low-carbon development within their countries even as multilateral discussions on global equity and climate justice continue.

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Impact of automation on productivity in a multisectoral economic system

Topic: Input-Output Theory and Methodology - III
Author: Wolfgang KOLLER
Co-Authors: Mikulas LUPTACIK

Impact of automation on productivity in a multisectoral economic system
                Koller., W. – Luptacik, M.

Technological progress and innovation, nowadays strongly associated with Industry 4.0 (internet of things) and digitalization, are main drivers of economic growth. Consequently they are in the focus of wide and intensive public debates as well as increasing scientific theoretical and empirical research. An important subarea of the ongoing technological transformation is automation Fundamental implications can be expected for the labour market. Crucial for the consideration of the impact of automation for the labour market is the relationship between automation and productivity change.

How does the adoption of industrial robots (as the most advanced area of automation) contribute

to the productivity growth compared to the contributions of the other production factors?

We developed a multi-sectoral model in the spirit of Ten Raa and Mohnen (2002) and based on Luptacik and Mahlberg (2016) in order to measure productivity growth of an economy without recourse to data on factor input shares or prices. The economy is represented by the Leontief input-output model which is extended by constraints on primary inputs. The primary inputs considered are production capital of three different categories, one of them being industrial robots, and labour of three different groups of educational levels. The primary input coefficients, capacity constraints and capacity uses for all primary inputs are determined in a capacity use model that is carried out beforehand as a step of data preparation. The novelty of our approach vis-à-vis prior work thus consists mainly in these two aspects: i) integrating a capacity use model into an input-output model and ii) extending the primary inputs with a focus to be able to carve out the role of industrial robots.

Following Chambers et al. (1996, 1998) and Luptacik and Mahlberg (2016) for the intertemporal analysis, we use the non-oriented proportional Luenberger indicator of productivity change. It is known (Färe et al., 2008) that in the special case of single output, constant returns to scale and Hicks neutrality, the Luenberger productivity indicator is equivalent to the Solow specification of technical change. It offers the possibility to decompose productivity change into catch–up or efficiency change (movement of an economy towards the frontier) and frontier shift or technical change (movement of the frontier). In the next step, as the main contribution and core of the paper, productivity growth is decomposed to estimate the contribution of each individual primary input or production factor (robots, physical capital, and labour according to the different skills) as well as of each individual commodity to the efficiency as well as to the technical change. The sum of change in efficiency and change in technology yields productivity change. In this way the impact of automation on productivity taking into account the complex interrelationships between different sectors of an economy can be estimated. Furthermore, the potential for the improvement of the performance and consequently for the competitiveness of an economy can be identified.

For illustration purposes, Austrian deflated input-output tables for the period 2011-2019 have been extended by robots, capital stocks and employment by educational levels (ISCED) and used for implementing the model. The robot stocks have been compiled from data provided by the International Federation of Robotics (IFR). The results provide interesting and useful insights into the contributions of the primary inputs and the contribution of the final demand structure to the economic growth.

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On the choice of technique and distribution in a finite world

Topic: Input-Output Theory and Methodology - II
Author: Maximilian KOSLOWSKI

Be it the climate and biodiversity crises, the corona-virus pandemic, or the slashed grain and gas supply ensuing the war in Ukraine - global change and challenges require economies to adapt and to mitigate. On the supply side of such necessary transformation, technological change – and technical change more broadly – as well as substitution effects constitute important aspects. Technical change, however, also occurs without the immanent presence of crises but simply because of development, and substitution may be driven by different causes, including technical change. Similarly, the distribution of goods and services is not only affected in times of need but also by other factors.

Often, multiple alternative methods of providing goods and services are available, some of them more established than others. In addition to the great variety of incumbent establishments' input and distribution patterns, obsolete and emerging alternatives are often known, with ever more of the latter arising. The primary and intermediate requirements of such a great spectrum of production and distribution means can vary widely and often in not obvious ways. It may thus happen that, contrary to original intention, some of these alternatives exacerbate existing socio-economic and environmental challenges through direct and indirect repercussions.

Input-output (IO) analysis allows for examining such changes in production structure on a sectoral level. The basic IO framework was extended in a series of studies to also cover environmental considerations (Ayres & Kneese, 1969; Leontief, 1970; Duchin, 1990). The underlying demand-driven model is deterministic and relies on a square technology matrix where it is assumed that each commodity is produced by exactly one sector. Although one can now modify the input structure of each sector one-by-one so as to create counterfactuals (e.g. Rose, 1984; Wilting et al., 2008; Moran et al., 2020), it is not possible to represent alternative input structures for the same homogeneous output simultaneously without altering the matrix along both dimensions.

Under the term choice of technique, a variety of considerations were brought to paper concerning the choice among different production methods in an IO setting. Among these, Carter compared in a seminal study the competitiveness of alternative technologies when researching structural change in the US economy. Duchin and Levine (2011) then condensed her model into a more parsimonious and general set-up. While Carter (1970) employed her model for retrospective analyses, Duchin and Levine (2011) articulated theirs as a tool for sustainability scenario-modelling. Since then, the so-called rectangular choice of technology model, or RCOT, has been applied in various case studies.

In a world experiencing polycrises of increasing intensity, alternative means of production and distribution need to be examined and valued against biophysical and other limitations. RCOT is a tool that allows, under certain assumptions, to capture snapshots of optimal production structures. In my present contribution, I ask: Are the model assumptions underlying this demand-driven, resource-constrained single-production model timely? Can its formalism be adapted to answer questions regarding optimal distribution? And what extensions are required to make its use for analysing future structural changes more meaningful and its implications more plausible?

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Decarbonization in the non-ETS with sector coupling via input-output linkages

Topic: Input-Output Analysis: Energy Policies - IV
Author: Kurt KRATENA

The EU climate policy architecture distinguishes the ETS (Emission Trading System) and the non-ETS and defines GHG targets for the latter, whereas for the ETS trading leads to a market price for CO_2. non-ETS in the member states. These targets can be achieved with a variety of policy measures, including price instruments. In any case, decarbonization in the Non-ETS implies electrification of end-use energy purposes accompanied therefore by shifting the burden of decarbonization to the electricity sector that is covered by the ETS. Several studies have already highlighted the potential overlapping in EU climate policy and the problems arising from that. In the worst case, large part of carbon reduced in one part of the energy system reappears in another part, a phenomenon known as leakage. For this purpose, the analysis must focus on the linkages between different sectors. These linkages must cover sector coupling in the energy system on the one hand and other energy sources on the other hand, as well as between energy and non-energy sectors.

The main research question in this paper is to account for all feedback mechanisms between ETS and Non-ETS sectors in the energy system and in the economy in a parallel manner. The macroeconomic IO model applied fully integrates the energy system and explicitly deals with different types of linkages: (i) input-output (IO) linkages in production and (ii) energy demand linkages between ETS and non ETS. The model therefore disaggregates the most important sectors from the perspective of climate policy: several energy intensive industries (ETS), electricity and heat generation (ETS), non-energy intensive industries (non ETS), mobility of households (non ETS), and heating of households (non ETS). For the non-energy intensive industries in non ETS, energy demand and technologies are also split up into heating and mobility, like in the household sector. The full integration of the energy system into a macroeconomic IO model guarantees that all changes in the energy system have a consistent

impact in the economy, both at the level of quantities and of costs and prices. The IO linkages in (i) therefore comprise quantity as well as price linkages. The model describes the national economy of an EU country that attempts to achieve emission targets for the non ETS using a policy mix. Electricity prices are described by a formalized merit-order price model that incorporates the emission cap and permit costs. Domestic carbon leakage takes place, when energy demand in the non ETS shifts from fossil fuels to electricity.

The analysis assumes decarbonization scenarios for heating and mobility (non-ETS) in Austria, by flexibly combining ambitious policy instruments from existing scenarios and combining them with other instruments aiming at shifts in investment behavior. Prices of appliances and the relative fuel price (fossil/electricity) are assumed to be the main drivers for investment behavior. The policy measures plus the model feedbacks change these drivers and guide the decarbonization process in non ETS. The feedback and general equilibrium effects working in the full model determine the impacts of decarbonization.

Global carbon footprints: a detailed look at affluence and technology effects

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - I
Author: Viktoras KULIONIS
Co-Authors: Erik DIETZENBACHER

Global efforts are needed to reduce CO2 emissions and guarantee a safe climate system that supports global sustainable development and wellbeing. Understanding drivers of global CO2 emissions is of great importance as the world strives to achieve global climate mitigation goals. Using structural decomposition analysis (SDA) we identify the key drivers behind changes in global and regional CO2 emissions from 2000 to 2014. We find that growth in global CO2 (+10.8 GtCO2) emissions was driven by increasing affluence (+14.3GtCO2) which outpaced the downward influence of changes in technology (-9.2GtCO2). Global results, however, mask considerable regional heterogeneity and different dynamics at the country level. The affluence effect was predominantly driven by capital investments in developing and emerging economies. In high income regions, technological improvements were strong enough to offset the positive pressures from increasing affluence. In these countries changes in population and trade structure were more important drivers than affluence. Although some countries/regions (e.g. EUR) demonstrate continuous and consistent emissions reductions these efforts need to increase considerably to reach climate goals.

The essentials of Leontief (1953) Dynamic Analysis

Topic: 50th Anniversary of Leontief's Nobel Prize: Growth and Development
Author: Heinz KURZ

Based on the seminal work: Wassily, Leontief (1953) "Dynamic Analysis" in Studies in the Structure of the American Economy, edited by W. Leontief et al. New York: Oxford University Press. Includes presentation of some archive materials and documents about this topic.

ILO's Structural Model for Sustainable Development: some applications on SSA countries

Topic: Assessing Employment Impacts Using Simulation Models: Some Sub-Saharan African Experiences
Author: Massimiliano LA MARCA
Co-Authors: Xiao JIANG

This paper presents an economy-wide structural simulation model that fucus on capturing the role of given structural characteristics of the economy in the short-run and longer-term structural change and development dynamics. The model is based on a SAM that by products, industries, and institutional sectors, covering the full sequence of production and income accounts in the system of national accounts (SNA). It may include industry and labour breakdowns based on the System of Environmental-Economic Accounting (SEEA), the classification of occupation and of status in employment and other international standard classifications. The model works allowing for the composition of different adjustment channels that bring product supply and demand into equality, and determine the different sets of prices, the functional distribution between primary factors of production and the personal distribution between households. These adjustment mechanisms allow capturing the characteristic features of significantly different economic sectors. Some applications to some sub-Saharan African economies illustrate how the model can adapt to a variety of country-specific socioeconomic characteristics and data availability by closely reflecting the national accounting structure and adopting parsimonious specifications.

Funding Childcare for the Poor: A CGE Analysis of the Sugary Beverage Tax in Philadelphia

Topic: Input-Output Modelling: Income Distribution Policies
Author: Michael L. LAHR
Co-Authors: Ye YAO, Xiaoyu LI

We model the economic impacts on Philadelphia of the 1.5 cent per ounce soda tax effects using an applied computable general equilibrium (CGE) model. Our analysis focuses the expenditure side of the analysis is limited here to a pre-K programs for families within 200% of the poverty line. This work will center on three aspects: (1) poor households' alternative uses of moneys formerly spent on sugary beverages, (2) the enhanced spending by the pre-K education industry, and (3) improvements in City productivity and income enabled by (re-)entry into the labor force of low-income parents of Philadelphia's pre-K students.

The soda tax reduces the quantity of sweetened beverages that are consumed within the City. This dampens employment and wages at least somewhat in the City's industries related to beverage distribution; but it concomitantly improves employment and wages in pre-K education. Subsidized pre-K induces some parents of the 3,300 participating children in lower-income families either to improve their level of education or to enter the labor force. Both should improve the quality of employed labor and, hence, enhance industrial production within the City.

As the tax was effected in 2017, we create a 2016 social accounting matrix for Philadelphia County articulated with household expenditures for four different income groups. The prime novelty other than the policy topic itself is that we concomitantly break labor use by industry by this same set of household types and shift income away from public welfare programs as poor families earn more income. We shock the city's economy with the tax. Subsequently, we examine

various scenarios for a change in labor supply as parents of the Pre-K children enter the labor force.

Revisiting Methods for Estimating Interregional Input-Output Accounts: It's Not Just About Trade Flows

Topic: Input-Output Accounts - II
Author: Michael L. LAHR
Co-Authors: Ana Lucia Marto SARGENTO, Joao Pedro FERREIRA, Fernando DE LA TORRE CUEVAS

Interregional input-output tables largely differ in the quantity and nature of the set of available information pertaining to interregional trade. With respect to ability to replicate interregional trade accurately, research to date suggests decreasing returns to scale persist with regard to both more theoretical expectations and added empirical data. A basic underlying assumption is that intermediate industry accounts of the economies in the interregional input-output tables exist and are accurate. In fact, if they exist at the subnational level, such accounts are, at best, roughly estimated and predicated on far less empirical information than is available for economies of nations. Moreover, intra-economy intermediate-industry flows are typically markedly larger than the set of a region's commodity in- and out-flows. So, if intermediate industry flows in a set of interregional input-output accounts are noticeably mis-estimated, it follows that interregional trade coincidentally derived using them must be even more conspicuously in error.

In this piece, we identify a few approaches typically used by researchers worldwide to develop subnational interregional input-output models: (1) a European approach that uses data available for NUTS 2 regions, (2) an American approach that uses data available for U.S. states, and (3) a very basic approach in which researchers have only employment data by region and reasonable travel time information among regions. We also examine variants of (1) and (2) in which we generate estimates of intermediate industry accounts via best-practice methods, i.e., those detailed in Lahr, Ferreira, and Többen (2020). The original variants estimate the accounts strictly via RAS and a gravity model. We further test to see how well the approaches estimate interregional input-output accounts of member states in the European Union (EU). In essence, aggregate all economies of the 27 member states, while maintaining sectoral detail, to produce a "national account". We then apply the five approaches—(1a), (1b), (2a), (2b), and (3)—so that each produces a coherent set of interregional accounts. Finally, we compare each to actual interregional accounts of EU member states published by Eurostat and, in turn, examine the benefits and trade-offs inherent to them.

Investigating the double dividend in a quantitative macroeconomic framework

Topic: Input-Output Theory and Methodology - V
Author: Gissela LANDA RIVERA
Co-Authors: Frederic REYNES

See long abstract uploaded

Disaggregating electricity in a supply-use framework extended with capital and investment matrices: The Spanish case

Topic: Input-Output Modelling: Energy Policies - I
Author: Raquel LANGARITA
Co-Authors: Ignacio CAZCARRO, Adrian ESPINOSA-GRACIA, Julio SáNCHEZ CHóLIZ

Taking the mitigation of the climate change in mind, and knowing the necessity of the electrification of the economy, as well as the need of that electricity to be green, several international treatments are being established to diminish the carbon emissions. Many researchers are interested in studying the effects of policies or measures regarding the energy and electricity sectors on the main socio-economic and environmental variables. Input-output model has been traditionally used to analyze this kind of impacts regarding energy and electricity sectors. However, recently, within the input-output framework, some authors prefer to use the supply and use tables (SUT), following Lenzen and Rueda-Cantuche (2012), since we can obtain a different picture of the same fact depending on which kind of model from those proposed by Eurostat (2008) we use to construct the symmetric table when the shock is applied in the SUTs (Cazcarro et al., 2020).

Taking all of this into account, in a previous work, whose objective was to analyze four electricity self-generation and self-consumption scenarios, we disaggregated the energy and electricity sectors in the supply-use framework, both by sectors and products, into five activities of the production process: generation, distribution, transmission, commercialization, and related activities. At the same time, generation was disaggregated into seven different technologies: Generation of hydropower; Generation of electricity from conventional thermal: coal; Generation of electricity from conventional thermal: oil; Generation of electricity from conventional thermal: gas; Generation of electricity from nuclear; Generation of electricity from wind; Generation of electricity from other types (where solar, biomass, and biogas are included). This was made for the case of Spain for 2016, a similar disaggregation than that made in Langarita et al. (2021).

In this paper, the objective is to extend this SUT framework with capital matrices (KSUT model) to assess the impact of investments, following Södersten and Lenzen (2020). Following this method, we first estimate capital stocks, flows, and consumption for Spain, using the 2016 supply and use tables, provided by the National Statistics Institute. Then, we disaggregate both the supply and use tables, and also the capital stocks, flows, and consumption according with the disaggregation previously made for the electricity sector.

This completely disaggregated KSUT model will be useful to analyze the impact of several policies and measures regarding energy and electricity sectors, such as future investments on renewable energies and on other priorities for the ecological transition, following the Spanish National Energy and Climate Plan-PNIEC guidelines (MTE, 2019) or some technological shocks implemented in the SUTs, obtaining the multipliers (and hence the associated effects and pressures) directly there with this form of capital endogeneization (on the endogeneization in the symmetric framework, see also Södersten et al., 2018). Moreover, the dynamization of the model will be very useful to understand the effect of the investments in the next periods.

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Economic complexity, international trade, and environmental pollution: an application of Miyazawa

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - II
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Since the formulation of the Environmental Kuznets Curve (EKC) at the end of the last century, several studies concerned with evaluating the relationship between economic development and environmental pollution have been developed, incorporating various factors in this analysis, such as trade openness, technological innovation, energy efficiency and economic complexity of countries. Although several studies explore the impact of each of these factors alone on environmental pollution, the literature still lacks an empirical study that seeks to systematize the joint relationship between international trade, economic complexity, and the level of environmental pollution in countries with different income levels. To fill this gap, this study analyzes the impact of international production and trade between developed and emerging countries, with different levels of economic complexity, on the pollution levels (measured by CO_2 emissions) of the producing nations and the receiving nations of polluting firms and/or dirty products.

We use the adaptation proposed by Fritz et al. (1998) for Miyazawa's regional trade multipliers, with data from the input-output and CO_2 emissions matrices, from the World Input-Output Database (WIOD), and the Economic Complexity Index (ECI), from the Observatory of Economic Complexity (OEC), for 36 countries over the period 2000 to 2014. The countries are divided into four regions, consisting of: (i) developed countries with high economic complexity; (ii) developed countries with low economic complexity; (iii) emerging countries with higher economic complexity; (iv) emerging countries with low economic complexity.

The results reveal that, in general, the more complex developed countries pollute less domestically than the developed countries with low complexity, corroborating the hypothesis that these countries have greater demand for more environmentally friendly policies and the greater complexity allows the accumulation of knowledge necessary for the development of green technologies. Furthermore, underdeveloped countries with higher complexity pollute more than less complex underdeveloped regions. This finding is in line with the hypothesis that countries

with higher complexity are more industrialized than countries with lower complexity and consequently demand more energy from fossil fuels, which generates higher levels of carbon emissions.

Trade between underdeveloped countries at different levels of complexity with developed countries of high complexity generates more internal spread of pollution in emerging countries than trade with developed countries of lower complexity, which supports the assumption of pollution havens. The study advances the literature by systematically showing the mechanisms of environmental pollution propagation in the trade interaction of developed and emerging regions of the world from the perspective of economic complexity, which is tied to product sophistication and the knowledge available for the development of green technologies in nations.

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Perfect-Foresight vs Bounded Rationality in a Spatial General Equilibrium Model: an application to the 2014-2020 European structural regional investments

Topic: Input-Output Theory and Methodology - IV
Author: Patrizio LECCA
Co-Authors: Francesca CRUCITTI, Simone SALOTTI, Philippe MONFORT

See long abstract uploaded

Measuring the economic contribution of firms and activities in terms of national income

Topic: Handbook of Extended Supply and Use Tables: Country Applications
Author: Oscar LEMMERS

Analysis how production translates into value added is well known. Part of that value added will flow abroad. Directly, e.g., because foreign owned multinationals transfer profits to the parent abroad. Indirectly, e.g., because an SME pays interest to a bank that uses it to pay divided to foreign stockholders. The research questions of this paper are the following. How much of the value added generated by industries, types of firms (non-multinational, domestic multinational, foreign multinational) and different types of final expenditure (e.g., household consumption, government consumption and exports) ultimately ends up as national income? And how much will flow abroad and end up as foreign national income?

We develop a method and illustrate it with data for the Netherlands for the reporting year 2015. First, we compile an extended input-output table where each industry is split into three types. These types are non-multinational, domestic multinational, foreign multinational. For example, metal manufacturing is split into metal manufacturing non-multinational, metal manufacturing domestic multinational and metal manufacturing foreign multinational. We use the existing input-output table, microdata about production, value added, international trade and a multinational indicator. Then we compile a flow of funds table, using a mix of macro and micro

data to split the income flows in the Dutch Sectoral Accounts. It shows income flows between each type of multinational in each industry, several sectors and rest-of-world. This allows for estimates at detailed level (for example, by industry, by type of enterprise, by type of final expenditure) how much of the value added flows abroad.

A novelty is that the indirect flow abroad is captured: income flows that flow abroad via other domestic entities. An example: when a manufacturer pays interest to a bank that uses it to pay dividends to a foreign entity. Other papers consider various types of income (e.g., interest, dividends, re-invested earnings) flowing abroad or various types of firms (e.g., multinationals and non-multinationals). To our knowledge, this paper is the first to do both.

The paper has three key messages and we quantify each of them. First, a substantial part of value added embedded in final expenditure flows abroad. Second, a sizeable part, also value added of domestically owned firms, first flows to a domestic entity and only then leaves the country. Third, there are substantial differences between industries and types of firms. This clearly shows that it is necessary to accommodate this heterogeneity in the analysis: one has to create an extended input-output table where industries are split by type of firm. The usual input-output table cannot properly answer the research questions.

Some examples of quantification: of the domestic value added, about 15 percent will ultimately end up abroad as an income payment. For value added at foreign owned multinationals, about a third ultimately ends abroad. For non-multinationals it is only about 2,5 percent and for domestically owned multinationals it is 10 percent. This is not surprising; foreign multinationals will transfer profits abroad to the parent. The domestically owned enterprises do not have foreign parents. Yet part of the value added at domestically owned enterprises flows abroad anyway, e.g., via payments to foreign stockholders. As far as different types of final expenditure are concerned, 18 percent of the value added embodied in exports is ultimately transferred abroad. It is much smaller for government consumption, where it is only 6 percent. This is because of the industry composition. In exports, many enterprises in the market sector are involved; they have income transfers abroad. However, in government consumption one of the main suppliers is government itself, which hardly has income transfers of value added abroad.

The impact of the Ownership Dimension on Functional specialisation: The Case of CEE Countries

Topic: Input-Output Modelling: Trade and Global Value Chains Policies - I
Author: Oscar LEMMERS

The emergence of international production networks has given rise to an ever more granular international division of labour with new opportunities for specialisation. Differences between countries are not only due to specialisation in different industries, but also because of specialisation in different tasks in the same industries. This paper focuses on the division of labour according to business functions – or value-chain functions – which represent one of the new dimensions of specialisation in international trade called functional specialisation. We measure functional specialisation based on business activities offshored by firms via FDI to determine the specialisation patterns of a given location. The data source is the FDI Market database. Functional specialisation gives us the answer on the question in which business functions a country is specialised. The policy relevance is that fabrication generally yields less value added than other business functions such as R&D. Countries might get stuck in fabrication instead of upgrade their specialisation pattern. Hence it is important to know what factors drive

these patterns.

Hence, the research question of this paper: what are the factors that determine functional specialisation in Central and Eastern Europe (CEE) countries? This is especially relevant for the "fabrication" function, which is dominant in these countries. We use the AMNE ICIO (Activities of Multinational Enterprises Inter Country Input-Output) database and apply standard input-output analysis. This allows us to estimate the direct and indirect trade activities of domestically and foreign-owned firms. These are subsequently considered as potential determinants of functional specialisation. Additionally, based on the global value chain literature and on international trade and economic development theories, we also included other variables. To be more specific, we check how wages, skills, GDP per capita, labour productivity might influence the functional specialisation patterns.

The use of the AMNE data allows us to take firm heterogeneity into account. In this extended input-output table, each industry is split. For example, metal manufacturing domestically owned and metal manufacturing foreign owned. The firm heterogeneity literature considers, among others, magnitude of foreign presence and the interplay between the different types of firms. An example of the latter is that foreign multinationals often form a gateway to other countries for domestically owned firms. The main novelty of the paper is that we combine several strands of economic literature, namely firm heterogeneity, global value chains and functional specialisation.

Our analyses focus on eight countries in Central and Eastern Europe: The Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia, and Slovenia. The analysis contains both manufacturing and services industries. The time period under concern is 2005-2014. To estimate the relation of functional specialisation with the variables mentioned above, we use ordinary least squares (OLS) with fixed effects as a baseline estimator. As a robustness check, we use a beta regression model because of the bounded character of dependent variables, between zero and one, when the endpoints are excluded. For the beta regression models, we present the average marginal effects.

Our preliminary results suggest a negative effect of wages on specialisation in a fabrication function: higher wages are paired with less specialisation. In turn, increasing labour productivity boosts specialisation in fabrication. Additionally, growing employment makes functional specialisation in fabrication increase. The growth of GDP per capita negatively affects functional specialisation in fabrication activities. Additionally, we find that domestic firms increase functional specialisation in fabrication lightly stronger than foreign-owned exporting firms, whether they export directly or indirectly.

How does the digital economy promote the development of the dual circulation pattern? -An analysis based on the input-output table of the digital economy.

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - VI
Author: Chuan LI
Co-Authors: Xu JIAN, Jialu SUN

This paper provides empirical evidence from China and uses China 's input-output table data to study the impact of digital economy development on the dual circulation (economic domestic circulation and international circulation) and its transmission mechanism. The research contents of this paper include: Firstly, this paper compiles non-competitive input-output tables considering

the digital economy sector in China from 2007 to 2020, and on this basis, calculates the total amount of digital economy, analyzes the dependence relationship between traditional economy and digital economy, and measures the contribution level of digital economy to the whole economy. Secondly, based on the perspective of supply and demand, the matrix analysis method is used to decompose GDP into domestic and international circulation, and the measurement index of domestic and international circulation participation is constructed. Thirdly, through the analysis of industry heterogeneity, the impact of digital economy on domestic and international economic circulation is studied. Fourthly, based on the SDA model, the driving factors are comprehensively analyzed. The results show that in terms of quantitative relationship, China 's position as the main body of the domestic economic circulation is basically established. The contribution rate of domestic economic circulation to GDP increased from 78.95 % in 2007 to 88.91 % in 2020. Consumption and initial investment are the primary driving forces to drive or promote China 's economic growth. The average annual growth rate of GDP created by the digital economy sector is 10.31 %, which is higher than the GDP growth rate in the same period, and has become an important driving force for economic growth ; the participation of the digital economy sector in the domestic and international circulations is similar to that of traditional industries, but the dependence on the international circulation is higher than that of traditional industries, more dependent on exports and intermediate inputs of imports, and the contribution rate to the GDP of the international economic circulation is always at a high level. From the decomposition results, the international economic circulation is mainly influenced by the effect of change in the coefficient of intermediate inputs of imports, the effect of change in the production structure and the effect of change in the coefficient of value added. This paper has the following innovations: firstly, from a theoretical perspective, this paper uses the input-output analysis method to comprehensively examine the development level of the digital economy and its impact on the economic circulation, and provides a complete framework for studying the quantitative relationship between the digital economy and the domestic and international economic circulations. Secondly, this paper constructs the measurement index of domestic and international economic circulation, and provides a complete quantitative analysis. Its connotation is consistent with the structural analysis of domestic and international economic circulation at the theoretical level, and achieves the organic unity of theory and practice. Thirdly, this paper manually compiled China 's non-competitive input-output table of digital economy from 2002 to 2020, and the selected data are relatively new, which has important research value for the current measurement of China 's domestic and international economic circulation level. Finally, this paper analyzes the mechanism and driving factors of how the digital economy affects the domestic and international economic circulation, and supplements the shortcomings of the existing literature.

Tracing Environmental Footprints along Global Value Chains by Routes, Production Layers, and Border-crossings

Topic: Input-Output Modelling: Trade and Global Value Chains Policies - I
Author: Meng LI
Co-Authors: Bo MENG, Yuning GAO

The nations and sectors are more closely connected to one another than ever before in an age of global value chains (GVCs), which are defined by production fragmentation and vertical specialization, and the composition of trade has become increasingly complicated. All GVC research places a strong emphasis on the challenges that production dispersion and border incursions have brought to our understanding of the economy. However, very few of them have attempted to explain precisely how economic and environmental effects are transferred from one

GVC to another through the various phases of production and border crossings. Here, we examine the transmission of environmental imprints using the Inter-Country Input-Output (ICIO) tables of the Organization for Economic Cooperation and Development (OECD) and the associated satellite data. Starting from the multi-regional input-output model (MRIO) and the forward production linkage-based decomposition, we separate the roles of each route, production layer and border-crossing. We develop the first Routes-Layers-Boundaries accounting framework that, to the best of our knowledge, can trace environmental footprints along global value chains and demonstrate how emissions, pollution, and other environmental stressors are transferred along various GVCs by traversing production layers and international borders from one country/sector to another. This research contributes to a better understanding of the complicated production systems that lead to the origin and absorption of environmental impacts in various nations through GVCs.

How does the low-carbon development of urban agglomeration narrow income inequality in China?

Topic: Input-Output Modelling: Energy Policies - II
Author: Xiaoyu LI
Co-Authors: Ye YAO, Zhenni CHEN, ZHAO ZENG, Huibin DU, Shuxian XU

Low-carbon development of urban agglomeration can not only optimize the allocation of resources by promoting the rapid and unimpeded flow of capital, technology, and other factors across administrative borders. It also can promote fairness through benefit-sharing while achieving the overall carbon targets of urban agglomeration. For addressing climate change, promoting the low-carbon development of urban agglomeration in China is inevitable. However, how does the low-carbon development of urban agglomeration narrow income inequality is unknown, which makes it difficult to provide suggestions for achieving effective and fair coordinated development of urban agglomeration. Therefore, our research question is how does the low-carbon development of urban agglomeration narrow income inequality in China?

In the process of low-carbon development, revenue recycling to complement carbon tax is a way to compensate or even offset the welfare loss induced by mitigation policies, and thus it is conducive to achieving social equity. Our paper evaluates the impacts of integrated carbon tax policy in the urban agglomeration on economics and household welfare and discusses the pathway to narrow income inequality by combining revenue recycling schemes. Among China's 19 national urban agglomerations, the Jing-Jin-Ji urban agglomeration is one of the largest urbanized and most carbon-intensive regions. Therefore, our paper takes the Jing-Jin-Ji urban agglomeration as a study region. The paper constructs a multi-regional computable general equilibrium (CGE) model for urban agglomeration based on various datasets, including a city-level multi-regional input-output (MRIO) table for Jing-Jin-Ji urban agglomeration 2012, national and city-level statistics yearbooks, and city-level statistical bulletin.

For the novelty of our paper, it lies in:

The first contribution is establishing a modeling tool to evaluate the effects of low-carbon policies of urban agglomeration. Existing modeling tools for assessing low-carbon policies mainly focus on the national and regional dimensions, and ignore the policy evaluation from the perspective of the city. Cities play a vital role in global carbon mitigation, and urban agglomeration, a highly developed spatial form of integrated cities, may become an important platform for future international competition. Lacking the city-level modeling tool is difficult to provide guidance for the implementation of low-carbon policies of urban agglomeration. Therefore, our paper for the first time tries to establish a city-level multi-regional CGE model to evaluate the low-carbon policies in China, which can fill the gap that existing research can not

provide detailed suggestions for urban agglomeration to address climate change.

The second contribution is designing a carbon tax policy aiming to narrow income inequality under the background of the low-carbon development of urban agglomeration. Actually, the imbalance within the urban agglomeration has become a serious problem, which is against the role of the community of interests for urban agglomeration, and is detrimental to playing the role of radiation. Under the background of addressing climate change, discussing how the low-carbon development of urban agglomeration narrows income inequality has become important. Existing research indicated that the low-carbon development of urban agglomeration is conducive to promoting social equity, while the specific pathways are unknown, which can not provide guidance for the coordinated development of urban agglomeration. Therefore, our paper would provide an effective pathway for urban agglomeration to narrow income inequality based on the integrated carbon tax policy supplemented by revenue recycling, which fills the gap that existing research can not provide suggestions for the coordinated development of urban agglomeration.

There are three preliminary findings in this paper. First, revenue recycling to complement carbon tax can compensate or even offset the GDP and welfare loss in the whole Jing-Jin-Ji urban agglomeration and each city. Second, not all revenue recycling schemes to complement carbon tax can reduce income inequality. Third, there is the least GDP loss when the carbon revenue is returned to all rural households in the cities of Hebei, and there is the least welfare loss and income inequality when the carbon revenue is returned to rural households with lower income in cities in Hebei.

Input-output analysis of embodied energy and carbon emissions: Impacts of imports data treatment on transmission dynamics

Topic: Input-Output Analysis: Energy Policies - II
Author: Yingzhu LI
Co-Authors: Bin SU

Input-output (IO) table has been widely used to investigate the relationship between the environment and human behaviors. Official IO tables usually follow the competitive imports assumption and need to be adjusted prior to analysis, which potentially gives rise to information distortion in the adjusted tables. China released both competitive and non-competitive IO tables for 2017, which allows empirical investigation of the bias in findings stemming from the imports data treatment. Focusing on energy and carbon emissions respectively, this study uses structural path analysis (SPA) to explore how the bias is generated in detail and the key sectors involved. Generally, this paper plans to contribute by (1) providing a comprehensive review of SPA studies on resource and environment related issues in China; (2) using SPA by layer to explore the bias in transmission mechanism within the production system arising from distorted intermediate inputs; (3) using SPA by path to identify the key channels that transit the net bias arising from both distorted intermediate inputs and final demand; and (4) discussing the implications of the findings on studies and policies about embodied energy and carbon emissions in China.

Revisiting the Role of ICT in China's Growth

Topic: Input-Output Modelling: Industrial Policies
Author: David Tao LIANG
Co-Authors: Harry X WU

Revisiting the Role of ICT in China's Growth

David Tao Liang and Harry X. Wu

Abstract: Based on the pioneer work on the estimation of China's ICT (information and communication technology) assets by industry in Liang, Wu and Fukao (2022) and the substantial revisions of the CIP (China Industrial Productivity) input-output, capital and labor accounts, we revisit the role of ICT in the Chinese economy since the reform. Methodologically, we follow our earlier growth accounting work to quantify the role of China's ICT (Wu and Liang, 2017) a la Jorgenson (2001). However, the newly available data allows us to investigate ICT-specific industries, identified by the direct measure of ICT intensity, in a framework that is coherently integrated with the CIP capital accounts including the estimated stock of IT and CT assets. Our new results still support our earlier findings that Chinese ICT-producing and intensive-using industries were the key driver to China's productivity growth. We show that over the 40 years investigated since 1978, while providing 34 percent of China's 8.3-percent annual value-added growth, these major ICT players contributed 130 percent to China's 1.1-percent annual TFP growth. We can therefore reiterate the proposition proposed in our 2017 paper that the rapid development of the ICT industries enabled the Chinese economy to compensate for its heavy productivity losses caused by other industries and the policy-induced misallocation of capital resources.

Keywords: ICT making and ICT intensive using; APPF (aggregate production possibility frontier) growth accounting; aggregation by Domar weights; resource reallocation; TFP (total factor productivity)

JEL Classification: C82, E22, E24, O47

Measuring the factor content of trade in a context of factor intensity ambiguities

Topic: Input-Output Theory and Methodology - III
Author: Pablo R. LIBOREIRO

Measuring the factor content of international trade is no trivial task. Indeed, as long as factor factor prices differ internationally and many factors are embodied into the production of commodities through trade in inputs, there are several ways that can plausibly be used to measure the factor content of trade. In this context of factor intensity ambiguities, a method proposed by Trefler and Zhu (2011) has recently prevailed in the literature, which consists of defining the factor content of trade as the actual factor content of the vector of net exports. However, this method suffers from at least two shortcomings. First, the definition of factor content is not consistent, since as long as factor content is measured from a net trade vector including both final and intermediate commodities, traded inputs are counted both as part of the net trade vector and also as part of the input matrix. Second, by measuring the actual factor content of trade in the usual way it is not possible to identify which is the factor content due to

trade specialization and which is the factor content due to mere factor substitution due to failling of factor prices equalization. Therefore, the present study proposes an alternative method to measure the factor content of trade. The present method starts from the definition of factor content based on the actual content of expenditure and estimates factor content of trade as the difference between the measured factor content and the factor content that would be measured if trade specialization were not considered. The method has been applied to the data available in the WIOD Release 2016 database for 7 factors and 41 countries. The novelty of the present study is that it proposes a new methof for estimating the factor content of trade that may be useful for research on topics of international trade with policy implications such as the environmental impact of trade or the relationship between trade and resources.

A price-quantity linear model as an extension of the standard models in input-output analysis: An empirical application on NextGenerationEU funds.

Topic: Input-Output Analysis: Industrial Policies and Prices
Author: M. Carmen LIMA
Co-Authors: Manuel A. CARDENETE, Ferran SANCHO

Price models have proved to be very useful linear tools in input-output (I-O) analysis for a first approach policy evaluation to assess price effects. Similarly, quantity-oriented models do the work for the assessment of quantity effects. However, both these I-O models reside in unconnected spheres: prices do not interact with quantities and quantities, in turn, do not interact with prices. Therefore, they have been questioned for their limited capacity when a more exhaustive and broader exercise is required. The aim of this paper is to contribute a possible improvement in the capability of this well-known instruments. We do so by presenting an extension of the classical, but separated, I-O models to an enhanced "price-quantity model" that connects the price model with the quantity model. This will allow us to obtain a wider range of results within the scope of the linear structure that characterizes the I-O model. Such a "price-quantity model" could be of particular interest by providing a broader set of interpretations and conclusions, which could shed light and provide academic support to policy decisions as an alternative to a more complex general equilibrium framework.

Once the theoretical basis of this proposal is presented and developed, we will implement our model by using a Social Accounting Matrix (SAM) as our database. For this case, we have worked on an updated and adequately disaggregated SAM for Spain to develop an empirical exercise based on this new "price-quantity model" to assess the impact of NextGenerationEU funds. These funds have become a key solidarity and recovery instrument jointly issued by all member-states for the first time in history of the EU with the aim of boosting economic growth, digital transition, greener economies, and welfare after the Covid-19 pandemic outbreak. With the help of our novel model, our goal is to assess the effects of this funds in a wide range of indicators with especial attention to activity levels in real terms, primary factors use, primary factors remuneration, and welfare, among other indices.

For the implementation of the model, it has been necessary to previously elaborate an allocation rule for the distribution of the amount of these funds to the aim of finding an equivalence among the budget items to be managed within different categories of projects and the corresponding accounts in the Social Accounting Matrix.

In short, SAMs are databases that enlarge the information provided by the input-output tables

with statistical information from the survey of household budgets, or from the national or regional accounting, among other sources. SAMs can behave as an instrument for the impact analysis of certain exogenous shocks. These enlarged databases are defined as extensions of the input-output tables and have been commonly used for their simplicity and their utility in impact assessment and evaluation of public policies. A SAM incorporates, for a given period and level of sectoral disaggregation, the complete flow of incomes in the economy and contains, in addition, an input-output table as submatrix. These more accurate databases, comprise economic transactions which enable us to extract information on the different economic agents such as producers, consumers, government and foreign sector; as well as on the behavior of productive factors. Consequently, they complete the information provided by the input-output analysis, whose data limitations have been deeply discussed in the literature. From a conceptual viewpoint, another key advantage of SAM models is that they project short-run policy evaluations, rather than the long-run adjustments typically supplied by Computable General Equilibrium (CGE) models; therefore, providing more focused insights on practical observable policy effects.

Keywords: Input-Output models, Social Accounting Matrices, Regional Accounting

JEL Classification: C67, D57, E37.

ICT Investment as Produced Input in Growth Accounting

Topic: Input-Output Theory and Methodology - III
Author: Chuan LIU

The information and communication technology (ICT) industry has experienced rapid production cost reduction in recent decades. The price decline of ICT investment goods gave rise to the extra proportional ICT capital deepening. Further, general machinery and transportation equipment incorporate increasingly ICT products like chips.

This paper traces the currently unmeasured contribution of the investment-specific technical change of the ICT industry through multiple channels to long-term economic growth. The growth accounting framework derives the productivity decomposition based on a dynamic input-output model with a forward-looking perspective. The model follows Barro (2021), treats consumption as the only final output, and assigns the investment goods as an intermediate input in the intertemporal view.

Since the ICT industry has been highly globalized since the 1990s, we use the world input-output tables from 1995 to 2009 from the WIOD (World Input-output Database) and reassign them into dynamic input-output tables, each spanning over five years. In this way, the intertemporal effect from different sectors and countries can be measured in the model. The data on capital stock and international and domestic capital flows of the investment goods is derived from the capital input dataset of EUKLEMS and capital flow data in the world input-output tables with some country-industry proportional mapping. Three asset types of ICT capital, including IT equipment, communication equipment, and software, and three asset types of non-ICT capital, including transportation equipment, other machinery, and non-residential construction, are considered.

This paper shows that ICT contribution is much more significant than the already documented scale during the IT boom period from 1995 to the early 2000s. The productivity contribution of ICT technical progress from the past and other sectors and countries is decomposed and can be helpful to digitalization and trade policymaking.

Energy demand-driven water stress and mitigation in China

Topic: Input-Output Analysis: Energy Policies - III
Author: Xi LIU
Co-Authors: Kuishuang FENG, Xu ZHAO, Honglin ZHONG

Within a watershed, interregional energy supply chains upstream from a region's purview place stress on local water availability. Unfortunately, reliable transboundary assessments of energy use on the water stress within watersheds largely remain lacking in China. We therefore investigate transboundary impacts on scarce water resources that are induced by energy demands (i.e., electricity, petroleum, coal mining, oil and gas extraction, and gas production). We develop a bottom-up high spatial resolution (scarce) water inventory for multiple sectors and link it to a 2017 multiregional input-output (MRIO) table of China to analyze scarce water use by region. We find that the energy-driven water footprint accounts for 21.6% of national water usage, of which 35.7% is scarce water. Moreover, non-electric power energy sectors contribute to around half of the nation's scarce water transfer. We identify three sets of regions whose water resources are stressed by energy demand, i.e., those in northern China and urban coastal clusters in both eastern and southern China. We then evaluate the impacts of eight mitigation options, including both production- and consumption-side measures, which would shift more than one third of the high stress areas in the Hai River and Northwest Rivers watersheds to low-to-moderate (or even low) stress. We highlight the need for transboundary collaboration to sustain water-constrained energy demand and to develop targeted measures to mitigate stress on water resources within a watershed.

Tracing metal footprints via global renewable power value chains

Topic: Input-Output Analysis: Energy Policies
Author: Xi LIU
Co-Authors: Rao FU, Honglin ZHONG, Kuishuang FENG, Jiashuo LI

The globally booming renewable power industry has stimulated an unprecedented interest in metals as key infrastructure components. Many economies with different endowments and levels of technology participate in various production stages and cultivate value in global renewable power industry production networks, known as global renewable power value chains (RPVCs), complicating the identification of metal supply for the subsequent low-carbon power generation and demand. Here, we use a value chain decomposition model to trace the metal footprints (MFs) and value-added of major global economies' renewable power sectors. We found that the MFs of the global renewable power demand increased by 97% during 2005—2015. Developed economies occupy the high-end segments of RPVCs while allocating metal-intensive (but low value-added) production activities to developing economies. The fast-growing demand for renewable power in developed economies or developing economies with upper middle income, particularly China, is a major contributor to the embodied metal transfer increment within RPVCs, which is partly offset by the declining metal intensities in developing economies. Therefore, it is urgent to establish a metal-efficient and green supply chain for upstream suppliers as well as downstream renewable power installers for just transition in the power sector across the globe.

The consequences of global reshoring trends in the EU carbon emissions

Topic: Input-Output Modelling: Sustainable Production and Consumption Policies - I
Author: Luis A. LOPEZ
Co-Authors: Mateo ORTIZ, Ángela GARCíA-ALAMINOS, Maria Angeles CADARSO

In this article, we use an environmentally extended multi-regional input-output model to assess how the new reshoring, nearshoring and greenshoring trends, which are shortening global production chains, affect the carbon footprint of the European Union. The identification of reshoring-intensive sectors is produced from the analysis of observed reshoring trends between 1995 and 2018 and the sectors identified as strategic in terms of reshoring in the EU's Open Strategic Autonomy (European Commission et al., 2021).

Input-output sub-systems analysis has been used to study the production structure of different sectors of the economy (Alcántara and Padilla, 2009). In our case, we will apply the sub-systems analysis technique to assess the importance of a sector or set of sectors in the economy as a supplier of intermediate goods and final goods. First, we isolate the intermediate goods sub-system and the final goods sub-system for a sector. After that, we apply the hypothetical extraction methodology (Dietzenbacher et al., 2019; (Zhang et al., 2020; Hertwich, 2021) to study the impact of the removal of these sectors on the overall carbon emissions of the European Union. The hypothetical extraction procedure is useful for quantifying the upstream emissions impact of the reduction in imports of intermediate and final goods. However, relocation processes do not imply a reduction in imports, but rather their substitution by production in the EU or other trading partners. Therefore, the source-shifting technique (Arce et al., 2016; de Boer et al., 2019; Giammetti, 2020; Gilles et al., 2021) is used to assess the net effect that relocation processes have on emissions, both at a global level and on specific sectors under the assumption that the production of the importing country is substituted.

The input-output model proposed here relies on the 2021 edition of OECD Inter-Country Input-Output (ICIO) Tables. This dataset contains multi-regional input-output tables with detail for 45 unique industries based on ISIC Revision 4 and 66 countries for the years 1995 to 2018 (http://oe.cd/icio). The data for carbon dioxide emissions is retrieved from the OECD Indicators on Carbon dioxide (CO_2) emissions embodied in international trade.

The hypotheses to be assessed in this research will evaluate the so far unknown implications of reshoring processes in terms of EU climate and trade policies. For example, we will determine whether reshoring strategies are more (or less) effective than nearshoring strategies in reducing the EU's total carbon footprint and whether these policies will mainly affect CO_2-intensive industries or relatively low-carbon industries. We will also be able to quantify the trade-offs caused by new trade trends, which are expected to increase direct emissions within the EU (reshoring) and its close partners (nearshoring), while achieving reductions in indirect emissions along EU's supply chain. Assessing the heterogeneous impacts on EU territorial emissions and indirect emissions will allow us to quantify the net effects that these new trade trends will have on global emissions.

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Exploring gender oriented policies and their multiplier effects: an empirical exercise with Next Generation EU Funds

Topic: Gender Issues in Input-Output Analysis: New Challenges and New Perspectives - I
Author: Jorge M. LOPEZ-ALVAREZ
Co-Authors: M. Carmen LIMA

Although the European Union and member states have developed different social, legal and economic mechanisms in order to eradicate gender inequality, it is an outstanding issue and a matter of relevant concern in our society nowadays. Actually, gender mainstreaming has become one of the priorities in the refunding of the European Union integration project in the aftermaths of the recent economic crisis. In this study we focus on the concept of gender budgeting as commitment tool for the present and coming years in order to give some light on how this goal might be better implemented and achieved. To this aim, we develop a methodological framework based on a multisectorial model computed on the basis of a disaggregated Social Accounting Matrix for Andalusia in 2020, in order to analyze whether alternative gender oriented allocation rules of Next Generation EU funds might impact on labor indicators of a European regional economy, as a counterfactual analysis of the currently approved baseline distribution. After defining several simulation scenarios, we assess the impact of alternative allocation criteria on different educational level groups by gender, as well as their implications in terms of households' consumption. Our results reveal that gender oriented budget policies might positively contribute to reduce the gender gap and report relevant multiplier effects that deserve to be explored.

Exploring the Economics of Urban Water: Valuation, Recycling, and Sustainability

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - IV
Author: Carlos Andres LOPEZ-MORALES

Global trends on population, urbanization, and localization of economic activities suggest that the global economy increasingly becomes urbanized, both in developed and developing countries. A highlight of this process is that the dynamic interactions among metropolitan zones, medium cities, small cities, and rural locations are becoming increasingly complex and intertwined. One of the most outstanding features of this complexity has to do with the way in which these economic entities appropriate water as an essential material input. In other words, the degree to which

hydrologic cycles are intervened is dependent on the urbanization process occurring in local watersheds. This paper explores the conceptual and theoretical understanding of the economics of water as an essential economic and ecological input for both social activity and ecological sustainability in the context of the urbanization process. The premise of this exercise is that economic models at different scales (national, regional, or local) should be capable of capturing the fundamentals of water's appropriation at different degrees or urbanization, so as to be able to assess alternative solutions to unsustainable situations. This paper presents an input-output model of an urban economy embedded in a highly urbanized water basin with the aim of exploring the interdependencies among hydrologic sustainability, competing economic uses, and the generation, treatment and reuse of wastewater under alternative scenarios of water availability. The model is formulated as a linear program based on the Rectangular Choice-of-Technology model and includes a set of equations representing the urban management abiding to mass-balance principles and capacity constraints of the urban infrastructure. While the model is aimed at empirical analyses of urban economies in different latitudes, the present paper presents a numerical example for a scenario analysis as a proof of concept. The findings measure and clarify the economics of water by distinguishing production costs, commodity prices and scarcity rents and highlight the important roles of treatment technologies, water infrastructure, and administrative arrangements as the foundation for a functioning governance adequate for the sustainability of urban water.

The definition and measuring of the bioeconomy in the global economy

Topic: Input-Output Modelling: Sustainable Production and Consumption Policies - IV
Author: Carlos Andres LOPEZ-MORALES
Co-Authors: Miriam BOYER

The bioeconomy can be defined as a project involving the promotion by the private sector and by some governments of particular technologies based on biogenic resources that are thought of as being renewable and therefore instrumental for responding to the climate and the ecological global crisis. Understanding the current significance of the bioeconomy has motivated several studies measuring its current size relative to economic systems. Existing estimates for the bioeconomy find that the bioeconomy in Europe is dominated by activities in agriculture, food and beverages, bio-based chemicals and pharmaceuticals, making up 6% of the region's gross domestic product (GDP) while employing around 18 million people. Similar estimates put the size of the bioeconomy in the United States at 6% of its GDP, while other studies feature slightly higher estimates: bioeconomic activities in Europe have a relative size in the range between 2% and 17% of national GDP. What it is that these estimates actually measure? Traditionally, economic sectors related to the direct use of natural resources do not make up huge portions of an economy's GDP, so we can ask whether the bioeconomy has reached its intended size already, or if it is still in the earlier stages of a longer period of expansion. By looking at the existing literature, this paper provides a critical assessment of existing definitions and methodologies for measuring bioeconomic activities, and explores the possibilities of providing measures based on input-output economics and databases. In particular, the paper argues that measuring the bioeconomy calls for a clearer understanding of alternative technologies going beyond the traditional classifications of economic sectors that constitutes the accounts of an input-output table.

Evolution of Tourism in the world economy 2005-2015: an analysis through the ICIO tables from OECD

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - V
Author: Ana LóPEZ-OJEDA
Co-Authors: Casiano A. MANRIQUE DE LARA PEñATE, Elisabeth VALLE

The importance of tourism has been consolidated in the world economy over the last decades. Tourism has become one of the world's leading economic activities, growing from 3.26% of global GDP in 2010 to 4.1% in 2019. However, due to COVID19, in 2020 it dropped to 1.8% (UNWTO, 2023). In relation with tourists' arrivals, they grew from 957.2 million in 2010 to 1465.8 million in 2019. During the pandemic the arrivals dropped to 409.1 million in 2020 and recovered until 917million in 2022 (UNWTO, 2023). Therefore, the analysis and monitoring of the tourism activities evolution is crucial. The growth of these activities has had important direct and indirect effects on the world economy and trade patterns. We believe Input-output analysis and tables can play a very relevant role in this analysis. Polo and Valle (2012) confirm that a close relationship has existed between tourism analysis and Input-Output Tables (IOT) and models (IOM) for a long time. This important tradition in the use of input output tables analysing tourism, is now reinforced by the existence of Inter Country Input-Output Tables (ICIO) for 67 countries (38 OECD countries and 28 non-OECD economies), the Rest of the World and split tables for China and Mexico and 45 industries from 1995 to 2015 from the OECD. There are other global multiregional input-output databases available, (in alphabetical order): Eora, EXIOPOL, Global Trade Analysis Project (GTAP), World Input-Output Database (WIOD) from the European Commission, but only WIOD and ICIO have made the effort to account for non-resident expenditure. The ICIO database shows the consumption of non-residents separated from those of the residents. which the value added created by tourism expenditure by country of origin has been analysed for all the countries included in the database (OECD, 2019).

Despite tourism development has a great economic impact on many economies, it also brings some environmental and socio-economic negative impacts. Tourism input-output model and multiregional input-output model appear in many research efforts related to environmental impacts. Lenzen et al. (2018) combine the information provided by tourism satellite accounts, integrated into a multi-region IO table, to estimate the carbon footprint of the tourism flows using IO models. Sun (2014) combines the use of tourism satellite accounts with an environmentally extended IO model to calculate the direct, indirect, and induced effects that are due to tourism demand. Sun (2016) adds structural decomposition analysis (SDA) to calculate different sources of the direct and indirect tourism GHG effects like intensity, structure final demand and Leontief effects. Tang and Ge (2018) used an Input-Output model to calculate the carbon emissions resulting from tourism consumption in Shanghai in 2012, finding that tourism carbon costs represented a higher rate of GDP than tourism direct gross value added. Similar results are found by Bouwmeester et al. (2014) for the EU27 countries between 2000-2007.

Using the ICIO tables we plan to describe the importance of tourism in the world economy for the period 1995-2015. We also pretend to calculate the impact of the carbon emissions related with tourism using these tables. In this respect, for the time being, we plan to concentrate in emissions related to air transport of tourists.

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From the roots to the present: input-output contributions in Growth and Development

Topic: 50th Anniversary of Leontief's Nobel Prize: Growth and Development
Author: Bart LOS

Based on the seminal work: Wassily, Leontief (1953) "Dynamic Analysis" in Studies in the Structure of the American Economy, edited by W. Leontief et al. New York: Oxford University Press. Includes presentation of some archive materials and documents about this topic.

The Effects of Trade on Differences between Male and Female Employment Growth in EU Countries, A GVC Perspective

Topic: Gender issues in Input-Output Analysis: New challenges and new perspectives - II
Author: Bart LOS
Co-Authors: Gaaitzen DE VRIES, Xianjia YE

In many countries in the European Union, female employment has grown faster than male employment. In the literature, several potential causes of this trend have been put forward. Besides supply-side factors related to waves of emancipation, technological progress (mainly machines reducing demand for workers performing physically demanding jobs) and trade have been put forward as explanations. In this paper, we will focus on quantifying the effects that are due to changes in international trade patterns. The period we consider is 2000-2014, which roughly corresponds with the period in which global trade grew at a much faster pace than the global economy.

Our analysis does not just look at consequences of changes in industry specialization that came with the increased global trade intensity. In the period studied, production processes became increasingly organized as global value chains (GVCs). The GVC revolution is not only characterized by increased industry specialization, but also implied 'functional specialization': whereas industry A in Country 1 is mainly taking care of the headquarter functions (e.g. R&D, marketing, etc.), industry A in Country 2 mainly performs fabrication activities. Like industry specialization, this type of specialization is also driven by comparative advantages of countries. Given our objective to quantify the effects of trade on the relatively rapid growth of female employment and the fact that the differences between male and female workers tend to be

larger for some business functions than for others, we should consider this question using data on employment by function. We present results based on an input-output based accounting approach that considers technological change within GVCs rather than within industries, and that considers changes in trade patterns as relocations of economic activity by function within GVCs.

The data we use are the 2016 release of the World Input-Output Database, complemented with new data on employment at industry level split by function and gender. In constructing the data, the functional split was based on the occupations of workers, using population censuses and national labor force surveys. The business functions we consider are fabrication, management, R&D and marketing.

Unilateral EU climate action, carbon leakage and CBAM – calculations with GINFORS-E

Topic: Input-Output Modelling: Energy Policies - II
Author: Christian LUTZ
Co-Authors: Maximilian BANNING

The GINFORS-E model has been applied in the project "Climate Protection Scenarios until 2050 Considering CO2 price Differences and Carbon Leakage" for the German Federal Environment Agency to quantify the socio-economic effects of unilateral EU climate action. Compared to previous modeling work, carbon leakage is considered in great detail under different design options of the EU-ETS.

The papers looks into macroeconomic and sectoral impacts of unilateral climate protection of the EU with regard to carbon leakage, and the design of the EU ETS including a CBAM. In the reference scenario the EU and the other countries do not take any additional climate protection measures. In contrast, the EU targets of 55% GHG reduction by 2030 and 95% by 2050 are met in three alternative scenarios, while nothing changes in the rest of the world. In these three scenarios, the design of the EU ETS, i.e., the allocation of emission allowances, is differentiated. The first assumes free allocation of emission allowances in the EU, the second full auctioning of all ETS sectors, and the third is in line with the EU fitfor55 proposal. It includes full auctioning and a CBAM on direct emissions, both introduced between 2026 and 2035, while compensation for indirect emissions from electricity is phased out until 2035. In further sensitivities, various assumptions such as the Armington elasticities, the design of the CBAM and the stronger participation of other countries in climate mitigation are examined.

GINFORS-E is a global model that it is designed for assessments of economic, energy, climate and environmental policies up to the year 2050. It is a bilateral world trade model based on OECD data, which consistently and coherently models exports and imports of 25 goods groups for 64 countries and one 'rest of the world' region. All EU-27 countries, additional European economies and international major trade partners are explicitly modeled. It incorporates a macro-model, consisting of exports and imports, other core components of final demand (private and public sector consumption and investment), markets for goods and the labour market, for each country. The country models are also divided into 36 goods categories in accordance with the OECD internationally harmonized input-output (IO) tables. For every country OECD bilateral trade data on industry level is linked to the IO tables. Each national model is linked to an energy model, which determines energy conversion, energy generation and final demand for energy for 19 energy sources disaggregated by economic sector based on IEA energy balances. Energy-related CO2 emissions are linked to energy use. The model considers technological trends and price

dependencies.

In the case of the unilateral EU climate ambition there is a partial shift of production out of the EU in carbon-intensive sectors such as chemicals, basic metals and non-metallic minerals because the costs in the EU increase. These carbon-intensive goods and the goods are subject to high international competition because they differ little in quality. Carbon leakage rates are highest in the case of full auctioning and lowest in the CBAM scenario. However, because these sectors contribute only a small part to value added in the EU, other macroeconomic effects predominate. For example, CO_2 reduction leads to a decrease in energy imports, an increase in energy efficiency and structural change, which has a positive impact on the EU economy. Overall, the GDP effects for the EU are slightly positive. Some energy exporting countries are negatively affected. The effects on the long-term growth path are very small, and significantly smaller than the expected negative macroeconomic effects of climate change. Free allocation of emission allowances is better for the EU economy than auctioning. Full allocation of emission allowances with a CBAM mechanism also performs slightly worse than free allocation. Carbon leakage occurs especially in the carbon-intensive sectors of the EU ETS. Free allocation of emission allowances and a CBAM can reduce carbon leakage.

Further sensitivity calculations show that the assumption of higher Armington elasticities slightly worsens the macroeconomic effects for the EU, as carbon leakage effects get larger. Elasticities of substitution between domestic and imported goods are important for carbon leakage. The design of the CBAM plays only a minor role for the economic impacts. With stronger climate ambition of other countries, the effects on EU GDP worsen slightly.

The policy conclusion can be summarized as follows: There is a risk of carbon leakage if the EU acts unilaterally. However, the effects are limited and can be further reduced by appropriate design of the EU ETS. They are not an argument against achieving the climate targets in the EU.

Identifying Critical Sectors in the Restructuring of Low-Carbon Global Supply Chains

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - I
Author: Keitaro MAENO

Based on recent events such as the COVID-19 pandemic and Russia/Ukraine conflict, global supply chain (GSC) restructuring has become an important issue for industries worldwide. In this urgent situation, industries need to transform their existing GSCs into new GSCs which have a low-carbon structure, in other words, they need to conduct low-carbon GSC restructuring to mitigate the climate change. The key questions for the low-carbon GSC restructuring are as follows. First, which sector (i.e., supplier) included in the relevant GSC can achieve the greatest CO_2 emission reduction through GSC restructuring, in short, which sector should be a policy target for relevant low-carbon GSC restructuring? Second, to what extent can the CO_2 emissions of a relevant GSC can be reduced through GSC restructuring?

To answer these research questions, this study empirically investigated the impact of relevant GSC restructuring targeting every sector using a practical hypothetical extraction method: HEM model. Specifically, this study applied a hybrid HEM model combined partial HEM and global extraction method (Dietzenbacher and Lahr, 2013; Dietzenbacher et al., 2019) to estimate the impact of "a unit" of relevant GSC restructuring targeting every sector included in a relevant GSC (i.e., marginal restructuring of a relevant GSC). In this study, marginal GSC restructuring is

defined by one percent extraction and substitution of a trade coefficient between a targeted sector and the other sectors included in a relevant GSC.

Furthermore, this study incorporated an indicator of the comparative advantage (i.e., the revealed comparative advantage index) of an extracted sector (i.e., a restructured sector in the relevant GSC) into the hybrid HEM framework to decide a reasonable partial extraction ratio reflecting a substitutability of an extracted sector. Through this process, this framework can describe the practical scale of relevant GSC restructuring and estimate the CO2 emission reduction potential of practical GSC restructuring.

The novelty of this study is the provision of intuitive and accurate evidence for the relationship between GSC restructuring and CO2 reduction to policymakers who are willing to implement low-carbon GSC restructuring by extending the scenario-based HEM into practical and flexible framework as a simulation tool for the real world.

As a case study, this study applied the practical HEM framework to the latest world input-output database (WIOD) in 2014 and estimated the impacts of restructuring Japanese and German automotive GSCs on CO2 emissions. The results showed the Chinese electrical equipment sector and Russian basic metals sector had the largest CO2 reduction effect by the unit of the restructuring of the Japanese and German automotive GSCs, respectively. The results indicated that these sectors should be a policy target for the low-carbon restructuring of the relevant automotive GSCs. Additionally, the results highlighted practical CO2 reduction potentials based on a reasonable scale of the relevant GSC restructuring, reflecting the substitutability of restructured sectors included in the automotive GSCs. The results implicated optimal strategies for the low-carbon GSC restructuring according to an attitudes of policy makers or GSC managers.

Finally, this study shows a guideline for policy makers to utilize the proposed framework. Furthermore, referring to the existing policies related to the GSC restructuring or the climate change mitigation in the real world, this study discusses effective policy implications for CO2 mitigation through GSC restructuring.

Climate hazards economic impact analysis using a Bio-MRSUT framework

Topic: Economics of Food Systems - II
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Regardless of its origin, causes and potential evolution, it seems clear that climate change is a phenomenon that is already leaving important consequences in the form of droughts, floods, increase in average temperatures, and other adverse phenomena, which translate directly in economic consequences: crop losses, destruction of infrastructure, forest fires, ... But these economic consequences and impacts should not be assessed solely from their direct quantification, but rather it is necessary to consider the indirect and induced effects that are produced through the circular flow of income. In this sense, this paper propose an analysis of the economic impact of biophysical shocks due to climate extremes requires a multi-sectoral framework that quantifies the interrelationships between production, demand and supply.

To measure these effects, the use of multisector models, of the Input-output type, is particularly appropriate, but not only the classic one based on linear multipliers. In this work, an alternative approach is presented based on an improvement of the modelling of disasters proposed by Faturay et al. (2020) and Huang et al. (2022), who use novel developments for the analysis of disasters with input-output models. This model tries to offer an alternative to the assumptions of the classic Leontief model, especially about the possibility of a reallocation of resources and production, both between the countries and regions of the EU, as well as with the Rest of the World. This model uses the technical coefficient matrix, but not its inverse and a maximisation of the joint output (or linked variables) of related zones or regions is proposed in the event of a catastrophic external shock, allowing the transfer of production between zones (regions and/or countries) and taking as the only restriction the maintenance of the supply as an input of the goods affected by the disaster. However, this optimisation algorithm generates a much more limited process of reallocation of output between regions than expected and that makes it hypersensitive to situations of strong initial shocks in production, so the model has been improved with the introduction of new restrictions and the relaxation of others, now allowing a flexible, more realistic reassignment that provides more coherent and feasible results.

Anyway, to provide a more comprehensive view, the traditional impact analysis model based on Input-Output models has been also applied, using the multiplier matrices resulting from the classic Leontief inverse, obtaining the so-called backward linkages of the initial direct effects of a shock (in this case, on the production/disposal of bio-economy output caused by climate hazards), to reflect the effects in the whole economy.

For this analysis, it has been necessary the elaboration of a new database, called Bio-MRSUT (Bio-economic Multi-regional Supply-Use Tables). This database, with coverage for the 28 MS of the EU is derived from EXIOBASE (Stadler et al., 2018), subsequently completed with additional information on certain bioeconomy sectors (agriculture, livestock, and biofuels) using the 2010 and 2015 BioSAMs (Mainar-Causapé et al., 2021) carried out by the Joint Research Centre (JRC). The Bio-MRSUT multiregional frameworks comprise, with reference to the year 2015, a total of 78 activities (44 of Bioeconomy) and 78 goods and services (44 of them bio-economics), for the 28 EU countries (including the United Kingdom) and the Rest of the World, (as well as the interrelationships and bilateral exchanges between all these territories). In addition, they contain the breakdown of final demand and value added, as well as taxes on activities and products and imports by origin (the resulting data matrix contains 4,529 rows and 4,669 columns). Also, a regionalised base, at NUTS 2 level, for Germany (38 regions), Austria (9 regions) and Spain (19 regions), has been estimated.

The characteristics of this database, which contains interrelationships between the 28 MS of the EU 2015 and has a complete disaggregation of agricultural and bio-based non-agricultural sectors and goods, makes it possible to simulate the effects that shocks, due to the climate hazards, have in certain sectors or commodities, allowing a first quantification, through the analysis of the damage attributable to climate change.

Empirical estimates of the elasticity of substitution of a KLEM production function without nesting constraints: The case of the Variable Output Elasticity-Cobb Douglas

Topic: Input-Output Theory and Methodology - II
Author: Paul MALLIET
Co-Authors: Frederic REYNES

The outcome of Computable General Equilibrium models applied to climate crucially relies on the estimation of elasticities of substitution. We use a generalized production function that overcomes the restriction imposed by a nesting structure of the Constant Elasticity of Substitution (CES) production function assumed in most CGE models.

Constructing a panel of 44 countries and 14 periods from the World Input-Output Database (WIOD) tables, we estimate the production functions for 54 sectors using a Seemingly Unrelated Regression model. We compare these results to two standard KLEM nesting structures used in CES specification and find direct implications on the estimation results, especially for Capital-Energy substitutability.

Climate impact assessment through input-output networks

Topic: Agent-Based Modeling and Input-Output Analysis - I
Author: Antoine MANDEL

This is a submission to the special session on ABM/complexity-IO macroeconomic models

Assessment of climate impacts is mostly based on equilibrium models considering expected value of impacts. This approach neglects a number of key features :(i) the spatial heterogeneity of impacts and of the distribution of economic activity, (ii) the tail of the distribution of impacts, (iii) the propagations of impacts out-of-equilibrium. In this paper, we develop an agent-based model of the propagation of shocks in input-output networks that overcome these shortcomings. Our approach starts from a representation of direct climate impacts on the production process of geolocalized firms. We then use an agent-based model to assess the propagation of impacts through global supply chains.

Carbon impacts of generational and consumption changes for an ageing Europe

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - II
Author: Miguel Ángel MARTíNEZ GARCíA
Co-Authors: Angeles CAMARA, Rosa DUARTE, Cristina SARASA

Consumption patterns and behaviour have changed over the years and even more so in a geographical area such as Europe, which is involved in a progressive process of population ageing. The group of senior age (60+) is increasing its proportion of all citizens. The impacts of the lifestyles of an ageing society on global carbon emissions are poorly understood.

In this paper, we quantify the evolution of greenhouse gas (GHG) emissions driven by European (EU) household consumption across age groups from 1999 to 2015. To do it, we first develop a

multi-regional and multi-sectoral input-output environmentally extended (emissions) model, which differentiates the consumption of European households by four age groups. The MRIO table for the year 1999 and 2015 provided by Exiobase 3 is used according to the NACE classification and coupled with the information on consumption patterns by age groups from Eurostat necessary for the breakdown of European households by different age groups. And, on the other hand, the structure of consumer spending (per thousand) is collected according to the COICOP classification. With this, we analyse the disparities in carbon emissions driven by the four different age groups by studying the direct and the indirect (embodied) carbon emissions driven by each age group of EU households. We also study the unequal distribution of environmental impacts from 1999 to 2015 in each age group and the evolution of these consumption patterns.

Then, we address a set of scenarios to simulate the carbon impacts of alternative projections of the consumption structure by age group up to 2050. To calculate this projection, we base our simulations on the previous evolution from 1999 to 2015 to launch alternative trajectories from 2015 to 2050. We also use the population data for the years 2015 and 2050 (projected) of the different age ranges of the household from Eurostat. The scenarios simulated combine the change in demand by household group, and also by different policies (regulations, changes in environmental awareness, fiscal policies) that can be applied to promote the change .To our knowledge, this is the first study to combine such analysis by age group for all countries of Europe together with a range of scenarios to explore environmental and economic outcomes associated with changes in household consumption choices, specifically in the group of senior age, considering the entire global supply chain.

Our results aim to shed light on the debate about demographic changes and environmental impacts and show a European-wide comparison of the emissions of the different age groups, highlighting the degree of responsibility of each household age group, and their respective changes over time.

Effects of Lifetime Changes of Residential Buildings on CO2 Emissions

Topic: Input-Output Analysis: Industrial Policies
Author: Sora MATSUSHIMA

In 2020, the Japanese government has proposed to set the 40% CO2 emissions reduction target in construction and residential buildings sector by 2030 compared to 2013 levels. To achieve the reduction goal, it is crucial to make an effective policy to the construction and residential buildings sector accounting for 40% of the total CO2 emissions in Japan. An important research question is to what extent lifetime changes of the residential buildings affect CO2 emissions from the lifecycle perspective? Few studies addressed this related research question. Müller (2006) used the lifetime distribution of housing and estimated stock dynamics for forecasting material flows for housing in Netherlands. However, Müller (2006) did not specify an appropriate lifetime distribution function in the housing sector statistically.

The novelties of this study are the following. This study is the first attempt to specify an appropriate lifetime distribution function in the housing sector statistically. In doing it, I used the detailed real estate data including older houses sold in Japan and complied lifetime data for older houses that were sold as a worthless attachment of land. The maximum likelihood method was used to select the appropriate lifetime distribution model for housing in Japan. The second attempt of this study is to develop and demonstrate a comprehensive life-cycle assessment (LCA)

framework considering the dynamics of residential buildings stock and flows by combining the specified lifetime distribution analysis with an environmentally extended input-output analysis. This study estimated the life-cycle CO2 emissions for housings in Japan using the comprehensive life-cycle assessment (LCA) framework that includes important life-cycle stages: production of housings, energy use in housings, and disposal of older houses. In estimating the life-cycle emissions, the time series dataset of CO2 emission intensity by the 3EID database (i.e., Embodied Energy and Emission Intensity Data for Japan Using Input-Output Tables) was used.

The results show that normal distribution was selected as the most appropriate lifetime distribution for housing in Japan. From the specified lifetime distribution, this study further estimated the average lifetime for housing as approximately 35 years.

It was further found that the lifecycle CO2 emissions for housings have decreased during the study period between 1970 and 2020, because construction starts of new houses and housing stocks have decreased during the study period. The reduction rate of CO2 emissions in 2020 compared to 2013 was 18.5%, implying that an additional substantial reduction of 22.5% is required in order to reach the target of a 40% reduction in 2030.

A detailed look at the life-cycle emissions shows that the use stage accounts for more than half of the total life-cycle emissions from housing, whereas the production stage of new houses also emitted a large amount of CO2 emissions, accounting for 30% of total stages of residential buildings lifecycle. This indicates that the production stage is an important stage in mitigating the lifecycle emissions. This study also finds a significant CO2 reduction potential of extending the lifetime of housing and discuss effective supply- and demand-side policies of residential buildings for a decarbonized society.

Macroeconomic and Employment Impacts of Achieving Net-Zero Emissions in the US by 2050

Topic: Dynamic Modelling of Economic Impacts of GHG Reductions
Author: Douglas S. MEADE

Policymakers and researchers have proposed a variety of decarbonization strategies to reduce GHG emissions in the US.   A important question is: "What will be the economic impacts of these strategies, and how will they affect US households and business?" In particular:

- Will decarbonization lead to a net increase in employment?
- What sectors face the greatest opportunities for job growth?
- How will job opportunities change over the coming decades?

In this study, the Inforum macroeconomic interindustry model LIFT was coupled to the ENERGYpathways model produced by Evolved Energy Research to analyze the macroeconomic and employment impacts of a set of decarbonization strategies that may enable the US to achieve net-zero emissions by 2050.

The paper describes the detailed features of the decarbonization strategies, and how they were implemented in the LIFT model. We report on salient features of the resulting structural change in the US economy, and the net changes in production in jobs at the industry level. Of special interest is the impact on fossil fuel and supporting industries.   Under any conceivable decarbonization scenario, economic activity in these sectors is expected to decline.   An open

question is whether investments in carbon-reducing technologies will create sufficient production and jobs to counteract these losses in the aggregate.

The net-zero technology and policy pathways examined in this analysis is based on Decarb America's Sectoral Policies Scenario, with the addition of supplemental measures to reach net-zero. The modeling approach combines a zero-emission vehicle standard, zero-carbon fuel standard (for diesel, gasoline, jet fuel, and hydrogen), electrification and efficiency standards for buildings, a clean energy standard for the power sector (100 percent clean electricity by 2050), and policies to reduce emissions of methane and ozone-depleting substances. Together, these policies are estimated to reduce overall U.S. emissions by 70 percent relative to current emissions, while reducing energy and industrial CO_2 emissions by 80 percent. Reaching the net-zero goal in this scenario thus requires further reductions in non-CO_2 greenhouse gases as well as additional CO_2 reductions from carbon removal (including land-based sequestration, direct air capture, and carbon capture and storage) and further emissions mitigation in the areas of bioenergy, industrial heat, and off-road transportation.

Two scenarios are explored. The first is the High Electrification/High Renewables pathway, which we also refer to as the core scenario. For the second net-zero pathway, under renewables deployment is more constrained, but the US economy still achieves net-zero by 2050. The reference to "net-zero" under both scenarios means that GHG emissions are reduced significantly and that all remaining GHG emissions released from human populations are counterbalanced by removing GHGs from the atmosphere, for example through forest restoration or direct air capture.

This study presents two complementary assessments of the economic impacts of achieving net-zero emissions by 2050. The first focuses on the direct employment impacts associated with the up-front investments in energy facilities and equipment to help achieve the net-zero target, as well as employment impacts associated with the operation and maintenance of these facilities. This first analysis does not capture spillover impacts associated with complex supply chain interactions or workers spending their wages.

The second analysis uses the Inforum LIFT model, and takes a broader perspective than the first by estimating the economy-wide economic impacts associated with reaching the net-zero by 2050 goal. As such, it was designed specifically to capture the spillover effects not accounted for in the direct employment impacts assessment. These spillover effects reflect a number of economic dynamics that affect industries and households across the broader economy. These include impacts up the supply chain from directly impacted industries as well as impacts for industries that produce goods purchased by workers in affected industries. The economy-wide assessment also reflects how changes in prices affect consumer spending patterns and how changes in investment affect productivity over time and the associated implications for output, employment, and income.

The paper synthesizes these two assessments, the findings of which highlight the importance of planning for the energy transition, particularly in helping affected workers and communities navigate the clean energy transition. Federal and state governments can draw upon the results of this study as they consider strategies for attracting new investments and industries and scaling up job training.

Non-negligible indirect risks of sea level rise: Evidence from Japan

Topic: Input-Output Analyses and IO Modelling of Disasters - II
Author: Bo MENG
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Non-negligible indirect risks of sea level rise: Evidence from Japan
Meng Yuan, Haoran Zhang, Bo Meng, Jinjun Xue

Abstract:
Sea level rise (SLR) is one of the most visible and alarming consequences of global climate change, which endangers social and economic impacts, particularly in low-lying areas and small island states at vulnerability. The potential risks of SLR have been widely evaluated in the scientific community, however, most studies have focused on the direct impacts on coastal areas while overlooking the potential propagation effect along the value chain. This paper aims to answer the research question: How and to what extent is the indirect risk of sea level rise affect the value chain, by carrying out an empirical analysis for a representative island country Japan. To this end, millions of financial transaction records between 302,845 firms across Japan are collected, which details the information of the firms including location, industry category, capital, transaction items, estimated transaction amounts, etc.

The assessment focuses on the spatial and industrial characteristics of the SLR risks. Based on an input–output model, the economic losses of various industries and regions across Japan caused by the disasters are estimated, which is specifically characterized as the impact on firms. The year 2019 before the COVID-19 pandemic is considered for analysis to eliminate distractions. The intermediate scenario of RCP4.5 defined by IPCC and the median global sea-level projections are considered here as which is recognized as closely aligned with the current global emissions and situation. To explore the spread extent of the effects of the hazard across industries and regions, the Gini index are adopted for quantitative analysis. The two indexes are originally used to measure the equality of income distribution across a population, in this paper, they are used to represent the wideness of the hazard spread. The more equal the industries and regions get affected by the hazard, the wider the impacts spread.

Results show that the indirect risks of SLR intensify the impacts on the entire value chain in Japan. From the national level, the direct risk leads to 0.97% economic losses, while the indirect risk doubles the number and reaches 1.9% of the total asset, which further results in an effect of 2.87% in total. In terms of industry classification, manufacturing, transportation and communication, construction, and agriculture are among the four industries that endeavor the largest effects with total economic losses above 3%, while the least affected industries (<1%) are electricity, gas and water, finance and insurance, and public affairs. Besides, it is found that indirect effects widen the spread of the value chain risks across industries as well as regions, visualized by a flatter Lorenz curve that is closer to the line of perfect equality (i.e., lower Gini index) for the indirect risk compared to that of direct risk.

Overall, our study provides important insights to understand the potential economic impacts of SLR and highlights the non-negligibility of the indirect risks of SLR through empirical analysis in Japan. SLR or to a larger extent climate change put everyone at risk directly and/or indirectly, thus there is a strong need to call for responsibility from all, instead of only the coastal area.

Keywords: Sea level rise; Indirect risks; Economic losses; Value chain; Japan

New Chinese Input-Output Tables: Considering Firm Size and Ownership

Topic: Compilation of National Supply, Use and Input-Output Tables
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New Chinese Input-Output Tables: Considering Firm Size and Ownership

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Abstract: Firms in China within the same industry but with different ownership and size have very different production technologies, energy efficiency, market powers and might face very different regulations, policy supports, or financial conditions. This fact has largely been ignored in most of the existing input-output (IO) empirical analysis literature due to the lack of relevant information on firm heterogeneity, thus potentially brings great challenges for researchers and policymakers who are facing complex issues relating to both firm size and ownership in China. Through matching almost all relevant Chinese economic census, firm level industry survey data, product and firm level customs trade statistics, and firm level taxation survey data, we aim to compile the first-ever time series Chinese IO tables, in which firm ownership (stated-owned, foreign-invested and private firms), and firm size (large-, medium- and small-sized) information is explicitly involved for the five benchmark years between 1997-2017. A linear programming method is used to compile this new type of Chinese IO tables and the corresponding satellite accounts for CO_2 emissions, pollution (Wastewater, Chemical Oxygen Demand, Ammonia Nitrogen, SO_2 Emissions, Particulate Matter, and Nitrogen Oxides), and patents (Invention, Industrial Design, Utility Model) by industry, firm size and ownership are also constructed. This work provides solid foundations for a diverse range of innovative IO-based research for China, in which firm heterogeneity information about size and ownership matters.

Greening the African Continental Free Trade Area

Topic: Input-Output Modelling: Sustainable Production and Consumption Policies - II
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(1) Research question

The African Continental Free Trade Area (AfCFTA) Agreement entered into force on 30 May 2019. It establishes a liberalized market through multiple rounds of negotiations. Phase I focuses on trade in goods and trade in services. Phase II covers investment, IPRs, competition policy, digital trade, and women and youth in trade.

While environmental considerations are largely outside the scope of current AfCFTA Agreement, they are becoming increasingly important. Establishing national carbon markets is also on the agenda of many African countries. Africa has the lowest share of global CO_2 emissions but is expected to be one of main affected regions by climate change. On the other hand, the high

economic growth of Africa and its trade expansion are expected to increase GHG emissions considerably. Up to COP27, many African countries have updated their Nationally Determined Contributions (NDCs). In most cases, the NDCs are constructed with an unconditional target to be met through national funds, and a conditional target subject to international support.

The objective of the paper is to assess the economic and environmental impacts of AfCFTA under the possibility of establishing African carbon markets. We try to answer the following question: how industrial transformation and economic development led by the trade reform can be made consistent with climate ambition?

Few studies address the environmental effects of AfCFTA. Bengoa et al. (2021) show that AfCFTA enhances production reallocation, increases CO_2 emission marginally, and non-CO_2 GHG significantly.

(2) Method used

We use the MIRAGE-Power to perform the policy assessment. It is a multi-regional, multi-sector, dynamic computable general equilibrium model, featuring a detailed representation of energy use. MIRAGE-Power is an extension of MIRAGE-e, incorporating a detailed representation of electricity power generation. In MIRAGE-Power, electricity is generated from multiple sources including renewables, nuclear, coal, oil, and gas. The regional/national electricity producer provides aggregate electricity for intermediate consumption and households. Electricity can also be traded. As renewables are large sources of African electricity generation, this feature is of particular interest to the African electricity market.

Beyond power, further features of MIRAGE-Power help analyzing trade policy with a focus on energy. First, energy is not considered as an intermediate consumption but directly substitutes with capital in the production function. In addition, energy is subject to independent productivity improvements. Second, CO_2 emissions are incorporated from the production process (intermediates) and household consumption. Climate policy is implemented in the model by two mechanisms: either a cap-and-trade mechanism or a carbon tax.

(3) Data used

The model also accounts for trade policies, based on highly disaggregated databases of the equivalents of tariff (MAcMap-HS6) and non-tariff protection (UNCTAD NTMs). We use GTAP-POWER 10.1 database for the 2014 base year calibration.

As climate policy always has a long-term objective, we first define a business as usual (BAU) social-economic projection to reflect economic growth until 2045. We use the macroeconomic projection (GDP, labor participation rate and skills, current account targets, investment and saving rates) from updated estimates of the MaGE model. We include in the baseline, policies such as tariffs (reflecting current existing RTAs/FTAs) and updated NDCs. We assume that up to 2030, climate policy covers nations that have an existing carbon market and submitted unconditional NDCs. From 2030 to 2045, the emissions of these countries are capped at the level of 2030.

(4) Novelty of the research

We first implement the AfCFTA Agreement, including liberalization of trade in goods in line with agreed AfCFTA modalities, along with a 50% reduction of actionable restrictions to trade in the

five AfCFTA priority services sectors plus health and education, as well as a 50% cut of actionable NTMs, all within the African continent only.

We implement, along with the AfCFTA, African carbon markets under 3 scenarios:
a) African countries impose an exogenous carbon tax of US$ 25/ton.
b) African countries reach 50% of their unconditional targets by 2030. We assume that African NDCs would be reached through national African carbon markets. As a result, the carbon tax is endogenous in this scenario.
c) We assume that African countries fulfill 50% and 25% of their conditional and unconditional commitments, respectively, by 2030.

The paper provides detailed results about: i) Impact on trade, GDP, and emissions; ii) Level of abatement with the exogenous carbon tax and the level of carbon price required to meet the targets as set in NDCs; iii) Change in primary energy mix and electricity mix with renewables to meet the requirement of African NDCs.

Risk Spillover of the Real Estate Sector Through the Input-Output Network Based on Inter-Sectoral Production Linkage

Topic: Input-Output Modelling: Industrial Policies
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Production linkage is one of the most prevalent interconnections between economic agents, and thus one of the most important risk transmission channels between companies and sectors. Due to the existence of inter-sectoral or inter-company linkages, the risk spillover effect from one company being in default to its related sectors is highly likely to occur through direct financial transactions, information dissemination, sentiment contagion and so on, and in some extreme cases even lead to nearly complete collapse of the whole industrial chain. As a pillar sector of the national economy, the real estate sector has a long industrial chain where there are many companies in various sectors, from upstream building materials to downstream home appliances, furnishings and decorations, penetrating almost every corner of the economic system. These companies in the industrial chain have established complex production linkage due to the credit-and-debt relationship in business transactions, joint cooperation in development or sales of the same product, which have generated financial interconnections, information dissemination and sentiment contagion. These complex production relationships potentially spill over the default risks in the real estate sector to its related sectors, and even further trigger systemic risks, which poses a great threat to the stable development of the entire economic system. The outbreak of several financial crises in history has been highly related to the risk spillover of the real estate sector. Therefore, it is important and urgent to explore the risk spillover effects of the real estate sector from the perspective of input-output production linkage.

Therefore, this paper constructs an input-output network between the real estate sector and other sectors based on the inter-sectoral production linkage illustrated by input-output tables, and quantitatively analyzes the impact of real estate sector risks on its related sectors based on the input-output network, specifically, the influence on sectors in the input-output network, such as the construction sector, when the real estate sector generates default risks or when real estate prices fluctuate drastically. Strategies for preventing and alleviating risk spillover in the real estate sector are provided based on the analysis of the input-output network. In this paper, the input-output table of 42 sectors in China from 1998 to 2018 are used to calculate the

coefficients and other indicators of the real estate sector and other sectors, and then a directed input-output network of the real estate sector and other sectors is constructed with these indicators. Accordingly, we analyze the spillover effects and risk transmission paths of the real estate sector on other sectors and find that: (1) the real estate sector does not have strong risk spillover effect on all industrial sectors, but has significant risk spillover through the input-output network to the financial sector, the typical upstream sector -- construction sector, and the typical downstream sector -- wholesale and retail trade sector; (2) the risk spillover of the real estate sector to other upstream and downstream sectors through the input-output network is affected by the real estate industrial cycle. This paper integrates input-output analysis and complex network analysis to study the risk spillover effect of the real estate sector from the perspective of production linkage, which expands the application of input-output analysis methods and enriches the theories and methodologies in financial risk research, and is of great theoretical significance.

IO approach to Employment Impact Assessments: A Brief Overview

Topic: Assessing Employment Impacts Using Simulation Models: Some Sub-Saharan African Experiences
Author: Guannan MIAO
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There exists several key players and approaches for employment impact assessment. While those approaches and methods have been frequently applied, and some of them have even been institutionalized, there has not been a literature that conducts a detailed review of these approaches by looking at their methodological foundations. This paper will first conduct such a review and come up with detailed comparison in terms of strengths and weaknesses for each approach. Second part of this paper applies these approaches to conduct an employment impact assessment of a concrete investment operation in a particular country, the results will be analyzed, compared and contrasted. The paper ends with a strategy and new proposal to develop an alternative approach that overcomes the main shortcomings of the existing approaches.

Size-extended SUIOT for Belgium: an overview of methodological issues and analytical possibilities

Topic: Handbook of Extended Supply and Use Tables: Country Applications
Author: Bernhard MICHEL
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Extended supply-and-use and input-output tables (ESUIOT) are a key tool when it comes to mapping how global production arrangements shape the economic activity within a country. In these tables within-industry firm-heterogeneity in terms of criteria such as size, trading status and ownership is taken into account through a systematic disaggregation of relevant industries. As an input for analytical work, ESUIOT contribute to enhancing the relevance of national accounts (NA).

This paper describes the construction process of size-extended SUIOT for Belgium for the year 2019 and highlights analytical possibilities provided by these tables. Heterogeneity in terms of size is likely to lead to within-industry technological differences. SUIOT that take these differences into account are of particular interest for determining how important small and medium-sized enterprises (SMEs) are for the Belgian economy and for understanding their role and position in

domestic and global value chains. Such insights are valuable for designing policies that lend effective support to SMEs.

Our work allows to highlight major methodological issues in the construction of size-extended SUIOT. The most prominent of these issues concerns the definition of firm size classes, which needs to take into account group affiliation. In first instance, we define three categories of firms: small firms, medium-sized firms and large firms. Then, we investigate the link with group affiliation: the idea is that small and medium-sized firms that are part of an enterprise group are likely to be different in technological terms from firms in the same size classes that are not part of a group. Therefore, we expand the definition to separate out small and medium-sized firms that belong to a large domestic or Belgian multinational group or to a foreign-controlled group. This yields a combined size-ownership classification with genuine small and medium-sized firms – those that are not part of a group or part of a small group –, pseudo small and medium-sized firms – those that belong to a large or foreign group – and large firms. Classifying firms from the business register into these categories requires data on employment, turnover and group affiliation. We provide a detailed overview of the data sources we have used (including a detailed discussion on how to measure group size with the data at our disposal) and report descriptive statistics for firms classified according to this combined size-ownership criterion.

For the construction of the size-extended SUIOT per se, we have gathered all the firm-level data used in the construction of regular SUT for Belgium and merged the firm classification into these datasets. Moreover, we have determined which industries should be disaggregated. We have then disaggregated these industries in the regular 2019 Belgian SUT based on these data. This work is done at the most detailed industry breakdown of the Belgian tables. In subsequent steps, we have also disaggregated the rows of the SUT and produced a split of the use table at basic prices according to the origin of the goods (domestic or imported). This allowed to derive a size-extended IOT, which we then integrate into the 2019 global multi-country table from FIGARO.

In analytical terms, we produce an IOT that is aggregated by ownership-size class. This provides an estimate of the share of genuine and pseudo SMEs in total value-added and employment. We also confirm within-industry technological differences between the three ownership-size-classes, and we analyse the integration of both types of SMEs into domestic and global value chains.

From the roots to the present: input-output contributions in International Trade

Topic: 50th Anniversary of Leontief's Nobel Prize: International Trade
Author: Sebastien MIROUDOT

Based on the seminal work: Wassily, Leontief (1953) "Domestic Production and Foreign Trade; The American Capital Position Re-Examined", Proceedings of the American Philosophical Society, 97(4): 332-349. Includes presentation of some archive materials and documents about this topic.

The 2023 edition of the OECD Analytical AMNE Database: methodology and new evidence on the role of multinational production in global value chains

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - VIII
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Inter-country input-output (ICIO) tables and trade in value added (TiVA) indicators have become an invaluable part of the international trade toolkit of researchers and policymakers alike. The global Leontief inverse has made it possible to measure international trade flows in value added rather than in gross terms and to identify the contribution of each country and industry to the value of final products.

One aspect that this strand of literature has struggled to shed light on is the role of multinational enterprises (MNEs). MNEs are very important actors in global value chains (GVCs) and, while their foreign affiliates undisputedly contribute to value added in the host countries, they are also likely to retain strong ties with the parent economy. Thus, understanding the relative contribution made by domestic- and foreign-owned firms in global production can be a matter of great interest for policymakers. In this paper, we first discuss the latest update of the OECD Analytical AMNE database which extends the OECD ICIO tables by an ownership dimension for the period of 2000-2019. In a second part, we present empirical evidence on the role of multinational production in global value chains over the past two decades.

Despite recent initiatives to build extended supply-use tables that incorporate an ownership dimension, national accounts generally do not provide separate data on the transactions of domestic-owned and foreign-owned firms. Consequently, the existence and magnitude of those transactions have to be inferred from other sources and in particular official statistics on Activities of Multinational Enterprises (AMNE). Our starting point and benchmark are the OECD ICIO tables, a series of ICIOs of the standard format in which transactions are observed at the level of country-industry pairs (i.e., regardless of ownership). We first estimate a breakdown of gross output, value added, exports and imports of intermediate inputs by ownership status (domestic versus foreign) for every industry, country and year. This breakdown is based on AMNE statistics from the OECD AMNE database and national sources, as well as on Trade by Enterprise Characteristics (TEC) data for trade flows. Additional sources (such as FDI statistics) and a variety of statistical methods are used to fill the data gaps and create a full set of estimates. Ensuring that AMNE data align well with the ICIOs poses a number of methodological challenges, ranging from differences in valuation (basic versus purchasers' prices) to accounting concepts (gross output versus turnover), survey unit definitions (firm versus establishment), industry classifications and sampling schemes.

Once available, this ownership-split dataset is used to disaggregate the ICIOs via a quadratic optimization approach. To begin with, starting values are generated for the Analytical AMNE table. To this end, each row and column of the ICIO is split into a domestic- and foreign-controlled component in proportion to the estimate of gross output by ownership constructed in the previous step. In essence, for any given country-industry pair, domestic firms and foreign affiliates are initially assumed to the same input and output structure. The Analytical AMNE table is then calculated as the solution to a constrained minimization problem. The objective function is a weighted sum of the square deviations from the starting values as well as the exogenous estimates of value added, import and export by ownership. The main constraints are that the Analytical AMNE aggregate values back to the original ICIO and that output by ownership

matches the exogenous estimates in all countries and industries.

The resulting Analytical AMNE tables consist of 41 industries (based on the ISIC Rev. 4 classification) and cover 77 countries over the period 2000-2019. Foreign ownership is determined based on majority: a firm is regarded as foreign if it has at least 50% of foreign ownership. Work is currently ongoing to extend the Analytical AMNE to a three-way ownership split up to the year 2019 in which domestic firms are further distinguished between those that have foreign affiliates ('domestic MNEs') and those that do not.

The 2023 edition of the Analytical AMNE database confirms that MNEs play an important role in global output and even more so in global trade. As observed in the case of trade flows and the international fragmentation of production, there is a slowdown in multinational production since the 2008-2009 Financial Crisis. But MNEs still rely on a complex network of foreign affiliates to serve global markets in 2019. Patterns of multinational production in value added terms shed more light on differences across industries as well as the evolution of firms' sourcing strategies in the context of rising uncertainty and geopolitical tensions just before the COVID-19 pandemic.

Environmental and social footprint analysis considering the production activities of the informal sector: the case of manufacturing industries of India

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - VI
Author: Haruka MITOMA

The informal sector is a set of activities that are imperfectly regulated by the governments, and it is hardly accounted on official statistics. In emerging and developing countries, such unofficial economic activities generate one-third of the total gross domestic product (GDP), hence the informal sector is the vital for supply chains in the regions. On the other hand, many study have demonstrated that the higher informality of economies have negative impacts on environment (e.g., carbon emission, air pollutant emissions) and welfare of people (e.g., poverty, poor working conditions). Although there are many studies that calculated environmental or social footprint, due to the lack of an input-output table, there are few studies focused on the contribution of the informal sector. This study is the first attempt to construct an extended input-output table that distinguishes the formal sector and the informal sector to explore how the informal sector contributes environmental and social footprint of the country. This study focuses on the informal sector of 25 manufacturing industries of India as a case study. Given the lack of regulations or supports targeting the informal sector, it is important to identify the contribution of the informal sector in environmental or labor footprint to understand how much of the emissions or employments can be covered by existing measures and which industry should be prioritized to introduce a policy targeting the informal sector.

India has the largest informal economy among emerging and developing countries, where the informal sector generates half of the GDP and 90% of employment. To compensate for the exclusion of the informal sector from existing official statistics, the Indian statistical office has conducted several surveys specific to the informal sector. Based on the results of these surveys, India's input output table implicitly includes informal production activities in the sense that formal and informal production activities belonging to a specific industry are not distinguished explicitly, and these activities are aggregated into a specific sector Therefore, it is necessary to distinguish between these two.

The data for estimating the input output table are followings. First, for estimating the input coefficient matrix specific to formal and informal sectors, informal sector's output and value added in national account of India was used. Second, for calculating the energy consumption of the informal sector, this study used the estimated value of the energy consumption of the informal sector in the previous studies. Third, for estimating the number of workers in the informal sector, this study used unit level data of Periodic Labor Force Survey. This survey also provides the characteristics of employment in the formal and the informal sectors such as education level, income, working condition of workers (e.g., whether to have a contract, paid leave, compensation for unemployment). The indicators for estimating the table showed the informal sector has a smaller intermediate input due to the higher value added ratio to its output. I also found the informal sector tends to have a higher energy intensity than the formal sector due to the higher dependency on coal. Regarding the labor, the share of employment in the informal sector accounts for 74% in rural area, 63% in urban area, and the share of worker in the lowest level of education (i.e., not literate) was much higher in the informal sector. The result on the footprint analysis showed the informal sector in several industries significantly contributed to the national carbon footprint and labor footprint of India. Specifically, in the supply chain of construction, which drives the largest CO2 emissions in India, the informal sector contributed about 15% of the carbon footprint. Considering the workers and owners of the informal sector are in a dire situation, it is crucial to involve their formal suppliers to address the environmental and social issues of the informal sector.

Structural Change and Economic Growth in a Supermultiplier Model: a dynamic input-output analysis of the Brazilian economy

Topic: YSI and Development Programme - I - Discussants: Rutger Hoekstra and Joaquim J.M. Guilhoto
Author: Felipe MORAES CORNELIO
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This paper aims to discuss the role of structural change in a demand-led pattern of growth. The principal purpose is to evaluate how and by which channels the interaction between structural change and economic growth occurs. This requires an input-output version of the model (and not the usual aggregate version). When occurs variations in the final demand (autonomous expenditures that do not generate capacity for the private sector), three effects characterize the Supermultiplier in this version: i) intermediate demand (Leontief multiplier); ii) induced consumption (Keynesian/Kaleckian multiplier), and iii) induced investment (flexible accelerator effect). The first effect represents the demand generated on sectors that supply intermediate goods and/or services for finals goods and/or services. The second is the effect of variations in the final demand on the consumption of non-durable goods and services. Finally, the last term captures entrepreneurs adapting the productive capacity to the demand/income changes of the economy. The effects of structural change would affect the technical coefficient matrices (Supermultiplier) and the composition of the autonomous final demand vector, it could have effects both in the growth rate and at the production's level - with repercussions on the patterns of international trade, propensities to consume and to invest, coefficients of domestic content and the sectoral composition of the economy. The model and methodology developed are similar to Freitas & Dweck (2010) and Freitas, Kupfer & Dweck (2010). Concerning the dynamic input-output model, investment plays a fundamental role because of its dual nature - on the one hand, generates demand for the economy in the current period (directly and by multiplier effect) and, on the other, increases the productive capacity of the followings periods (accelerator). In this way, the Capital Flow Matrix (CFM) explains the investment component of the model, since it is

possible to disaggregate the allocation of investment in sectors and products (Miguez, 2016). The data used are the disaggregated versions of Brazilian 2015 Input-Output Tables (127 products and 67 activities) and Supply and Use Tables (128 products and 68 activities) available by Instituto Brasileiro de Geografia e Estatística (IBGE). To make compatible all the data for the simulations, it was necessary to reduce the level of aggregation to 91 products and 40 activities. The growth trajectories of output and the production structure will be analyzed through simulations in the R software. Those trajectories are not predictions, but a basis of comparison between hypothetical scenarios. The simulations require, besides the data of the input-output matrices, other databases for the parameterization of the model. Among these are the estimation of potential output and the degree of utilization of the average capacity of the economy. The simulations also depend on the elaboration of scenarios about the Brazilian economy and on a baseline scenario to compare the alternative scenarios. The quality of these scenarios is crucial for the empirical relevance of the model. At the end of the paper, it will be possible to get evidence on which sectors bring more dynamism to the economy (in particular the Brazilian one) and patterns of growth for different productive structures.

Toward a High Spatial Resolution Value Added and Employment Satellite Account for Norway

Topic: Input-Output Analyses and IO Modelling of Disasters - II
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In disaster analysis it is typical to consider a spatially bounded event and evaluate its impact on production, value added, and employment in affected sectors. Identifying the sectors exposed to a spatially defined stressor requires a multi-region input-output table with regional resolution and/or, as we explore here, a spatially explicit satellite account of production and employment. Motivated by the research question, "What is the scale and character of GDP in Norway generated within 10 meters of current sea level or in a potential riverine flood zone?", this paper discusses approaches for generating a satellite account for value added and employment with high spatial resolution. We discuss potential data sources, challenges, and the value of data sharing with colleagues doing CO_2 emissions accounting.

Balancing Sustainability and Labor: Policy Solutions for the Italian National Integrated Plan for Energy and Climate

Topic: Recent Developments in Stock-Flow Consistent Input-Output Modelling - II
Author: Guilherme Spinato MORLIN
Co-Authors: Marco STAMEGNA, Pietro GUARNIERI, Simone DALESSANDRO

The Italian National Integrated Plan for Energy and Climate (PNIEC) proposes fundamental policies for substantially reducing emissions and the overall carbon footprint of Italy. As structural changes are made to enable the green transition, it is imperative to implement strategies that prevent productivity gains from exacerbating social and labor market inequalities. Therefore, we examine the socioeconomic impacts of PNIEC in a simulated framework using the Ecohesion model (Cieplinsky et al., 2021). The dynamic macro-simulation model relies on an input-output analysis of the Italian economy, which allows for structural analysis of the composition of output, employment, and emissions. The input-output structure is dynamized through an endogenous process of technical change, which depends on the evolution of relative cost and a random

component. Moreover, the Ecohesion model features heterogeneous workers distinguished by gender and three different skill levels, providing a detailed analysis of labor market inequality. Simulations reveal that the transition and mitigation investments of PNIEC can significantly help reduce emissions to a level below 100 kton, but they tend to increase unemployment and inequality. Therefore, we analyze policies targeting the labor market and income inequality, namely Minimum Wage, an upper constraint to the ratio between top and bottom wages, working time reduction with no loss of payment, a Job Guarantee, a universal basic income, and a Wealth Tax. We assess policy effectiveness based on various measures of inequality, including the Gini coefficient, the gender wage gap, the ratio between top and bottom wages, the Palma ratio, and the labor share. Of the policies studied, universal basic income is the most effective in immediately reducing inequality. Both universal basic income and working time reduction lead to a persistent decrease in unemployment in comparison with the PNIEC scenario. In addition, working time reduction has the benefit of increasing the labor share. The introduction of a wealth tax reduces inequality while it improves public balance. These policies, however, have little effect on other measures of inequality in the labor market. On the other hand, the minimum wage significantly impacts wage polarization and the gender wage gap, thus contributing to an equal distribution in the labor market. Since policies perform well for different indicators, a combination of policies can be more effective for a general improvement of labor market outcomes. We test the effect of different combinations of policies. A policy mix including Job Guarantee and working time reduction potentializes gains in terms of low unemployment and greater labor share. When the two policies are combined with a minimum wage, there is a substantial improvement in the gender gap and wage polarization. Overall, introducing social and labor market policies can increase employment and the labor share while reducing inequality, and protecting workers from the radical structural changes associated with the green transition. A more fairly distributed income and better working conditions are both desirable and strategic for facilitating the ecological transition while avoiding social barriers that could cause unnecessary delays in the process.

Implications of healthy diet in India - An economy, environment and nutrition nexus approach

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - V
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India is one of the most populous countries in the world at 1.39 billion, endowed with the 'demographic dividend' of the largest shares of working age population (58%). Despite being host to a relatively young population, the public health status of the country remains alarming. Non-Communicable Diseases are responsible for 5.87 million deaths annually, constituting 60% of the total deaths in India. India ranks second in terms of the number of diabetic patients after China and around 135 million or approximately 10% of the Indian population were affected by obesity. In India, the NCD mortality between 2006-15 led to a projected cumulative loss to the national income of USD 237 billion and by 2030 the productivity loss is expected to be 17.9 million years.

The WHO recommends four key points to ensure healthy diet practices – i) energy intake (calories) should be balanced ii) Fat intake should not exceed 30% iii) limiting intake of sugars to less than 10% and iv) salt intake to less than 5g per day. In India, the daily calorie intake varies, with the highest and lowest decile urban population based on Monthly Per Capita Expenditure consuming 3,079 kcal/day and 1,643 kcal/day. However, some similarities were observed across

different categories. The animal and plant-based protein and fruits and vegetable intake is lower than the reference diet across urban and rural regions, whereas whole grains consumption is higher than the reference diet, except amongst the richest households who, in turn, consume higher share of processed food. The average Indian household sources 47% of its calorie intake from whole grains of which 70% is constituted by cereals and consumes more starchy vegetables, dairy, and palm oil compared to the reference diet.

The promotion of a balanced healthy diet for optimal nutritional intake is expected to have significant economic ramifications, since the changes in the consumption pattern of the households will have an economic impact on the agricultural supply chain, particularly in India with 54.6% of the total workforce employed in the agriculture sector while contributing 17.8% to the country's Gross Value Added. Along with the economic implications of the changing food consumption pattern, the sustainability of the food systems needs to be ensured. In India, the agriculture sector constitutes 14% of the total GHG emissions of which CH4 constitutes the highest share (72%) from enteric fermentation and rice cultivation, followed by N2O (21%) directly and indirectly from agricultural soils.

The issue of addressing unbalanced dietary habits is largely directed towards the young working age population in urban regions from public health as well as economic perspective. As of 2021, 34.6% of the population resided in urban regions in India and 58.4% of the total population are 'adults' or the working age population which is expected to increase to 37.2% and 61%, respectively by 2030. Thus, the nexus between nutrition, the economy and environment will be comprehensively addressed to ensure the welfare of the country.

The economy-wide impact of changing dietary patterns and nutritional disorders has not been investigated thus far in India. Studies on the economic impact of healthy dietary patterns and the consequent environmental impact of changing food systems are mutually exclusive from each other.

Given this backdrop, the objectives of the study are listed below:
i)   To evaluate the economy-wide impact of adopting a healthy diet in India by bridging the gap between the actual and required nutritional intake recommended by the EAT Lancet commission and the Indian Council of Medical Research and National Institute of Nutrition, India across different working age groups amongst the urban population using the Indian Supply Use Table 2018-19.
ii)   To estimate the GHG and water footprints by following the healthy diet guidelines in different scenarios, combining different food habits.

The GHG emissions per kg of food for 36 broad food groups were adopted from Green, et al., (2018). To estimate the total (direct and indirect) water footprint, the green and blue water usage for agricultural crops were adapted from the Water Footprint Network (Mekonnen & Hoekstra, 2011). The cumulative expenditure on the crops, fruits and vegetables, livestock, and fish products is mapped with the Annual Per Capita food consumption in urban India, derived from the latest National Sample Survey.

By studying the backward linkages of diverse categories of food items, growth in GDP and employment generation is expected to be witnessed in the economy while converging towards the reference dietary recommendation. With an increase in the working age population which largely constitutes the middle-income groups, the meat, and other animal-based protein intake is expected to increase with changing lifestyles and eating habits. This would imply an increase in the GHG and water footprint.

Structural Emission Attribution in the Global Supply Chain and Climate Policy Making

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - II
Author: Fumiya NAGASHIMA
Co-Authors: Shohei TOKITO, Tesshu HANAKA

Previous studies have demonstrated that it is crucial to establish complementary supply chains from both an economic and environmental perspective, as well as implement environmental policies that focus on international coordination and global supply chain management. To develop effective policies to mitigate climate change, it is important to understand the emission accounting of the sectors comprising the global supply chain network and implement the appropriate policies. Focusing on the relationship between sectors' position in the global supply chain and its policy implications, this study develops a structural position analysis framework based on input-output analysis. We calculated the gross emissions from all supply chain paths passing through a specific sector and transaction using the HEM and decomposed them into three types: production-oriented emissions (POEs), consumption-oriented emissions (COEs), and betweenness-oriented emissions (BOEs). Our framework reveals high-priority sectors and transactions, and the best strategies for CO_2 emission reduction in the global supply chain. We also expand the discussion on emission reduction policies to inter-sectoral and international collaboration based on a multi-regional input-output table, focusing on cross-border transactions. The results indicate that Chinese industries with large HEM impacts are the production- and betweenness-oriented, while the U.S. has industries with large HEM impacts in the betweenness- and consumption-oriented, similar to Europe. In terms of budget allocation for climate mitigation, the main focus in China is on reducing emission intensity and the use of intermediate goods with high emissions for the manufacturing sectors, while, in the U.S. and Europe, policies to promote the reduction of direct emissions from production of goods for exports through carbon taxes are important. Policy makers in those countries joint emission reduction policies should be coordinated to take advantage of each country's emission reduction potential. Our findings suggest that, in Asian countries, carbon emissions originate mainly from intermediate goods trades, suggesting the need for mandatory life cycle assessment reporting and emissions disclosure. Moreover, the Asian region has many large betweenness-oriented trades in terms of its overall industry and is a hub connecting upstream industries with high emission intensity and extensive final consumption in each region. Taking advantage of the vast trading blocs (e.g., the Trans-Pacific Partnership and the Regional Comprehensive Economic Partnership), thorough supply chain emission control and the establishment of a green supply chain in Asia will greatly contribute to global emission reduction. Further, we identify that the structural position of basic iron sector in China, Latin America, and Europe are similar. If our framework is to be carried out within global network, it could be coordinated with these countries with a similar industrial structural position to promote a common "transition" strategy. Furthermore, by providing new incentives to reduce HEM impact in addition to the assigned amount and credits of carbon emissions under the Paris Agreement, further emission reduction can be achieved through clean development mechanism (CDM) and Joint Implementation (JI) if countries involved in emissions (intermediate inducers) that have been previously overlooked can be identified. To reduce GHG emissions, including those in developing countries, it is necessary to create new rules to keep the benefits of CDM for emitting countries. In this context, it is imperative to add value to the reduction potential of the entire supply chain by providing new incentives for consumption policies and the establishment of green supply chains.

Impact of Promoting the Use of Wood in Buildings on CO2 Emissions in Japan

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - III
Author: Ai NAGATA
Co-Authors: Sora MATSUSHIMA, Seiya IMADA, Shigemi KAGAWA

Toward the realization of a decarbonized society, the use of wood, a material with lower environmental impact, is being promoted in buildings in Japan. A look at the floor area of construction starts in Japan shows that although the share of 'low-rise' residential construction starts made of wood is higher than that made of other materials such as concrete, the number of new housing starts is on a downward trend during the period between 2000 and 2020. On the other hand, it is important to note that the share of 'medium- and high-rise' residential construction starts made of wood is considerably lower than that made of other materials such as concrete due to engineering problems. The Japanese government has enforced the Law on the Promotion of the Use of Wood in Public Buildings since 2010 and promoted the use of wood to reduce CO2 emissions.

An important research question is to what extent CO2 emissions can be mitigated through the promotion of the use of wood in building construction? To the best of our knowledge, few studies addressed this research question, however they did not provide a comprehensive analysis framework to estimate the change in life-cycle CO2 emissions associated with expanding the use of wood in building construction instead of the use of other materials. To the best of our knowledge, this study is the first attempt to develop a new life-cycle analysis framework with a focus of detailed construction technologies and to estimate the life-cycle CO2 emissions under the construction technology change scenarios. Based on the Japanese Input-Output Tables in 2015 and the Embodied Energy and Emission Intensity Data (3EID) for Japan Using Input-Output Tables provided by the National Institute for Environmental Studies of Japan, we firstly calculated the amount of direct and indirect CO2 emissions (i.e., carbon footprint) induced by the final demand of residential construction (wooden), residential construction (non-wooden), non-residential construction (wooden), and non-residential construction (non-wooden) in Japan in 2015.

Secondly, we estimated the carbon footprint of buildings in 2030 based on the medium- to long-term construction investment in 2030 forecasted by the Research Institute of Construction and Economy, and analyzed the changes in the carbon footprint of buildings during the period between 2015 and 2030. The results show that construction investment level for different construction technologies will be 98% for residential construction (wooden), 100% for residential construction (non-wooden), 134% for non-residential construction (wooden), and 134% for non-residential construction (non-wooden) in 2030 compared to 2015. We found that if there are no technological changes in buildings, the total of the carbon footprint of buildings (i.e., residential construction (wooden), residential construction (non-wooden), non-residential construction (wooden), and non-residential construction (non-wooden)) is shown to be 116% in 2030 compared to 2015.

We further found that under the scenario for replacing non-wooden buildings with wooden buildings, the amount of direct and indirect CO2 emissions from the manufacture of buildings will be significantly reduced due to a rapid replacement of concrete with relatively higher CO2 emission intensity mainly used in reinforced concrete (RC) construction (the main construction method for nonresidential buildings) with lumber with relatively lower emission intensity. Finally, we suggest a demand-side policy (i.e., subsidy policy and/or ecolabeling policy) aiming at the

promotion of 'medium- and high-rise' residential construction starts made of wood.

Analysis of the regional socio-economic effects of the basic income in South Korea

Topic: Input-Output Analysis: Income Distribution Policies - II
Author: Sang-Ho NAM

Analysis of the regional socio-economic effects of the basic income in South Korea

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Abstract

The basic income debate is an important issue in South Korea. This debate was quite hot especially in the national president election campaign in the first quarter of 2022.

Proponents of the basic income argue that basic income is the most efficient policy instrument in reducing inequality and poverty. Empirical results from partial equilibrium analysis, which mostly focus on the distributional and/or poverty issues, advocates basic income.

On the other hand, Opponents of the basic income do not put much credit on the distributional improvements. They emphasize that we need to consider other aspects of the economy.

In this paper, we apply a CGE-Microsimulation approach to investigate the pros and cons of the basic income in South Korea.
The basic tool is the TERM-Korea Regional CGE model, which uses the most recent input-output table of the South Korean economy.

We first present national results, and sectoral results follows next. In the summary part of the paper, we present the policy implications for the basic income scenario.

Keywords: basic income, socio-economic effect, regional analysis, CGE model, TERM-Korea

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1. the research question;

This paper analyzes the socio-economic effects of the hypothetical introduction of basic income in South Korea. South Korea is a very dynamic country and experienced rapid increase in the welfare expenditure in last 10 years.

Therefore, there is a huge need for the evaluation of the proposed policy effectiveness both at the pre-policy stage and ex-pose stage. The regional CGE model developed here is expected to serve as a major tool for the welfare policy effectiveness of the South Korean Government.

2. the method used;

In this paper, CGE-Microsimulation model is used. First, we extend existing national CGE model to distinguish 17 provinces in South Korea in bottom-up manner.

Next, 229 county data are used in a top-down manner. With this CGE-MS model we can analyze regional income distribution and/or poverty at the county level.

3. the data used (if any); and

We start with the 2015 inter-regional input-output table from the Bank of Korea released in June 2019. Later we use National Income Account data to update the benchmark database for the TERM-Korea model. We also combined the regional data on population, income and consumption at the county level.

4. the novelty of the research.

The TERM model stands for "The Enormous Regional Model" and first developed in 2002 by Professor Mark Horridge and Professor Glyn Wittwer of the Monash University (they both are now with Victoria University) in Melbourne, Australia. The TERM model is rooted from the Monash CGE model developed by Professor Peter Dixon and Professor Maureen Rimmer.

The TERM-Korea model is the first regional CGE model that distinguished all the 19 provinces in South Korea. In addition, we combined the information at the county level to the TERM-Korea model. This will be the fundamental workhorse for the analysis of welfare policy in South Korea.

Identifying Technology Clusters with Similar Production Technologies and Its Policy Implications

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - VI
Author: Waka NISHIFUJI
Co-Authors: Haruka MITOMA, Kayoko SHIRONITTA, Shigemi KAGAWA

The Paris Agreement (2015) argued that, as a world-wide effort to deal with the threat of climate change, developed countries need to achieve financing, technology development, and technology transfer to support developing countries. To achieve the common goal of reducing global CO_2 emissions, it is important for both technology owners (e.g., developed countries) and users (e.g., developing countries) to have a deeper understanding of the environmental impacts derived from their own production technologies. And through effective policies, countries need to efficiently improve their production technologies toward building a low-carbon society.

We should also pay attention to the environmental impacts of imported goods as well as domestic goods. Countries should understand the environmental impacts derived from the production technologies of their trade partners and take a responsibility for the indirect environmental impacts they induced by trade, either by carrying out technology transfers from their own countries to import partners or by supporting technology transfers from other countries.

Who should offer their technology and who should be offered it is the important question to achieve mitigation of CO_2 emissions through a technology transfer. The Paris Agreement does not provide workshop guidelines or opportunities to discuss how countries achieve CO_2

reductions through a technology transfer. Many studies discussed the effect of technology transfer based on the grouping of countries according to the size of economy (e.g., GDP). However, one concern that is often raised when implementing technology transfer is the disparity in technology levels between the technology offering countries and offered countries. It has been argued that if the disparity is too large, the cost of introducing and operating new technologies may be enormous and the technology transfer itself may be ineffective (Ando, 2003). Therefore, it is important to focus on the similarity in the production technologies to develop technology transfers successfully.

This study is the first attempt to divide countries in groups according to the similarity of their production technologies and estimate the CO2 emission reduction potentials achieved by technology transfers between the groups.

We used the World Input-Output Database (WIOD) and grouped the production structures (i.e., input coefficient matrices) of 43 countries and regions in 2014 by applying the Ward method, a hierarchical clustering method. It should be noted that the cluster analysis identifies a specific cluster belonging to countries and regions with similar production technologies. The technology cluster analysis based on the input-output tables sheds light on an importance of technology transfers between technology clusters.

As a result, six clusters were identified from the WIOD database in 2014. Furthermore, we estimated the carbon footprint (consumption-based CO2 emissions) of each technology cluster, and we found that there exists a large gap in the average carbon footprint of the countries belonging to the clusters. The comparison of the carbon footprints of the technology clusters founded in this study will help governments understand their own environmentally inefficient industries and suggest countries that they should request technology transfer for those industries. We also found that technology transfer according to the results of this study have the potential to reduce CO2 emissions in a country's manufacturing industry by 10 to 20% on average.

Economic, Social and Environmental Consequences of the Decline in Foreign Tourist Demand in Japan due to the COVID-19 Pandemic

Topic: YSI and Development Programme - V - Discussants: André Carrascal and Michael L. Lahr
Author: Yusuke OGA
Co-Authors: Shigemi KAGAWA

Travel restrictions owing to the COVID-19 pandemic dramatically reduced the number of foreign visitors to Japan. Although Japan has doubled inbound revenue since 2012, that of 2020 was approximately 85% less than previous year due to the pandemic. Moreover, tourism is closely connected to various industries such as eating services. Therefore, the loss of tourism demand spills over into other domestic industries. The impacts spread across economy, society, and environment in Japan. When policymakers consider countermeasures against the COVID-19 pandemic, they should comprehensively evaluate the economic, social, and environmental impacts of the pandemic and efficiently allocate limited resources to important stakeholders. However, there are some difficulties in quantifying the impacts of the pandemic exactly and comprehensively. Considering this situation, the research question of this study is to evaluate the exact impacts of the pandemic and identify stakeholders indirectly affected by inbound markets because industries are closely connected in various markets.

The novelties of this study are to identify important stakeholders (i.e., key industrial sectors) in the supply chains associated with the inbound final demand and to suggest concrete policies to not only recover the economic activities centered around the key sectors largely affected by the pandemic but also mitigate CO2 emissions associated with the tourism supply chains.

We developed a novel analysis framework combining an input-output analysis framework with a counterfactual model (with and without the pandemic) to determine the final demand by foreign visitors and to quantify the direct and indirect value-added losses (economic impact), employment-opportunities losses (social impact), and CO2 reductions (environmental impact) caused by the decline in foreign tourism in Japan. In the counterfactual model, we used a linear trend model specified by using the ordinary least squares method.

We used the number of foreign visitors to Japan from the Japan National Tourism Organization, the per capita travel consumptions of visitors from 21 countries and regions to Japan from the Japan Tourism Agency was used to estimate, the 2015 input-output table from the Ministry of Internal Affairs and Communications, and the embodied energy and emission intensity data from 3EID (Nansai et al., 2022).

These direct losses of final demand directly and indirectly induced 5.8 trillion JPY (44.1 billion U.S.$) of value-added loss (economic impact), loss of labor opportunities of 980 thousand people (social impact), and 14.1 Mt-CO2 of CO2 reduction (environmental impact). Our data, which identified the impacts by industrial sectors, can be used to provide evaluation criteria for the distribution of limited resource taking into those three aspects.

These three aspects (economic, social, and environmental) were strongly affected by hotels, eating and drinking services, and rail passenger transport, which account for a large part of tourist consumption tendency. In particular, accommodations and eating and drinking services induce a huge electricity demand and indirectly contribute to the reduction of CO2 emissions from the electric-supply industry. Accordingly, we suggest two important factors for the development of the most sustainable and efficient countermeasures: recovery of economic and social losses and reduction of the CO2 emissions associated with the inbound final demand. Firstly, to recover the economic and social loss, we recommend that the government should offer stipends for each sector depending on the magnitude of the loss, and our data can be used to provide evaluation criteria for the distribution. Policymakers should consider ways to restore the economy, identified by the amount of value-added loss. The results of our analysis cover not only the direct effect, which is easy to recognize without any calculations, but also the indirect and income effects, which are more difficult to estimate and more easily overlooked. Therefore, if policymakers aim to consider ways to reduce unemployment risks due to the pandemic, they can use the result of the social impact in the same way as the economic impact. Secondly, we recommend that the government incorporates a mechanism into the counter-COVID-19 measures to determine the incentives that should be distributed to the industries to improve business conditions while reducing their environmental impact. The main source of CO2 emissions in Japan's inbound-related supply chain is the sector that generates electricity to supply the hotel and eating and drinking service industries. Ultimately, efforts must be made to reduce the CO2 emissions associated with economic activities in the two industries.

Do the metrics matter? Region-specific carbon footprints of Brazilian products

Topic: Input-Output Modelling: Sustainable Production and Consumption Policies - II
Author: Thais Diniz OLIVEIRA
Co-Authors: Ana Clara DURAN, Paula C. PEREDA, Ademir ROCHA

Sustainable development has become a global commitment to ensure the continuity of future generations while allowing countries to develop without exceeding safe boundaries. Achieving sustainable production and consumption patterns involves adopting strategies to minimise environmental and social costs. From the production side, it implies decoupling economic growth from environmental degradation, increasing the efficiency of natural resources use. With regard to consumption, it is related to the process of purchasing, consuming, and disposing of products, including lifestyle changes to limit over-use. However, production and consumption sustainability can be assessed as long as environmental information is available, requiring better measurements and indicators.

This analysis represents a significant advancement in the quantification of carbon footprints in Brazil. By using an environmental extended input-output approach and incorporating detailed emission data, it links environmental issues and production and consumption. Unlike previous studies, this research provides country-specific carbon footprint information for each Brazilian state, accounting for emissions from all sources including agriculture, land use, energy use, industrial process, and waste. Most studies to date are limited to energy-based emissions or used life cycle databases that may not be nationally representative, and disregard emissions from land use and deforestation, resulting in underestimated carbon footprints. Including these emissions in the carbon footprint of Brazilian products is highly relevant given that they represent a large share of total national emissions but also because disregarding them may undermine efforts to meet the climate commitments.

To fill this gap, we adopted an empirical approach based on an estimated Multi-Regional Input-Output (MRIO) matrix for 2015 and emissions data from Mapbiomas and SEEG to develop a comprehensive understanding of the carbon intensity of 128 products across Brazilian states. To calculate the carbon intensity coefficient (tonnes of CO2e/US$ million), we first created a correspondence between emissions sources and the MRIO products. Mapbiomas database captures the loss of natural area (in pixels) converted into carbon biomass while SEEG details emissions of other sources at disaggregated levels and for several Greenhouse Gases (GHGs).

Our evidence shows that the metrics matter when quantifying the carbon footprints of products in Brazil, particularly those food-related given the large economic and environmental heterogeneity across regions. This reflects the particularities of each state in terms of productive structure as well as socio-ecological system and emissions profile. For example, land use represents 50% of the nationwide carbon footprint of cattle and other live animals and animal products while in Para

 it corresponds to 77% of its total carbon footprint. This is the major emissions-intensive MRIO product in Brazil.

The findings highlight the importance of considering region-specific car- bon footprints rather than compiled databases in order to avoid misleading policy decisions aimed at promoting sustainability. To investigate the effects of implementing mitigation policies, the paper proceeds with an estimation of a Quadratic Almost Ideal Demand System (QUAIDS) from household

expenditure data, the Brazilian Household Budget Survey (POF), reconciled with the MRIO products in the next stage. While improved supply-side production techniques have the potential to mitigate the environmental impact of production, there is also significant room for demand-side options, including shifts towards more sustainable and healthier dietary choices. The next stage will consider policies to address these issues.

Price re-interpretations of the basic IO quantity models result in the ultimate input-output equations

Topic: Input-Output Theory and Methodology - I
Author: Jan OOSTERHAVEN

This note shows that Leontief's well-known demand-driven input-output (IO) quantity model may also be interpreted as the almost unknown revenue-pull IO price model, but measured in value terms instead of in prices. It is also shown how these two demand-driven models may be combined into a single ultimate demand-driven IO equation. An analogous result holds for the supply-driven quantity model and the cost-push price model, which results in a single ultimate supply-driven IO equation. The new price interpretation of the Leontief quantity model opens up hitherto unused possibilities to simulate interindustry demand-driven inflation processes, just as the price interpretation of the Ghosh quantity model enables simulations of supply-driven inflation processes.

Keywords Leontief model, Ghosh model, Supply-driven inflation, Demand-driven inflation, Ultimate input-output equations

Sustainability of Spanish households' consumption: A Miyazawa's extended input-output model

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - X
Author: Pilar OSORIO
Co-Authors: Maria Angeles CADARSO, Maria A. TOBARRA-GOMEZ

Climate change mitigation is one of the major challenges to be addressed during this decade worldwide. Tackling it will require a rapid response and a full understanding of demand-side drivers. According to the 2030 Agenda of the United Nations and the European Green Pact of the European Union, analysing the sustainability of household consumption is a priority objective to fulfill the target set in the Paris Agreement. In fact, the latest IPCC report (IPCC, 2022) estimates that changes in household consumption patterns can have a mitigation potential of 40-70%.

To evaluate household consumption sustainability, multiregional input-output models are a useful tool widely used that quantifies all the emissions embedded in the production process through the global value chains, due to an increment in final demand. However, Leontief's basic model has a limited scope since it only contains output multipliers and maintains all final demand as exogenous. As an improvement, Miyazawa (1976) introduced some novelties, closing the model by understanding households as a decision-making unit and introducing it through consumption coefficients and labour income coefficients, which are reflected in income multipliers.

This close model provides a deeply understand the nexus production-consumption and the total effects of an increase in final demand (other than consumption) through the global value chains

by sector and regions (direct and indirect effects) and induced consumption activities (Miller and Blair (2009), Temursho and Hewings (2021)). Furthermore, this overview of the complex nexus output-income should be complemented with an environmental dimension. Output production has certain emissions associated, and, at the same time, output implies the generation of income and more additional emissions are generated due to the consumption of that income.

In this paper, we aim to evaluate consumption sustainability in Spanish households by using the Miyazawa multipliers and extensions in an environmentally extended multiregional input-output model for the first time to our knowledge. As contributions, this research allows us to analyse the initial emissions generated by an increase in the autonomous demand (measured in CO_2), and the additional emissions generated due to the consumption of income by regions and sectors. Following Miyazawa's model, the multiregional enlarged emissions multiplier, the interregional income multiplier, and the multisectoral income multipliers are calculated, taking only Spain as the origin region. To this end, we use OECD Inter-Country Input-Output (OECD, 2021a) Table for 2018, and additional OECD data of carbon emissions (OECD, 2021b) and compensation of employees (OECD, 2021c), estimating missing information for the ROW region. The model is run for 67 regions and 45 industries. However, results are presented aggregated into 7 regions (Spain, Rest of Europe, China, NAFTA –which contains Canada, EEUU, Mexico–, BRIIAT –which contains Brazil, Russia, India, Indonesia, Australia and Turkey– , East Asia –which contains Japan, Korea, Laos, Malasya, Myanmar, Phillippines, Singapore, Thailand, Vietnam– and Rest of the World) and 16 sectors.

In comparison to Leontief's basic model, this model enables a more comprehensive results of sectoral carbon responsibilities, including induced consumption, mapping out the changes in emissions responsibility when the nexus production-consumption is considered. In addition, it allows us to analyse how emissions vary due to changes in the distribution of household consumption or changes in the matrix of consumption coefficients.

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Generational effects in UK Household Carbon Footprints

Topic: Consumption-Based Accounts of Household Types
Author: Anne OWEN
Co-Authors: Milena BUCHS

Aligning household expenditure surveys with Environmentally-Extended Input-Output databases allows for the calculation of carbon consumption-based accounts of household types. Many studies have used this process to understand the differing Carbon Footprints of income groups, age groups and household located in different subnational regions. The United Kingdom's Living Costs and Food Survey (LCFS) has origins in the 1950s and the modern-day version of this household survey has a consistent dataset with a time series of 20 years from 2001 to 2020. The UK is also one of the few countries in the world to report its Consumption-based Greenhouse Gas Emissions as an Official Statistic and presents these as a timeseries from 1990-2020. These are calculated using the UKMRIO database.

In this paper we use the LCFS aligned with the UKMRIO, and rather than calculating the carbon footprints of age groups, we follow cohorts through time, assessing the changing impact of the Greatest, Silent, Babyboomer, Gen X, Millennial and Gen Z generations. We find that in the UK, households increase their emissions as they reach retirement age, then reduce once they reach very old age. But there may also be a generational effect in play. Babyboomers took on an even greater share of emissions than the generation before them as they reached retirement, but Gen X did not increase their emissions share to the levels of Babyboomers in middle age. In 2020, Millennials use even less of their fair share compared to Gen X at a similar life stage.

Between 2001 and 2020 the UK's Carbon Footprint reduced, but the drivers behind this reduction are complex. There have been reductions in the emissions intensity of products mainly due to the decarbonisation of the electricity sector. There have also been reductions due to a change in overall spend after the global financial crisis in 2008 and the COVID-19 pandemic in 2020. We also observe differences in the reduction by generation. But is there evidence of a 'generational effect'? Has the UK's footprint reduced due to a reduction in the number of 'high-carbon' Babyboomer and Silent generation headed households and an increase in the number of 'low-carbon' Millennials, or is the reduction due to the change in spend by households as they age? Will future generations change their expenditure habits as the age in the same manner as previous generations or is there evidence that spend patterns are unique to cohorts?

To unravel the story of the change in UK consumption emissions and better understand the role of generational change we use a structural decomposition analysis to determine the drivers of difference in carbon footprint. We first assess each generational cohort to determine the role of population change, total spend and spend by product on their changing impact. We then combine the decompositions to the entire UK to quantify the role of generational change. Understanding the differing cohort impacts and their contribution to emissions change has use in future climate policy as we strive to both predict future consumption emissions pathways and consider targeted emissions reduction policies by different types of household.

Constructing a China's provincial multi-year Multi-Regional Input-Output database: 1987-2017

Topic: Input-Output Accounts - II
Author: Chen PAN
Co-Authors: Jianwu HE, Shantong LI

China has a large territory and numerous provinces with different resource endowments, locational conditions, and development foundations. On the one hand, the large variances mean that when investigating issues about China, not only the nation-wide but also the provincial analysis should be involved. On the other hand, these variances lead to a large amount of interprovincial trade and a complex trade network. It is necessary to take the role of trade into consideration when analyzing the economy-related issues. As an efficient method to describe the economic links between regions, the Multi-Regional Input-Output (MRIO) model has been widely used to analyze the economy-related issues, such as carbon emission, pollutions, resources, value-added, etc. However, as China's nation-wide data have been well developed, the regional data are still fragmental. There is a lack of regional MRIO database of a long time span constructed with consistent methods, especially at the provincial level.

To fill this gap, this study aims to construct a China's provincial multi-year MRIO database with the principles of keeping reliable information as much as possible, following the 'bottom-up' method, using the National Account data as a benchmark, and having no entrepôt. We collect Chinese provincial Single-Regional Input-Output (SRIO) tables for 1987, 1992, 1997, 2002, 2007, 2012, and 2017, and reconstruct the data of international trade and domestic trade for each province in the provincial SRIO tables using the customs data. The method of minimizing cross entropy and gravity model are then used to estimate the interprovincial trade flows based on the railway transportation data of goods, as well as several other datasets. With all these information, based on the Chenery-Moses model, we finally build a multi-year MRIO database of the mainland China covering 31 provinces and 42 sectors. We also analyze the characteristics of Chinese provincial economy from 1987 to 2017 using multipliers based on the MRIO database as an example of application.

This study constructs a Chinese provincial MRIO database with consistent methods throughout the years, covering the longest time span when China's provincial SRIO tables available. The database provides a foundation for studies about China's economy-related issues at the provincial level, such as the domestic and global value chains, inter-regional emission flows, regional coordinated development, and related regional policy researches, etc.

Modeling the labor demand of the construction industry with regard to the implementation of the green transformation in Germany.

Topic: Dynamic Modelling of Economic Impacts of GHG Reductions
Author: Frederik PARTON

With the "Fit for 55 Package", the EU Commission sets the target of reducing the European Union's greenhouse gas emissions by 55 percent by 2030 in order to meet the targets of the Paris Agreement on Climate Change. In Germany, the targets are specified by the Climate Protection Act. This provides for a reduction of CO_2 emissions by 65% by 2030 compared with 1990 levels, and in 2045 Germany is to achieve greenhouse gas neutrality, i.e. there is to be a balance

between greenhouse gas emissions and their reduction. In order to achieve the overall goal of emission savings, the Climate Protection Act provides a monitoring system for the energy-, industrial-, transport-, buildings- and agriculture sector.

The targets for the buildings sector are ambitious. The sector already showed an excess of 2 million metric tons of CO_2 for 2021 compared with the permitted level of 113 million metric tons of CO_2 equivalents. As a result, the relevant ministries submitted an emergency program to ensure compliance with the sector's annual emission levels for the following years. The emergency program assumes, that the medium- and long-term climate targets in the buildings sector only can be achieved if there is a rapid and significant increase in the pace of renovation, including both an increase in the rate and depth of renovation, and if the heat supply is decarbonized at the same time. In concrete terms, this means implementing or promoting measures in the areas of renovation and insulation of existing buildings, promotion of new methods such as serial renovation, optimization of existing heating systems and increased installation of heat pumps.

All the measures mentioned in the emergency program require a large number of additional qualified workers from professions in the construction industry (Helmrich et al. 2021), an industry in which 58% (DIHK 2023) of companies already complain about shortages of skilled workers. It is therefore of central interest to political decision-makers to know the future medium- and long-term demand for employees in the construction sector, broken down as deeply as possible by economic sector, in order to incorporate this knowledge into education policy decisions, to counteract the shortage of skilled workers and to make the green transformation a success.

This study addresses the above-mentioned question with a long-term forecast of the labor demand in the German construction sector until 2050. The labor demand of the construction sector is differentiated down to the 2-digit level of the classification of economic activities (WZ-2008). This is of particular importance because the implementation of the green transformation, i.e., more energy-efficient refurbishment and optimization of heating systems, will primarily require skilled workers in the finishing trades (WZ-43) and less in building construction (WZ-41) or civil engineering (WZ-42).

The future labor demand of the construction sector is modelled within the new 'Construction module' of the Q-INFORGE model. This is an extension of the INFORUM-Model INFORGE (Ahlert et al. 2009, Becker et al. 2022) (INterindustry FORecasting Germany) of the Institute of Economic Structures Research (GWS www.gws-os.com, Germany Osnabrück). Q-INFORGE is developed together with the Institute for Employment Research in Nürnberg (IAB) and the Federal Institute for Vocational Education and Training in Bonn (BIBB). Q stands for the QuBe-project - qualifications and occupations in the future (www.qube-projekt.de). The QuBe-project has been working together since 2007 and, among other things, produces the skilled labour monitoring for the Federal Ministry of Labour and Social Affairs in Germany since 2016. The standard Q-INFORGE model is based on the system of national accounts and uses the IO-Tables to project eg. production, labour demand and professions. Each economic sector is modelled in detail. Final and intermediate demand, unit costs and prices have impact on the specific production and the employment of 63 economic sectors. The behavioural equations are econometrically estimated using data from 1991 to 2022. The model runs year by year from 2023 until 2050. For this study, the new 'construction module' is used, which expands the Q-INFORGE model and makes it possible to split what was previously considered the construction industry into building construction (WZ-41) civil engineering (WZ-42) and finishing trades (WZ-43).

In the presentation, the modelling of labor demand within the 'construction module' is discussed in detail and the empirical results of the forecast of labor demand until 2050 for building

construction (WZ-41), civil engineering (WZ-42) and finishing trades (WZ-43) are presented.

A Stock-Flow Consistent Input-Output model to study the relevance of interindustry product flows in green energy transition policies

Topic: Recent Developments in Stock-Flow Consistent Input-Output Modelling - I
Author: Mattia PETTENA
Co-Authors: Marco RABERTO

Our model aims to provide relevant contributions to the literature through innovations in modelling methodology and by addressing research questions related to the energy transition.

As for the modelling methodology, we build what is one of the first macroeconomic models that fully integrates the methodology underlying the Leontief input-output quantity model with heterodox dynamic macro-modelling. In addition to a household, a bank, a government, and a central bank, our framework features six highly interdependent industrial sectors, producing five types of goods: minerals, fossil fuels, manufacturing goods, miscellaneous goods/services, and electricity through either renewables or fossil fuels. Each industry needs intermediate inputs and investment goods from all the others in order to produce.

We improve upon the Leontief model by (i) introducing production constraints that can arise from limits in the availability of capital or intermediate inputs—with rationing in the supply of goods by the constrained sectors that may follow either the Mixed model approach or a strict proportional rationing rule; and (ii) by allowing for perfect substitutability between green and brown electricity (with grid priority for the first), thereby departing from the assumption of perfect complementarity between intermediate inputs that is typical of input-output models. These two novelties of our model introduce non-linearity in an otherwise linear input-output industrial production framework.

The model follows the Stock-Flow Consistent macroeconomic methodology that has gained increasing popularity during the last fifteen years.

The model is intended to represent the world economy, with a single representative country. Industries' technical coefficients, as well as their greenhouse gas (GHG) emission intensities, are calibrated from the Exiobase dataset. The latter also provides the proportions of goods involved in industries' investment process. Industries' initial capital stocks, their capital productivities and capital depreciation rates are estimated from the EuKlems database.

Two paths are exogenously set regarding the development of renewable power capacity: a business-as-usual scenario, and a Net Zero by 2050 scenario. The model shows the different implications of the two scenarios in terms of GDP growth, investment, GHG emissions, electricity and fossil fuels requirements, and industries' relative weight. For instance, the Net Zero scenario features a relatively higher weight of the minerals industry, compared to the BAU scenario, due to the critical role minerals play in the development of renewable power capacity. While the Net Zero scenario is characterized by lower intermediate input requirements in terms of technical coefficients, thereby suggesting a lower production level and thus a lower overall implied investment level compared to the BAU, the higher investments in the electricity sector due to the green transition may more than balance off.

The macroeconomic and environmental effects of the energy transition depend largely on the capital intensity and energy intensity of the green electricity sector, which in our model are still arbitrary to some degree, due to lack of data. Therefore, our work explores the parameter conditions under which the Net Zero scenario may lead to lower/higher GDP growth and lower/higher GHG emissions compared to the BAU scenario.

A Comparative Assessment of Nowcasting Approaches For MRIO Databases

Topic: Methodological and Statistical Challenges for Analyses of Integration of Developing Countries in Regional and Global Value Chains - I
Author: Alec PHILLPOTTS

A Comparative Assessment of Nowcasting Approaches For MRIO Databases

The lack of timeliness of Environmentally Extended Multi-Regional Input Output (EEMRIO) tables due to data limitations and lengthy compilation processes constitutes a major constraint to enabling policy-orientated research, as well as any other real-time application. Whilst this is acknowledged by analysts and MRIO compilers, there is little in the literature that provides a comparative assessment of the methodologies capable of adopting an alternative "nowcasting" approach to create carbon multipliers.

The need for a nowcasting approach has been further exacerbated by high inflation. EEMRIOs rely on price to act as an accurate proxy for the amount consumed, and thereby associated emissions. Periods of high inflation cause the price-quantity relationship to break down as in high inflation environments, pure monetary values over-inflate the physical quantities they represent. There is a clear need to investigate the potential methods to resolve this problem, and without a robust understanding of the effects of price changes on estimates of environmental impacts, the drawbacks of using lagged data will continue to loom over the real-time deployment of EEMRIO produced carbon multipliers. Given the considerable economic, technical, and human resources required to create MRIO databases, it is apparent that utilizing more frequent, external datasets is required to nowcast MRIOs towards the present day. The use of projections and nowcasting is not alien to this context, with projections occasionally required in the compilation, balancing and revisions of MRIOs and the inclusion of nowcasted years in major databases such as EXIOBASE and FIGARO.

By grounding outputs in known official datasets, nowcasting avoids the unbounded uncertainties associated with forecasting, creating a credible justification for its deployment in contexts where the infrequency of data threatens usability. However, as MRIO databases aim to illustrate the complex and interrelated structure of the global economy, questions must be asked as to how granular exogenous data must be to produce accurate results, particularly as dynamic changes in structure are caused by various moving parts.

Focusing on price, this paper conducts an empirical comparative assessment on the methodologies aimed at adjusting annual carbon multipliers against benchmark counterparts, created by the UKMRIO. These methodologies will be assessed by a set of measurements of goodness of fit, selected from the existing literature, to provide rankings of accuracy, allowing for comparison across both year and industry of reference. The empirical analysis will shed new light on the necessary parameters for effective nowcasting, testing across the years 2001 and 2020 to explore the potential difficulties with nowcasting in changing economic conditions. Following this

multiplier-level assessment, nowcasted multipliers are assigned to transaction data generated by a sample of commercial clients (n=275) of a large retail bank in the United Kingdom. This provides opportunity to draw comparisons against objective sources of emission data, such as the Streamlined Energy and Carbon Reports (SECR) declared in company annual accounts.

The outcome of this assessment is intended to illustrate the relationship between differences in the complexities of approaches and the accuracy of yielded results, considering the intrinsic uncertainties associated with any form of projection. The outputs of this study can then form a basis for closing the gap between EEMRIO's reference year and year of application, providing a meaningful solution to a substantial barrier for EEMRIO application.

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The Carbon Footprint in the EU Climate Law: an opportunity for Official Inter-Country Input-Output Tables?

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - VII
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During the first two decades of this century, there has been an explosion of studies calculating carbon footprints, that is, the overall upstream greenhouse gas (GHG) emissions to maintain the final demand of a country or a region using inter-country input-output (ICIO) databases, such as Eora, WIOD or Exiobase. Such analyses have focused on identifying the drivers of GHG emissions along supply chains, linking source of GHG emissions upstream, known as direct emissions, with the industries and households downstream that consume products made with polluting inputs, known as embedded or indirect emissions. Another crucial aspect analysed in such works was carbon leakage. This refers to the extent to which more stringent environmental regulations in one region could cause the production of more carbon-intensive industries to be transferred to regions with lower climate ambitions. However, these environmental ICIO databases differ in their compilation methods and underlying data, and do not replicate official national supply and use, and input output tables. For this reason, although they are valuable tools for setting the policy agenda, it has been argued that they cannot be used for monitoring policy impact. Single country National Accounts Consistent (SNAC) ICIO databases found in the literature were developed to counteract this situation, namely, to analyse the role of a given economy in global supply chains. Nevertheless, recent developments towards compiling official or quasi-official ICIO databases, such as the OECD's, ECLAC's or Eurostat's FIGARO ICIO databases, and their gradual harmonization of compilation methods and data inputs, could bring about a change in this situation. In addition, being part of a regular production process, such as the FIGARO ICIO database, which became an official Eurostat's statistic in 2022 with annual new releases, ensures timely production and prevents risks of discontinuation, which can occur in pilot academia-based ICIO projects.

In this paper, we revisit the question addressed in the SNAC literature, which is to what extent ICIO databases that are fully consistent with official national input-output statistics can lead to new potential applications in policymaking. We focus on the European Union (EU) policies to combat climate change, specifically on the application of official ICIO within two frameworks: i) as

monitoring indicators in the proposal for a new Carbon Border Adjustment Mechanism (CBAM), and ii) as binding targets in the EU climate law and national energy and climate plans (NECPs). The main purpose of the CBAM is to prevent carbon leakage, as the EU's increasing ambitions increases this risk (e.g. the intermediate target of reducing net GHG emissions by 2030, compared to 1990 levels, was recently increased from 40% to 55%). Accordingly, the CBAM will ensure that the same carbon price is applied to domestic and imported products, providing incentives to foreign industries to innovate and reduce emissions. The legislative proposal for establishing a CBAM was put forward in mid-2021, and currently is awaiting EU Parliament's first reading position. However, the proposal do not detail how the level of emissions in the EU will be measured. The document mentions unspecific 'emission statistics', 'sector statistics' or 'trade statistics'. These statistics could inform on trade flows between CBAM sectors, and embedded CO_2 emissions, but computing the overall impact of potential carbon leakage policies is certainly more challenging. We argue that this could be achieved using the FIGARO ICIO.

Further, despite the commitment of EU authorities to prevent carbon leakage, the main progress indicators in the European Climate Law adopt a territorial perspective, e.g. EU climate-neutrality by 2050. This is also the case of most NECPs, although there are countries, such as France, currently considering including carbon footprint indicators to monitor the impact of their national mitigation policies. It is clear, therefore, that there exist a policymaking need for indicators complementing the territorial perspective. In this paper, we provide an exploratory assessment of the roadmap for such a change in paradigm, paying special attention to the main methodological limitations (e.g. shift from survey to modelling as the predominant approaches) and obstacles of political nature (e.g. in climate diplomacy). We conclude that FIGARO ICIO-based carbon footprint indicators could be employed in both frameworks, as complementary impact measure of CBAM and as a binding target in national and EU laws.

The Economic and Environmental Consequences of the Electric Vehicle Transition in India

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - III
Author: Vishnu Sivadasa PRABHU
Co-Authors: Kakali MUKHOPADHYAY

Over the past decade a worldwide, collaborative resolution towards promoting environmentally sustainable business strategies and products has been witnessed with the pro-active participation of developed and developing countries. Such global partnerships have been promoted and solidified by the United Nations through resolutions such as the SDG 2030, Paris Declaration on Electro-Mobility and Climate Change, 2015 and the most recent being the COP27 event 2022 in Egypt. In pursuit of decarbonization strategies, the global automobile industry has been confronted with structural changes brought forth by the advent of the Electric Vehicles (EVs) revolution.

To this end, India is pursuing a 'twin-transition trajectory' with the expansion of RE sources in the power sector and the expansion of EV in the transport sector. This decarbonization strategy is aligned with India's global commitment towards SDG 2030 goals 7, 11 and 13 and the long-run target of net-zero emissions by 2070 announced during COP26 in Glasgow, UK 2021. There is tremendous scope for the adoption of EVs in the Indian automobile market, which is the seventh-largest commercial vehicle manufacturer, fifth-largest car manufacturer and the largest two-wheeler manufacturer in the world. The government has also announced an ambitious long-term target of achieving a 30% share of EV sales by 2030. Despite increasing policy push for

EV adoption, its share in the Indian automobile market remains negligible. As of 2022, the total EV sales constitute only 0.61% of the registered motor vehicles in India, thus highlighting a steep gap to be covered in the next eight years to achieve the target.

The EV battery is the most important component of an EV, constituting 35-50% value addition. The Lithium (Li)–ion batteries are the optimal choice for EVs because of declining cost prices, advanced manufacturing technology, higher lifespan, low weight and high energy storage potential. Currently, China has a market monopoly over Li-ion batteries, with 70% production capacity for cathodes and 85% for anodes and half of the lithium, cobalt and graphite processing and refining capacity in the world. Given this scenario, India is expected to depend on China for raw materials supply for EV battery manufacturing. Nevertheless, with the easy availability of low-cost labour and the government's incentivisation to encourage capital investment in the industry, the country is expected to witness significant economic impact by steadily increasing its battery manufacturing capacity.

With increasing EV sales, the burden on the power sector is also expected to increase in the long run-in order to meet the EV battery charging demand. As a result, not only the charging infrastructure needs to be properly planned, but the source of energy supply will determine the environmental burden on the country. Currently, almost 75% share of electricity generation is from coal-fired Thermal Power Plants which is largely attributed to the ease of access to coal. However, India aims to change the course of the power generation mix by expanding the share of solar energy, targeted at 280 GW capacity by 2030. Thus, the decarbonization strategy of the road transport sector will be determined by the synergy between the potential of EV penetration, complemented with EV charging infrastructure from clean energy sources.

The macroeconomic impact of EV battery manufacturing has been given minimal importance in Indian or global EV literature. While studies on the synergy between EV charging and electricity mix are prevalent in literature, the resulting environmental cost of power generation and air pollution from coal-TPPs and the net-macroeconomic impact has not been explored.

Given this backdrop, this study aims to fulfil the following objectives,
i.   To estimate the macroeconomic impact of EV battery manufacturing using the Indian Supply-Use Table 2018-19.
ii.   To estimate the energy and environmental burden of EV battery charging in different electricity mix scenarios, published by the Central Electricity Authority, Ministry of Power, Government of India.
iii.   To quantify the environmental cost of EV battery charging and estimate the Environmental-adjusted GDP contribution using the System of Environmental and Economic Accounting (SEEA) framework.

Preliminary results indicate an overall positive macroeconomic impact on total output, GDP and employment of 0.83%, 0.18% and 0.29%, respectively. The highest inter-industry impact is observed in mining and mineral sectors such as copper, manganese and bauxite which need to be incentivised for ramping up domestic production. Solar-powered EV battery charging vehicle leads to 96% lower CO_2 emissions compared to coal power with the elimination of SOx and NOx emissions. Thus, a simultaneous decarbonization strategy for the power and transport sector will be mutually beneficial, with the ultimate goal of achieving carbon neutrality in the

Growth of what? An exploration of pathways for global economic demand with low fossil fuel use and high employment

Topic: YSI and Development Programme - I - Discussants: Rutger Hoekstra and Joaquim J.M. Guilhoto
Author: J.Christopher PROCTOR

Growth of what? An exploration of pathways for global economic demand with low fossil fuel use and high employment

This paper is motivated by the search for economic pathways which are simultaneously environmentally and socially sustainable. One aspect of such a pathway is the relative composition of economic demand. Different sectors have very different environmental and social footprints. While much attention is paid to aggregate growth rates of economic activity, the composition of growth is crucial to understanding the actual social and environmental effects of growth. In short, to know the impact of a 2 percent growth rate, one must know which 2 percent is growing.

The research question of this paper is to identify pathways for the evolution of global economic demand which simultaneously reduce the use of fossil fuels and maintain a sufficiently high level of employment to enable social stability. To do so, the paper will use an input-output database to create a systems dynamics model which will show the energy and employment requirements of various sets of growth rates for sectoral final demand for the global economy. These sets of sectoral growth rates will represent different plausible scenarios, or pathways, which can be used as inputs in further climate-economy modeling work.

The model is based on a dataset created for the MEDEAS World integrated assessment model. MEDEAS is a large-scale systems dynamics model which combines a demand-led economic system with a representation of the bio-physical limits to growth in the shape of an energy availability feedback which constrains economic activity to the amount of energy produced within the model. At the core of the MEDEAS economic system is a 35-sector input-output framework, adapted from the World Input Output Database, with global data running from 1995 to 2009.

The paper will present a concentrated model built with the MEDEAS database. The model will include a Leontief inverse of technical coefficients, a set of sectoral energy intensities by five types of energy carriers (electricity, heat, solids, liquids, gases) and a set of sectoral labor intensities at the global level. The energy intensities include both energy used in the process of production, with data taken from the World Input Output Database, and for energy used in household consumption, with coefficients calculated separately within the MEDEAS database. Labor intensities will be adapted from the World Input Output Database.

The model will run to 2050, with energy and labor intensities evolving exogenously based on pathways taken from the literature. The technical coefficient matrix will evolve with respect to changes in the energy intensities according to the method proposed in Nieto et al. 2023. These evolutions will provide ongoing plausible background assumptions regarding the productive structure of the economy over the next thirty years. This will allow us to exogenously set differentiated rates of growth for sectoral levels of demand, and receive approximate estimations of the total energy and labor requirements of those growth paths.

To create these sets of differentiated growth rates, we will categorize sectors based on 1) the relative intensity of their use of solid, liquid and gas energy, 2) their relative labor intensity, and

3) their importance in the deployment of renewable energy. By focusing only on energy in the form of solids, liquids and gas and not of electricity and heat, we hope to directly identify reductions in the use of fossil fuels. In doing so, we assume that the rebalancing of sectoral demand will be done in the context of an energy transition, where electricity generation becomes increasingly provided by renewable sources. This also provides justification for the third consideration, as we do not want to project substantial declines in sectors which will be critical in the energy transition.

We believe that this paper will be a novel application of input-output analysis to the topic of the sectoral composition of the economy with respect to social and environmental limits. The primary output of the model will be sets of sectoral growth rates which achieve both reductions in fossil energy use and a stable level of employment. These sets will provide coherent scenarios of different economic pathways which would aid policymakers in respecting the limits set in the Paris Agreement. These demand scenarios would be fully compatible with the larger MEDEAS model, and could serve as the starting point for building more complete techno-economic scenarios.

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Redistributive effects of consumption and income from subsidies to passenger transportation in the Brazilian economy

Topic: Input-Output Analysis: Income Distribution Policies - I
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Brazilian households already spend practically the same amount on transportation and food. Despite the importance of public transport, it has become increasingly expensive for users, with increases in fares and reduced quality. Thus, it is necessary to discuss the role of subsidies to public transport, as well as the evaluation of the impact of the subsidy policy on the redistribution of household income, taking into account the peculiarities of different groups by income level. These effects can be captured by a national Dynamic Computable General Equilibrium (CGE) model, with a Social Accounting Matrix (SAM) as a data structure, detailing the generation and appropriation of income by different sources and expenditure structures, as well as the breakdown of 5 representative households and 4 passenger transport services. To evaluate the potential of the built model, this research performs the application involved with the redistributive and economic effects of subsidies in selected activities of urban public transport of passengers in the Brazilian economy. The conclusive results indicate that policies related to subsidies contribute positively to the economy, in addition to generating positive effects for the internal market of the Brazilian economy by favoring typical households in the middle and lower positions of the composition of income and consumption. Regarding sectoral results, the increase in household income contributes to an increase in the production of those sectors that are more related to household consumption, mainly due to the consumption profile of households in lower income strata, contributing to the increase in production and investment sector. The reduction of the impact of transport on the income of individuals and households contributes to the redistribution of income in the consumption of other goods, mainly those related to food and

services.

An attempt to assess the interdependence between prices and the structure of inputs on the basis of input-output tables expressed in constant and current prices

Topic: Inflation and Supply Chain Adaptation in Dynamic Interindustry Modelling
Author: Michał PRZYBYLIńSKI
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An attempt to assess the interdependence between prices and the structure of inputs on the basis of input-output tables expressed in constant and current prices

Input-output tables make it possible to trace with high accuracy, on the one hand, changes in technological processes expressed in changes in the structure of real intermediate inputs, and on the other hand, the impact of price changes on these structures. Changes in the prices of intermediate products resulting from broadly understood changes on the supply side are transferred to production costs and, consequently, to the prices of final goods, according to the cost formula. Both producers and final consumers try to adapt to these changes by changing the structure of their purchases. Substitution mechanisms cause a decrease in the share of these intermediate inputs which prices relatively increase. The structure of consumption changes in a similar way.

From the point of view of price formation, the strength of the imbalance between demand and supply is decisive. A price shock may therefore have its source on both the demand and supply side. Input-output tables and models allow to assess the strength of the adjustment mechanisms and, consequently, the transfer of price impulses. The condition is that the data should be expressed both in current and constant prices.

Our motivation to try to take advantage of this opportunity stems from the dramatic events that have significantly changed the rules of the global economy in recent years, primarily the COVID-19 pandemic, as well as the war in Ukraine.

The method we used was to calculate price indices for individual industries on the basis of the input structure, both based on the Laspeyres formula and the Paasche formula. The difference in the obtained results indicates the direction in which the change in the real cost structure contributed to the change in the basic prices of individual products. The higher index calculated on the basis of the Laspeyres formula proves that the change in the structure of outlays contributed to the slowdown of inflation impulses - a rational substitution took place. A higher Paasche index means that changes on the real side forced price changes. In the next step, we supplemented this analysis with changes in the structure of final demand.

The availability of symmetrical tables expressed in fixed prices (prices from the previous year) is still very limited. That is why the study was conducted on the basis of data describing the Danish economy, published on the website of Statistics Denmark. The choice of Denmark as the subject of the study results also from the limitations of the availability of the latest statistical data, i.e. tables for the analyzed period reaching 2021. The Dannish tables are symmetrical input-output

tables presented according to the Danish Industry Classification (DB07), which is a version of the international nomenclatures NACE, Rev. 2, ISIC, Rev., at the level of 69 branches. In an EU-perspective there is a high degree of comparability with national accounts and input-output tables made by other countries.

The obtained results do not confirm the hypothesis about the substitution effect of expenditures towards the reduction of production costs. On the contrary, the results suggest that the causal relation is the opposite: an increase in demand for intermediate products (or reduction of supply) causes their prices to rise. In the context of further considerations, a detailed analysis of individual cost items should be undertaken, which would allow indicating those that played the crucial role in shaping the overall indices.

This lack of data is one of the main reasons why empirical analyzes of changes in quantities are unpopular. In particular, there are no studies identifying the role of the price component. This article tries to fill that gap. The novelty of this article also lies in the fact that economic processes taking place during the pandemic are analyzed - the literature on this subject is quite rich, but it does not use the potential of input-output models, which is also due to common delays in the publication of data. It will be particularly interesting to use the method we tested next year, after publishing the tables for 2022, a year of high inflation.

Thanks to a unified methodology for creating IO tables, the described procedure can be applied universally. Necessary time series of IO tables expressed in previous year's prices will certainly become widely available, and the level of detail will almost certainly increase.

Pointing to the potential of input-output tables expressed in fixed prices was one of the motivations for writing this article. The authors hope that in this way they will encourage statistical offices to pay more attention to the construction of such tables.

Stressed economies respond more strongly to climate extremes

Topic: Agent-Based Modeling and Input-Output Analysis - II
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Economies experience stress for various reasons such as the global Covid-19 pandemic beginning in 2020. The associated lock-downs caused local economic losses and the disruption of international supply chains. In addition, such stress alters the effects of short-term shocks as caused by climate extremes, especially their propagation through the economic network and the resulting repercussions. Here we show that the combined adverse impacts of tropical cyclones, river floods, and heat stress on global consumption is strongly enhanced when the economy is under stress. This increase results from aggravated scarcity causing higher consumer prices. Modeling climate impacts during Covid-19, we find that in a stressed economy with the current network structure, consumption losses due to climate extremes double in the US and triple in China. The simulated effects intensify when climate shocks grow stronger. Our results emphasize the amplifying role of the interaction between climate change and its socioeconomic backdrop.

Monitoring the sustainability of the German Bioeconomy

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - XI
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Bioeconomy (BE) is seen as an important strategy to promote sustainable development and to contribute to achieving climate goals. Against this background, many countries and organizations have published bioeconomy-related strategies. However, BE is not sustainable per se, but needs to be designed in a sustainable way. Based on the food vs. fuel debate the discussion of trade-offs has expanded to include such as global equity, water scarcity, soil degradation, and land use change (Dietz et al., 2018). Previous research identified synergies and trade-offs for nearly all Sustainable Development Goals (SDGs) (Ronzon and Sanjuán, 2020).

Approaches to measuring and evaluating the bioeconomy should be developed, as inadequate monitoring and lack of impact assessment can lead to over- or under-regulation of the bioeconomy (Dietz et al., 2018). To be able to assess the sustainability of the bioeconomy, monitoring of not only the direct but also indirect environmental, social and economic effects along global biomass related value chains is necessary. The German government has also adopted a national bioeconomy strategy and started to establish a suitable bioeconomy monitoring system. In this context several footprint indicators have already been developed and calculated for the bioeconomy in Germany (Bringezu et al., 2021a; Hennenberg et al., 2022; Egenolf et al., 2021; Bringezu et al., 2021b), but these only consider the environmental dimension, and the data and methods still offer potential for further development.

The aim of this paper is to calculate the ex-post socio-economic footprints of the German BE between 1990 and 2020 based on an improved MRIO database and footprint calculation considering throughflows in addition to production and consumption-based accounting (Beaufils et al., 2023). We expand the footprint indicators to further dimensions of sustainability considering labor volume and wages by gender and skill-level. While the global environmentally-extended multi-region input-output (EE-MRIO) database EXIOBASE (Stadtler et al., 2018) was used for the previously mentioned footprint calculations, here the global EE-MRIO database GLORIA (Lenzen et al., 2021) is applied. GLORIA offers the advantage of a higher spatial resolution and is expected to be continuously updated.

The improved footprint calculation developed in Beaufils et al. (2023) is based on the Hypothetical Extraction method (HE), which allows to assess the German contribution to the footprints of other countries as a producer of intermediate bio-based products. We fully extract agriculture, forestry and fishery sectors as primary producers of biomass as well as the food industry and apply partial extractions to other manufacturing sectors based on their shares of sub-industries handling biomass.

Our results improve the monitoring of the German bioeconomy and thus supported policy making with regard to a sustainable design of the relevant strategies and measures, such as the ban of palm oil from energetic use in the EU. This is particularly relevant since only a minority of countries with bioeconomy strategies have mentioned the potentially negative impacts of biobased transformation on sustainable development (Dietz et al., 2018). Where particular attention is required for the SDGs 2 (Zero Hunger), 8 (Decent Work and Economic Growth), 9 (Industry, Innovation and Infrastructure) and 12 (Responsible Consumption and Production) (Ronzon and Sanjuán, 2020).

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FIDELIO: four modules linking input-output and general equilibrium modelling

Topic: Input-Output Theory and Methodology - I
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Research question: How can we dissociate the many different effects occurring simultaneously inside a CGE model in order to improve the interpretation of modelling results?
Method used: A modular approach including IO analysis and CGE modelling by the FIDELIO model (Fully Interregional Dynamic Econometric Long-term Input-Output)
Data used: 2015 FIGARO multi-regional Input-Output tables from Eurostat
Novelty of the research: The interpretation of CGE modelling results can be significantly improved by the dissociation of the direct, indirect, investment, re-distributional and substitution/rebound effects.

The FIDELIO model (Fully Interregional Dynamic Econometric Long-term Input-Output) answers to the recent need for more transparent economic impact assessment models. The past trend was for impact assessment models to be able to answer to all questions within one model, resulting in larger models that were built on larger databases. The counter side was that these models were becoming more and more complex (Bulavskaya et al., 2014).

The modular approach of FIDELIO can improve the transparency of complex models significantly. The FIDELIO modules can be switched on or off in order to go from a standard Input-Output model to a full econometric model and theoretically everything in between. FIDELIO shows that the two most common impact assessment tools, IO and CGE models (Koks et al., 2016), do not need to be

viewed as substitutes (Rose, 1995; West, 1995), but are an integral part of a continuum of different economic models that have in common the IO-data.

In this paper we apply four so-called modules: 1. The Input-Output module estimates the direct and indirect effect by applying an Input-Output analysis; 2. The Input-Output Investment module expands from the first module and endogenizes the investment agent and activates capital accumulation. This module estimates the investment multiplier effect in addition to the direct and indirect effect; 3. The National Accounts Matrix module (also known as the Social Accounting Matrix model) endogenizes in addition households and the government. It closes the system with the redistribution of incomes and thus this module simulates in addition the re-distributional effects; 4. The full econometric module activates prices in addition to the third module and simulates the substitution and rebound effects.

A comparison of the modelling results between the four modules, allows for the dissociation of direct, indirect, investment, re-distributional and substitution/rebound effects. This modular approach thus enables an advanced decomposition of modelling results. It increases the traceability of the many effects occurring simultaneously inside a CGE model. This can significantly improve the interpretation of CGE modelling results as well as increase the understanding of a model's properties.

The proposed method will be used for an ex-ante evaluation of the Next Generation EU funds. This fund is the EU's initiative to speed up the recovery after the pandemic by investing in a more green, digital and resilient Europe. The simulation scenario will model the NextGenerationEU's spending of €723.8 billion euro on research and innovation from 2021 to 2027. Half of the budget is financed by the EU Member States, while the other half is in the form a loan. The reference scenario will assume no NextGenerationEU fund and the individual EU Member States can use their budget for their own national investments instead. With the proposed method we not only estimate the total impact on the EU economy of this programme but also provide insights into the most relevant effects and actors related to the impact of NextGenerationEU.

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Input-output analysis of the energy sector in Brazil for the years 2000 and 2015

Topic: Input-Output Analysis: Energy Policies - IV
Author: Carolina SILVA RIBEIRO
Co-Authors: Roberto Maximiano PEREIRA

The main energy sources in Brazil are oil, natural gas, electricity, mineral coal, wind energy, biodiesel and sugarcane products. In recent years, renewable energy generation has been gaining prominence and contributing to the reduction in the use of fossil fuels. In this context, it is questioned how the changes that occurred in the Brazilian energy sector contribute to the energy transition? This paper analyzes the structural changes that occurred in the energy sector in Brazil for the years of 2000 and 2015. To do so, it uses the input-output matrices estimated by the Brazilian Institute of Geography and Statistics (IBGE) for both years. It should be noted that, as the energy data (physical flows) of the National Energy Balance (BEN) presented a different sectoral disaggregation from the input-output matrices for Brazil, the need arose to make the two bases compatible, which generated a matrix with disaggregation for fourteen productive sectors. The sector analysis will be based on two parts. The first will consist of an exploratory analysis of the sector, using classic input-output indicators (e. g. key sector, analysis of employment, income and production multiplies). The second will be based on the hybrid input-output model. The hybrid model will allow verifying the direct, indirect and total requirements of the energy sector. The results of this article will enable a better understanding of the energy sector in Brazil and the fight against climate change through the use of more renewable sources.

Keywords: Energy sector; Input-output; Hybrid models.

Smile Without a Reason Why: Functional Specialization and Income Distribution in Global Value Chains

Topic: Input-Output Analysis: Employment Policies
Author: Federico RICCIO

In recent years, the investigation of labour share dynamics has regained attention in the economic debate, with evidence showing a sustained and widespread decline in the portion of value accrued by workers. Much of this research has focused on advanced countries, finding extensive support for the decline in wage share starting in the 1970s (Karabarbounis and Neiman, 2014). More recently, due to the increased availability of data, similar trends have been detected in developing countries as well (Guschanski and Onaran, 2023; van Treeck, 2020; Riccio et al., 2022).

This research investigates the effects of Global Value Chain (GVC) integration and associated functional specialization on the decline of the labour share of value added. We show that wage compression strategies ease GVCs' participation, increasing firms' international competitiveness, especially in developing countries. Additionally, GVCs integration allows advanced countries to retain more remunerative tasks while pushing emerging markets to specialise in low-skill, low-wage occupations. Combined with the global dissemination of technology and a reduction of worker bargaining power, we identify these phenomena as major contributors to the decrease in the labour share.

Our results show that Global Value Chains (GVCs) are structured hierarchically, with advanced

countries receiving higher value from global production networks due to their greater market power and technological advantage. This favourable initial condition allows them to benefit from functional specialization in upstream tasks, which partially offset the decline in their labour share. Unfortunately, production workers are the biggest losers in this process, accounting for most of the drop in labor share. This is especially concerning, since production functions make up more than 50% of the workforce in both advanced and developing countries, leading to a rise in wage inequality globally.

Throughout this work, we use Timmer et al. (2015)'s methodology to track value added in global value chains, decomposing the final product into the value added in each stage of production. Following Chen et al. (2018) decomposition procedure, we combine input-output tables and wage flow in each stage to compute vertically integrated (GVCs) labour share.

We employ world input-output tables (Timmer et al. 2014) that contain data on intermediate inputs which flow across industries as well as across countries. Additionally, we collect information on wages and employment levels from Socio-Economic accounts and on the occupation structure from Timmer et al. (2019). This approach enables us to disentangle the impact of GVC penetration and international functional recombination on worldwide labour share dynamics.

The Input-Output Archive: International Trade

Topic: 50th Anniversary of Leontief's Nobel Prize: International Trade
Author: Josef RICHTER
Co-Authors: Albert E. STEENGE

Based on the seminal work: Wassily, Leontief (1953) "Domestic Production and Foreign Trade; The American Capital Position Re-Examined", Proceedings of the American Philosophical Society, 97(4): 332-349. Includes presentation of some archive materials and documents about this topic.

The Input-Output Archive: Environment

Topic: 50th Anniversary of Leontief's Nobel Prize: Environment
Author: Josef RICHTER
Co-Authors: Albert E. STEENGE

Based on the seminal work: Wassily, Leontief (1970) "Environmental Repercussions and the Economic Structure: An Input-Output Approach", The Review of Economics and Statistics, 52(3): 262-271. Includes presentation of some archive materials and documents about this topic.

The Input-Output Archive: Growth and Development

Topic: 50th Anniversary of Leontief's Nobel Prize: Growth and Development
Author: Josef RICHTER
Co-Authors: Albert E. STEENGE

Based on the seminal work: Wassily, Leontief (1953) "Dynamic Analysis" in Studies in the Structure of the American Economy, edited by W. Leontief et al. New York: Oxford University Press. Includes presentation of some archive materials and documents about this topic.

The Input-Output Archive: Innovation and Structural Change

Topic: 50th Anniversary of Leontief's Nobel Prize: Innovation and Structural Change
Author: Josef RICHTER
Co-Authors: Albert E. STEENGE

Based on the Seminal work: Leontief, Wassily and Faye Duchin (1986) The Future Impact of Automation on Workers. New York: Oxford University Press.
Includes presentation of some archives materials and documents about this topic.

An integrated energy-economic model for the energy transition: insights on critical raw materials exploitation

Topic: Input-Output Modelling: Energy Policies - III
Author: Lorenzo RINALDI
Co-Authors: Matteo Vincenzo ROCCO, Emanuela COLOMBO

In recent years, the need to undertake an energy transition has been increasingly prominent in the political debate and the effects of such an ongoing transition are leading to increasing global energy investments. The switch to the vast adoption of low-carbon technologies would lead to less environmentally-impactful energy production processes, however, it surely requires structural economic changes in terms of global supply chains. In particular, the concern around such technologies regards their relevant critical raw materials (CRMs) content, which consequently opens important geopolitical and energy security implications, and their role in global job creation/loss. These two dimensions are currently under investigation in the scientific literature and a comprehensive answer represents a substantial research gap. Such a complex context needs to be represented within complex and integrated modelling frameworks. Energy System Models (ESMs) are usually the favourite choice when dealing with the impact evaluation of long-term global energy scenarios. However, it is necessary to create a link between ESM and other macroeconomic tools to keep into account the above-mentioned complexities. This is the purpose of DYNERIO, an integrated modelling framework developed by the authors, composed of three soft-linked modules: (i) an ESM, responsible for optimizing sustainable technological pathways under specific policies constraints, usually minimizing the least total net present cost (NPC) of the energy system configuration; (ii) an environmentally-extended multi-regional input-output (EEMRIO) model, reflecting results of ESM onto non-energy industries and capturing the overall economic impact, including influence on employment, of the pathway; (iii) a third module consisting of a system of linear equations allowing to dynamically assess region- and technology-related CRMs extraction and recycling (dynER). This study presents an application of the DYNERIO framework within an extended global energy transition case study aiming at

providing extended energy-related and economic insights. Two global energy scenarios have been implemented: in the first scenario the ESM provides a least-NPC-oriented transition trajectory shaped under policy constraints classifiable as "stated and announced"; the second scenario builds upon the first with the significant difference regarding the relaxation of some policy constraints and the change of the objective function of the ESM, which in this case is the minimization of the total CO_2 emissions. The deployment of energy technologies and the production of their respective services, coming as a result of the ESM module, are then provided as inputs of EEMRIO and dynER modules allowing for the assessment of the implications on CRMs exploitation. A sensitivity analysis is also provided on materials and technology prices.

Economic, social and environmental impact assessment of MSP for UK marine-related industries

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - II
Author: Alberto ROCA FLORIDO
Co-Authors: Simon MAIR

Marine spatial planning (MSP) is a process of coordinating the use of marine resources in an attempt to achieve economic, social, and environmental objectives. This is an extremely challenging goal, and the benefits of MSPs are contested. In this seminar, we develop a marine input-output model for the United Kingdom. We use this model to explore relationships between greenhouse emissions, employment and gross value added in marine-related sectors and other industries. Based on our results, we identify three clusters of marine-related sectors, each characterised by a different relationship between environmental and socio-economic goals. Analysing the clusters could allow marine spatial planners to understand better how their policies will impact communities and the broader environment and prioritise accordingly.

Possible impacts of an increase in bio-methane production on European economies

Topic: Economics of Food Systems - I
Author: Bartlomiej ROKICKI

The Russian invasion on Ukraine has led to dramatic changes in global energy and food markets. In the case of Europe, the supply of fossil fuels seems to be the main problem that bothers most of the policy makers. Hence, the recently adopted by the European Commision the REPowerEU Plan focuses on the ways to reduce the dependence of Russian gas, oil and coal. One of the proposed measures is a significant increase in bio-methane production from current 3 bcm to 35 bcm by 2030 (and possibly to and 167 bcm in 2050) so that it would cover 20% of projected gas demand. Estimated cost of required investment amounts to euro 37 billion.

This paper applies the MAGNET model (The Modular Applied GeNeral Equilibrium Tool) to analyse different long-term scenarios related to the proposed increase in bio-methane production in Europe. We show both the overall macroeconomic impacts of proposed measure along with the impacts related to broadly defined bio-economy sector. We verify under what circumstances projected investments may allow to reach the production target and whether the above target is actually achievable. We also consider an additional shock to the markets that could be caused by potential Ukraine accession.

Impacts of a green hydrogen value chain on the labor market in Germany

Topic: Dynamic Modelling of Economic Impacts of GHG Reductions
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Impacts of a green hydrogen value chain on the labor market in Germany

Hydrogen has the potential to play a key role in the energy transition. It can contribute to decarbonize the industry, transport or heating sector and to achieve the national climate targets. Hydrogen produced via electrolysis from renewable energies is considered as «green» hydrogen. The German National Hydrogen Strategy aims at fostering the usage of green hydrogen, promoting its market rollout and establishing a green hydrogen value chain (BMWi 2020). Recently, hydrogen is not only discussed regarding climate policy but is also evaluated as an option to decrease the dependency on supplier countries for fossil fuels (BMWK 2022). However, establishing a green hydrogen value chain raises the question of how the labor market will be affected by labor supply and demand changes.

Our study analyses the impact of a green hydrogen value chain on employment, occupations and qualifications in Germany until 2045. The results are based on demographic and economic modelling in conjunction with the scenario technique. For the economic modelling, several assumptions for future technological and economic developments are made and integrated into the QINFORGE (Qualification and Occupation in the INterindustry FORecasting GErmany) analytical tool. The economic core of the QINFORGE model is the macroeconomic input-output model INFORGE (INterindustry FORecasting GErmany) which is based on the INFORUM modelling approach. INFORGE enables econometric forecasting and simulation as the model is disaggregated according to economic sectors, production areas and groups of goods. The extended QINFORGE model further forecasts labor market demand and supply, disaggregated by 63 economic sectors, 144 occupational groups and four requirement levels (Zika et al. 2023).

The data for the demographic and economic modelling is based, amongst others, on the German Microcensus (last survey year 2019). It is an official representative statistic of the Federal Statistical Office - involving one percent of all households in Germany each year - and provides information on the population and the labor market. The German national accounts – including the input-output-tables (until 2021) – are the basis for the projection of the overall economy. The Federal Employment Agency's register data of employees subject to social insurance contributions (SVB) and of those in marginal employment only (AGB) provide additional information on the employed population by occupation and the corresponding wages paid (until 2020) (Maier et al. 2022).

To identify the economic and labor market effects of a green hydrogen value chain, two scenarios are computed using the QINFORGE analytical tool. The first scenario is a baseline projection which extrapolates past trends and behaviors in the education system, the labor market and economic development neglecting the development of a green hydrogen value chain. The second, alternative scenario assumes the development of a green hydrogen value chain according to assumptions derived from a broad literature review. The model relationships remain unchanged in both scenarios. Thus, differences in the results lead to direct, indirect, and induced overall impacts to the economy and labor market entailed by the development of a green hydrogen value chain (Mönnig et al. 2019, Becker et al. 2022).

The scenario analysis shows that establishing a green hydrogen value chain will lead to an overall higher level of employment in Germany, but labor demand development differs across economic sectors and occupational groups. Direct positive effects are especially pronounced in the construction and engineering sector and their related occupations due to an additional expansion of renewable energies needed for green hydrogen production. Other economic sectors directly and positively affected are research and development as well as manufacturers of machinery and equipment leading, inter alia, to a higher demand for occupations in machine-building and -operating as well as electrical engineering. Negative effects on single economic sectors and occupational groups remain low. However, and in contrast to other studies evaluating the employment effects of hydrogen use, negative employment effects are considered in our analysis.

Taxation of Sugar-Sweetened Beverages: Simulations in a Computable General Equilibrium Model for Brazil

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - V
Author: Maria Victoria Garcia ROSA
Co-Authors: Larissa Barbosa CARDOSO, Kenia B. DE SOUZA, Flaviane Souza SANTIAGO

Sugar-sweetened beverages (SSB) consumption is increasing worldwide, but higher growth rates have been seen in developing countries. Brazil is one of the Latin American countries with a higher level of consumption of SSB. The high sugar content in these beverages and regular consumption of SSB has impacts on individual health and contributes to the increased prevalence of chronic diseases such as obesity. In addition to the potential health outcomes generated by a SSB taxation policy, the effects on the economy must be examined. Considering that, the objective of this article is to analyze the wide-economy impacts of SSB tax in Brazil in the short- and long-term. To analyze these effects, we used a national dynamic Computable General Equilibrium (CGE) model calibrated for the Brazilian economy and evaluates the effects on macroeconomic indicators of production, employment, household consumption, prices and tax revenue in four scenarios. The model's database was calibrated using data from the 2015 Brazilian input-output matrix released by the Brazilian Institute of Geography and Statistics (IBGE), the sugar-sweetened beverages sector (the focus of this work) was disaggregated based on data from the Annual Industrial Survey (PIA) of 2015 considering the participation of Nectars and soft drinks in the Other food products sector and Soft drinks in Other Beverages. The final model has 124 products and 124 productive sectors. Two sets of simulations were performed in which different rates were applied to the sugar-sweetened beverages sector, with different assumptions about government spending. In the first set of simulations, it is considered that the variation in tax revenue resulting from the change in taxation does not change the total volume of government spending. In turn, in the second set of simulations, the resources collected with the tax on the sugar-sweetened beverages sector are directed to the Public Health sector, increasing public expenditures in this sector, in the same amount collected with the taxation. For each of the two sets of simulations, four policy scenarios were considered: 1) an increase of 10p.p. in the taxation of the sector from 2023; 2) an increase of 20p.p. in the taxation of the sector from 2023; 3) an increase of 30p.p. in the taxation of the sector from 2023; and 4) gradual increase from 10 to 30p.p. in sector taxation between the years 2023 and 2025. In all simulations, with the increase in taxation in the sugar-sweetened beverages sector, an increase in the sector's costs is expected, which are partially passed on to consumers in the form of price increases. The main results show negative effects for the SSB sector, with an increase in prices and a reduction in the level of economic activity. At the same time, as recommended, families reduce SSB consumption, in reaction to rising prices. When there is no change in government

spending, negative results are observed in the short term in macroeconomic indicators. The introduction of a tax on SSB sector contributes to reduce household and government consumption, exports, and the price index. However, these effects contribute to a reduction in GDP in all scenarios. Over time, exports are encouraged, investments are resumed, and price indexes rise. The observed effects have repercussions on the labor market, generating a reduction in employment and wages in the short term. The fall in employment, however, is reversed in the long term, reaching the end of the period with positive variations. The wage mass, however, did not recover and maintained negative variations throughout the period. On the other hand, when the resources collected from taxation are reintroduced into the economy in the form of increased public spending, the negative macroeconomic effects are reversed, maintaining similar results for the SSB sector. Additionally, when comparing the strategy of establishing a fixed tax of 30p.p. or a gradual increase until reaching the same percentage, it is observed that the tax revenue is less affected and that in the last year of the analyzed period, the effects on the different economic indicators are slightly less expressive with the gradual increase.

Global Value Chain Disruptions: The Role of Firm Heterogeneity

Topic: Input-Output Modelling: Trade and Global Value Chains Policies - I
Author: Juan Carlos RUIZ GARCIA

How do global value chain disruptions in the form of external shocks transmit to the local economy through input-output linkages? Do firms balance efficiency and resilience in their usage of external inputs? To answer these questions, I propose a tractable multisector model that matches the economy's input-output structure and trade flows. The production process embeds complementarity-substitutability between locally and externally produced inputs at a granular disaggregated level. Guided by two empirical regularities, (1) a small set of firms import intermediate inputs and (2) the propensity of importing increases with firm productivity, I introduce heterogeneous producers under monopolistic competition in each sector. Firms optimally decide which foreign inputs they adopt in the production process. Under the firm-heterogeneity framework, only firms using externally produced intermediate inputs are directly exposed to external shocks. They impose an externality by propagating the external shock to the local economy through inter-sector linkages. I also show that the elasticities of output with respect to foreign inputs are downward biased in a representative agent framework, which leads to a lower response in the aftermath of a foreign shock. I validate the internal mechanisms of the model by showing indirect empirical evidence on the relative importance of the impact of the trade shock on directly exposed firms against the local ones. Finally, an optimal policy is proposed to correct the uncovered externality by balancing efficiency and resiliency.

I use data from several sources to calibrate and validate the mechanisms of the model:
>> Business structure from Eurostat for the firm heterogeneity
>> Input-Output linkages from Figaro for the production function/technology
>> Firm trade data for the relation between firm and input adoption decision
>> Historical aggregate trade data flows for the size of the external shock
>> Firm-level data from Orbis to validate the mechanisms of the model

The novelty of the research:
>> First-of-class model that introduces firm heterogeneity in an otherwise general Input-Output set-up
>> Endogenous trade network formation and flows with micro-foundation at the firm level
>> Shows why a representative framework set-up yields biased results

>> Novel transmission mechanism that uncovers an unexplored externality

Improving Self-Sufficiency In Rice Production In Senegal: An Economy-Wide And Distributional Analysis

Topic: Economics of Food Systems - I
Author: Amarendra SAHOO
Co-Authors: Emanuele FERRARI, Valeria FERREIRA, Victor NECHIFOR

Improving food security is a top priority for the Senegal government. The country highly depends on the imports of food crops, about 30%. Rice is one of the most consumed food staple in Senegal, of which, imported rice constitutes about 45% of the total domestic demand. Most of the rice production in Senegal is rainfed (70%) and only around 5% of the total irrigation in the country is used for the rice production. Although yield in rice has risen over the year from 2000, it seems to have stagnated in recent years (FAOSTAT). With the rapid demographic development, the level need for rice has been on the rise, both among rural and urban households. In view of supporting the food security, country has pursued the trade policies and improving trade efficiencies that help reduce the cost of imported food items. Increased access to imported rice is expected to push the food security in country. However, it may affect the regional self-sufficiency in domestic rice activities and hence farm income. Additional policies supports to rice production, e.g. increase in productivity in factors (irrigated and rain-fed land, labour and capital) and inputs as fertilizers or introduction of higher yield varieties, can enhance the self-sufficiency, farm income, and food security further.

This study uses a recursive dynamic computable general equilibrium (CGE) model, namely DEMETRA (Dynamic Equilibrium Model for Economic development Resources and Agriculture) (McDonald et al, 2016), and microsimulation approach to assess the impacts of reducing trade costs and improving rice productivity on growth, food security, and poverty. The model is calibrated based on the Social Accounting Matrix (SAM), which accounts for 14 regions, 61 activities, and 70 commodities, including nine non-marketable subsistence food crops.

The study uses a microsimulation approach to analyse the poverty and distributional impacts of the proposed scenarios. This is a top-down approach in which consumption changes of the representative households in the CGE model are linked to consumption of the households in the survey the microsimulation model. The household information is based on the Harmonized Survey on Households Living Standards 2018-2019. The results show that improving rice productivity can enhance growth, food security and reduce poverty at regional level.

Towards the compilation of eSUTs for Italian economy

Topic: Compilation of National Supply, Use and Input-Output Tables
Author: Federico SALLUSTI
Co-Authors: Stefania CUICCHIO

It is strongly agreed that a wider granularity within the SNA framework of accounting would boost the capability of identifying and interpreting emerging phenomena (e.g., the role of Multi-National Enterprises, the formation of Global Value-Chains) and the increasing heterogeneity of structures, strategies and performances of different typologies of economic operators (e.g., the difference between smaller and larger business units, the difference among firms with different degree of

international openness).

In this context, the compilation of extended Supply and Use Tables (eSUT) represents a promising way to meet those emerging analytical needs. Moreover, the information included in eSUT framework may also provide a starting point for the compilation of extended Input-Output Tables (IOT), which can be in turn used for impact and structural (relational) analyses.

This work presents the state of art of the compilation of the eSUT framework for the Italian economy. In particular, the scheme considers three dimensions for the sectoral break-down: governance (domestics, MNEs with Italian headquarter, MNE with foreign headquarter), market orientation (domestic market, only importer, only exporter, two-way trader) and size-class (1-10, 10-50, 50-250, more than 250 workers). By integrating the modalities of these dimensions, 48 strata are obtained. For each industry (98 sectors of economic activity), a set of aggregates (production, intermediate costs, value added, employment, compensation of employees, gross operating surplus, number of firms, exports, imports) are broken-down using the above mentioned strata. International trade is also broken down by geographical area of origin/destination.

At this stage, the coverage ranges from 80% to 90% depending on the given aggregate. As for regular economy, the current framework includes: survey and census, administrative data, combined data, imports and exports of goods. As for exhaustiveness adjustments, it includes: value added from un-registered workers, business units outside the scope of SBS, micro-firms, outworkers and under-reporting. The present framework does not include: conceptual adjustments (ESA2010), imports and exports of services, illegal economy and the balancing of supply and demand.

This granularity has been obtained by exploiting firm-level information provided by different Istat databases (Frame-SBS, ASIA, COE-TEC and other, Frame-underground), which allowed to use microdata in order to assign the variables related to each business unit to the given strata. Aggregates for which estimates are provided by domain are assigned to the given strata following assumptions.

The work also provides some preliminary results concerning the role of Multi-National Enterprises (in terms of characteristics, international trade and performance) and the structure of the generation of value added and performances by market orientation, further than an analysis of the role of small and medium enterprises in the Italian economy.

At the current stage, the pilot allowed to replicate a large part of the main national accounts aggregates by economic activity analyzing interesting issues related to the patterns of the Italian business system. Future developments aimed at completing the scheme should include: the representation of international trade in services (including merchanting and processing) from microdata; the inclusion of conceptual adjustments and balancing of SUT; the disaggregation by product and the representation of intermediate consumption and final demand (consumption and investments); the definition of IOT framework following the eSUT disaggregation.

An index of static resilience in interindustry economics

Topic: Input-Output Modelling: Industrial Policies
Author: Ferran SANCHO
Co-Authors: Betty AGNANI, Ana Isabel GUERRA

We present a novel indicator of economic resilience that captures the ability of an economy to adjust and recover from a negative shock that may occur either on the demand or the supply side. In the construction of this index, we start from Leontief's Input-output model, expanding the concept of constrained multipliers in input-output first introduced by Guerra and Sancho (2011). We implement a linear programming (LP) problem that 1) computes the countervailing changes in the final demands (or in the total supplies) of the non-shocked production units that would keep total GDP at least at the initial pre-shock level and 2) maintains the adaptation as close as possible to initial final demand structure (or supply structure). Our proposed economy-wide resilience indicators are static or short-term resilience indices. In this sense, in the application of the methodology, we are also assuming that the technology and the endowment of factors are conserved. Furthermore, the fact that GDP remains unchanged adequately captures the concept of "resilience" as it ensures that the economy recovers from the negative shock.

In the construction of the resilience index, the linear programming problem minimizes the needed re-scaling in the non-shocked sectors when facing a given sector faces a negative shock. The endogenous re-scaling refers to the changes that would take place in the final demand (or supply) flows of the non-shocked sectors. The minimal change identified by the LP problem is the basis of the resilience index. If the index is larger than 1, this implies that the structure of the economy is insufficient to counteract the loss in total output from the negative shock. In other words, the economy would need more resources than the pre-shock to get the system back to its initial equilibrium. This reveals the fragility of the shocked sector in the context of that economy. On the other hand, if the resilience index is smaller than 1, the adjustment in the final demand (or supply) of the non- shocked sectors is less than the neutral scaling changes in final demand, revealing the strength of the economy to recover from the shock. In other words, the larger the scale of the needed adjustment in response to the negative shock, the smaller is the resilience of the economic system.

In showing the applicability of our approach, we compute and thus compare the demand and supply resilience indices for a group of ten OECD economies: Australia, Canada, France, Italy, Germany, Colombia, Mexico, Spain, United States and United Kingdom. Thanks to our approach, this empirical exercise not only allows ranking this group of economies in terms of their static demand and supply degree of resilience but also identifying in each economy which sectors are more or less sensitive to unexpected negative-shocks. In doing so we have used the most recent domestic Input-Output tables published by the OECD statistics.

In addition, we have extended our empirical exercise and we have applied our approach to two "realistic scenarios". The first one refers to a demand shock that partially captures the COVID-19 crisis. In doing so, for the group of these 10 OECD economies, we have evaluated the resilience demand index introducing a simultaneous negative shock in the final demand sector that were most affected by the restrictions. Namely, the wholesale and retail, transportation and storage, accommodation and food services, arts, entertainment and recreation, among other "high-contact" service sectors. The second scenario, instead, relates to a recurrent negative supply shock: an energy supply shortage.

In our view, the main contribution of our approach relies on the fact that it makes possible the

construction of an objective resilience index from a general equilibrium perspective, i.e., considering the existing interindustry linkages. As stated bellow, this index helps to identity which economies are more resilient and, in each of them, which sector or production units are more (or less) able to face negative economic shocks. Consequently, the information provided by this static resilient indicator can be useful to improve the design of those policies that search for making economies less "sensitive" to potential negative exogenous shocks.

Estimating the Uncertainty of Greenhouse Gas Emission Accounts in Multi-Regional Input-Output Modelling

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - IX
Author: Simon SCHULTE
Co-Authors: Stefan PAULIUK

Introduction

Global multi-regional input-output (GMRIO) analysis is widely seen as the most appropriate framework to quantify national greenhouse gas (GHG) emissions from a consumption perspective. The robustness of GMRIO-based results, however, has been questioned by several comparative studies between GMRIO databases. Those inter-database comparisons showed partly large deviations in the results of which a considerable part could be attributed to the GHG emission satellite accounts.

Inter-database comparisons, however, only capture the variability caused by the assumptions and data sources that vary between databases. Thus they miss the uncertainty arising from assumptions and data sources that are uniform between databases. Therefore, inter-database comparisons are unsuitable for obtaining a reliable quantitative assessment of the actual uncertainty of GMRIO-based results.

Against this background, we use error propagation methods to quantify the uncertainty of GMRIO-based carbon footprints. We focus on the uncertainty arising from the GHG emission accounts, whereby covering the main GHGs CO_2, CH_4 and N_2O. We use Monte-Carlo simulations to estimate how uncertainty propagates from raw data inputs (i.e. emission inventories) and auxiliary data (e.g. to breakdown emission data to GMRIO sectors) to the final GHG emission accounts, and then further to the GHG footprints.

Material & Methods

We construct GHG emission accounts for the year 2015 for the EXIOBASE industries and regions using emissions data from the UNFCCC national inventories and the EDGAR database. To align the system boundary from the territorial to the residential principle, we use data from Eurostat, the Worldbank and Selin et al. (2021). To allocate aggregate emissions from the UNFCCC/EDGAR sectors to detailed EXIOBASE sectors we use proxy data from the EXIOBASE Supply-Use Tables. The allocation of emissions from road transport to industries and household consumption is largely based on Physical Energy Flow Accounts from Eurostat.

Uncertainty data for emission inventories are extracted from National Inventory Reports (NIR) for the UNFCCC emission inventories, and from Solazzo et al. (2021) for the EDGAR data. We use Dirichlet distributions parametrized in a Maximum Entropy framework to propagate the uncertainty from the (aggregate) UNFCCC/EDGAR sectors to the (disaggregate) EXIOBASE

sectors.

Unlike the (few) existing studies that applied error propagation to study the uncertainty of (G)MRIO-based carbon footprints (Karstensen et al., 2015; Lenzen et al., 2010), we also include correlations. By assigning uncertainty values to the raw data instead of to the intermediate model outcomes (i.e. the GHG emission accounts), we implicitly capture all correlations that result from the structure of our model for building the emission accounts. Correlations between raw data points from the emission inventories we model following the assumptions made in Solazzo et al. (2021).

Results

The output of our work are GHG extensions for the year 2015 in the EXIOBASE industry/country resolution that include uncertainty estimates for each coefficient and information on correlation structures between the coefficients. The uncertainties vary widely between sectors, countries/regions and GHGs. Unlike in existing studies, the amount of uncertainty and the sectoral/regional variability is not primarily driven by simplistic assumptions (e.g. power law regression based on the assumption that the uncertainty of a sector depends only/mostly on a sectors absolute size), but explicitly based on the uncertainties of raw data inputs and of models/proxies used to allocate inventory data to EXIOBASE sectors/countries. Moreover, our results contribute to the debate which role correlation structures play in the evaluation of the uncertainty of carbon footprints.

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Waste Input-Output tables as an effective tool to examine circularity in production processes: evidence from Italy

Topic: Recent Developments in Stock-Flow Consistent Input-Output Modelling - II
Author: Luca SECONDI
Co-Authors: Guido FERRARI, Mengting YU

Achieving circularity in economic processes is recognised as one of the most important challenges of the modern developed economy. However, for the Circular Economy Action Plan to be effective, a greater understanding of the link between economic activity and waste generation is required. Indeed, increasing resource efficiency, preventing waste generation and using waste as a resource are at the heart of the circular economy with considerable potential to reduce environmental pressure. Circular strategies and business models can also help alleviate the growing concern over dependence on imported resources and access to critical raw materials, some of which play a key role in the development of renewable and low-carbon energy

technologies.

The aim of this paper is to obtain and examine the Waste Input Output table for the Italian economy, linking data from waste generation sources to the national and territorial economic accounts. The lack of data for the same time requires the use of the Cross-Entropy approach to carry out meaningful data merging and integration.

The availability of a waste input-output table will make it possible to examine different aspects of waste accountability, starting on whether and to what extent the length of the supply chain affects the waste generation rate and to better understand the flow of resources through the various supply chains up to the estimation of industry-output waste coefficients and impact multipliers.

The essentials of Leontief and Duchin (1986) The Future Impact of Automation on Workers, with inputs from Faye Duchin

Topic: 50th Anniversary of Leontief's Nobel Prize: Innovation and Structural Change
Author: Mònica SERRANO

Based on the Seminal work: Leontief, Wassily and Faye Duchin (1986) The Future Impact of Automation on Workers. New York: Oxford University Press.
Includes presentation of some archives materials and documents about this topic.

When only economic growth cannot reduce income inequalities: the case of China

Topic: Income Distribution in Input-Output: Applications of Miyazawa's Model
Author: Mònica SERRANO

Income inequality is a challenge problem that strongly affects the economy and society. The impact is strong, significant, and wide (Dabla-Norris et al., 2015). Based on a long-time span analysis for OECD economies, Cingano (2014) shows that income inequality has a negatively and significant impact on economic growth and retards the human capital accumulation of those countries in the bottom group also affecting education (Comfort et al., 2001) and health levels (Chetty et al., 2016).

Being the largest developing economy, China faces inequality problems more mixed and deeper than developed countries. The Chinese inequality magnitude has been dramatically increasing since the marketization reform in 1978. According to Piketty et al. (2019) the top 10 percent income share increased up to 41%, while the bottom 50 percent decreased a 15% from 1978 to 2015. The analysis shows China's inequality level approaches that of US, even though its level was close to that of Nordic countries at the very beginning of the period. This trend implies that China's income inequality has been increasing with its economy grows for the last decades, reaching a GINI coefficient ranged between 0.53 and 0.55 in the period 2005-2012 (Yu & Xiang, 2014). Results by Yu & Xiang (2014) rank China's income inequality among the highest in the world, being significantly driven by structural factors such as regional disparities and the rural-urban gap. Evidence from Young (2013) shows that the urban-rural gap accounts for about 40% of country inequalities generally, and people migrating from rural hometowns to urban regions are likely to earn more wages. This conclusion is in line with Yang (1999), which

decomposes inequalities in two Chinese provinces and finds the urban-rural income differences occupies a large share of total inequalities. The literature suggests the necessity to get deeper insights into China's urban-rural income gap, also considering regional differences.

Theoretically, individual income is affected by three components: remuneration of primary factors (labour and capital), through the effect of relative prices in consumption, and government interventions. The first one, the renumeration of primary factors, is key in China's distribution system today. After the abolishment of planned economy system labour supply, capital investment, intellectual properties, etc. are all legally permitted to get involved in production activities, although there still are some restrictions due to Chinese political system. The second factor, changes in relative prices, has a statistically significant impact on income inequality (Slottje, 1987). Third factor, goals of government interventions are achieved via taxation and subsidize or even other redistributive policies. By adjusting the tax rate and relocate tax revenues to those in need, the government can proactively intervene the distribution process.

As discussed, urban-rural income inequality in China has been long-existing, impose negative impact especially on the welfare of those living in rural areas with low income and impairs the long-run growth. Specially, this gap problem is closely related with regional disparities for levels of development of over the provinces in China that differ largely.

In this context, this paper aims at analysing to what extent China's economic structure might downsize the existing urban-rural income gap in Chinese provinces. The paper seeks the interdependence between income, consumption, and production, to see if marginal increase of labour compensation stimulated by new production needed to satisfy additional consumption is large enough to eliminate the divergency trend. The geographical distribution of production (income generation) and consumption processes makes interrelationship occurs in different regions, linking the increase of one product consumption by one household-type in one region with the labour compensation (income generation through production) of another household-type that works in a different sector in another region.

This paper develops an income distribution model based in Miyazawa (1976) in a multiregional and multisectoral setting. The analysis combines income, consumption, and economic data for two-type of households (urban, rural), 31 Chinese provinces, and 42 economic sectors for China 2012. Results based on the country-level data suggest that extra consumption stimulated is not large enough to let the urban-rural income gap go down, while results based on the regional-level data lead to more detailed conclusion after taking regional disparities into consideration. Nonetheless, the current economic structure of China would amplify the urban-rural income gap if there is not any specific intervention from the government to redistribute income. It is advised to use a mix of tools including government interventions to help alleviate the urban-rural income gap in China today.

CO2 mitigation through global supply chain restructuring with consideration for the environmental efficiency of international shipping

Topic: Input-Output Modelling: Sustainable Production and Consumption Policies - IV
Author: Tomomi SHODA
Co-Authors: Shigemi KAGAWA, Keitaro MAENO, Taiga SHIMOTSUURA

To tackle climate change and its negative impacts, the Paris Agreement was adopted in 2015,

and more than 120 countries and regions have set a goal of "net zero carbon dioxide emissions". Decarbonization of all industries is essential for all countries to reach the goal. In particular, 23% of global CO2 emissions are embodied in traded goods through the global supply chain (GSC). Therefore, the reduction of CO2 emissions from the GSC has attracted great attention. According to Maeno et al. (2022), the restructuring of the GSC has the potential to significantly reduce the carbon footprint of production. However, it should be noted that the development of the GSC has caused the geographic separation of production areas and consumption areas, which makes the GSC highly dependent on international shipping. In other words, the restructuring of the GSC, accompanying the change of production areas, could lead to changes in the international shipping network. In other words, the restructuring of the GSC has a strong influence over the environmental efficiency of shipping network and the whole process of trade, including production, transportation, and consumption. This research starts from a simple question that if Japan should change importing destination from China to other countries when considering not only the CO2 emissions from production but also the CO2 emissions from transportation. Based on above, the purpose of this research is to simultaneously identify CO2 emission hotspots in the GSC (CO2 emission-intensive industry clusters in the supply chain network of industries) and CO2 emission hotspots in the international shipping network (ports and routes with high CO2 emissions from departing and arriving container ships) by combining the GSC network with international shipping network and to propose CO2 emission reduction strategies for the GSC that explicitly take into account the detailed shipping network.

In this research, we collected the data of movements of 8881 container ships owned by top 10 container ship companies from Sea-web Movements Database provided by the IHS Markit Ltd in 2018-2020, and calculated the CO2 emissions from these container ships in bottom-up methods. Then, we visualized the CO2 emissions network for more than 44 million shipping routes and identify environmentally-important routes and ports by using network centrality analysis and cluster analysis. Next, we calculated the share of ports and routes and combined the environmental consequences with WIOD database and broke down the importing destination into port level. The result shows that the port of Tokyo (Japan) is the hotspot in the international shipping network, and the supply chain of manufacturing industries is the hotspot in the GSC network of Japan. We suggest that the environmental policies which mitigate the CO2 emissions should focus on manufacturing industries and the port of Tokyo (Japan).

The novelty of this research is focusing on the strong connection between the GSC network and the shipping network during the process of international trade and combining the GSC network and the shipping network. Since "carbon neutrality" has been noticed, there are some researches focusing on the decarbonization of the GSC, such as Maeno et al. (2022), and also some researches focusing on the decarbonization of the shipping network, such as Guo et al. (2022). Definitely, it is important to decarbonize the production process of goods and services in production areas in order to mitigate CO2 emissions from the GSC, but it is also important to consider the decarbonization of the international shipping network at the same time. This research provides a new framework to comprehensively analyze the environmental consequences of international trade by treating production and transportation as a whole, without splitting them up.

Simulating the Socio-Economy-Environment Impacts of Ecotaxes in India: An Environmentally-extended Social Accounting Matrix Analysis

Topic:
Author: Ganesh SIVAMANI
Co-Authors: Rajat VERMA

Climate mitigation strategies are on the rise across the globe to achieve commitments of net-zero carbon emissions. Pricing carbon, either directly or indirectly, provides a price incentive to the producers to gradually move away from the polluting sources of inputs or outputs. India has already amended its Energy Conservation Act in 2022 to implement carbon prices. Therefore, it is important to examine the impact of such governmental policies on the economy, and particularly households, who will bear the incidence of such taxes. For developing countries like India, the effect of such policies on marginalised and low-income households is a pertinent question that needs examination.

We aim to answer three questions in this paper: first, what is the incidence of proposed environmental taxes (ecotaxes) on the households in India; second, what are its impacts on the Indian economy, wages of the labourers, and environmental pollution; and third, how can revenue recycling dampen the impacts on the affected marginalised households. In this paper, we seek to analyse these issues using an Environmentally-extended Social Accounting Matrix (ESAM).

We have constructed an ESAM for India 2019-20 (CSEP-ESAM), which is used for this analysis. The CSEP-ESAM consists of households disaggregated by region (rural and urban), quintiles of annual consumption expenditures, and social categories identified in India (Scheduled Tribe (ST), Scheduled Caste (SC), Other Backward Caste (OBC), and Other Social Group (OSG)). The first three categories are marginalised groups in India. The level of disaggregation of industries, factors of production, households and environmental accounts provided in CSEP-ESAM is novel for India, both in terms of the level of detail and its recency. To the best of our knowledge, this work on the impacts of ecotax has not been not been attempted before in the India context using an ESAM.

To address our research questions, we have used the methodology of Verma (2021), which had altered the methodology of Datta (2010). This method has been used to analyse the incidence of a proposed carbon tax on 5 polluting sectors (fertilisers, aluminium, iron and steel, coal-powered electricity generation, and cement) by using a price-vector model for computing the change in the relative prices of the 45 sectors of production, 32 categories of labour, 1 category of capital, and 40 categories of households of the CSEP-ESAM. Thereafter, the relative price changes are used to measure the per-household tax burden on the 40 categories of households (2 regions, 4 social categories, and 5 quintiles) by computing the change in the budget shares for these households, to give the tax incidence for each household group. We analyse four ecotax scenarios which were determined by using the prevailing Goods and Services Tax rates in India – 5%, 12%, 18% and 28% – across the 5 polluting sectors.

The pollution coefficients for air emissions (GHGs), and land degradation have been used to compute their pollution share from the ESAM. The impact on the economy has been simulated by modifying the methodology proposed by Grottera et al. (2015), as also has been done by Verma and Sivamani (2022). The impact on the air emissions (GHGs) and land degradation have been computed by using the pollution coefficients from the ESAM.

We have applied the ecotax on the gross value of output (Output-Net Indirect Taxes) of the 5 polluting sectors. For each of these cases, we have looked at revenue recycling scenarios. The revenue recycling values come in the form of government transfers to households, and are in proportion to the impact of the taxes on household incomes. For each scenario, taxes are recycled only for Quintiles 1 and 2. These are applied to either all social groups, or only the marginalised social groups (ST/SC/OBC). Further, these are either applied only to the rural sector, rural and urban equally, or slightly higher for the rural sector.

We find that ecotax policy scenarios appear to be progressive for both rural and urban India, depicting that the costs of these policies are not disproportionate across region or social categories. These preliminary findings suggest that revenue recycling can help reduce the impact of the ecotax on GDP and household expenditure, and further reduces the air emissions intensity compared to a no-recycling scenario.

A Python Based Multi-Regional Input-Output Analysis Toolbox: Pymrio - newest updates and future developments

Topic: Advances in Open Source Software for Input-Output Compilation, Analysis and Quantitative Impact Assessment
Author: Konstantin STADLER
Co-Authors: Hazim HUSSEIN, Mohamed BADR, Peter MAXWELL, Candy DECK, Ruslan ZHURAVCHAK

Pymrio is an open-source tool for Environmentally-Extended Multi-Regional Input-Output (EE MRIO) analysis, developed in Python. The tool provides a high-level abstraction layer for global EE MRIO databases. This enables a harmonized approach towards common EE MRIO data tasks, including

- automatically downloading (specific years and versions) from a EE MRIO database repository,
- reading the downloaded raw EE MRIOs data into a common, Pandas Dataframe based structure,
- easy access to MRIO matrix values by implementing label based indexing,
- common, unit-tested functions for calculating production/consumption based accounts, aggregation, stressor origin analysis etc.
- visualization and reporting of results

Pymrio is a (MR)IO type agnostic tool which can handle any (MR)IO database with a consistent sector classification. Pymrio currently includes parser for several openly available monetary EE MRIO databases (EXIOBASE v1-v3, WIOD, Eora26, OECD-ICIO) while others are planned to be implemented in the near future (e.g. GLORIA, FIGARO). This makes Pymrio ideally suited for data pipelines which need to process several MRIO databases, as for example for the MRIO comparisons website on www.environmentalfootprints.org .

Since Pymrio is an already established tool we will focus this presentation on the latest additions to functionality and the near future development plan. Thus, after briefly outlining the internal structure of Pymrio we will present a tutorial covering:

1. Available consistent data storage formats for EE MRIOs, including a newly implemented, efficient data storage format based on the Apache Parquet data file format.
2. Improved performance for MRIO analysis based on parallelizing calculations on either GPU or toward cloud/HPC systems.

3. How to make use of the improved performance for conducting Monte Carlo based uncertainty/sensitivity analysis with Pymrio.

Pymrio is an open source project which welcomes contributions. These can be in form of improvements on the documentation, bug-fixes or adding completely new functionality. The code is hosted on Github, and we will show how to contribute to Pymrio with a focus on how to initiate/discuss a new contribution, preferred code style and required test coverage.

We will then put Pymrio in a wider context of available Input-Output and Industrial Ecology related tools. There we touch on connected open-source projects, like a new system to add custom extensions to the EXIOBASE MRIO system, which makes use of Pymrio. We will also show how Pymrio can be used together with the open source Python package country converter CoCo to automatically build aggregation definitions for MRIO countries to regions without the need to manually build concordance matrices.

Finally, we will present how to obtain Pymrio from the standard Python packaging repositories (PyPI and conda-forge). This will also include a short introduction into the Industrial Ecology Open Source dashboard and it Input-Output section (https://github.com/IndEcol/Dashboard), which can be used by any researcher to present Open Source tools for our field.

In summary, we aim to give IO researchers, with some basic coding skills, a good understanding on how to use Pymrio as well as the necessary knowledge to report issues and actively contribute to its development. In addition, we hope that by highlighting the existence of the dashboard for collecting Industrial Ecology and Input-Output tools we can contribute to more open code sharing and development in IO research and analysis.

The essentials of Leontief (1970) Environmental Repercussions and the Economic Structure: An Input-Output Approach

Topic: 50th Anniversary of Leontief's Nobel Prize: Environment
Author: Albert E. STEENGE

Based on the seminal work: Wassily, Leontief (1970) "Environmental Repercussions and the Economic Structure: An Input-Output Approach", The Review of Economics and Statistics, 52(3): 262-271. Includes presentation of some archive materials and documents about this topic.

A Study on the Accuracy of Heterogeneous Input-Output Models Based on Monte Carlo Simulation

Topic: Input-Output Theory and Methodology - VI
Author: Jialu SUN
Co-Authors: Xu JIAN, Ji KANGXIAN, Chuan LI

Abstract: The heterogeneous input-output model has found widespread application in research on trade value-added, energy, and environment in recent years. However, due to the lack of data on trade flows between various types of enterprises when compiling heterogeneous input-output tables, scholars have had to rely on assumptions of proportionality and optimization methods to construct intermediate flow matrices. Based on a thorough study of existing methods for compiling heterogeneous input-output tables, this study proposes a novel method based on

Monte Carlo simulation for generating initial values for intermediate flow matrices, which are then adjusted using the TRAS method to ensure conformity with the structural characteristics of the heterogeneous input-output model. The study then measures the accuracy of the Leontief inverse matrix, output multipliers, and export value-added. By simulating the intermediate flow matrix elements 10,000 times under two scenarios, i.e., normal distribution and lognormal distribution, and varying the mechanism for forming the standard deviation of the intermediate flow matrix elements during the simulation, the study shows that the uncertainty of the intermediate flow matrix, Leontief inverse matrix, output multipliers, and export value-added of the Chinese non-competitive input-output model adapted from ICIO-DF(2016) exhibits a decreasing trend. The results of the study indicate that in the process of establishing a heterogeneous input-output model, as long as the total matrix, such as output, value-added, final demand, imports, and exports, are accurately estimated, even if the intermediate flow matrix obtained from proportionality assumptions and optimization methods is biased, the accuracy of the Leontief inverse matrix, output multipliers, and export value-added can still be maintained and improved in order, and the empirical research results obtained from the model can still maintain a high overall accuracy.

Key works: Heterogeneous input-output model; Distinguish between domestic and foreign investment; Monte Carlo simulation; TRAS; Accuracy

Towards regionalization? Assessing its effects on foreign shock exposure and welfare

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - V
Author: Kailan TIAN

The COVID-19-related supply disruptions catapulted the issue of risk in global supply chains (GSCs) to the top of policy agendas. Quite a few policy proposals stress that making GSCs shorter and more domestic can reduce the exposure to foreign supply shocks. It brings a narrative that globalization is withering but regionalization and nationalism are rising. But is this trend good? Can making GSCs more regional and national reduce a country's exposure to foreign supply shocks? How will regionalization change a country's trade and welfare? In this paper, we use a quantitative trade model to simulate the effects of regionalization. We distinguish three regions (North America, Europe, and Asia) and define regionalization as increasing barriers to inter-regional trade but decreasing intra-regional trade barriers. In our simulation, we use the most recent global multi-regional input–output (GMRIO) tables from the Organization for Economic Co-operation and Development (OECD) and tariff data from World Integrated Trade Solution (WITS) software. Our results show that regionalization reduce countries' exposures to foreign supply shocks on average, but the welfare losses for most countries far exceed the benefits from the lower foreign exposure. This paper is among the first to ex ante evaluate the economic effects of a potential regionalization using a global input-output framework. It provides important policy implications for international trade and GSC governance.

Implementation of carbon pricing in an aging world calls for targeted protection schemes

Topic: Input-Output Analysis: Income Distribution Policies - II
Author: Peipei TIAN
Co-Authors: Kuishuang FENG, Laixiang SUN, Heran ZHENG, Klaus HUBACEK, Jiashuo LI, Honglin ZHONG, Xiangjie CHEN, Dan LI

Understanding the impact of climate fiscal policies on vulnerable groups is a prerequisite for equitable climate mitigation. The elderly, especially the low-income elderly, as one of the most vulnerable groups, have largely been ignored in current climate policy designs. Here, we quantify and compare the distributional impacts of carbon pricing on different age-income groups in the US, the UK and Japan first and then on different age groups in 31 countries. We find that the elderly are more vulnerable to carbon pricing than younger groups in all income groups. In particular, the low-income elderly and elderly in less wealthy countries face greater challenges because carbon pricing lead to both higher rate of increase in living cost among low-income elderly and greater income inequality within the same age group. In addition, the low-income elderly would benefit less than the younger group within the same income group in the commonly proposed carbon revenues recycling schemes. The high vulnerability of the low-income elderly to carbon pricing calls for targeted social protection along with climate mitigation polices towards to an aging world.

Spatial distribution of the tourism carbon footprint in a Spanish region

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - VII
Author: Maria A. TOBARRA-GOMEZ
Co-Authors: Nuria GOMEZ, Ángela GARCíA-ALAMINOS, Marina SáNCHEZ

Recent studies have focused on analysing the impact of tourism on sustainability from different perspectives (Cai, 2016; Cardenete et al., 2022; Lenzen et al., 2018; Sun et al., 2020). In this sense, the recent experience due to the pandemic and the lockdown has increased the need for in-depth studies of the consequences of changes to tourism patterns, particularly if this industry is to approach the sustainable goals set in the Glasgow Declaration on Climate Action in Tourism (50% less emissions by 2030, net zero before 2050).

Given the importance of tourism in Spain, there are several sources of information for this type of analysis. Expenditure surveys, such as EGATUR (for foreign tourism) and ETR/FAMILITUR (for domestic tourism) (INE, 2022), provide data according to different characteristics, like month, country of origin, region of destination, length of the stay and total expenditure for international tourist, while the characterisation of domestic tourism is even more detailed (month, region of origin, province of destination, some socioeconomic variables for the tourist, and the level and pattern of spending).

Data by the Satellite Tourism Account (STA, INE, last available data for 2021) bridges the gap between expenditure data from surveys and demand according to national accounts, so we can calculate the carbon footprint for both types of tourism, following the methodology in (Cadarso et al., 2022). We use a multiregional input output (MRIO) approach with the FIGARO database for 2020, including data for CO_2 emissions. This database provides input-output data for 64 industries-46 regions, but it also has regional detail (55 industries), so a more precise calculation

can be made that takes into account the specific production structure in a particular region, by nesting the regional IO data for that one region within the general model. To obtain our vector of demand, we allocate from the STA the tourism demand corresponding to the chosen region by considering the proportion it represents in the expenditure surveys.

That footprint is, however, not homogenously distributed within the territory. Locations receive vastly different amounts of tourists, from different origins, with varying levels and patterns of spending. Recently, the Spanish National Statistics Office (INE) has started to publish data based on the location of mobile phones, by municipality, of foreign and domestic mobile phones in their trips inside Spain. These experimental statistics use mass data from phone antennas together with algorithms to transform them into variables that measure tourism flows (INE, 2022).

The objective of this paper is to combine the granularity of these data with the calculation of the tourism carbon footprint using a MRIO approach to determine how the impact of domestic and foreign tourism is distributed within a particular Spanish region, Castilla-La Mancha. From the calculated carbon footprint (including specific regional IO data), number of tourists and nights, spending levels per nationality for foreign tourists from EGATUR and the detailed information on province of origin, level, and pattern for domestic tourists from the ETR/FAMILITUR, we will obtain a carbon footprint per tourist and night (according to their country or province of origin). We will then distribute that impact spatially according to the number of tourists and length of stay in the municipalities that make up the Castilla-La Mancha region from the data on mobile phones.

To our knowledge, this is the first instance that this type of data is combined with IO data to allocate the carbon footprint spatially by municipality. Our results show how most of the impact is in the main tourist locations, particularly for international tourists, like Toledo. However, the relative effect in small municipalities attracting an increasing amount of national rural tourists is also relevant and should be taken into account when designing regional tourism promotion policies.

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The Carbon Footprint Effects of Bilateral International Migration Flow to the U.S.A.

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - II
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Co-Authors: Futu FATURAY, Shigemi KAGAWA, Waka NISHIFUJI

The UNEP reported that per capita consumption-based GHG emissions are highly unequal between and within countries. The EORA carbon footprint database also shows that there existed a large difference in the per capita consumption-based CO_2 emissions across countries and the U.S.A. shows higher per capita consumption-based emissions of 20.9 t-CO2e larger than country average of 8.84 t-CO2e. The U.S.A. ranks second in the per capita consumption-based emissions in the world in 2021. This implies that lifestyle of the U.S. people was relatively carbon-intensive in a comparison with other countries.

On the other hand, we observe that 740 thousand immigrants obtained permanent resident status in the U.S.A. in 2021 and lived there. An important research question is how the lifestyle of the immigrants changed before and after the migration and what were the net effects of their lifestyle changes on the CO_2 emissions? In addressing this question, this study combines an environmentally-extended multi-regional input-output analysis framework with immigrants flow analysis framework and estimates the net consumption-based CO_2 emissions of immigrants flowing from a specific country to the U.S.A. (i.e., difference in the consumption-based emissions of immigrants before and after the migration). In doing it, we used both the EORA database during 2000 to 2021 and the detailed immigrants flow statistics during 2000 to 2021 provided by the U.S. department of homeland security.

To the best of our knowledge, this study is the first attempt to shed right on the role of the migration in the environment. The empirical results show that 740 thousand immigrants to the U.S. contributed to increasing CO_2 emissions by approximately 9 Mt-CO2e due to their lifestyle changes in the U.S., accounting for 0.2% of the total CO_2 emissions of the U.S. in 2021. Although it seems that the additional annual CO_2 increase by the immigrants' consumption activity was trivial in 2021, we further found that immigrants flowing to the U.S. during this two decades contributed to more than 250 Mt-CO2e, accounting for 5% of the U.S. emissions in 2021. Thus, it is crucial in reducing the consumption-based emissions by immigrants in the U.S. Another important finding is that bilateral migration flows from major five countries of India, Mexico, China, Philippine, and Dominican Republic to the U.S.A. occupied a large portion of 57% of the total of the net consumption-based emissions of immigrants to the U.S. in 2021.

Finally, based on the results, this study suggests a more comprehensive migration policy including carbon tax policy to immigrants with higher net consumption-based emissions.

A Montgomery Additive Decomposition with disaggregate factors within the Leontief Inverse.

Topic: Input-Output Theory and Methodology - VI
Author: Marcelo Resende TONON
Co-Authors: Esther DWECK, Fabio Neves Peracio de FREITAS

Structural Decomposition Analysis (SDA) of input-output tables assists in identifying the leading drivers in changes throughout the time of a given variable. There are multiple ways of performing a given decomposition, each having its own advantages and drawbacks. In the case of Additive SDA, de Boer and Rodrigues (2020) recommend the Montgomery Decomposition or the Bennet Indicator. On the one hand, since the Montgomery method is simpler than the Bennet Indicator,

demanding only one decomposition form, it should be a better choice for the general practice of SDA, except when 'changes-in-sign robustness' is required. On the other hand, identifying the contributions of nested factors inside a Leontief Inverse or different kinds of inverse matrices—such as the Miyazawa Matrix— is, until now, bounded to the Bennet method. Despite its relevance to the input-output field, the decomposition of 'nested factors' did not receive the same highlights as other themes of SDA, with little development. This paper continues the discussion provided by Muradov (2021), in which different methods to decompose the Leontief Decompose are compared through their results. We evaluate his considerations in parallel with those of Rose and Casler (1996), specifically the Multiplicative and Additive Identity Splitting methods. We connect both works by demonstrating how the Additive Identity Splitting method can be a 'complete' decomposition, without any residual term, as displayed in Muradov (2021). We then introduce a new decomposition method that allows us to consider the contributions of the nested factors inside the Leontief Inverse while using the Montgomery Decomposition. This new method first calculates the weights of the contributions to the changes of each cell of the Inverse Matrix by those of its nested factors. Then these weights are used at the Montgomery decomposition for decomposing the contributions of the Inverse Matrix to the changes of the decomposed variable. The new method is compatible with the Additive and Multiplicative Identity Splitting methods or all of the shortcuts tested by Muradov (2021). The proposed method requires a smaller number of decomposition forms than other complete methods, thus alleviating the computational burden of the SDA. The limitations of this new method are that: (1) it is not change-in-sign robust, as any other Montgomery Decomposition; (2) it requires that if the change of a cell of the inverse matrix is zero, all of its nested factors must also have contributions equal to 0 to that cell; which is an improbable case. Moreover, we illustrate how, given the aforementioned limitations, the traditional hierarchical decompositions, using Bennet method, can also be seen as a distribution of the nested factors proportionally to their contributions to their nest matrix. Therefore, we demonstrate that the values from the traditional hierarchical decomposition and those of our proposed method differ because of the difference between the Bennet and Montgomery methods at the first-level decompositions.

Who brings the emissions home? Investigating the effect of female breadwinner household in greenhouse gases emissions patterns

Topic: Gender issues in Input-Output Analysis: New challenges and new perspectives - II
Author: Francisca TORO
Co-Authors: Mònica SERRANO, Esteban FERNANDEZ-VAZQUEZ

The field of research focusing on the relationship between household consumption and environmental impact has been increasing since the pioneering work of Herenden and Tanaka in 1976. It has been found that households consume more energy indirectly through the purchase of goods and services than directly through the consumption of energy itself. Household income has been identified as one of the main factors that influence the environment, with several studies indicating a strong correlation between household income and energy requirement or emissions. Moreover, household demographic characteristics have a great influence on the household environmental footprint. Changes in population size, urbanization, and household composition have implications on consumption growth and production activities, affecting emissions.

This study aims to examine the effect of evolving characteristics of modern western societies on greenhouse gases emissions, focusing on the phenomenon of female breadwinner households, a term used to refer to women being main economic income producer on households, that represent a relatively new scenario around the world, representing a significant proportion of

households across developed countries today. Different studies support the idea that increase of female breadwinner household has consequences in internal household organization and increase in economic resources provided by women leads to an increase in female bargaining power within the household. Therefore, an increase in female breadwinner household might be reflected in decision-making power and, consequently, in the demand for different goods and services, such as food, transport, or fashion commodities. Furthermore, the demand for different products may be influenced by differences in women's and men's concern and knowledge of environmental issues.

Given that a significant proportion of greenhouse gas emissions are generated by private household consumption, an increase in female breadwinner households may have significant effects on global greenhouse gas emissions. However, the potential effect of feminization on greenhouse gas emissions has not yet been fully studied. This research aims to test the hypothesis that female and male breadwinner households present significant differences in greenhouse gas emissions patterns induced by consumption.

We investigate this issue by studying a sample of Spanish households' consumption baskets for 2008, 2014, and 2018, linking consumption levels with emissions through Input-Output approach. The analysis focuses on the aggregation of 6 greenhouse gases, 62 industries, and 39 products grouped into 12 categories under the COICOP classification. The study combines three statistical data sources: Input-Output Tables estimated from Supply and Use Tables, the Environmental Accounts, and the Household Budget Survey. Furthermore, the datasets are combined with additional information that allows linking sectorial indicators in the Input-Output Tables with Household Budget Survey microdata (Bridge Matrices). After calculating a vector of direct and indirect greenhouse gas emissions for each household sampled, the Propensity Score Matching estimator is applied to capture the mean differences in emissions between female and male breadwinner households with identical characteristics isolating the effect of gender.

The preliminary results indicate a significant negative effect of female breadwinner households on greenhouse gas emissions patterns derived from household consumption, primarily due to the use of private transport by male breadwinner households. The study highlights the importance of considering gender as a relevant factor when analyzing the environmental impact of household consumption. The findings suggest that an increase in female breadwinner households may lead to a reduction in greenhouse gas emissions. Moreover, the study contributes to the growing demand for research linking the environment and gender, to the collection of environmental data disaggregated between women and men, and to expose the role of women in sustainable production and consumption.

The Unit Structure Analysis of Energy Price Shock in Japan

Topic: Input-Output Analysis: Energy Policies - IV
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Co-Authors: Shigemi KAGAWA, Sora MATSUSHIMA

Japan is poor in natural resources and relies on imported natural resources for domestic primary energy needs by over 95%, implying that Japan is seriously vulnerable to an increase in prices of imported energy resources. Primary energy prices of crude oil, coal, and natural gas have increased by 80 to 90% in Japan during the period between 2015 and 2022. Thus, the Japanese economy has clearly experienced a rapid increase in energy prices due to the global energy supply insecurity caused by the Russian aggression against Ukraine. It is important to note that

the rapid energy price increase has a significant impact on the production cost of a wide variety of industries because they directly and indirectly use primary energy via product supply chains. An important research question is what are the most vulnerable industries or supply chains that have suffered from the recent energy price shock in Japan? In addressing this research question, we focused on cost pass-through describing that a business entity changes the price of goods and services in response to a change in the energy cost of producing them. To model the cost pass-through via product supply chains, we developed a novel cost-pushed unit structure approach that is capable of describing an adjacency matrix by weighting the energy cost increases embedded in transactions between sectors. We then applied a cluster analysis to the adjacency matrix to find supply chains (i.e., industry groups) with overconcentrated energy cost increases in the supply chain network. In Addition, we quantitatively clarified the effect of a surge in primary energy prices of crude oil, coal, and natural gas in 2022 using the Leontief input-output price model. Regarding the data for this study, we used the 2005, 2011, and 2015-linked input-output tables (IOTs) for Japan and estimated the IOTs in constant 2015 prices using the GRAS method. We also used the time series dataset for energy prices of imported crude oil, coal, and natural gas. From the results based on those data, we found that petroleum products contributed to over 50% of the increased cost pressure on the whole industry in Japan. We also found that more than 20% of the cost pressure from petroleum products was concentrated in the following three industries, namely, Chemical industry, Agriculture and fishery industry, and Transportation industry. Therefore, the supply chain paths from the Petroleum product industry to the three industries (i.e., Chemical industry, Agriculture and fishery industry, and Transportation industry) are vulnerable to higher energy prices and thus they should be the highest priority sectors to mitigate energy-related cost pressure on the whole Japanese industry. Furthermore, the industry cluster analysis clarified that a chemical-related cluster including 'basic petrochemicals', 'petrochemical aromatics', 'thermoplastic resin', and 'aliphatic intermediates' received the highest cost pressure via the supply chains. We suggest that industry clusters (i.e., stakeholders) with higher energy-related cost pressure identified in this study should improve energy efficiency as a group through supply chain engagement to ease the cost pressure. Policymakers should define priority on them and financially support higher priority clusters in energy efficiency improvements.

Production efficiency of animal feed plants using food waste in Japan

Topic: Regional Input-Output Economics - I
Author: Junji TSURU
Co-Authors: Shigemi KAGAWA, Tomoaki NAKAISHI, Daigo USHIJIMA

75% of feeds for livestock raised in Japan was dependent on imports in 2022 (Ministry of Agriculture, Forestry and Fisheries, 2023). In addition, feeds account for 34% of the livestock industry's operating costs for feeding cattle, 50% for milk cow, 63% for feeding pigs, and 57% (broiler management) and 48% (ovum management) for poultry farming in 2022 (MAFF, 2023). If we continue to rely on imports for livestock feed, not only will we be unable to avoid rising of food prices triggered by increased import prices of the livestock feed, but we may also be left with safety concerns due to the effects of feed additives.

Animal feed from food waste, known in Japan as "eco-feed," is important for Japanese food and livestock industries because it is expected to reduce not only food waste disposal but also feed costs and thus improve productivity in both the food and livestock industries. However, eco-feed production plants are not operationally managed well because they are generally facing

challenges such as low production capacity and lack of smooth production. Therefore, it is necessary to identify the most efficient management patterns for eco-feed production plants and to provide opportunities to learn the efficient production technologies.

To our best knowledge, there are few studies that have estimated the production efficiency of eco-feed plants. One exception is early work by Nakaishi and Takayabu (2022), however, they were only able to identify the monthly production efficiency of a "single" eco-feed plant due to limitations in data availability. To provide more comprehensive policy implications, it is necessary to focus on the production efficiency of "multiple" eco-feed plants across Japan.

This study applies data envelopment analysis (DEA) to input-output data of 17 eco-feed plants in Japan to quantitatively assess eco-feed production efficiency on a plant-by-plant basis. In doing so, the most efficient eco-feed production plants and the most efficient eco-feed production methods in Japan can be identified. This study is the first comprehensive evaluation of the relative production efficiency of multiple eco-feed plants, and contributes to the sustainability of both the food and livestock industries.

First, we arranged a comprehensive input-output database for production activities of 17 specific eco-feed plants in Japan from Biomass Utilization Technology Information Database ver2.1 (Japan Center for Regional Environmental Resources, 2022), consisting of three inputs (i.e., number of employees (person), amount of biomass delivered (t), and land value (million JPY)) and one output (amount of eco-feed produced).

Second, a meta-frontier DEA framework was applied to the constructed input-output database to estimate efficiency scores, standardized in the range of 0 to 1, for 17 specific eco-feed plants. DEA is one of the frontier approaches based on linear programming to assess the relative production efficiency of multiple decision-making units (DMUs). The DMUs in this study are 17 eco-feed plants in Japan. While there is one production frontier estimated in the conventional DEA framework, the advanced framework of meta-frontier DEA employed in this study can estimates multiple group frontiers based on the food waste type used.

Third, from the estimated efficiency scores of each eco-feed plant, DMUs with an efficiency score of 1 were considered optimal plants, and DMUs with an efficiency score less than 1 were considered inefficient plants. Through this estimation process, the cost reduction potential of each plant was identified by finding improvements in the efficiency of each toward the DMU with the optimal efficiency value.

From the results, we found that the average efficiency score among the 17 Eco-Feed plants was 0.44 and the three plants of Eco-Feed Corporation, Murata Shoten, and Aiwa Sangyo Sasagami Plant were identified as the most efficient eco-feed plants with an efficiency score of 1. In addition, the results demonstrate that improvements of production technologies in the 14 inefficient Eco-Feed plants can contribute to considerably reducing their production cost. Finally, we suggest providing technical workshops to learn cost-minimizing eco-feed production methods from the efficient eco-feed plants identified in this study and expanding the competitive eco-feed market.

Using input-output to disentangle the farm income problem in Tuscany: an integrated macro-micro level analysis

Topic: Regional Input-Output Economics - IV
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Co-Authors: Tommaso FERRARESI

The analysis of value chains through input-output tables has been widely recognised by economic literature (e.g., Koopman et al., 2014; Bentivogli et al., 2019). The creation and use of interregional tables at the international level has allowed estimating multiple indicators relating to the position of sectors and regions within the global supply chains (e.g., World Bank, 2019). Alternatively, many studies have analysed the effects of participation in global value chains from a micro-economic perspective (e.g., Giovannetti and Marvasi, 2018), often with no connections with the macro-economic level. Indeed, this integration is still largely unexplored, often because financial indicators at the firm level are missing and not always consistent with the information provided in interregional tables. This is especially true for some sectors, like agriculture, whose fiscal regimes are atypical and for which statistical information at firm level is incomplete and often dispersed in several sources of data.

The aim of this paper is to analyse the distribution of the value added in the Tuscan agri-food chain and, in particular, to understand the position of agriculture along the value chain. One of the main aim of the 2023-2027 Common Agricultural Policy is to improve the position of farmers along the agri-food chain, in order to increase their incomes, so as to deal with the "farm income problem" (e.g., Gardner, 1992), but also to limit the asymmetric transmission of prices along the value chain. In fact, in time of constant prices and stable supply, the issue turns to be less crucial, even if some imbalances along the supply chain might still persist. However, the triggering of inflation and the increasing probability of supply crises at the global level, due to the diffusion of unpredictable natural disasters associated to climate change, have recentralised the issue of redressing these imbalances.

Our analysis makes use of an interregional input-output table for Italian NUTS2 regions (see Paniccià and Rosignoli, 2018), augmented in order to single out value added generated in both production and post-production phases by the food final demand. We then single out the contribution in terms of value added of each sector and region from raw materials to consumption. Second, we build up a novel microeconomic dataset of Tuscan firms, derived from administrative and statistical sources, in which all the sectors of the economy are represented, together with their balance sheets, and assess how macro-economic indicators are mirrored by micro-performances of firms at work for the agri-food value chain.

In such a perspective, the novelty is twofold. First, going beyond an input-output representation of the economy at basic prices, we have estimated the distribution of value added along the agri-food value chain, also considering post-production stages, namely commercial services and transportation. Second, the macro-economic assessment has been integrated with a micro-economic evaluation of the financial results of the firms involved into the agri-food chain.

The results show that out of 100 Euros of agricultural products sold in Tuscany, the gross operating margin of the agricultural sector is 30 Euros. In the case of food products, the margin is even lower. These results are in line with Nucera et al. (2016) and Finizia and Merciai (2012) and they are consistent with the input-output analysis too. If, in absolute terms, in the very specific case of Tuscany, there is still an income gap between agriculture and the other sectors, the margin of profitability out of sales is comparable with the rest of the economy. As a result,

producers seem to struggle to gain a fair profit between the price faced by consumers and the price imposed on them by commercial operators.

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The Economic and Environmental Consequences of a Carbon Tax in Japan

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - VIII
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The Japanese government has ratified the Paris Agreement and according to "Global Warming Countermeasures Plan (2021)" and the Ministry of the Environment aims to reduce the amount of greenhouse gases emitted in 2030 by 46% compared to that in 2013. The enforcement of a carbon tax is a significant policy for reducing CO_2 emissions in Japan. The carbon tax introduced in Japan is one of environmental taxes that imposes a tax to industries which emit a lot of CO_2 such as shipping, importers of crude oil, and importers of coal. The tax rate is determined according to the amount of direct CO_2 emissions due to the consumption of fossil fuels.

The Japanese government has introduced a global warming tax to CO_2 emissions from the consumption of fossil fuels including crude oil, coal, and natural gas since 2012. The current tax rate is 289 JPY per ton of CO_2 which is less than 1/10 of other countries which have implemented carbon tax. The Japanese government will impose a carbon tax on five industries including petroleum products (i.e., petroleum importers), coal products (i.e., coal importers), commercial power generation (i.e., power plants), city gas, and trading companies in 2028.

This study focuses on four industries of coal products, petroleum products, commercial power generation, and city gas and identifies industries which receive the largest impact from a carbon tax, using both the input-output price model and the supply-chains network model based on the price model. There are many studies that describe the advantages and disadvantages of carbon taxes, but few of them identify the economic and environmental effects of a carbon tax in the supply chain complexity.

This study quantitatively analyzes the carbon tax-induced effects in the detailed supply chain paths in Japan. Firstly, we estimated the monetary and physical amounts of fossil fuels imported by each of the above-mentioned four industries using the detailed physical input-output table of

2015. Secondly, we calculated the amount of carbon dioxide directly emitted by the four industries using the carbon dioxide emission factor provided by the Ministry of the Environment of Japan. Then we calculated the amount of carbon tax imposed on the four industries. The carbon tax rate has not been determined in Japan so far and therefore we assumed carbon tax rate following tax rates introduced in the EU countries. Finally, we calculated the changes in price index of domestic products due to the enforcement of the carbon tax.

From a result based on the 2015 input-output tables of Japan, we found that total Carbon Footprint of fossil fuels imported by four industries including coal products, petroleum products, commercial power generation, and city gas was about 926 Mt-CO2e. If a carbon tax of 2,890 JPY per ton of CO2 emissions (i.e., the least carbon tax rate in the EU countries) is applied to the four industries, the government would obtain the revenue from tax of 2,678 billion JPY and the composite Laspeyres price index of domestic products would rise by 7%. Furthermore, we found that price increase effects in the supply chain groups centered around five industries of pig iron, basic petrochemical, in-house power generation, petrochemical aromatic, and crude steel (converter) increased the most. Based on the results of this study, we suggest that the government should financially support to improving energy efficiency within the supply chain groups identified in this study and determine the best way to use of tax revenues.

Estimating the GHG emissions mitigation effects of "buying local food" through a life cycle analysis: the case study of Japanese seven regions

Topic: Regional Input-Output Economics - I
Author: Marina UEMATSU
Co-Authors: Haruka MITOMA, Tomomi SHODA, Shigemi KAGAWA

Greenhouse gas (GHG) emissions from food system accounted for 34% of the global GHG emissions in 2020. To mitigate the GHG emissions from the food system, it is crucial to focus on food supply chains including cultivation of agricultural products, transportation, packaging, sales, and disposal and make a policy toward a greener food system. The concept of "food miles" which represents how far the food traveled before it reaches the final consumers, penetrated Japanese society and "buying local food" has been promoted to reduce GHG emissions in the transportation stage through decreasing the food miles.
On the other hand, we should note that the existing food trade network reflects the comparative advantage of regions due to its geographic feature. Hence, the production shift to local food can offset the GHG emissions reduction effect in transportation stage through the increase of intermediate input for food production. However, there are few studies that consider the net effect of buying local food in a country.

This study investigates the impact of buying local food on life cycle CO2 emissions associated with cultivation and transportation of food in Japanese seven regions (i.e., Hokkaido, Tohoku, Kanto, Kansai, Chugoku, Shikoku, Kyushu). We focus on major five vegetables (i.e., radish, onion, cabbage, carrot, and Chinese cabbage) which are widely produced and consumed in Japan. The novelty of this study is that we estimated the detailed intermediate input structure of agriculture sector by the seven regions based on the income and expenditure survey to agricultural enterprise. We consider twelve intermediate input including energy, fertilizer, agricultural chemicals, farm machine, land improvement, packaging. For energy input, we used different input coefficients for open cultivation and intensive cultivation (indoor cultivation) which requires extra energy input to control the temperature in the facilities.

To calculate the direct and indirect CO_2 emissions in cultivation, we use CO_2 emission coefficients based on the environmentally-extended input-output table of Japan (3EID) published by National Institute for Environmental Studies. Finally, CO_2 emissions in cultivation stage are calculated by multiplying the embodied CO_2 emission coefficient row vector with the estimated input coefficient column vector.

We found that the embodied CO_2 emissions intensity of food cultivation are significantly varies among regions. The intensity was lowest in Hokkaido (4.4kg-CO_2/thousand JPY) and was the highest in Shikoku region (7.3 kg-CO_2/thousand JPY). For Hokkaido which has a vast land, the share of open cultivation was the highest among the regions.

For calculating the CO_2 emissions in transportation stage, we constructed food transportation network matrix using food trade data published by wholesales market in each region and CO_2 emissions intensity for unit truck transportation published by truck association of Japan. In Japan, more than 90% of domestic food transportation are covered by truck transportation. We considered the transportation share and the intensity of private and industry trucks respectively. We found the total CO_2 emissions from transporting the five vegetables focused on this study was 480 kt-CO_2. Food transports from Hokkaido to Kanto region which including Tokyo was the largest contributor, it accounted for 15% of the total emission. It was followed by that from Hokkaido to Kansai region including the second largest city and that from Hokkaido to Kyushu region which is the longest travel from Hokkaido.

Based on the results, we investigated the CO_2 mitigation effect of the buying local food by the case of shifting from cultivation in Hokkaido to Kanto. Specifically, we set a scenario of substituting vegetables produced in Kanto for those imported from Hokkaido to Kanto and change substitution rate between 1% and 50%. The results show that the purchase shift decreased the life-cycle CO_2 emissions. However, even in the scenario of an extreme shift with the substitution rate of 50%, the reduction effect was only 4% of the total CO_2 emission. Therefore, to mitigate the life cycle CO_2 emissions from the food system effectively, policy makers should focus on the other CO_2 mitigation policies such as restructuring the transportation network or shifting transportation by trucks to that by railway or shipping which have lower CO_2 emission intensities.

A Compilation of SEEA and Application to Input-Output Accounts

Topic: Input-Output Analysis: Industrial Policies - I
Author: Keiji UJIKAWA
Co-Authors: Xuemei SHEN, Yu ZHANG

Recently, the System of Environmental-Economic Accounting (SEEA) that is a satellite system of the SNA has become an international statistical standard as a means of analyzing integrated policies regarding climate change / circular economy / SDGs issues and the interaction with the economy. In 2017, the United Nations Statistical Commission approved SEEA as supporting framework for applying the SDGs to policies.

In the transition from the Input-Output Table system to the Supply and Use Table system, the United Nations has recommended the compilation of Physical Supply and Use Table (PSUT) that is one of primary accounts in SEEA. SEEA application to policies are required at research and practical levels. Related former studies have also attempted to evaluate SDGs goals using the framework of SEEA and the extensions.

These days, the compilation and application of the Environmental Extended Input-Output Table based on SEEA Applications and Extensions have been emphasized concerning the application of SEEA to analysis. On the other hand, the application of SEEA using the CGE models that can deal with changes in price and quantity at the same time are being attempted in the analysis of policy issues.

According to the research question above, in this research, we adopted the method to compile several Japanese SEEA Accounts including PSUTs and transform them into Environmental Extended SAMs (EESAM) with monetary and physical data. Furthermore, we have constructed SEEA-CGE models using these SEEA accounts, PSUTs and EESAMs for SDGs policy analysis.

We have constructed a statistical framework for evaluation of circular economy and decarbonized society scenarios against climate change that also link to SDGs policies using the stock / flow data of various materials and energy sources by monetary and physical terms. For the policy analysis above, we have specifically compiled composite Japanese Air Emission Accounts, Physical Energy Accounts and Material Flow Accounts (Waste accounts) including corresponding PSUTs by sectoral data such as greenhouse gases, energy / material inputs, waste emissions. In 2022, the Cabinet Office published the official Air Emission Accounts and has also attempted to estimate sectoral Environmentally Adjusted Multifactor Productivity using the accounts. The first author was a member of the research group, and this research is positioned as a continuation of this work and its development with related accounts for further policy analysis.

Based on SEEA accounts above, we have also compiled an Environmental Extended SAM for construction of a SEEA-CGE model for policy analysis including SDGs. In this model, various environmental factors such as greenhouse gases, energy / material inputs, waste emissions are incorporated as variables and policy analysis on circular economy / decarbonized society scenarios are attempted in correspondence with the SDGs targets.

Nowadays, SEEA is widely used to provide information on related policies for policy issues such as circular economy, climate change, and green growth. The various SEEA applications have been incorporated into the green growth strategies in recent years. For the novelty of the research, we believe that our research is one of the pioneering attempts through the compilation of composite SEEA accounts and CGE model for application to policy analysis including SDGs as described above and hope that our research will contribute to analysis for corresponding integrated policies.

An Application of the Multiregional Input-Output Model (MRIIM) approach to assess the disruptions caused by the Earthquake in Turkey

Topic: Input-Output Analyses and Input-Output Modelling of Disasters - I
Author: Amin ULLAH
Co-Authors: Yousaf ALI

Natural disasters in the form of earthquakes are one of the biggest threats to economic growth for a country. Such an event is responsible for creating disruptions at the economic, social, and environmental levels and can push an economy on its back foot. The recent earthquake in Turkey and Syria is its biggest example, which took more than 50000 lives and caused huge damage to the major infrastructures. Such an event causes disruptions not only in the region where it occurred but also leads to ripple effects in the other sectors of different regions and economies.

Therefore, keeping the aforementioned discussion in mind, the current study will analyze the perturbations caused by the earthquake with a primary focus on Turkey and the major economies in the European Union (EU) i.e., Germany, France, and Italy. For this purpose, the study will incorporate Multi-Regional Inoperability Input-Output Model (MRIIM) by taking the recent data available into consideration (1). Such an application will try to answer the research question, the disruptions caused by the Turkish earthquake in various sectors of the different advanced EU economies i.e., to compute the ripple effects in other sectors produced by changes in a sector owing to the earthquake event. Based on the application, the study will lay down the foundation for making the sectors resilient from future similar disasters by identifying the most critical sectors in the economies. The study will also formulate necessary recommendations for the policymakers to ensure that both economic and social damages are brought to a minimum. The application of MRIIM in the case of Turkey's earthquake scenario lays down the foundation for the novelty, and upon its conclusion, a first-of-its-kind study.

Keywords: Earthquake, Turkey, Syria, MRIIM, FUCOM, EU, Inoperability

(1) The data will be based upon the Input-Output Tables available on Eurostat & World Input-Output Tables (WIOD) data sources for multiple economies.

Life-cycle CO2 Reduction Potential through the Operational Efficiency Improvements in the Japan's medical sector

Topic: Regional Input-Output Economics - I
Author: Daigo USHIJIMA
Co-Authors: Haruka MITOMA, Tomoaki NAKAISHI, Shigemi KAGAWA

CO2 emissions from medical sector account for 4.6% of the total CO2 emissions in Japan in 2011 and it is crucial to mitigate its emissions through a relevant policy. The medical sector is capita-intensive and it needs a wide variety of capital equipment to provide medical services. In addition, the number of capital equipment such as diagnostic imaging devices of computed tomography (CT) and magnetic resonance imaging (MRI) mainly used in hospitals has rapidly increased by 60.2% between 1999 and 2020 due to the Japan's aging society and the capital-intensive activity has contributed to increasing the life-cycle CO2 emissions via material and energy consumptions. It should be noted that the number of these devices installed in the hospitals per capita largely varied between prefectures in Japan. Data also shows that a negative correlation existed between the number of devices per capita and the number of medical examinations (i.e., provision of medical services) in prefectures, implying that the equipment are being used inefficiently. We examine the potential of reducing costs and life-cycle environmental impacts through optimal allocation of CTs and MRIs among 47 prefectures of Japan by using a new method modelled by both data envelopment analysis (DEA) and life-cycle analysis (LCA). For the empirical analysis, we use a comprehensive hospital database including the number of CT and MRI introduced in hospitals in 47 prefectures of Japan, the number of radiology technologists and the number of radiologists employed in the hospitals, and the actual number of their medical examinations in the hospitals and estimate the relative operational efficiency of each prefecture through the DEA. The DEA results show that prefectures with the highest operational efficiency score of 1 are mostly found in east regions of Japan such as Hokkaido, Kanto (Saitama, Chiba, Tokyo, and Kanagawa), and Chubu (Nagano, Aichi). Prefectures with lower operational efficiency score are located in Kyushu (Fukuoka (0.728), Oita (0.707), Saga (0.705), Kumamoto (0.601), Miyazaki (0.593)), and Shikoku (Kagawa (0.751), Kochi (0.642)). Thus, there was a large efficiency

gap in the Japanese hospitals. We also find that the cost reduction potential nationwide is estimated to be 313 billion yen, and the CO2 emission reduction potential from reducing devices is 732 kt-CO2e, which accounts for approximately 1% of the life-cycle CO2 emissions from the healthcare sector in Japan. It is important to note that 42.4% of hospitals of Japan responded "not much" or "not at all" in a questionnaire survey on future energy reduction opportunities for hospitals. Thus, the questionnaire survey result shows that approximately 40% of hospitals are stuck with measures to reduce their environmental impact. On the other hand, the CO2 emission intensity target described in the "Action Plan for Low Carbon Society in Hospitals" is a 1.57% reduction from the previous year. Therefore, we conclude that there exists a large potential for CO2 emission reduction through efficient use of capital equipment in the Japan's medical sector. The government should promote reallocation of equipment and joint use among medical institutions in the future to prevent further environmental burden caused by inefficient equipment operation.

Expanding Eurostat's FIGARO MRIO database: industry disaggregation, and environmental and labour extensions

Topic: Input-Output Analysis: Industrial Policies - I
Author: Arkaitz USUBIAGA
Co-Authors: Iñaki ARTO, Ignacio CAZCARRO, Erik DIETZENBACHER, Pablo PINERO, Maria Victoria ROMÁN, José M. RUEDA-CANTUCHE

Despite the existence of various MRIO databases, the policy uptake of the results is limited. Multi-database comparisons have reported relevant differences in the monetary structure, extensions and footprint results of the main MRIO databases. In order to overcome some of these problems, some countries have combined official data produced by their national statistical offices with existing MRIO databases to decrease their country uncertainty of the results, while at the same time increasing their acceptability for policy uses. Despite these exceptions, countries still lack MRIO databases consistent with their national statistics.

While the OECD and Eurostat have produced their own 'official' MRIO databases (namely ICIO and FIGARO), these still lack sufficient sectoral detail and environmental and social extensions to more accurately represent environmental footprints. For instance, having a single agricultural sector is problematic when calculating carbon footprints because the emission profiles of the underlying products are very different.

Against this background, the European Commission's Joint Research Centre (JRC) funded a project to build a high-resolution MRIO database based on Eurostat's FIGARO database, which was to include energy, air emission and labour extensions. The main novelty of FIGARO-e (or FIGARO extended) is that is largely consistent with official statistics, thereby substantially increasing its potential use in policy. This first version of the database covers the year 2015, and represents 46 countries (plus a rest of the world region), 176 industries and 213 products. It includes a labour extension split by gender and skill, two energy extensions and four extensions for greenhouse (GHG) gas emissions (carbon dioxide, methane, nitrous oxide and fluorinated gases).

The methodology followed and the main features of the database can be summarised as follows:
• The original FIGARO MRIO database, which represents 64 products and 64 industries has been disaggregated to 176 industries and 213 products using the industry and product structures of EXIOBASE v3.8.2.
• The labour accounts represent the number of persons engaged (thousands) using data from

the OECD TiVA indicators and EXIOBASE v3.8.2. The data is split by gender and skill (one version based on education and another one based on occupation). The allocation to the disaggregated industry classification has used labour splits from the EXIOBASE labour accounts.

• The energy accounts provide information on primary energy supply and net energy use. The are based on the energy balances from the International Energy Agency, which are bridged to the residence principle. Then, the energy supply and use data is allocated to the disaggregated industry and final consumption categories based on information from the FIGARO-e monetary MRIO data.

• The GHG emissions from combustion processes are calculated based on the energy data (and emission factors) and allocated to industries and final consumption categories based on information from the FIGARO-e MRIO database. The emissions from non-combustion processes originate from a disaggregated version of the EDGAR database. The data from European countries is then benchmarked to the official GHG emission accounts from Eurostat, which are given in a 64-industry resolution.

As shown above, the resulting database is largely consistent with official statistics and dataset from well-established international institutions. Thus, FIGARO-e represents another step towards the institutionalisation of MRIO database production.

FIGARO-e will be integrated into the JRC's Trade-SCAN tool, a user-friendly modelling interface developed by the JRC for the calculation of global value chains indicators. The new features will benefit the analysis of the environmental and labour effects of globalisation and the impact assessments of the new EU Green Deal related policies as well as the Environmental taxation policy of the EU.

Modeling Transition Pathways through Environmental Stock-Flow Consistent Input-Output Models: the case of Argentina

Topic: YSI and Development Programme - IV - Discussants: Bart Los and Rosa Duarte
Author: Sebastian VALDECANTOS

In December 2020, Argentina updated its nationally determined contributions (NDC) of greenhouse gas emissions to 359 million metric tons of CO2 equivalent in 2030, which is 25.7% lower than the initial target set four years before. Being the new NDC target roughly equal to the current level of greenhouse gas emissions, the fulfillment of the target finds the country at a crossroads: either it remains stagnant or it shifts its productive structure away from high emitting activities, like agriculture and cattle raising, which would entail severe consequences in terms of the balance of payments. As a result, the country finds itself in a trilemma where given its economic structure the simultaneous attainment of moderate (not even high) economic growth, external and environmental sustainability is not feasible. A possible way out of this trap would consist of undertaking a process of structural change based on the energy sector, in such a way that all the emissions except for the ones coming from the primary sector are significantly reduced.

The goal of this paper is to build an empirically calibrated model that is capable of representing the multiple processes underlying the trilemma that Argentina and, most likely, most Latin American economies face in the context of the green transition. Such a model needs to account for the sectoral specificities of the economy as well as for the interactions between the economy, the environment and the financial side (mainly the one linking the economy to the rest of the world), and at the same time overcome the problems that have render IAMs useless for

policy-making purposes. The model developed in this paper is an Environmental Stock-Flow Consistent Input-Output Model (ESFCIO) disaggregated at 31 productive sectors for the year 2017, which social accounting matrix is extended to incorporate the greenhouse gas emissions of each productive sector and the financial assets and liabilities of each institutional agent, thus obtaining a modeling tool that integrates production, income, financial and environmental accounts in a consistent way. The model is used to simulate two different scenarios of a transition toward a more sustainable economy, one where all productive sectors increase their energy efficiency and reduce their production-related emissions and another one where the transition is led by the most relevant sectors in terms of exports, employment generation and greenhouse gas emissions. The results of the simulations show that a stable green transition is possible, although conditional on a regular flow of financing during the period that structural change takes place.

Brazilian exports and income distribution: an input-output analysis for 2002-2014

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - I
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International trade broadens the consumer market, and it also creates value-added and income. However, this income generated is heterogeneously distributed among household groups, which may impact the income distribution within a country. According to Goldberg and Pavcnik (2007), one of the few insights that are consensual in trade theory is that changes in a country's exposure to world markets affect the distribution of resources.

The impacts of international trade on countries' income have been widely discussed in theoretical and empirical literature. However, due the ascending globalization, the concern about its impacts on income inequality has become more relevant in the last decades. This process includes reductions in policy and transport barriers to trade and hence, greater international trade flows. As observed in Goldberg and Pavknik (2007), this phenomenon coincided with a period of increasing within-country inequality in many regions, mainly the developing ones, leading economists to attempt to link globalization to inequality.

Empirical studies relating trade openness and income inequality found that the direction and magnitude of this relation differ for each country and time, depending on factors such as development and income level, productivity, social and institutional structure, and trade reforms specificities (Goldberg and Pavknik, 2007; Meschi and Vivarelli, 2008; Bergh and Nilsson, 2010; Çelik and Basdas, 2010; Bensidoun, Jean and Sztulman, 2011; Atif et al.; 2012). These papers, like most of the literature, used econometric approaches. Otherwise, Alsamawi et al. (2014) used input-output analysis to calculate the inequality footprint of nations, that is, the income distribution (measured by Gini index) that each country produces elsewhere in the world, for importing goods. Their main finding was that most developed countries (more egalitarian) import from developing countries (more unequal), for instance, China, Russia, Brazil, Thailand, and the Philippines.

The matter about trade impact on income is especially relevant for Brazil. Although Brazilian inequality has slightly fallen since 2000 (IPEA, 2016), it is still remarkably high, and it started to grow again after 2016, according to Continuous National Household Sample Survey (hereafter, PNADC) from IBGE (2020). Indeed, Brazil presents the fourth highest Gini index of upper-middle-income countries (World Bank, 2020).

For Brazil, the link between globalization and this large inequality is not clear. As exposed by Castilho, Menéndez and Sztulman (2012), the country has experienced a large increase in trade openness between 1998 and 2004, mainly due to growth in export exposure. Nonetheless, they found evidence, based on time series data (for 1987-2005), that rising export exposure tends to decrease poverty and inequality in Brazilian states. Alsamawi et al. (2014), using input-output data from 1990 to 2010, found that Brazilian inequality footprint is much smaller than its within-country Gini index. As explained above, this represents de income distribution of imports. Despite the abovementioned literature, an important question remains unanswered: what is the contribution of each partner to the inequality footprint of Brazilian exports?

In this context, we aim to assess the domestic income inequality linked to the Brazilian exports. Thus, we assess the generated income, direct and indirectly, from exports and its distribution among the income groups through an input-output analysis and the hypothetical extraction method. We use the World Input-Output Database (WIOD) for 2002-2014 and household income data from National Household Sample Survey (PNAD) to calculate some index, such as domestic income per group in Brazilian export to each partner, domestic income per group in Brazilian export of each industry to each partner, domestic income per group in Brazilian gross exports, and others.

Using input-output stock-flow consistent models to simulate and assess "circular economy" strategies

Topic: Recent Developments in Stock-Flow Consistent Input-Output Modelling - II
Author: Marco VERONESE PASSARELLA
Co-Authors: José Bruno FEVEREIRO, Ben PURVIS, Oriol VALLES CODINA

Abstract. The Circular Economy (CE) paradigm has gained momentum in both academic and industrial circles in the last decade. Despite the intuitive association of a transition towards a CE with a more sustainable society, there has been limited scrutiny about its economic viability. To address this, there is a need for macro- and meso-economic tools to assess the impacts of CE policies on society, the economy, and the ecosystem. The field of ecological macroeconomics can fulfil this need through various promising modelling approaches. However, much work remains to be done. The aim of this article is twofold. Firstly, it provides a short literature review of macro- and meso-economic modelling developments addressing CE issues, focusing on the most widely used approaches and tools. Our review highlights that the engagement of the macro- and meso-economic literature with the CE topic has been, thus far, overly simplistic. On the one hand, most methodological proposals based on computational general equilibrium (CGE) models do not appear adequate to assess the success of CE initiatives, as they lack an explicit description of the structural change required to achieve the transition. Additionally, the more comprehensive literature based on traditional input-output (IO) analysis seems to focus mainly on ex-post assessments or on simple exogenous changes to final demand patterns, rather than providing a dynamic view of the phenomenon. On the other hand, while stock-flow consistent (SFC) models have gained momentum in ecological macroeconomics in the last decade, their main limitation is that they only consider aggregate output, so neglecting the interdependencies between different industries. This is the reason a hybrid approach seems necessary. Secondly, based on the previous point, the article argues that the combination of IO with SFC modelling techniques is one of the most promising methods to simulate, assess, and compare CE strategies. In order to support this, the main features of a simplified IO-SFC model for a capitalist economy are presented and discussed. In such a model, money is endogenously created, production is

demand-driven, and the macro-economy is divided into industries that produce goods and services, as well as generating waste and CO2 emissions. Results show that restructuring production and consumption patterns in order to adopt CE-driven practices is not enough to ensure the transition towards a more sustainable economy, as long as production decisions remain driven by private interests.

Keywords: Circular Economy, Stock-Flow Consistent Models, Input-Output Analysis, Waste, Carbon Emissions

JEL Classification: E16, E17, C67, D57

Highlights:
- There has been limited scrutiny about the economic viability of circular economy strategies
- Ecological macro- and meso-economics can provide analytical tools to assess the impacts of circular economy policies on society, the economy, and the ecosystem.
- The article provides a literature review of macro- and meso-economic modelling developments addressing circular economy issues.
- The article argues that the combination of input-output analysis with stock-flow consistent modelling is one of the most promising methods to simulate, assess, and compare circular economy strategies.
- Results show that restructuring production and consumption patterns in order to adopt circular practices is not enough to ensure the transition towards a more sustainable economy, as long as production decisions remain driven by private interests.

Main research questions:
- What is the economic viability of circular economy practices?
- How can input-output and stock-flow consistent modeling techniques be used to assess the impacts of circular economy policies on society, the economy, and the ecosystem?

Policy Responses to Labour Saving Technologies: Basic Income, Job Guarantee, and Working Time Reduction

Topic: Recent Developments in Stock-Flow Consistent Input-Output Modelling - III
Author: Davide VILLANI
Co-Authors: Simone DALESSANDRO, Tiziano DISTEFANO, Guilherme Spinato MORLIN

This paper investigates policy responses to the rise of labour saving technologies and their potential negative effects on employment and inequality. There is a growing debate concerning the role that new technologies will have on a broad set of spheres. Several authors estimate that new technologies have a major negative impact on the employment (Arntz et al. 2016; Frey and Osborne 2017; Nedelkoska and Quintini, 2018). Another consequence of the interplay between the rising new technologies and the substitution of capital for labour relates to growing inequalities (Lankish et al. 2019; Acemoglu and Restrepo, 2022) and impact negatively on the labor share (Dao et al., 2019; Acemoglu and Restrepo, 2020; Autor and Salomons, 2020; Dauth et al., 2021, among others).

As per the increasing number of studies, the latest advancements in technology could have a more disruptive impact than previous technological waves. This trend may eventually result in a continuous decrease in the employment level, the labour share of income and lead to higher inequalities. Therefore, it is essential to discuss the potential disruptive effects of strong

technological shocks and the possible role of diverse policy measures.

In this paper we ask how three different policy measures – basic income (BI), job guarantee (JG), and working time reduction without loss of payment (WTR) – could affect the economy in the wake of a technological shock.

We assess the impact of these policies using the EUROGREEN model (D'Alessandro et al. 2020). This is an Input-Output-Stock-Flow model which allows the analysis in the long run of a large set of variables of interest. The dynamic macro-simulation model builds on data from a wide set of sources such as Eurostat, EU KLEMS, the World Input–Output Database, the OECD and the International Energy Agency. Input-Output techniques are used to estimate the propagation effects of technological shocks along the productive structure of the economy, as well as on sectorial employment and carbon emissions.

We build different scenarios in which the effects of these policies are implemented against a reference scenario of high labor productivity growth. The policies are evaluated based on per capita GDP, Gini coefficient, labor share, unemployment rate, and deficit-to-GDP ratio. We find that JG reduces the level of unemployment significantly and permanently, whereas BI and WTR only temporarily affect the unemployment rate. WTR effectively increases the wage share and generates the lowest deficit-to-GDP ratio in the long run.

The introduction of a wealth tax further reduces inequality and helps to offset the increase in public spending associated with JG and BI. Then, we explore how these policies could be implemented together. A combination of all policies (BI, JG, WTR, and WT) delivers the highest per capita GDP, lowest unemployment rate, and best distributive outcomes.

Overall, this paper addresses a highly relevant topic, nurturing the debate on the expansion of labour-saving technologies and discussing the feasibility of novel economic policies to face the possible negative impacts of technological shocks. Our findings suggest that these policies are effective in counterbalancing the negative effects of technological shocks that increase labor-saving technologies. The flexibility of the EUROGREEN model would also allow to implement further alternative scenarios.

Patterns of technical change and labour saving trends in six advanced economies

Topic: Input-Output Analysis: Employment Policies
Author: Davide VILLANI
Co-Authors: Ariel Luis WIRKIERMAN

The aim of the paper is to study the sectoral concentration patterns of technical change and labour saving trends in six advanced industrial economies (US, UK, Germany, Japan, France and Italy) for the 1995-2015 period.

We compute technical change relying on a multisectoral physical productivity measure based on the notion of vertically hyper-integrated labour content of commodities as per Pasinetti (1988). Different from other traditional measures of productivity growth (e.g. TFP growth) which reflect additive real cost reductions rather than physical productivity changes, vertical hyper-integration makes possible to quantify and depict the concentration pattern of labour-saving trends across a set of growing subsystems (in the sense of Sraffa 1960). In order to perform our computations we

articulate a dataset integrating the OECD Input-Output Database and the OECD STtructural Analysis (STAN) Database.

These computations are functional to address two research objectives.

First, we study the relationship between sectoral productivity and patterns of technological development at the country level. For each country, we create Harberger (1998) diagrams adapting the original formulation to our unit of analysis, i.e. we switch from the industry to the (growing) subsystem. This representation allows us to estimate the pervasiveness and curvature of the diagrams, following the proposal in Inklaar and Timmer (2007). The pervasiveness indicator quantifies the cumulative share of sectors with positive contributions to productivity growth while the curvature indicator measures the extent to which sectoral growth differs from the evolution of aggregate productivity. Using these two indicators we characterise the patterns of technological change across countries. We find that the pace of productivity change is positively correlated with the degree of pervasiveness and negatively correlated with the curvature. Overall, these findings suggest that the way technological progress is distributed across subsystems matters. A more balanced technological development is related to higher productivity growth.

Second, we link the estimations of labour saving trends and productivity growth to the literature on routinisation and automation (Autor et al. 2003; Acemoglu and Autor 2011; Autor 2013). According to this stream of research, occupations with a higher routine content can be more easily automated and ultimately replaced by machines and industrial robots. By knowing the occupational structure of each industry and its corresponding routine content, it is possible to estimate which sectors are more exposed to labour displacements. This procedure is followed by Marcolin et al. (2016), who create a Routine Intensity Index (RII) for 18 industries. We compare our estimation of labour saving trends and physical productivity growth with the RII to establish to what extent this index is mapping actual processes of productivity growth. We find that there is a positive relationship between labour saving trends and the degree of routinisation. The industries with the highest routine content tend to correspond to those subsystems that have recorded higher labour saving trends.

To sum up, our application of the Harberger (1998) diagram and derived indicators to the hyper-integrated labour content of commodities provides novel evidence on the relationship between sectoral productivity imbalances and the aggregate pace of productivity growth, from an input-output perspective.

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An in-depth ex-ante assessment of the employment and macroeconomic impacts of the Malawi M1 Road Rehabilitation project

Topic: Assessing Employment Impacts Using Simulation Models: Some Sub-Saharan African Experiences
Author: Luis Alberto VILLANUEVA MARTINEZ
Co-Authors: Xiao JIANG

Using the ILO's Structural Model for Sustainable Development (SMSD) we conduct an ex-ante employment and macroeconomic impact of the M1 Road Rehabilitation project in Malawi. The model builds on data from the IFPRI Social Accounting Matrix (SAM) for Malawi which contains detailed information on production, income generation and distribution. The model is calibrated based on the IFPRI SAM and is characterized by sector-level adjustment mechanisms that reflect features of a low-income commodity-dependent economy. The simulation is conducted to assess the temporary employment impact of the implementation of the project as well as the permanent employment impacts generated by the expansion of transport sector capacity as the result of the M1 Road Rehabilitation project. Since sectors of the IFPRI SAM can be matched to GTAP sectors, we can obtain employment effects by gender, occupations, age group and informality.

The drought in Andalusia: Analysis of the economic impact and evaluation of the SOS Plan

Topic: Regional Input-Output Economics - IV
Author: Paula VILLEGAS MARTOS
Co-Authors: Manuel A. CARDENETE, Luz Dary BELTRAN JAIMES

Droughts is currently a topic of special relevance and interest worldwide. According to the Environmental Portal of Andalusia, droughts are a major risk in the region. This natural phenomenon can be direct and/or indirect. Direct effects are those specific to a sector, with changes in production, added value or employment focused on activities that use water as a critical or important part of the production process, such as the public water supply, agriculture or electricity. Indirect effects are derived from the former, that is, a reduction in supply can affect the productivity of a company and, therefore, the flow of goods and services through sectoral interconnections and supply chains. Both factors motivate this research, as severe droughts affect the demand for goods and impact the main economic aggregates.

The objective of this study is to estimate the impact of the drought in which the region finds itself

and the SOS Plan launched by the Junta de Andalucía to address the water shortage on the Andalusian economy. For this, we use input–output methodology and the Social Accounting Matrix of Andalusia database. We carry out two simulations: the first takes into account only the effect of the drought, and the second further includes the injection of money from the public administration.

The results obtained reveal notable consequences of the drought on the economy (-6.2% in terms of income and -7.4% in terms of GDP) that could be reduced in the event of good execution of the aforementioned plan (-3.2% in terms of income and -3.9% in terms of GDP). In addition to economic problems, other issues such as social or political concerns may arise. Due to the essentiality of water itself, there is a serious problem to tackle in the coming years with some possible solutions such as technological changes or restructuring production structure.

Keywords: Social accounting matrix, drought, Andalusia

JEL codes: C67, C68, D57, D58, Q25, Q54

Global energy inequality in households

Topic: Input-Output Analysis: Energy Policies - III
Author: Yang WANG
Co-Authors: Yuru GUAN, Klaus HUBACEK, Yuli SHAN

Global wealth and income distribution is extremely unequal among countries and households. Reduced inequalities is one of United Nations Sustainable Development Goals. There are wide studies about how to reduce inequalities, and the reasons and the impacts of inequality. The economic inequality also translates to energy inequality. Energy consumption is perceived as a better indicator of inequality as it captures the flow of durable goods and services which represent income and standard of living and are sustained by energy quantities . Households' direct energy consumption and energy footprints (or indirect energy use) are unequally distributed among countries and household groups due to differences in the size and patterns of household expenditure. In order to achieve more equitable energy use worldwide, it is crucial to understand the current global distribution of energy consumption by household groups. However, previous studies about energy footprints and inequality seldom consider different energy types, economic sectors, and detailed household categories.

By using the latest GTAP v11 dataset (MRIO table and energy data of 160 countries in 2017), and global expenditure data from World Bank (201 expenditure bins of 116 countries which almost consist of 90% of the global population), we computed country- specific energy footprints by 201 household groups and 6 energy types using an environmental-extended multi-regional analysis and revealed the global household energy inequality by using Gini coefficients. We find that the direct energy uses of 116 countries were 1,787 Mtoe in 2017, while the energy footprints induced by the consumption of these countries were 9,390 Mtoe. The inequality of energy footprints varies across different countries and economic sectors. In general, energy footprint Gini coefficients are negatively correlated to GDP per capita. European countries have the lowest energy equality, while African countries have the highest. China and the USA have a relatively large energy footprint and large energy inequality. As for economic sectors, the Transport sector is the most unequal sector in most developed countries, and the inequality of this sector is strongly related to the economic development levels of countries. In the meantime, the Manufacture sector is more likely to be the most unequal sector in developing countries such as

Cambodia, Vietnam and China, which play the role of manufacturing factories in the world. Besides, the electricity energy footprints of the Water sector are the most unequal in most African countries which implies the Africa's low energy efficiency in water industries. Meanwhile, the trade among countries or regions not only allows the exchange of goods and services but also leads to the enlargement the energy inequality among and within countries. By comparing the inequality of direct energy use and energy footprints, it is found that the Gini coefficients which represent the energy inequality, are enlarged by the complex supply chains among countries.

Such detailed measures of global household energy inequalities could help us understand the current energy conditions among and within countries, inform policy interventions to promote energy transition, and achieve equitable energy access to more affordable energy while satisfying the basic needs and even improving the living standards of poor countries and poor households.

To what extent can household classifications be used as a proxy to calculate household level consumption-based carbon accounts?

Topic: Consumption-Based Accounts of Household Types
Author: Jasmine Jevera WELLS

Environmentally Extended Multi Regional Input Output (EE-MRIO) models are widely used to analyse the impacts of consumption and are a useful tool for the development of environmental policies. Applications have recently emerged in the commercial domain, as consumption-based carbon accounting has gained wider interest. Some financial service providers and consumer apps have begun to apply EE-MRIO multipliers to financial transaction data with the aim to measure the carbon footprints of their retail and business customers. Given purchases are reflective of daily user consumption, the methodology can derive personalised carbon profiles as a function of one's spend. Customers are provided with feedback about their total carbon impact and key sources of emissions, enabling them to understand and take steps to reduce their carbon footprints. While the validity of the approach has been positively recognised, activities and purchases are not always captured through card transactions. Moreover, purchase-based carbon footprint estimates tend to lack granularity at the product level, as bank statements do not record the receipt-level breakdown. Some consumer apps have attempted to address these shortfalls by combining 'bottom-up' survey data volunteered by users to improve their carbon estimates. Although this approach promises personalised footprint estimations that closely align with users' lifestyles, it lacks scalability as it relies on supplementary information that is not always accessible nor guaranteed.

This research paper explores the potential for using household classifications to better estimate the detailed spending patterns and hence the carbon footprint of clients from a major U.K. bank. The Output Area Classification (OAC) is one such classification system. The OAC is a geodemographic classification which clusters households in census collection areas of the U.K. by socio-demographic similarities. The OAC associated with each bank account can be recorded, as address level data is captured within the dataset. National household expenditure surveys such as the U.K.'s annual Living Cost and Food Survey (LCFS) provide detailed and representative accounts of households' basket-level spend. Given each survey entry's OAC type is recorded, we can estimate spending patterns by OAC.

Applying UK-MRIO conversion factors to the LCFS dataset, a predictive model will be built to estimate the carbon footprint profile for each OAC category. The model will be trained based on

longitudinal spending patterns of OAC households for years 2009 – 2018 (n = 53,479), and later tested on the two most recently available LCFS datasets (years 2019 and 2020). The model's predictive power will be assessed through a series of goodness-of-fit statistical techniques, to enable a comparison of predicted and observed results. The analysis will help identify which spend categories, OAC groups and test-years generate the most accurate CO_2 emissions predictions. To improve the model's predictive power, this research paper will look to explore alternative classification techniques to derive household groupings that best describe carbon footprints of different household types.

Using the proposed archetype method as a shortcut approach for predicting carbon footprints presents exciting and novel avenues of research to both commercial and policy spheres. In the context of policy, the findings of this study will deliver important insights regarding emission patterns across different consumer groups. This will enable policymakers to derive targeted measures and move beyond a 'one-size-fits-all' approach to carbon mitigation strategies.

Global labour requirements in the world economy: a GVC decomposition approach

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - V
Author: Ariel Luis WIRKIERMAN
Co-Authors: Nadia GARBELLINI, Raffaele GIAMMETTI

With the second globalisation unbundling (Baldwin, 2016), productivity became an international concept. To internalise inter-country spillovers through input linkages, a productivity measure should be defined at the global value chain (GVC) level, rather than at the level of individual industries.

In this context, labour productivity would be the ratio of final output to employment across the entire inter-country value chain. Its reciprocal, i.e. the labour requirements per unit of final output, allows to capture the labour saving trends taking place in the world economy.

The main research question of our paper is: what have been the different channels that contributed to the dynamics of global labour saving trends in the 'hyper-globalisation' period (1995-2009)?

To answer this question, our paper identifies different channels contributing to global saving of labour requirements by means of an input-output-based decomposition, taking the GVC as its granular unit of analysis. In particular, *within* each GVC we distinguish whether a reduction in labour requirements was due to direct labour saving trends or to a geographical/sectoral reorganisation of the GVC. *Across* countries *within* a global sector, we identify the contribution of changes in countries' final output market shares to global labour requirements (a competitiveness effect). Finally, *across* global sectors, we identify the contribution of changes in sectoral final output shares to global labour requirements (a global demand shift effect).

A key novelty of our paper is that it allows to capture the interplay between different factors -- direct labour saving, GVC reorganisation, competitiveness and global final demand shifts -- explaining the evolution of labour productivity at a global scale, for a period of notorious expansion of international production fragmentation in the world economy.

As regards the dataset(s) used, given that we wish to capture volume effects, we use the 2013

release of the World Input-Output Database (WIOD) (Timmer et al., 2015) for period 1995-2009, estimating labour sourced from the rest of the world (ROW) region, which is not included in the Socio-Economic Accounts (SEA) of WIOD. We estimate it using data from ILO modelled estimates, together with the detailed structure of inter-industry employment of selected developing countries, following WIOD methodology. Moreover, we use gross output vectors in current and past-year prices of WIOD Dec-2014 release to build a chain-linked price (and exchange rate) index, to express all magnitudes in constant USD. Finally, as preferred for studying labour productivity, labour input is measured in hours worked.

Our preliminary results suggest that, within the GVC, input sourcing offshoring (i.e. GVC reorganisation) had a negative effect on productivity, as GVCs sourced inputs (and hence, labour) from locations and industries with relatively lower (direct) labour productivity (thereby increasing countries' domestic productivity but decreasing it along the inter-country value chain). However, this negative effect was offset by saving of direct labour requirements. Moreover, the competitiveness effect reflected a notorious shift in GVC labour distribution from the global North to the global South.

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Comparison of adaptation measures against climate change and uncertain supply chains

Topic: Inflation and Supply Chain Adaptation in Dynamic Interindustry Modelling
Author: Marc Ingo WOLTER

Climate change (flooding in the south-west of Germany in 2021) and broken supply chains (war against Ukraine until 2022) have recently had significant consequences for economic development in Germany. Both impacts are examples for a growing number of uncertainties in future. To better cope with such uncertainties, economies should prepare to take countermeasures. Do countermeasures to both challenges – climate change and uncertain supply chains - have a similar effect on economic development? For policy makers in Germany, it is of interest, if both measures can be taken despite bottlenecks on the labour market at the same time. Therefore, the structural impacts on the labour market should be different.

A scenario analysis is applied to identify the effects on the economy of the countermeasure against climate change and uncertain supply chains. Therefor the INFORUM-Model INFORGE (INterindustry FORecasting Germany) of the Institute of Economic Structures Research (GWS www.gws-os.com, Germany Osnabrück) is used. In order to determine in particular the effects on the number of jobs required, the extended Q-INFORGE model is used for the scenario analysis. Q-INFORGE is developed together with the Institute for Employment Research in Nürnberg (IAB) and the Federal Institute for Vocational Education and Training in Bonn (BIBB). Q stands for the QuBe-project - qualifications and occupations in the future (www.qube-projekt.de). The QuBe-project has been working together since 2007 and, among other things, produces the

skilled labour monitoring for the Federal Ministry of Labour and Social Affairs in Germany since 2016. Q-INFORGE based on the system of national accounts and uses the IO-Tables to project eg. production, labour demand and professions. Each economic sector is modelled in detail. Final and intermediate demand, unit costs and prices have impact on the specific production and the employment of 63 economic sectors. The behavioural equations are econometrically estimated using data from 1991 to 2022. The model runs year by year from 2023 until 2050.

As countermeasure are analysed expenditures in climate adaptation on the one hand (impact eg. on agriculture and construction) and an enlargement of circular economy (impact eg. on material use and household spending) on the other hand. The results of both scenarios will be compared with the QuBe-Baseline-Projection. It is used the Baseline-Projection of the 7. Wave. The model Q-INFORGE is update every two years (last wave 2022). The QuBe-Baseline includes trends and behavioural equations that can be identified in the past and add such impacts that are known (legislation) or are inevitable (climate change).

The results of the scenarios will be compared with respect to value added, employment and structural change. Structural change is defined as the change of employment and production on the level of economic sectors. Furthermore, the impact of the scenarios on professions on the three-digit-level of the German classification of profession will be analysed. For this the results of each scenario are compared with the results of the baseline-projection and deviations are calculated. The deviations of both scenarios are compared.

It is expected that the results will show different consequences for economic development. The results will differ by economic sectors, by professions and in the temporal course. The results will show whether existing shortages in the labour market will increase or not. The analysis will give a new glance at the contribute of econometric IO-models to the risk management of policy makers.

Composition and Influencing Factors of Employee's Compensation in China—Based on the perspective of Global Value Chain

Topic: Input-Output Modelling: Income Distribution Policies
Author: Kaiyao WU
Co-Authors: Qiuhua ZHOU

(1)   The research questions.
This paper analyzes the composition of employees' compensation in China from the perspective of global value chain. How does this composition change with global value chain? What are the factors influencing these changes?

(2)   The data used.
All the data is from World Input-Output Database (WIOD), WOID Socio-economic Accounts (SEA) and China Labor Statistic Yearbook.
·   WIOD and SEA are both the latest versions and provide the annual data from 2000 to 2014. They cover 28 members of the EU and other major economies, including 15 major countries and regions. 56 sectors data of each country are clearly displayed in them.
·   The relevant data of China Labor Statistical Yearbook were matched with compensation of employees (COMP) of SEA to analyze the composition and influencing factors of employment in China.

(3)   The method used.

Based on the data, we will construct the labor compensation coefficient matrix. And then we do the following algebraic decomposition calculation:

· First, we expend the WWZ(2017)'s method to decompose China's total labor compensation into 4 components paid for by the global value chain. Each component is presented as a matrix of coefficients as well.

· Second, we apply Structure Decomposition Analysis (SDA) to calculate the influencing factors of the change of employee's compensation in China's different sectors. The coefficient matrix obtained in the previous step is further divided into domestic effect, spillover effect (influence between two countries) and feedback effect (influence between three countries or more).

(4) The novelty of the research.

On the one hand, we propose the labor compensation coefficient matrix based on the global value chain decomposition. In this way, we can analyze the composition of Chinese employees' compensation for participating in GVC's activities comprehensively.

On the other hand, different from other empirical methods of econometrics, this paper applies a matrix algebraic decomposition method, SDA, to analyze the international and domestic factors affecting China's compensation from GVC perspectives. The results of the calculation not only allow for a direct decomposition of the factors involved in the change of compensation, but also allow for a quantitative analysis of the precise size of its change impact.

Seven Unsustainable Sectoral Processes; US trade and industry in the last two decades

Topic: Recent Developments in Stock-Flow Consistent Input-Output Modelling - III
Author: Giuliano Toshiro YAJIMA
Co-Authors: George SOKLIS, Nikolaos RODOUSAKIS

The US economy in the last two decades has experienced a number of ups and downs, including major events such as the dot-com bubble in the early 2000s, the Great Recession in 2008-2009, and the COVID-19 pandemic in 2020. Drawing upon an input–output framework, this paper analyses the intersectoral structure of the US economy, using the data from the OECD IO tables for the past two decades. In particular, we argue that the US trade deficit has been affected by the decline in US manufacturing share of GDP in the past two decades. For this purpose we employ, among others, a model of matrix multipliers which, except for the technical conditions of production, also considers imports, income distribution, savings, and consumption patterns out of wages and profits.

Thus, this article focuses on intersectoral analysis and indexes for trade and industry sector and especially on estimation of output, employment and import multipliers, departing from the Classical assumption of the saving propensity out of profits (wages) equal to one (zero) and a common consumption pattern (out of wages and profits). The primary consideration of our results aims to provide insights for policy makers in order to be able to evaluate different plans to combine growth and economic efficiency with social cohesion and justice. For those reasons, our empirical evidence is presented in a simple and easy way that allows the policy makers the evaluation of any possible recovery and sustainable program.

The analysis revealed that the US trade and industry sector has experienced several unsustainable sectoral processes, including a (i) fall in the trade balance in machinery and equipment and HT industries, (ii) a rise in import multipliers in machinery and equipment and HT industries, (iii) a fall in manufacturing share of GDP in machinery and equipment and HT

industries, (iv) a rise in commodities share of GDP, (v) a rise in commodities trade balance, (vi) a fall in consumption share of wages, and (vii) a fall in employment multipliers for the US, particularly in manufacturing.

The fall in the trade balance in machinery and equipment and HT industries has resulted in a negative impact on the US economy, as the US is importing more machinery and equipment than it is exporting. This has been further compounded by the rise in import multipliers in these sectors, which means that an increase in imports results in a greater decrease in domestic production. Additionally, the fall in manufacturing share of GDP in these sectors has led to a decrease in the overall contribution of manufacturing to the US economy. The rise in commodities share of GDP and commodities trade balance has led to an unsustainable focus on resource extraction and export, rather than investing in value-added industries.

Furthermore, the fall in consumption share of wages has had a negative impact on the US economy, as households have less disposable income to spend on goods and services. This has led to a decrease in domestic demand and a decrease in economic growth. The fall, finally, in employment multipliers, particularly in manufacturing, has led to a decrease in job creation ability and can lead to a decline in the overall contribution of manufacturing to employment in the US. This can be further exacerbated by the increase in automation and offshoring of manufacturing jobs, which has a negative impact on the US workforce.

To sum up, the unsustainable sectoral processes within the US trade and industry sector have had a significant negative impact on the US economy, including a decrease in employment and economic growth. In order to address these issues, the US must shift towards a more sustainable and value-added economy, with a focus on innovation and investment in high-tech industries, renewable energy, and sustainable agriculture. Additionally, policies must be put in place to address the negative impacts of resource extraction and to promote a more equitable distribution of income and wealth. By addressing these unsustainable sectoral processes, the US can create a more resilient and sustainable economy for the future.

Expanding the geographical coverage of OECD's TiVA database to include more developing countries – recent experiences

Topic: Methodological and Statistical Challenges for Analyses of Integration of Developing Countries in Regional and Global Value Chains - I
Author: Norihiko YAMANO
Co-Authors: Colin WEBB

This paper provides an overview of the experience gained during the recent expansion of the OECD's Inter-Country Input-Output (ICIO) and Trade in Value Added (TiVA) databases during which ten more developing countries were added in response to the emergence of non-G20 and non-OECD economies in recent decades. The increasing importance of developing economies in the global economy is reflected by their increased shares in GDP, trade flows, number of households, and population. According to the UN National Accounts Main Aggregate database, the sum of GDP shares of non-G20 and non-OECD economies increased from 7% in 1995 to 11% in the early 2020s. Moreover, the exports of goods and services from these economies now account for about 20% of global trade flows.

The latest edition of the TiVA database includes 76 countries, ten more than the previous edition. The expansion added five African countries, two South Asian countries, and two Eastern European

countries. Inclusion of the most populous countries with populations of over 100 million, namely Pakistan, Nigeria, Bangladesh, and Egypt, enables the Input-Output model to be used to derive more robust indicators, particularly regarding carbon footprints and food security issues.

To be included in the TiVA database, OECD has defined ideal and minimum requirements of available national statistics required for inclusion in the underlying ICIO tables. No country meets the ideal requirements (e.g. time-series of Supply and Use Tables from the mid-1990s, consistent with latest 2008 SNA time series and with the necessary level of industry and product disaggregation; and, detailed bilateral trade in goods and services statistics) although some countries come relatively close. With an eye on the minimum requirements, the first step was to compile published national statistics and review their coverage and quality, digesting the format and classification systems used in each data source, detection of outliers, and harmonising national format to the standard format used as an input to ICIO construction. Where appropriate, notably during 'formal' projects, a statistical assessment report was produced and shared with the relevant national statistics providers. Bilateral online and in-person meetings were then held with national statisticians, consultants and other stakeholders to discuss best practices; availability of unpublished statistics that could be shared; and, determine improvements that could be made to national statistics, and the challenges faced, in the short- and medium-term, to improve the quality of TiVA indicators.

The participants in these statistical capacity building exercises included National Accounts and Supply-Use compilation teams at the national statistics offices, consultants for international organisations, Balance of Payments compilers at Central Banks, and merchandise trade statistics and Customs agencies or finance ministries. Examples of common issues facing statistical agencies in developing countries are 1) high turnover of staff members to retain institutional memory, 2) availability of survey results and administrative records in electronic format for earlier years, 3) unique classification formats of products and industry dimensions for certain years due to limited resources to conduct regular economic census surveys.

Increasing geographical coverage also involves a range of technical and methodological challenges when developing the ICIO tables. Decreasing the share of the "rest of the world" in the model in principle improves the overall inter-industry linkages across countries. However, it increases the chance of starting the balancing procedures of intercountry flows with greater discrepancies in the model's initial values at the same time. Another technical challenge is that the increased number of target economies and extended years of coverage raises the processing, memory and storage pressures in the computing environment.

Once individual countries are included in the ICIO/TiVA framework, the industry and trade structures become fully comparable with other countries, and a suite of indicators becomes available. Despite the challenges of the underlying statistical preparations, further expansion of country coverage is essential to derive more reliable indicators for regional value chains under the evolution of trade agreements with neighbouring economies.

Measuring labour force participation in Global Value Chains by gender

Topic: Gender Issues in Input-Output Analysis: New Challenges and New Perspectives - I
Author: Norihiko YAMANO
Co-Authors: Ricardo CHIAPIN PECHANSKY, Peter HORVáT

Improving women's economic empowerment requires policy action across a wide range of areas, including gender inequalities in participation and decision-making roles in international trade activities. Although trade policies themselves are not inherently discriminatory, they can impact male and female employment differently due to initial conditions, such as the distribution of employment across economic activities. Some sectors may have a higher proportion of female workers compared to others. In most countries, industries such as education, financial services, tourism-oriented sectors, and healthcare have a relatively high share of female employment compared to male-dominated industries such as mining, manufacturing, construction and transportation services.

To better understand the employment impacts of trade and industrial policies with the evolution of global production networks, the Organisation for Economic Co-operation and Development (OECD) has developed a set of Trade in Employment (TiM) indicators. Following the framework Trade in Value Added (TiVA) indicators, they provide insights on the impacts of increased international trade on sectoral employment and compensation of employees sustained by foreign demand. This is achieved by combining employment by industry (http://oe.cd/io-emp) with the 2021 edition of OECD's Inter-Country Input-Output (ICIO) tables (http://oe.cd/icio). By exploiting detailed survey data from various sources such as National Accounts, Labour force surveys (LFS), Economic and population censuses, Business surveys, and using a similar methodology, we extend these indicators to investigate the effects of participation in GVCs on employment by workforce characteristics, focusing here on the gender dimension.

National Accounts statistics are designed to provide a consistent picture of labour input, value added and gross output by sector, even for relatively detailed industries. Therefore, the LFS and census data are used only indirectly as attribute shares by an industry applied to industry employment from National Accounts from the top industry to down through the industry level of ICIO tables. Yet, additional consideration is required to incorporate the gender-gap of unpaid family member employment and part-time employees.

This paper describes the sources, limitations and methods used to develop internationally comparable harmonized estimates of employment by industry and gender, for OECD 38 countries covering the period 2008 to 2018, and how they are applied to the industry dimension of ICIO tables to produce indicators of trade in employment by gender. We present results for the number of employment and compensation of employees by industry (for selected economies) engaged in international trade, split by gender.

In general, across OECD countries, men tend to participate more directly in GVCs, through employment in primary and manufacturing exporting sectors while women tend to be more indirectly linked to GVCs, via greater representation in upstream service sectors. However, there are some exceptions where female workers are more directly linked to foreign demand, such as in tourism-oriented sectors (hotel, restaurants, and recreation services) and business services. The TiM indicators by workforce characteristics (gender) offer policymakers insights for understanding the detailed economic impacts of trade and industry policies and can contribute to policy discussions related to women's economic opportunities in global value chains.

To further develop this discussion, it is also important to expand the country coverage of this paper. Women in developing counties often face additional challenges to economic opportunities. For example, barriers include access to education, poor working environment in assembly factories, opportunities for entrepreneurship, and discriminatory practices. Therefore, generating employment and compensation indicators for developing countries is important for increasing the potential for economic growth and development, and can be a future extension of this study.

Extended Supply-USE Tables by Firm Heterogeneity for China

Topic: Handbook of Extended Supply and Use Tables: Country Applications
Author: Cuihong YANG
Co-Authors: Yiying SHI, Rui WEI, Zhuoying ZHANG, Kunfu ZHU

Foreign invested enterprises (FIEs) and domestic owned enterprises (DOEs) are different in many aspects, such as production input, export pattern and impacts on the local economy. For example, compared with DOEs, FIEs are more export-oriented. Besides, FIEs and DOEs play different roles in generating local value-added. A large part of value-added from global value chain in developing economies is generated by affiliates of multi-national enterprises (MNEs). What's more, FIEs and DOEs have different performance on technology dissemination and skill building. Therefore, firm heterogeneity should be reflected when compiling supply and use tables (SUTs) and input-output tables. Otherwise, the simple homogeneous assumption will cause biased estimation in many cases and thus mislead policy makers. Given the SUTs compilation practice in China, this presentation introduces the methods to estimate China extended SUTs with firm heterogeneity (ESUTs), and introduces data source and data processing of ESUTs compilation. Based on the above China's ESUTs and extended input-output table for 2012, we made some empirical analysis on the differences between FIEs and DOEs in terms of value added and income in exports.

Notes: Submission to the special session "Handbook of extended supply & use tables: country applications" organized by Osar Lemmers.

Gendered Motivations of Economic Change in China, 2002-2017

Topic: Gender issues in Input-Output Analysis: New challenges and new perspectives - II
Author: Ye YAO
Co-Authors: Michael L. LAHR

Economic development affects genders differently through an economy's industrial structure. For example, in China, while the absolute number of employed men has risen, it has fallen for women. And, as in other nations, substantial gender employment gap exists, varying by sector and level of education achievement of workers. We use a structural decomposition approach to examine the proximate causes of employment change by gender in China. Besides using input mix, final demand mix, and the make-up of the basket of goods and services required by final demand as factors of employment change by gender, we also examine the apparent effects of educational achievement for Chinese workers by gender. Finally, we use the change in labor/output coefficients by industry to examine the effects of labor productivity. Thus, we can explore drivers of recent change in employment over time, gender, industries, and education levels. The main dataset for this analysis is a series of four Chinese national IO tables from 2002

to 2017. We aggregated to the IO tables to 19 industries, which ensured a match between employment and other economic information from China's statistic yearbook. Our results confirm that technological change and structural improvements in China have benefited the nation's female workers more than its male workers from 2007 to 2017. Also, we find that improved labor productivity has been particularly important in closing China's gender employment gap. Final demand (both its mix and structure) as well as the share of workers with a college education have also improved job growth. This is a first step in China for studying gendered employment using an input-output model.

Environmental Sustainability of Electric Buses and their Operations

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - III
Author: Devrim Murat YAZAN
Co-Authors: Orkide Nur KARA, Luca FRACCASCIA

The electrification of public bus transport are carried out utilizing different technological solutions, like trolley, battery or fuel cell buses. The available technologies are broadly reliable, but in particular, there are still uncertainties about different charging scenarios.

Through a case study in the Netherlands, this study aims to analyze the environmental and economic sustainability of the electric battery bus transportation based on three charging strategies: overnight charging, opportunity charging and the combination of overnight and opportunity charging. Second, this research aims to provide a practical contribution to the stakeholders to better design the operations of electric battery bus transportation. In order to reach these goals, the research question has been identified as: What are the net environmental and economic costs/benefits of battery buses with overnight charging, opportunity charging and the combination of both strategies?

Enterprise input-output (EIO) modeling is adopted to assess the environmental and economic sustainability of the supply chain of battery bus transportation in the case of a bus line operating in a Dutch city. The impact of the implementation of the charging strategies on the sustainability of the supply chain is quantified using scenario analysis. The methodology consists of two model implementation. First, a physical input-output model is adopted to display the material, energy and CO_2 emissions which are then integrated into a monetary input-output model via cost/price vectors.

The findings show that the opportunity charging scenario has the lowest primary input consumption and CO_2 generation with a yearly emission of 164,314 kg, the lowest environmental costs with € 12,324/year, and the lowest total costs with € 318,608/year. The study is novel as the first one that analyzes the sustainability of electric buses and related operations via EIO model and provides practical implications to municipalities targeting to increase the use of the electric battery buses.

Multinationals' technological transfer on right-sourcing strategies: an environmental assessment for the European Union

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - VII
Author: Jorge E. ZAFRILLA
Co-Authors: Mateo ORTIZ, Nuria GOMEZ

The current global context, reshaped by the climate emergency and recently abruptly by geopolitical and post-pandemic aspects, presents an opportunity to reconfigure the global production chains bidirectionally. Multinational corporations' influence along production chains will be key in addressing the new economic, technological, and environmental challenges derived from this reconfiguration. This paper presents an environmental assessment of multinationals' strategies for reshaping their supply chains to integrate nearby low-carbon suppliers (right-sourcing). The analysis will focus on multinationals operating in the European Union and explore right-sourcing strategies through own-technological transfers within the European Union borders or to strategic partners.

The processes of global production fragmentation have shown the weakness and low levels of resilience of regions such as the European Union in terms of international dependency in some key industries and sectors. In response to this situation, the EU has proposed a trade policy review to seek for own-security and reduce dependencies in critical areas, all within the framework of the so-called Open Strategic Autonomy (Cagnin et al., 2021). The strategy presents economic, political, technological, social, and environmental opportunities to encompass a wide range of policies aimed at strengthening the EU's autonomy, resilience, and active role along global value chains. In this sense, this paper will be focused on evaluating the technology-environment nexus and identifying synergies between multinational right-sourcing strategies and the EU's objectives of increasing autonomy and reducing the carbon footprint of its supply chains.

This window of opportunity for the EU industries is aligned with the UNFCCC Technology Mechanism for the 2023-2027 Programme (UNFCCC, 2022). The UNFCCC has identified the necessity of promoting technology development and transfers to support countries to accelerate climate action achieving the Paris Agreement goals through transformative technologies. Right-sourcing strategies by multinationals could lead to this greener spread of EU technologies within and beyond the EU borders.

The environmentally extended MRIO model proposed in this paper will use the ICIO-AMNE database developed by the OECD. This database presents a depiction of the activities of multinational enterprises combined with the ICIO tables (Cadestin et al., 2018). The methodology proposed in this paper will first identify the multinational greener industry performances within the EU and, second, the emission hotspots along EU global production chains. Based on our findings, we will propose potential right-sourcing strategies in terms of multinational technology transfers. The method will follow Wiebe (2018) proposal to identify industries and countries where technology transfers would lead to significant upstream emissions reductions. We will also use the Jiang et al. (2022) proposal to evaluate the technology gaps between parent companies and foreign affiliates in identifying multinationals performances from industries and regions with higher potential to transfer low-carbon technologies.

Once emissions hotspots and best technologies performances are identified, we will propose some source-shifting scenarios following the approach suggested by (Gilles et al., 2021), to simulate the technology transfers. The results will allow us to evaluate the potential role that

multinationals located in the EU can play in leading greener transitions within the EU borders, looking for more internal environmental resilience, and positioning EU industries as global spreaders of environmental-friendly technologies.

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Economic Loss and Recovery of Foreign Direct Investment under Natural Disaster: The case of Shanghai in the 2010s and 2050s

Topic: Input-Output Analyses and Input-Output Modelling of Disasters - I
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Co-Authors: Laixiang SUN

Since the frequency and severity of natural disasters (NDs) are expected to become greater in the future, substantial risks and deep uncertainties would be confronted by firms and industries, even the entire business and broader economic environment. Increasingly scholars from international business field have emphasized the significance of incorporating the risk induced by NDs into decision-making for effective business management and foreign direct investment (FDI) in particular. FDI is regarded as the driving force behind to support economic growth and development in developing and under-developed regions over the past decades. As the two popular entry mode choices for FDI to a host country, both "Joint-Venture" and "Wholly Owned firm" are facing several challenges from the host region, such as the changes in the institutional, political and economic environment. However, only a few studies try to consider NDs' impacts within the host area to FDI, largely because ND is viewed as an unpredictable and unmanageable event. This study is interdisciplinary by nature, takes a novel approach by bringing in climatological and engineering design, with industrial economics perspectives and zoom in the city of Shanghai, one of the megacities in the world with invaluable positions in politics and economic development in Far East. Using the case of Typhoon Winnie, which was the worst tropical cyclone typhoon in 1997 that impacted Shanghai and the surrounding coastal areas in China, the research question we are exploring is: to what extent might "Sino-foreign Joint Ventures" (SJVs) and "Wholly foreign Owned Firms" (WOFs) be affected by climate change?

We take both climate change and socioeconomic structure development into account in performing an integrated analysis to evaluate the economic impact and recovery of Typhoon

Winnie on firm and industrial level in Shanghai with the outlook of the year 2013 and 2050. The research first started with the hydrodynamic model, Delft3D-Flow Flexible Model to estimate tide, wave, the typhoon-induced storm surge and inundation area in the city. Then we calculated the industrial direct economic loss (capital loss) based on the spatial information and damage-curves that build from this research. We further applied the Flood Footprint Model (FFM) to quantify the indirect/cascading economic impact at industrial and regional level. FFM follows the principle of the Input-Output (IO) analysis which in principle captures the transaction flows between producers and consumers in a given economy. Taking this IO model as the backbone of FFM, allows us to assess disaster-induced indirect economic evaluation throughout the entire supply chain activities by taking production bottleneck into account. Undertaking the FFM, we are able to explore how a natural disaster threat impacts on industry sectors and regions as well as how each sector makes bounce back and recover from the disruption of supply chain and production activities. Regarding the sample firms, we collected information about 4,035 overseas-funded (including Hongkong, Macao and Taiwan regions in China) manufacturing firms around Shanghai with the platform of the Third National Economic Census of China (2012-2015), including 1,281 SJVs and 2,754 WOFs, share nearly 55 percent of gross industrial output values and 88 percent of delivery values by industrial exports within Shanghai.

We estimated economic loss caused by Typhoon Winnie within Shanghai in 2013 and 2050 based on sample firms, and our results show that climate change brings higher economic losses of an extreme event to WOFs than SJVs. Moreover, we analysed the heterogeneity of climate risk faced by sample firms in Shanghai from both sectoral and geographical perspectives, and discussed whether WOFs or SJVs at indusial level are more vulnerable to climate change. Finally, we will explore how the recovery of sample firms in the aftermaths of natural disasters. This research is the first study which estimate direct losses at the firm-level and consider the indirect losses and recovery costs for a known worst case of tropical cyclone compound flood event in China. We expect this paper will make contributions from below views. 1) Theoretical contribution to location advantage in the international business research field, since the natural disaster-induced direct and indirect economic risks have been considered with IO-based analysis. 2). The interdisciplinary approach is novel in understanding the complexity of climate change and its impact on international business, as this integrated modeling work successfully coupled the state-of-art hydrodynamic model and IO-based model, while this modeling framework can be applied to other coastal cities. 3) Since systematic biases and cost-benefit may be existed and overlooked within country-based analysis, this study only 'zooming in' to smaller geographical scales, such as Shanghai city and district.

A Prototype empirical Stock-Flow Consistent Input-Output Ecological model of the Italian economy

Topic: Recent Developments in Stock-Flow Consistent Input-Output Modelling - III
Author: Francesco ZEZZA
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This work aims at establishing a research agenda for building an empirical, multisectoral macroeconomic policy model for Italy. This country currently faces multiple challenges in both its productive structure and in its public finance outlook, as it set to move towards a different energy mix while reaffirming its commitment to bring down its government deficit and debt. We argue that these medium-term objectives are at odds, as narrowing the budget deficit could endanger investment in energy transition. Moreover, to quantitatively assess the risks and opportunities of this dual policy, an evaluation tool that accounts for the dynamic inter-relations between the real

economy, the industrial structure, the financial sector, and energy resources still needs to be designed.

To do so, we draw upon two streams of applied macroeconomic literature, namely Stock-Flow Consistent (SFC) models and Input-Output methodologies. SFCs are dynamic, medium-scale Keynesian macro-econometric models based on a rigorous accounting framework (Godley and Lavoie 2007; Nikiforos and Zezza 2017). The model consistency can be identified in four principles (Zezza and Zezza 2019): (i) flow consistency, i.e., every flow must come from somewhere and go somewhere else – for example, in an open economy model, exports of one country are the imports of another one; (ii) stock consistency, i.e., every asset owned by an agent (sector) is the liability of another one (or more) in the system; (iii) stock-flow consistency, i.e., every flow implies the change in one or more stocks; (iv) quadruple entry principle, i.e., every transaction is recorded four times in the accounting matrix, twice as a flow of expenditure and twice as a change in balance sheets. Input-output analysis, on the other hand, is a practical extension of the classical theory of general interdependence which views the whole economy of a region, a country or the entire world as a single system and sets out to describe its operation in term of directly observable basic structural relationship (Leontief 1987). Input-output analysis dissects the main industrial blocks of an economic system, as well as the transmission mechanisms inherent in the production process, indicating the structural characteristics of such a system (Garbellini and Wirkierman 2014). Leontief's sectoral and disaggregated perspective is useful to provide a quantitative description of the structural properties of the various components of the economic system. If the standard Keynesian analysis considers the multiplier process through the consumption function - that is, via the income-expenditure channel, the IO approach focuses on a different aspect of the process, i.e., that relating to the production process of intermediate goods within the circular flow and therefore to industrial interdependencies (Miyazawa 1960).

We contribute to the existing literature in multiple ways. First, we discuss how to extend the model of the Italian economy presented in Zezza and Zezza (2022) to include an I-O structure with 15 industries, using multiple data sources (i.e., the financial and non-financial accounts of institutional sectors and I-O tables, provided by Bank of Italy and Istat), and how to coherently connect these different accounts. The SFC structure of the model features six-institutional sectors, and details transactions for stocks and flows of 3 financial assets/liabilities and their feedback effect on real variables. Second, we provide an overview on how to develop the extended accounting framework further, to also include Energy Balances data (provided by Eurostat). Finally, we provide a first assessment of the potential uses for such a framework, discuss its limitations, and possible avenues for further extensions.

Keywords: Stock-Flow Consistent models; Input-Output Approach; Italian Economy; Energy Balances
JEL: C67; C50; Q43

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SFC-IO and CGE models: a comparison

Topic: Recent Developments in Stock-Flow Consistent Input-Output Modelling - I
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SFC-IO and CGE models: a comparison

Abstract

Stock-flow Consistent (SFC) macroeconomic models are gaining ground for their consistent joint treatment of real and financial markets. The vast majority of such models has been developed in the Post-Keynesian tradition, where the output level is determined by aggregate demand both in the short and the long run, which is usually treated as the point of convergence of stock-flow ratios after a sequence of out-of-equilibrium adjustments.

SFC models have recently been expanded to incorporate a more detailed treatment of the supply side, introducing an input-output structure (thereby being called SFC-IO), to better consider the systemic interdependencies among economic sectors, which is crucial in many applications (e.g., economic impacts of climate change). This new line of research is still in its infancy, with no attempt so far to build a full empirical model for a country. The seminal paper by Berg et al. (2015) is theoretical; the Eurogreen model discussed in D'Alessandro et al. (2020) is not fully SFC; Di Domenico (2021) presents a theoretical SFC model with an IO structure of only three industries. However, the robustness of the SFC approach is attracting interest from academics and practitioners: the latest example is the SFC model developed for the Italian Treasury (Barbieri Hermitte et al., 2023).

The input-output extension of SFC models makes them closer to another popular class of models, the one of Computable General Equilibrium (CGE)., Indeed, CGE models share with the SFC ones the method of parameters' calibration based on a detailed Social Accounting Matrix (SAM). However, CGE models lack a thorough treatment of financial markets, whereas they may be better suited to capture some substitution processes driven by variations in relative prices.

Our paper contrasts the two methodologies, focusing on their application to empirical modeling for a whole country using available IO tables. Which are the comparative advantages of employing one approach, over the other, in specific assessment exercises? Could we devise a convergence of the two methods into an integrated model? We illustrate the key points through a comparative numerical simulation example using data from the Italian economy.

Keywords: Stock-Flow Consistent models, Input-output, Computable General Equilibrium models.

JEL: C68, E12, E16

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Drivers and Changing Patterns of Household Carbon Footprints in China (1997-2017)

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - VII
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Background: To encourage economic progress, China's government has been pushing domestic consumption as a substitute for its waning growth in investment and exports. However, China's energy conservation and climate mitigation policies have focused on industries and have largely neglected households. China's households have experienced fairly radical lifestyle changes during the few decades. With rapid income growth, Chinese households 'moved up' the consumption ladder. Newly formed middle class has been emulating energy-addicted Western lifestyle with the purchase of cars, bigger homes, and more labor-saving appliances. Although China has also been promoting greener policies for growth, of which green consumerism is a prime component. Given its energy security concerns, global warming pressures and internal environmental concerns, China undoubtedly should be more cautious and alter its energy and climate policy course to include households. This study aims to examine the changing carbon footprint trends of Chinese households, explore related driving forces and identify emission hotspots.

Method: This study examines the long-term trends of household CO2 emission from 1997 to 2017, explores related driving forces of changing household indirect household carbon emission, explore mitigation potential from supply perspective. Environmentally extended input–output analysis, structural decomposition analysis (SDA) and structural path analysis (SPA) were used to assess the changing carbon footprint of Chinese households. Based on multiplicative SDA, we decompose household indirect CO2 emissions into six partial factors changes in total population, urbanization rate, energy efficiency, interindustry input mix, household consumption preferences, and per capita household consumption level. Doing so yields insights into how progress in industrial technology, household income, urbanization, and lifestyles has affected energy use in the production of goods and services used by households. Structural Path analysis was used to identify emission hotspots and quantify environmental impact transmission in the entire supply chain. Sensitivity analysis was used to determine the system boundary of SPA.

Findings: From 1997 to 2017, Chinese households' CO2 emission use had risen 154% from 1181

million metric tons (MMT) to 2997 MMT. Per capita household carbon footprint rose from 655 kg CO2 in 1997 to 1280 kg CO2 in 2017 for rural households and from 1594 kg CO2 to 2708 kg CO2 for urban households. The rural-urban gap of household direct carbon footprint narrowed while that of indirect carbon footprint has enlarged. In 2017, household consumption accounted for 30% of China's total CO2 emission. SDA analysis indicate that household consumption preferences and urbanization have elevated household indirect carbon emission. Fortunately, industrial energy efficiency gains and cleaner energy structure have largely offset household consumption rises. SPA analysis demonstrated that the direct inputs from the sectors of "utilities", "manufacture of non-metallic mineral products" and "Transportation and Storage" generated the most important energy flows, while the service sectors such as "Commercial, Catering, & Hotels", "Education, Health, Sports and Recreation" significantly but indirectly influenced CO2 emission.

Why have China's large enterprises exported cleaner than small and medium ones?

Topic: Input-Output Analysis: Trade and Global Value Chains Policies - VII
Author: Junrong ZHANG
Co-Authors: Kailan TIAN, Lingxiu ZHU, Cuihong YANG

To export cleaner has been one important assignment of China's transition to a green economy. Although emissions related to China's exports have been investigated extensively, the size heterogeneity of export enterprises is often disregarded. In this study, we re-evaluate China's export-related CO2 emission performance of large, medium, and small enterprises by compiling extended input-output tables that differentiate the production activities of three different-sized enterprises. We find that a high proportion (68% in the year 2007 and 56% in 2012) of CO2 emissions embodied in China's industrial exports were emitted by small and medium-sized enterprises. The emission intensities for exports (EIEs) show that China's large enterprises exported clearly cleaner than small and medium ones. We further adopt the structural decomposition analysis to identify the driving factors of the EIEs gaps. The findings imply that the higher share of imported intermediate inputs and the cleaner export bundles were the two major determinants that drove the lower EIEs of large enterprises. Our research provides significant policy implications for achieving China's target of providing cleaner products for the international market.

Research on China's domestic and international markets from the regional perspectives

Topic: Regional Input-Output Economics - I
Author: Yibing ZHANG
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Abstract: Since the reform and opening up, China's economy has developed rapidly by integrating into the international market characterized by the specialization of global value chain. The domestic market contributes significantly to its economic growth. However, as a result of the change of the international environment and the transformation of the domestic development stage, many new features, trends and challenges have emerged in the domestic and international markets. It is necessary to further stimulate the potentiality and vitality of the domestic market and strengthen the mutual promotion of the domestic and international

markets. So it is important to systematically analyze the performances, changes and economic impact of domestic and international markets over long periods.

Based on the inter-regional input-output model the paper proposed a method to decompose the regional(provincial) output into four parts according to the different sources of demand. The first part is 'intra-provincial', which is used to satisfy its own demand. The second part is 'inter-provincial', which is to meet the demand from the other provinces in China. The third part is 'direct-aboard', which is exported directly to meet the abroad demand. The last part is 'indirect-aboard', which is provided for other provinces to product and finally export to satisfy the abroad demand indirectly. The domestic market demand includes intra-provincial and inter-provincial, and the latter two parts are international market demand. Subsequently, we analyzed and explained the performance of international and domestic markets from the regional perspectives. The study contributes to a better understanding the impact of dual markets and their interactions. The data we used was China inter-provincial input-output table for multiple years (1987-2017) compiled by the Development Research Center of the State Council. The database is based on the Provincial Input-Output Tables published every five years by China's National Bureau of Statistics. It is the latest, comprehensive, and in-depth China inter-provincial input-output database.

First, the analysis indicated that although the proportion of intra-provincial in national output continued to decline in general, from 63% in 1987 to 49% in 2017, it still had a significant impact on the economy. The provinces with high intra-provincial proportion are primarily found in areas with sizable population and complete economic structure. Second, thanks to the improvement of domestic infrastructure and deepening the specialization among the provincial production, the share of inter-provincial has increased from 25% in 1987 to 36% in 2017. Its role has become increasingly prominent. Additionally, the provinces with high inter-provincial proportion are spread out geographically, more provinces can get benefits from it. Third, the proportion of international market demand has gradually increased from 1987 to 2007. After the international financial crisis in 2008, the influence of the international market on the economy has waned. The overall proportion of international market demand decreased from 23% in 2007 to 18% in 2012 and 15% in 2017 respectively. But the international market is still an indispensable driving force of China's provincial economy. Particularly, the economic benefits of international markets are relatively concentrated in the south and eastern coastal areas. Fourth, the upward trend of indirect-abroad shows that the domestic market and the international market are increasingly inseparable. The share of processing trade is gradually decreasing, while cross-border production is rising. In order to increase economic potential and achieve high-quality development, regions should further specialize through their comparative advantages and strengthen the connection between domestic and international markets.

Evaluating the vulnerability of physical and virtual water resource networks in China's megacities

Topic: Input-Output Analysis: Sustainable Production and Consumption Policies - IV
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The water resource networks that provide water for urban consumption consists not only of physical water supply, but also water embodied in imported goods and services i.e. virtual water supply or external water footprint. However, the dependence on external water footprint introduces a risk to cities when the water of the exporting region is overexploited. It remains

unknown that if relying on external water footprint will increase or decrease the vulnerability of cities' water resource networks.

Previous studies have evaluated virtual water flows, as well as direct vulnerability (vulnerable to internal water shortages) and indirect vulnerability (vulnerable to external water shortages) for cities based on bilateral commodity flow data, However, the bilateral trade data has the limitation of being unable to distinguish between intermediate and final demand products, thus is difficult to trace the life cycle processes of water use along complex supply chains. In contrast, the accounting framework based on the multi-region input-output (MRIO) table has the advantage of showing whole industry supply chain effects, and provides relatively more detailed sector disaggregation for industrial products. However, to best of our knowledge, there is no study applying a MRIO analysis approach to evaluate and compare the direct and indirect vulnerability of physical and virtual water resource networks in different megacities.

Here, we evaluate the vulnerability of urban water resource networks for China's six megacities i.e. Beijing, Tianjin, Shanghai, Chongqing, Guangzhou, and Shenzhen. The vulnerability index was developed through combining a refined MRIO table with both water footprint and water scarcity footprint analysis. The Chinese MRIO table formally contains four Chinese provincial-level megacities: Beijing, Tianjin, Shanghai and Chongqing. Accordingly, existing relevant studies within China using the MRIO approach tend to have only considered these four megacities, and have ignored two other recognized megacities; Shenzhen and Guangzhou. In order to give a comprehensive analysis of the water footprint of China's megacities, we have thus extended the existing Chinese MRIO table to include Shenzhen and Guangzhou using a gravity model.

The results showed that megacities need to import large volumes of virtual water embodied in food related sectors to balance their physical water shortages. The external blue water footprint (BWF) of the six megacities accounted for 80.7% of their total BWF, and was almost twice their physical water supply. The large share of external BWF helped Beijing, Tianjin, and Shanghai, which suffer extreme water stress in their urban areas, to decrease their total vulnerability by 39%, 33%, and 28% respectively, but conversely increase their vulnerability to external water shortages i.e. indirect vulnerability. Establishing megacity physical and virtual water resource networks based on input-output analysis provides an opportunity for urban water planners to internalize the risk of their external water footprint. Avoiding import water-intensive products from regions suffering extreme water stress, or managing indirect vulnerability through cooperation with those regions are suggested as viable water management approaches.

Impacts of Russia-Ukraine conflict on Russian states and their recovery pathway

Topic: Input-Output Analyses and Input-Output Modelling of Disasters - I
Author: Heran ZHENG
Co-Authors: Jing MENG, Daoping WANG, Xin WANG

The Russia-Ukraine conflict since February 2022 has intensified geopolitical frictions and most OECD countries have announced punishing sanctions against Russia. Restrictions imposed by these countries on Russia's commodities export would result in economic losses through global supply chains. Especially, Europe is the region affected most, meanwhile, Russia would suffer economic losses as well. Existing studies have attempted to discuss the effects of the Russia-Ukraine conflict on the economy from European countries' view, however, no study quantitatively evaluates economic losses burdened by Russia, let alone at the regional scale in

Russia. Given the important role of Russia in the world's top energy and food supplies, a bad economic level in Russia can also threaten the energy security and the economic stability of other countries through the supply chains. Considering the close relations among global countries, it is necessary to quantify the regional economic losses in Russia to stress the importance of cooperation in trade globalization.

In this context, our study first constructs the multi-regional input-output (MRIO) table for 85 districts of Russia in 59 economic sectors by employing hybrid methods . Then, we further link Russian MRIO with global MRIO from GTAP to trace the supply chain and understand the spillover effects induced by other countries' sanctions across Russian regions. Finally, we use the disaster impact model which is an extension of the adaptive regional input-output (ARIO) model to simulate the propagation of sanctions induced by the European Union, United Kingdom, United States, Canada, Japan, and Ukraine on the Russian regional economy during the one-year conflict since February 2022. Moreover, we simulate the economic losses under different sanction durations by setting a series of scenarios. The study helps mitigating geopolitical frictions and promoting cooperation to keep trade smooth is needed to avoid supply-chains-induced economic losses in globalization.

Global inequality under planetary boundary

Topic:
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Disproportionate income distribution between and within countries had led to severe consumption and consumption-based environmental footprints inequality. Unsustainable development has pushed resource demand and environmental impacts even over the planet's limits. Here we combined the input-output analysis and the detailed global expenditure data to reveal the environmental impacts and the inequality of different income groups from a consumption perspective, and the global and national sustainability by comparing each income group's impacts to six planetary boundaries. Results show that severe inequality coexists with serious environmental consequences from almost all the income groups' consumption, which had already exceeded most of the per capita planetary boundaries. Inequality and the over-boundary impacts of different income groups' carbon, nitrogen, and phosphorus footprints are more severe than other factors at the national and global levels, even for lower income groups. Meanwhile, higher and relatively more equal income countries show less environmental inequality but much greater over-limit impacts on the global environment, except for the United States. To achieve sustainable and equitable development, all income groups must make an immediate and significant shift toward sustainable consumption.

An Adjustment of China's Energy Consumption Data and the Estimation of the Sectoral Energy Intensity

Topic: Input-Output Analysis: Energy Policies - II
Author: Lingxiu ZHU
Co-Authors: Erik DIETZENBACHER, Cuihong YANG

China's energy consumption has been rapidly increasing along with its economic boom, leading to more concern about the global environment and climate change. Previous studies have

discussed aspects of reliability and consistency in China's energy data. In so doing, they particularly focused on the time dimension (e.g. inconsistencies in time-series data) and on the size dimension (e.g. inconsistencies when aggregating provincial to national data). However, in this paper, we also observe data inconsistencies within a single specific year for China's energy consumption. These inconsistencies exist at the aggregate (i.e. overall national) level and at the sectoral level. Therefore, this paper investigates the origins of the inconsistencies by analyzing the data processing. Taking the year 2017 as an example, a solution is proposed. This yields a new estimate for the sectoral energy consumption and the energy intensity. Finally, we replicate an existing study using our adapted energy data and compare the results. The comparison shows a gap suggesting that more attention should be paid to the energy accounting systems.

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CARRASCAL-INCERA, ANDRE	UNIVERSITY OF OVIEDO, SPAIN	Parallel Session 4, University - Room 1 Ground Floor Parallel Session 11, Ancient Tower - Room 1 Parallel Session 11, Ancient Tower - Room 1
CARRICO, CAITLYN	UNECA, CAMEROON	Parallel Session 6, Municipality - Room 2 Ground Floor
CARVALHO, TERCIANE	FEDERAL UNIVERSITY OF PARANÁ, BRAZIL	Parallel Session 8, University - Room 3
CAZCARRO, IGNACIO	FUNDACIÓN AGENCIA ARAGONESA PARA LA INVESTIGACIÓN Y EL DESARROLLO (ARAID); BC3-BASQUE CENTRE FOR CLIMATE CHANGE – KLIMA ALDAKETA IKERGAI, SPAIN	
CESARINI, SAMUELE	UNIVERSITÀ DEGLI STUDI DI TERAMO, JAMAICA	
CHEN, QUANRUN	UNIVERSITY OF INTERNATIONAL BUSINESS AND ECONOMICS, CHINA	Parallel Session 3, University - Room 2 Ground Floor
CHEN, QUANRUN	UNIVERSITY OF INTERNATIONAL BUSINESS AND ECONOMICS, CHINA	Parallel Session 2, University - Room 1 Ground Floor
CHEN, RONGJIE	RENMIN UNIVERSITY OF CHINA, CHINA	Parallel Session 1, Municipality - Room 4 Ground Floor
CHEN, XIANGJIE	DEPARTMENT OF GEOGRAPHICAL SCIENCES, UNIVERSITY OF MARYLAND, COLLEGE PARK, UNITED STATES	Parallel Session 6, Municipality - Room 4 Ground Floor
CHEN, ZHENNI	XIAN JIAOTONG UNIVERSITY, CHINA	
CHENG, WENYIN	IDE-JETRO, JAPAN	Parallel Session 7, University - Room 1 Ground Floor
CHEPELIEV, MAKSYM	PURDUE UNIVERSITY, UNITED STATES	Parallel Session 5, Municipality - Room 3 Ground Floor Parallel Session 8, Ancient Tower - Room 1

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
CHIAPIN PECHANSKY, RICARDO	OECD, FRANCE	
COELHO, ANA	UFRJ, BRAZIL	Parallel Session 7, University - Room 3
COLOMBO, EMANUELA	POLITECNICO DI MILANO, ITALY	
CORONG, ERWIN	CENTER FOR GLOBAL TRADE ANALYSIS, PURDUE UNIVERSITY, UNITED STATES	Parallel Session 9, University - Room 2 Ground Floor
COSTA, LUCAS	UFRJ, BRAZIL	
COVERI, ANDREA	UNIVERSITY OF URBINO CARLO BO, ITALY	Parallel Session 8, Municipality - Room 2 Ground Floor
CRUCITTI, FRANCESCA	JRC SEVILLA, SPAIN	
CUCIGNATTO, GIACOMO	SAPIENZA UNIVERSITY OF ROME, ITALY	
CUICCHIO, STEFANIA	ISTAT, ITALY	
DALESSANDRO, SIMONE	UNIVERSITY OF PISA, ITALY	
DE LA TORRE CUEVAS, FERNANDO	UNIVERIDADE DE SANTIAGO DE COMPOSTELA, SPAIN	Parallel Session 3, University - Room 3 Parallel Session 10, Municipality - Room 3 Ground Floor
DE SCHUTTER, LIESBETH	VIENNA UNIVERSITY OF ECONOMICS & BUSINESS, AUSTRIA	
DE SOUZA, KENIA	FEDERAL UNIVERSITY OF PARANÁ, BRAZIL	
DE VRIES, GAAITZEN	UNIVERSITY OF GRONINGEN, NETHERLANDS	
DECK, CANDY	NTNU, NORWAY	
DEDEGKAJEVA, ILJEN	STATISTICS ESTONIA, ESTONIA	Parallel Session 6, Ancient Tower - Room 1
DELGADO, MARÍA	LOYOLA UNIVERSITY ANDALUSIA, SPAIN	
DELLISANTI, ROBERTO	POLITECNICO DI MILANO - DEPARTMENT OF ARCHITECTURE, BUILT ENVIRONMENT AND CONSTRUCTION ENGINEERING, ITALY	Parallel Session 3, University - Room 3
DEN NIJS, SACHA	VRIJE UNIVERSITEIT AMSTERDAM, NETHERLANDS	Parallel Session 1, University - Room 2 Ground Floor
DENG, NANA	UNIVERSITY COLLEGE LONDON, UNITED KINGDOM	
DEVEZA, ANA	UNECA, ETHIOPIA	
DI DOMENICO, LORENZO	UNIVERSITÀ CATTOLICA DEL SACRO CUORE, ITALY	Parallel Session 8, University - Room 1 Ground Floor
DI FILIPPO, GIOVANNA	UNIVERSIDADE FEDERAL DE JUIZ DE FORA, BRAZIL	
DIETZENBACHER, ERIK	UNIVERSITY OF GRONINGEN, NETHERLANDS	Parallel Session 1, Municipality - Room 1 2nd Floor Parallel Session 2, University - Room 1 Ground Floor
DINIZ, TIAGO	INDEPENDENT RESEARCHER, BRAZIL	
DISTEFANO, TIZIANO	UNIVERSITY OF PISA, ITALY	
DISTELKAMP, MARTIN	GWS, GERMANY	
DU, HUIBIN	TIANJIN UNIVEISITY, CHINA	
DUARTE, ROSA	UNIVERSITY OF ZARAGOZA, SPAIN	Parallel Session 3, University - Room 1 Ground Floor Parallel Session 7, Municipality - Room 2 Ground Floor
DUPARC-PORTIER, GEOFFROY	UNIVERSITY OF STRATHCLYDE, UNITED KINGDOM	Parallel Session 6, University - Room 3
DURAN, ANA CLARA	UNIVERSITY OF CAMPINAS, BRAZIL	
DWECK, ESTHER	INSTITUTO DE ECONOMIA DA UFRJ, BRAZIL	
EGUINO, HUASCAR	IADB, UNITED STATES	
EL MELIGI, ANDREA	EUROPEAN COMMISSION, JOINT RESEARCH CENTRE, SPAIN	Parallel Session 5, Ancient Tower - Room 1 Parallel Session 8, Ancient Tower - Room 1
ESPINOSA-GRACIA, ADRIAN	UNIVERSITY OF ZARAGOZA, SPAIN	Parallel Session 6, Municipality - Room 4 Ground Floor
FARIA, WESLEM	FEDERAL UNIVERSITY OF JUIZ DE FORA, BRAZIL	
FATURAY, FUTU	THE UNIVERSITY OF QUEENSLAND, AUSTRALIA	Parallel Session 6, University - Room 2 Ground Floor

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
FENG, KUISHUANG	UNIVERSITY OF MARYLAND, UNITED STATES	
FERNANDEZ-VAZQUEZ, ESTEBAN	UNIVERSITY OF OVIEDO, SPAIN	Parallel Session 4, University - Room 2 Ground Floor
FERRARESI, TOMMASO	IRPET, ITALY	
FERRARI, EMANUELE	EUROPEAN COMMISSION - JRC - IPTS, SPAIN	
FERRARI, GUIDO	UNIVERSITY OF FLORENCE, ITALY	Parallel Session 9, Municipality - Room 3 Ground Floor
FERREIRA, JOAO	FACULTY OF ECONOMICS, UNIVERSITY OF COIMBRA, PORTUGAL	
FERREIRA, VALERIA	UNIVERSITAT ROVIRA I VIRGILI- DEPARTMENT BUSINESS MANAGEMENT, SPAIN	
FEVEREIRO, JOSÉ	UNIVERSITY OF SHEFFIELD, UNITED KINGDOM	Parallel Session 5, Municipality - Room 4 Ground Floor
FIGUS, GIOELE	UNIVERSITY OF STRATHCLYDE, UNITED KINGDOM	Parallel Session 2, Municipality - Room 4 Ground Floor
FLEGG, ANTHONY	UNIVERSITY OF THE WEST OF ENGLAND, BRISTOL, UNITED KINGDOM	Parallel Session 10, Municipality - Room 3 Ground Floor
FONTAGNE, LIONEL	PARIS SCHOOL OF ECONOMICS AND CEPII, FRANCE	
FRACCASCIA, LUCA	POLITECNICO DI BARI, ITALY	
FREIRE-GONZÁLEZ, JAUME	INSTITUTE FOR ECONOMIC ANALYSIS, SPAIN	Parallel Session 5, University - Room 3
FREITAS, FABIO	FEDERAL UNIVERSITY OF RIO DE JANEIRO, BRAZIL	
FU, RAO	INSTITUTE OF BLUE AND GREEN DEVELOPMENT, SHANDONG UNIVERSITY, WEIHAI, P. R. CHINA., CHINA	
FUENTES SAGUAR, PATRICIA	UNIVERSIDAD PABLO OLAVIDE, SPAIN	
FUKAO, KYOJI	HITOTSUBASHI UNIVERSITY, JAPAN	
GALLANT, BEN	UNIVERSITY OF SURREY, UNITED KINGDOM	Parallel Session 9, Municipality - Room 2 Ground Floor
GALLEGATI, MAURO	UNIVPM, ITALY	
GAO, XIANG	ACADEMY OF MATHEMATICS AND SYSTEMS SCIENCE, CHINESE ACADEMY OF SCIENCES, CHINA	Parallel Session 9, Municipality - Room 4 Ground Floor
GAO, YUNING	TSINGHUA UNIVERSITY, CHINA	Parallel Session 5, University - Room 2 Ground Floor
GARAU, GIORGIO	UNIVERSITY OF SASSARI - DEPARTMENT OF HUMANITIES AND SOCIAL SCIENCE, ITALY	Parallel Session 5, Municipality - Room 4 Ground Floor
GARBELLINI, NADIA	UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA, ITALY	
GARCÍA-ALAMINOS, ÁNGELA	UNIVERSIDAD DE CASTILLA-LA MANCHA, SPAIN	Parallel Session 4, University - Room 2 Ground Floor
GATTO, ALESSANDRO	WAGENINGEN UNIVERSITY AND RESEARCH, NETHERLANDS	
GHEZZI, LEONARDO	IRPET, ITALY	
GIAMMETTI, RAFFAELE	UNIVERSITY OF CASSINO AND SOUTHERN LAZIO, ITALY	Parallel Session 4, Ancient Tower - Room 1 Parallel Session 8, Municipality - Room 2 Ground Floor
GILJUM, STEFAN	VIENNA UNIVERSITY OF ECONOMICS AND BUSINESS (WU), AUSTRIA	
GILLES, ENRIQUE	COLEGIO DE ESTUDIOS SUPERIORES DE ADMINISTRACIÓN - CESA, COLOMBIA	Parallel Session 10, Municipality - Room 1 2nd Floor
GITTINS, PETER	OFFICE FOR NATIONAL STATISTICS, UNITED KINGDOM	Parallel Session 6, Ancient Tower - Room 1
GOLINUCCI, NICOLÒ	POLITECNICO DI MILANO, ENEXTGEN, ITALY	Parallel Session 2, Ancient Tower - Room 1 Parallel Session 7, Municipality - Room 3 Ground Floor
GOMEZ, NURIA	UNIVERSIDAD DE CASTILLA-LA MANCHA, SPAIN	
GONÇALVES, EDUARDO	FEDERAL UNIVERSITY OF JUIZ DE FORA, BRAZIL	
GONG, XIAONING	UNECA, ETHIOPIA	Parallel Session 5, Municipality - Room 2 Ground Floor

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
GONZALEZ, ANDRES	UNIVERSIDADE DE SANTIAGO DE COMPOSTELA, SPAIN	Parallel Session 4, Municipality - Room 1 2nd Floor
GORZAŁCZYŃSKI, ARTUR	UNIVERSITY OF LODZ, POLAND	
GOYAL, SRISHTI	UNIVERSITAT ROVIRA I VIRGILI, SPAIN	Parallel Session 1, Municipality - Room 1 2nd Floor
GUAN, YURU	UNIVERSITY OF GRONINGEN, NETHERLANDS	Parallel Session 3, Municipality - Room 3 Ground Floor
GUARNIERI, PIETRO	UNIVERSITY OF PISA, ITALY	
GUCI, LEDIA	BUREAU OF ECONOMIC ANALYSIS, UNITED STATES	
GUERRA, ANA ISABEL	UNIVERSIDAD DE GRANADA, SPAIN	
GUEVARA, ZEUS	MONTERREY INSTITUTE OF TECHNOLOGY AND HIGHER EDUCATION, MEXICO	Parallel Session 9, Municipality - Room 1 2nd Floor Parallel Session 10, University - Room 2 Ground Floor
GUILHOTO, JOAQUIM	IMF, UNITED STATES	Parallel Session 9, University - Room 2 Ground Floor
GUO, JIEMIN	BEA, UNITED STATES	Parallel Session 6, University - Room 2 Ground Floor
GUTIERREZ, DAVID	UNIVERSIDAD AUTÓNOMA DEL ESTADO DE HIDALGO, MEXICO	
HABIBI, ARASH	JÖNKÖPING INTERNATIONAL BUSINESS SCHOOL, SWEDEN	Parallel Session 11, Municipality - Room 1 2nd Floor
HAGINO, SATORU	CABINET OFFICE, JAPAN	Parallel Session 9, Municipality - Room 3 Ground Floor
HAMBŸE, CAROLINE	FEDERAL PLANNING BUREAU, BELGIUM	
HAMDI-CHERIF, MERIEM	OFCE - SCIENCES PO, FRANCE	Parallel Session 8, University - Room 3
HAN, XUE	ASIAN DEVELOPMENT BANK, FRANCE	Parallel Session 6, Municipality - Room 2 Ground Floor
HANAKA, TESSHU	DEPARTMENT OF MATHEMATICAL INFORMATICS, GRADUATE SCHOOL OF INFORMATICS, NAGOYA UNIVERSITY, JAPAN	
HATA, SHO	MATERIAL CYCLES DIVISION, NATIONAL INSTITUTE FOR ENVIRONMENTAL STUDIES, JAPAN, JAPAN	Parallel Session 11, Municipality - Room 1 2nd Floor
HE, JIANWU	DEVELOPMENT RESEARCH CENTER, THE STATE COUNCIL, CHINA, CHINA	
HE, KEHAN	UNIVERSITY COLLEGE LONDON, UNITED KINGDOM	Parallel Session 11, Municipality - Room 3 Ground Floor
HELENA OLIVEIRA DE MEDEIROS, ELVIRA	FEDERAL UNIVERSITY OF JUIZ DE FORA (UFJF), BRAZIL	
HEMBACH-STUNDEN, KATHARINA	GWSMBH - INSTITUTE OF ECONOMIC STRUCTURES RESEARCH, GERMANY	Parallel Session 2, Municipality - Room 3 Ground Floor
HENRIQUES, SOFIA	LUND UNIVERSITY, SWEDEN	
HEWINGS, GEOFFREY	UNIVERSITY OF ILLINOIS, UNITED STATES	
HIENUKI, SHUNICHI	SOCIO-ECONOMIC RESEARCH CENTER, CENTRAL RESEARCH INSTITUTE OF ELECTRIC POWER INDUSTRY, JAPAN	Parallel Session 6, Municipality - Room 1 2nd Floor
HO, MUN	HARVARD UNIVERSITY, UNITED STATES	
HORVÁT, PETER	OECD, FRANCE	Parallel Session 5, Municipality - Room 3 Ground Floor
HOSOSHIMA, CHISATO	KYUSHU UNIVERSITY, JAPAN	Parallel Session 1, Municipality - Room 3 Ground Floor
HOU, SIYU	UNIVERSITY OF GRONINGEN, NETHERLANDS	Parallel Session 4, Municipality - Room 1 2nd Floor
HOWELLS, THOMAS	BUREAU OF ECONOMIC ANALYSIS, UNITED STATES	
HU, JINXUE	NETHERLANDS ECONOMIC OBSERVATORY, NETHERLANDS	
HUANG, YONGMING	CHINA INSTITUTE OF DEVELOPMENT STRATEGY AND PLANNING, CHINA	
HUBACEK, KLAUS	UNIVERSITY OF GRONINGEN, NETHERLANDS	
HUSSEIN, HAZIM	NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY, NORWAY	
IMADA, SEIYA	KYUSHU UNIVERSITY, JAPAN	Parallel Session 11, University - Room 1 Ground Floor

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
IN T VELD, DAAN	PBL NETHERLANDS ENVIRONMENTAL ASSESSMENT AGENCY, NETHERLANDS	Parallel Session 1, Municipality - Room 1 2nd Floor
INOUE, HIROYASU	UNIVERSITY OF HYOGO, JAPAN	Parallel Session 4, Ancient Tower - Room 1
IVANOVA, DIANA	UNIVERSITY OF LEEDS, UNITED KINGDOM	
JACKSON, ANDREW	UNIVERSITY OF SURREY, UNITED KINGDOM	Parallel Session 7, University - Room 3
JACKSON, TIM	UNIVERSITY OF SURREY, UNITED KINGDOM	
JARAIZ, MARTIN	UNIVERSITY OF VALLADOLID, SPAIN	Parallel Session 7, Ancient Tower - Room 1
JIAN, XU	SCHOOL OF ECONOMICS AND MANAGEMENT , UNIVERSITY OF CHINESE ACADEMY OF SCIENCES, CHINA	
JIANG, XIAO	INTERNATIONAL LABOR ORGANIZATION, SWITZERLAND	
JIMÉNEZ, SOFÍA	ZARAGOZA UNIVERSITY, SPAIN	Parallel Session 7, Municipality - Room 4 Ground Floor
JINGWEN, HUO	TINGHUA UNIVERSITY, CHINA	Parallel Session 8, Municipality - Room 1 2nd Floor
JOSHI, SURABHI	INDIA	
KAGAWA, SHIGEMI	KYUSHU UNIVERSITY, JAPAN	Parallel Session 1, University - Room 1 Ground Floor
KAN, SIYI	UNIVERSITY COLLEGE LONDON, UNITED KINGDOM	Parallel Session 8, Municipality - Room 1 2nd Floor
KANGXIAN, JI	SCHOOL OF ECONOMICS AND MANAGEMENT,UNIVERSITY OF CHINESE ACADEMY OF SCIENCES, CHINA	
KANITKAR, TEJAL	NATIONAL INSTITUTE OF ADVANCED STUDIES, INDIA	
KARA, ORKIDE	UNIVERSITY OF TWENTE, NETHERLANDS	
KARINGI, STEPHEN	UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA, ETHIOPIA	
KEEBLE, ELEANOR	UNITED NATIONS, ETHIOPIA	
KHONKHLONG, SUPPAKORN	CHINESE INSTITUTE OF DEVELOPMENT STRATEGY AND PLANNING, WUHAN UNIVERSITY, CHINA	
KILIAN, LENA	UNIVERSITY OF LEEDS, UNITED KINGDOM	Parallel Session 3, Ancient Tower - Room 1
KIM, JIYOUNG	OKAYAMA UNIVERSITY, JAPAN	
KIRAN, JOAN	NATIONAL INSTITUTE OF ADVANCED STUDIES, INDIA	Parallel Session 7, Municipality - Room 4 Ground Floor
KOLLER, WOLFGANG	INSTITUTE FOR INDUSTRIAL RESEARCH, AUSTRIA	Parallel Session 8, Municipality - Room 3 Ground Floor
KOSLOWSKI, MAXIMILIAN	NTNU, NORWAY	Parallel Session 7, Municipality - Room 3 Ground Floor
KRATENA, KURT	CESAR - CENTRE OF ECONOMIC SCENARIO ANALYSIS AND RESEARCH, SPAIN	Parallel Session 10, University - Room 2 Ground Floor
KUHLA, KILIAN	POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH, GERMANY	
KULDASHEVA, ZEBO	CHINA INSTITUTE OF DEVELOPMENT STRATEGY AND PLANNING, WUHAN UNIVERSITY, CHINA	
KULIONIS, VIKTORAS	LUND UNIVERSITY, SWEDEN	
KURZ, HEINZ	UNIVERSITY OF GRAZ, AUSTRIA	Parallel Session 4, University - Room 1 Ground Floor
LA MARCA, MASSIMILIANO	INTERNATIONAL LABOUR ORGANISATION, SWITZERLAND	Parallel Session 3, Municipality - Room 2 Ground Floor
LAHR, MICHAEL	RUTGERS, THE STATE UNIVERSITY OF NEW JERSEY, UNITED STATES	Parallel Session 2, Municipality - Room 2 Ground Floor Parallel Session 11, Municipality - Room 4 Ground Floor
LANDA RIVERA, GISSELA	OFCE - SCIENCES PO, FRANCE	Parallel Session 10, Municipality - Room 3 Ground Floor
LANDINI, SIMONE	IRES PIEMONTE, ITALY	
LANGARITA, RAQUEL	UNIVERSITY OF ZARAGOZA, SPAIN	Parallel Session 5, University - Room 3

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
LEÃO, LUCAS	FEDERAL UNIVERSITY OF JUIZ DE FORA, BRAZIL	Parallel Session 2, University - Room 2 Ground Floor
LECCA, PATRIZIO	ICADE, UNIVERSIDAD PONTIFICIA COMILLAS, SPAIN	Parallel Session 9, Municipality - Room 3 Ground Floor
LEGOFF, GREGORY	IMF, UNITED STATES	
LEIVA, FRANCISCO	STUDY CENTER - SANTA FE BOARD OF TRADE, ARGENTINA	
LEMMERS, OSCAR	STATISTICS NETHERLANDS, NETHERLANDS	Parallel Session 1, Ancient Tower - Room 1 Parallel Session 4, Municipality - Room 3 Ground Floor
LEVERMANN, ANDERS	POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH, GERMANY	
LI, CHUAN	SCHOOL OF ECONOMICS AND MANAGEMENT, UNIVERSITY OF CHINESE ACADEMY OF SCIENCES, CHINA	Parallel Session 6, University - Room 2 Ground Floor
LI, DAN	SHANDONG UNIVERSITY, CHINA	
LI, JIASHUO	SHANDONG UNIVERSITY, CHINA	
LI, MENG	SHANGHAI JIAO TONG UNIVERSITY, CHINA	Parallel Session 4, Municipality - Room 3 Ground Floor
LI, SHANTONG	DEVELOPMENT RESEARCH CENTER OF THE STATE COUNCIL, CHINA	
LI, XIAOYU	TIANJIN UNIVERSITY, CHINA	Parallel Session 6, University - Room 3
LI, XIN	SCHOOL OF ECONOMICS AND MANAGEMENT, WUHAN UNIVERSITY, CHINA	
LI, XINBEI	INSTITUTES OF SCIENCE AND DEVELOPMENT, CHINESE ACADEMY OF SCIENCES, CHINA	
LI, XIUTING	UNIVERSITY OF CHINESE ACADEMY OF SCIENCES, CHINA	
LI, YINGZHU	ZHEJIANG UNIVERSITY, CHINA	Parallel Session 2, Municipality - Room 3 Ground Floor
LIANG, DAVID	IDE-JETRO, JAPAN	Parallel Session 11, University - Room 1 Ground Floor
LIBOREIRO, PABLO	UNIVERSIDAD POLITÉCNICA DE MADRID, SPAIN	Parallel Session 8, Municipality - Room 3 Ground Floor
LIMA, M. CARMEN	UNIVERSIDAD PABLO DE OLAVIDE, SPAIN	Parallel Session 1, Municipality - Room 4 Ground Floor
LIN, CHEN	SCHOOL OF ECONOMICS, RENMIN UNIVERSITY OF CHINA, CHINA	
LIU, CHANGWEI	WUHAN UNIVERSITY, CHINA	
LIU, CHUAN	UNIVERSITY OF HAMBURG, GERMANY	Parallel Session 8, Municipality - Room 3 Ground Floor
LIU, SHUQIN	SCHOOL OF MANAGEMENT, MINZU UNIVERSITY OF CHINA, CHINA	
LIU, XI	INSTITUTE OF BLUE AND GREEN DEVELOPMENT, SHANDONG UNIVERSITY, CHINA	Parallel Session 1, Municipality - Room 3 Ground Floor Parallel Session 3, Municipality - Room 3 Ground Floor
LIU, YU	INSTITUTE OF POLICY AND MANAGEMENT, CHINESE ACADEMY OF SCIENCES, CHINA	
LLOP, MARIA	CREIP, DEPARTAMENT D'ECONOMIA, UNIVERSITAT ROVIRA I VIRGILI, SPAIN	
LOPEZ, LUIS	UNIVERSIDAD DE CASTILLA-LA MANCHA, SPAIN	
LOPEZ-ALVAREZ, JORGE M.	JOIN RESEARCH CENTER - EUROPEAN COMMISSION, SPAIN	Parallel Session 4, Municipality - Room 2 Ground Floor
LOPEZ-MORALES, CARLOS	EL COLEGIO DE MÉXICO, MEXICO	Parallel Session 4, Municipality - Room 1 2nd Floor Parallel Session 11, University - Room 3
LÓPEZ-OJEDA, ANA	UNIVERSITY OF LAS PALMAS DE GRAN CANARIA, SPAIN	Parallel Session 5, Municipality - Room 1 2nd Floor

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
LOS, BART	UNIVERSITY OF GRONINGEN, NETHERLANDS	Parallel Session 4, University - Room 1 Ground Floor Parallel Session 7, Municipality - Room 2 Ground Floor
LUCERO, JOAQUIN	UNIVERSIDAD NACIONAL DEL LITORAL, ARGENTINA	
LUPTACIK, MIKULAS	UNIVERSITY OF BRATISLAVA, AUSTRIA	
LUTZ, CHRISTIAN	GESELLSCHAFT FÜR WIRTSCHAFTLICHE STRUKTURFORSCHUNG MBH, GERMANY	Parallel Session 6, University - Room 3
LUZ, FELIPE	UFPR, BRAZIL	
MAENO, KEITARO	KYUSHU UNIVERSITY FACULTY OF ECONOMICS, JAPAN	Parallel Session 1, University - Room 2 Ground Floor
MAINAR CAUSAPÉ, ALFREDO	UNIVERSITY OF SEVILLE (DEP. APPLIED ECONOMICS III), SPAIN	Parallel Session 8, Ancient Tower - Room 1
MAIR, SIMON	UNIVERSITY OF YORK, UNITED KINGDOM	
MALISZEWSKA, MARYLA	WORLD BANK, UNITED STATES	
MALLIET, PAUL	OFCE - SCIENCES PO, FRANCE	Parallel Session 7, Municipality - Room 3 Ground Floor
MANDEL, ANTOINE	UNIVERSITY PARIS 1 PANTHÉON-SORBONNE, FRANCE	Parallel Session 4, Ancient Tower - Room 1
MANRIQUE DE LARA PEÑATE, CASIANO	UNIVERSITY OF LAS PALMAS DE GC (ULPGC), SPAIN	
MARIASINGHAM, MAHINTHAN	ASIAN DEVELOPMENT BANK, PHILIPPINES	
MARTÍNEZ GARCÍA, MIGUEL ÁNGEL	UNIVERSIDAD REY JUAN CARLOS, SPAIN	Parallel Session 2, Municipality - Room 1 2nd Floor
MATSUSHIMA, SORA	KYUSHU UNIVERSITY GRADUATE SCHOOL OF ECONOMICS, JAPAN	Parallel Session 9, Municipality - Room 4 Ground Floor
MAXWELL, PETER	NTNU, NORWAY	
MEADE, DOUGLAS	INFORUM/IERF, UNITED STATES	Parallel Session 9, Ancient Tower - Room 1
MELICIANI, VALENTINA	UNIVERSITY LUISS GUIDO CARLI, ITALY	
MENG, BO	IDE-JETRO, JAPAN	Parallel Session 4, Municipality - Room 4 Ground Floor Parallel Session 6, Ancient Tower - Room 1
MENG, JING	UNIVERSITY COLLEGE LONDON, UNITED KINGDOM	
MEVEL, SIMON	UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA, ETHIOPIA	Parallel Session 9, University - Room 3
MEYER, MARK	INSTITUTE OF ECONOMIC STRUCTURES RESEARCH (GWS), GERMANY	
MI, ANRAN	UNIVERSITY OF CHINESE ACADEMY OF SCIENCES, CHINA	Parallel Session 11, University - Room 1 Ground Floor
MI, ZHIFU	UNIVERSITY COLLEGE LONDON, UNITED KINGDOM	
MIAO, GUANNAN	ILO, FRANCE	Parallel Session 3, Municipality - Room 2 Ground Floor
MICHEL, BERNHARD	FEDERAL PLANNING BUREAU, BELGIUM	Parallel Session 1, Ancient Tower - Room 1
MIDDELANIS, ROBIN	POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH, GERMANY	
MIROUDOT, SEBASTIEN	OECD, FRANCE	Parallel Session 2, University - Room 1 Ground Floor Parallel Session 9, University - Room 2 Ground Floor
MITOMA, HARUKA	KYUSHU UNIVERSITY GRADUATE SCHOOL OF ECONOMICS, JAPAN	Parallel Session 6, Municipality - Room 1 2nd Floor
MONFORT, PHILIPPE	EUROPEAN COMISSION DG REGIO, BELGIUM	
MONSALVE, FABIO	UNIVERSITY OF CASTILLA-LA MANCHA, SPAIN	
MORAES CORNELIO, FELIPE	FEDERAL UNIVERSITY OF RIO DE JANEIRO, BRAZIL	Parallel Session 5, University - Room 1 Ground Floor
MORAN, DANIEL	THE CLIMATE AND ENVIRONMENT INSTITUTE NILU, NORWAY	Parallel Session 4, Municipality - Room 4 Ground Floor

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
MORLIN, GUILHERME	UNIVERSITY OF PISA, ITALY	Parallel Session 10, Municipality - Room 2 Ground Floor
MUKHOPADHYAY, KAKALI	MCGILL UNIVERSITY, CANADA	Parallel Session 5, Municipality - Room 1 2nd Floor
NAGASHIMA, FUMIYA	KINDAI UNIVERSITY, JAPAN	Parallel Session 2, University - Room 2 Ground Floor
NAGATA, AI	KYUSHU UNIVERSITY, JAPAN	Parallel Session 3, Municipality - Room 1 2nd Floor
NAKAISHI, TOMOAKI	KYUSHU UNIVERSITY, JAPAN	
NAKAJIMA, KENICHI	NATIONAL INSTITUTE FOR ENVIRONMENTAL STUDIES, JAPAN	
NAM, SANG-HO	ADELMAN INSTITUTE FOR ECONOMICS, KOREA, REPUBLIC OF	Parallel Session 6, Municipality - Room 4 Ground Floor
NAMEGABE, JEAN LUC	UNITED NATIONS ECONOMIC COMMISSION FOR AFRICA (UNECA), CAMEROON	
NANSAI, KEISUKE	NAT. INST. FOR ENV. STUDIES (NIES), JAPAN	
NECHIFOR, VICTOR	EUROPEAN COMMISSION JOINT RESEARCH CENTRE, SEVILLE, SPAIN	
NEWING, ANDY	UNIVERSITY OF LEEDS, UNITED KINGDOM	
NISHIFUJI, WAKA	KYUSHU UNIVERSITY, JAPAN	Parallel Session 6, Municipality - Room 1 2nd Floor
NOTTEN, TOM	CENTRAAL BUREAU VOOR DE STATISTIEK, NETHERLANDS	
OGA, YUSUKE	KYUSHU UNIVERSITY, JAPAN	Parallel Session 9, University - Room 1 Ground Floor
OLIVEIRA, THAIS	UNIVERSITY OF SÃO PAULO, BRAZIL	Parallel Session 9, University - Room 3
OOSTERHAVEN, JAN	UNIVERSITY OF GRONINGEN, NETHERLANDS	Parallel Session 6, Municipality - Room 3 Ground Floor
ORTIZ, MATEO	UNIVERSIDAD DE CASTILLA-LA MANCHA, SPAIN	Parallel Session 8, University - Room 3
OSORIO, PILAR	UNIVERSITY OF CASTILLA-LA MANCHA, SPAIN	Parallel Session 10, Municipality - Room 1 2nd Floor
OTTO, CHRISTIAN	POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH, GERMANY	
OWEN, ANNE	UNIVERSITY OF LEEDS, UNITED KINGDOM	Parallel Session 3, Ancient Tower - Room 1
PAGLIALUNGA, ELENA	UNIVERSITY OF URBINO, ITALY	
PAN, CHEN	INSTITUTE OF QUANTITATIVE & TECHNOLOGICAL ECONOMICS, CHINESE ACADEMY OF SOCIAL SCIENCES, CHINA	Parallel Session 11, Municipality - Room 4 Ground Floor
PARTON, FREDERIK	INSTITUTE OF ECONOMIC STRUCTURES RESEARCH (GWS), GERMANY	Parallel Session 9, Ancient Tower - Room 1
PARZIANELLO, LUCIANA	UFPR, BRAZIL	
PASSONI, PATIEENE	UNIVERSIDADE FEDERAL DO RIO DE JANEIRO, BRAZIL	
PAULIUK, STEFAN	UNIVERSITY OF FREIBURG, GERMANY	
PEDAUGA, LUIS	UNIVERSIDAD DE LEÓN, SPAIN	
PEGOUE, ACHILLE	INTERNATIONAL MONETARY FUND, UNITED STATES	
PEREDA, PAULA	UNIVERSITY OF SAO PAULO, BRAZIL	
PEREIRA, ROBERTO	SEPLAN - SECRETARIA DO PLANEJAMENTO DO ESTADO DA BAHIA, BRAZIL	
PEREIRA, XESÚS	UNIVERSIDADE SANTIAGO DE COMPOSTELA, SPAIN	
PEROBELLI, FERNANDO	FEDERAL UNIVERSITY OF JUIZ DE FORA, BRAZIL	
PERUCCA, GIOVANNI	POLITECNICO DI MILANO, ITALY	
PETTENA, MATTIA	UNIVERSITÀ DI GENOVA, ITALY	Parallel Session 9, Municipality - Room 2 Ground Floor
PHILIPPIDIS, GEORGE	CITA, ARAGÓN, SPAIN	
PHILLPOTTS, ALEC	UNIVERSITY OF LEEDS, UNITED KINGDOM	Parallel Session 5, Municipality - Room 2 Ground Floor
PINACHO, RUTH	UNIVERSIDAD DE VALLADOLID, SPAIN	
PINERO, PABLO	JRC, EUROPEAN COMMISSION, SPAIN	Parallel Session 7, Municipality - Room 1 2nd Floor

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
PRABHU, VISHNU	GOKHALE INSTITUTE OF POLITICS AND ECONOMICS, INDIA	Parallel Session 3, Municipality - Room 1 2nd Floor
PRADHAN, PRAJAL	POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH (PIK), GERMANY	
PROCTOR, J.CHRISTOPHER	UNIVERSITY OF TECHNOLOGY OF COMPIÈGNE, FRANCE	Parallel Session 5, University - Room 1 Ground Floor
PROQUE, ANDRESSA	FEDERAL UNIVERSITY OF SÃO JOÃO DEL-REI (UFSJ), BRAZIL	Parallel Session 5, Municipality - Room 4 Ground Floor
PRZYBYLIŃSKI, MICHAŁ	INSTITUTE OF ECONOMETRICS, UNIVERSITY OF ŁÓDŹ, POLAND	Parallel Session 10, Ancient Tower - Room 1
PURVIS, BEN	SHEFFIELD UNIVERSITY MANAGEMENT SCHOOL, UNITED KINGDOM	
QUANTE, LENNART	POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH, GERMANY	Parallel Session 7, Ancient Tower - Room 1
RABERTO, MARCO	UNIVERSITY OF GENOA, ITALY	
RABERTO, MARCO	UNIVERSITY OF GENOA, ITALY	
REUSCHEL, SASKIA	INSTITUTE OF ECONOMIC STRUCTURES RESEARCH (GWS), GERMANY	Parallel Session 11, Municipality - Room 1 2nd Floor
REYNES, FREDERIC	TNO - NETHERLANDS ORGANISATION FOR APPLIED SCIENTIFIC RESEARCH, NETHERLANDS	Parallel Session 6, Municipality - Room 3 Ground Floor
REYNES, FREDERIC	NEO - NETHERLANDS ECONOMIC OBSERVATORY, NETHERLANDS	
RIBEIRO, CAROLINA	UNIVERSIDADE FEDERAL DO DELTA DO PARNAÍBA - UFDPAR, BRAZIL	Parallel Session 10, University - Room 2 Ground Floor
RIBEIRO, DANIELLE	UNIVERSIDADE FEDERAL DE JUIZ DE FORA, BRAZIL	
RICCIO, FEDERICO	SCUOLA SUPERIORE SANTANNA, ITALY	Parallel Session 7, Municipality - Room 4 Ground Floor
RICHTER, JOSEF	UNIVERSITY OF INNSBRUCK, AUSTRIA	Parallel Session 1, University - Room 1 Ground Floor Parallel Session 2, University - Room 1 Ground Floor Parallel Session 3, University - Room 1 Ground Floor Parallel Session 4, University - Room 1 Ground Floor
RINALDI, LORENZO	POLITECNICO DI MILANO, ITALY	Parallel Session 7, University - Room 3
ROCA FLORIDO, ALBERTO	UNIVERSITY OF YORK, UNITED KINGDOM	Parallel Session 2, Municipality - Room 1 2nd Floor
ROCCHI, PAOLA	UNIVERSITY OF BARCELONA, SPAIN	
ROCCO, MATTEO	POLITECNICO DI MILANO, ITALY	
ROCHA, ADEMIR	UNIVERSITY OF SÃO PAULO, BRAZIL	
RODOUSAKIS, NIKOLAOS	CENTRE OF PLANNING AND ECONOMIC RESEARCH, GREECE	
RODRIGUEZ DEL VALLE DEN OUDEN, ADRIAN	HALLE INSTITUTE FOR ECONOMIC RESEARCH, GERMANY	
ROITBARG, HERNAN	IHUCSO (UNL-CONICET), ARGENTINA	
ROKICKI, BARTLOMIEJ	UNIVERSITY OF WARSAW, POLAND	Parallel Session 5, Ancient Tower - Room 1
ROMÁN, MARIA	EC JRC, SPAIN	
RONSIEK, LINUS	GWS – INSTITUTE OF ECONOMIC STRUCTURES RESEARCH, GERMANY	Parallel Session 9, Ancient Tower - Room 1
ROSA, MARIA	UNIVERSITY OF WARWICK, BRAZIL	Parallel Session 5, Municipality - Room 1 2nd Floor
ROSON, ROBERTO	CA'FOSCARI UNIVERSITY, ITALY	
RUEDA-CANTUCHE, JOSÉ M.	EUROPEAN COMMISSION, SPAIN	
RUIZ GARCIA, JUAN CARLOS	JOINT RESEARCH CENTRE - EUROPEAN COMMISSION, SPAIN	Parallel Session 4, Municipality - Room 3 Ground Floor
SAFARZYNSKA, KAROLINA	WARSAW UNIVERSITY, POLAND	
SAHOO, AMARENDRA	INSTIICE OF ENVIRONMENTAL SCIENCES (CML), NETHERLANDS	Parallel Session 5, Ancient Tower - Room 1

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
SALLUSTI, FEDERICO	ISTAT, ITALY	Parallel Session 6, Ancient Tower - Room 1
SALOTTI, SIMONE	EUROPEAN COMMISSION, SPAIN	
SÁNCHEZ, MARINA	UNIVERSIDAD DE CASTILLA LA MANCHA, SPAIN	
SÁNCHEZ CHÓEZ, NAPOLEÓN	ESCUELA POLITÉCNICA NACIONAL, ECUADOR	
SÁNCHEZ CHÓLIZ, JULIO	UNIVERSITY OF ZARAGOZA, SPAIN	
SANCHO, FERRAN	UNIVERSITAT AUTÒNOMA DE BARCELONA, SPAIN	Parallel Session 11, University - Room 1 Ground Floor
SANJUÁN LÓPEZ, ANA	CITA - GOVERNMENT OF ARAGON, SPAIN	
SANTIAGO, FLAVIANE	FEDERAL UNIVERSITY OF JUIZ DE FORA - UFJF, BRAZIL	
SANTIAGO DOS REIS, FILIPE	FEDERAL UNIVERSITY OF JUIZ DE FORA (UFJF), BRAZIL	
SARASA, CRISTINA	UNIVERSITY OF ZARAGOZA, SPAIN	Parallel Session 1, Municipality - Room 3 Ground Floor
SARGENTO, ANA	POLYTECHNIC INSTITUTE OF LEIRIA, PORTUGAL	
SAVONA, MARIA	UNIVERSITY OF SUSSEX, UNITED KINGDOM	
SCHULTE, SIMON	UNIVERSITY OF FREIBURG, GERMANY	Parallel Session 9, Municipality - Room 1 2nd Floor
SEARA E PEREIRA, MARIA FILIPA	PURDUE UNIVERSITY, UNITED STATES	
SECONDI, LUCA	UNIVERSITY OF TUSCIA, ITALY	Parallel Session 10, Municipality - Room 2 Ground Floor
SERRANO, MÒNICA	UNIVERSITY OF BARCELONA, SPAIN	Parallel Session 3, University - Room 1 Ground Floor Parallel Session 11, Ancient Tower - Room 1
SEYDEWITZ, TOBIAS	POTSDAM INSTITUTE FOR CLIMATE IMPACT RESEARCH, GERMANY	
SHAN, YULI	UNIVERSITY OF BIRMINGHAM, UNITED KINGDOM	
SHAO, XUAN	南京大学, CHINA	
SHEN, XUEMEI	RITSUMEIKAN UNIVERSITY, JAPAN	
SHI, YIYING	ACADEMY OF MATHEMATICS AND SYSTEMS SCIENCE,CAS, CHINA	
SHIMOTSUURA, TAIGA	KYUSHU UNIVERSITY, JAPAN	
SHIRONITTA, KAYOKO	FUKUOKA WOMENS UNIVERSITY, JAPAN	
SHODA, TOMOMI	KYUSHU UNIVERSITY, JAPAN	Parallel Session 11, University - Room 3
SIE, LINTJE	THE UNIVERSITY OF QUEENSLAND, AUSTRALIA	
SILVA, CLÁUDIO EURICO	UNIVERSIDADE FEDERAL DE JUIZ DE FORA, BRAZIL	
SIVAMANI, GANESH	CENTRE FOR SOCIAL AND ECONOMIC PROGRESS, INDIA	
SOKLIS, GEORGE	CENTRE OF PLANNING AND ECONOMIC RESEARCH, GREECE	
STADLER, KONSTANTIN	INDUSTRIAL ECOLOGY PROGRAMME, NORWEGIAN UNIVERSITY OF SCIENCE AND TECHNOLOGY (NTNU), NORWAY	Parallel Session 2, Ancient Tower - Room 1
STAMEGNA, MARCO	UNIVERSITY OF PISA, ITALY	
STEEN-OLSEN, KJARTAN	ASPLAN VIAK AS, NORWAY	
STEENGE, ALBERT	UNIVERSITY OF GRONINGEN, NETHERLANDS	Parallel Session 1, University - Room 1 Ground Floor
STÖVER, BRITTA	GWSMBH, GERMANY	
STRASSNER, ERICH	BUREAU OF ECONOMIC ANALYSIS, UNITED STATES	
SU, BIN	ENERGY STUDIES INSTITUTE, NATIONAL UNIVERSITY OF SINGAPORE, SINGAPORE	
SUN, JIALU	SCHOOL OF ECONOMICS AND MANAGEMENT, UNIVERSITY OF CHINESE ACADEMY OF SCIENCES, CHINA	Parallel Session 11, Municipality - Room 3 Ground Floor
SUN, LAIXIANG	DEPARTMENT OF GEOGRAPHICAL SCIENCES, UNIVERSITY OF MARYLAND, UNITED STATES	
SUN, YA-YEN	THE UNIVERSITY OF QUEENSLAND, AUSTRALIA	
TAHAVORI, MOHAMMAD AMIN	VITO, BELGIUM	
THISSEN, MARK	PBL NETHERLANDS ENVIRONMENTAL ASSESSMENT AGENCY, NETHERLANDS	
THOMASSIN, PAUL	MCGILL UNIVERSITY, CANADA	

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
TIAN, KAILAN	ACADEMY OF MATHEMATICS AND SYSTEMS SCIENCE, CHINESE ACADEMY OF SCIENCES, CHINA	Parallel Session 5, University - Room 2 Ground Floor
TIAN, PEIPEI	SHANDONG UNIVERSITY, CHINA	Parallel Session 6, Municipality - Room 4 Ground Floor
TOBARRA-GOMEZ, MARIA A.	UNIVERSIDAD DE CASTILLA - LA MANCHA, SPAIN	Parallel Session 7, Municipality - Room 1 2nd Floor
TÖBBEN, JOHANNES	GWS, GERMANY	
TODA, HARUKA	KYUSHU UNIVERSITY, JAPAN	Parallel Session 2, Municipality - Room 1 2nd Floor
TOHMO, TIMO	UNIVERSITY OF JYVÄSKYLÄ, FINLAND	
TOKITO, SHOHEI	YAMAGATA UNIVERSITY, JAPAN	
TONON, MARCELO	FEDERAL UNIVERSITY OF RIO DE JANEIRO, BRAZIL	Parallel Session 11, Municipality - Room 3 Ground Floor
TORO, FRANCISCA	UNIVERSITY OF BARCELONA, SPAIN	Parallel Session 7, Municipality - Room 2 Ground Floor
TSUKIOKA, AOI	KYUSHU UNIVERSITY, JAPAN	Parallel Session 10, University - Room 2 Ground Floor
TSURU, JUNJI	KYUSHU UNIVERSITY, JAPAN	Parallel Session 1, University - Room 3
TURCHETTI, SARA	IRPET, ITALY	Parallel Session 4, University - Room 3
UEHARA, SHO	KYUSHU UNIVERSITY, JAPAN	Parallel Session 8, Municipality - Room 1 2nd Floor
UEMATSU, MARINA	KYUSHU UNIVERSITY, JAPAN	Parallel Session 1, University - Room 3
UJIKAWA, KEIJI	YOKOHAMA NATIONAL UNIVERSITY, JAPAN	Parallel Session 8, Municipality - Room 4 Ground Floor
ULLAH, AMIN	UNIVERSITY OF MACERATA, ITALY, ITALY	Parallel Session 2, Municipality - Room 4 Ground Floor
ULRICH, PHILIP	GWS MBH, GERMANY	
USHIJIMA, DAIGO	KYUSHU UNIVERSITY, JAPAN	Parallel Session 1, University - Room 3
USUBIAGA, ARKAITZ	BASQUE CENTRE FOR CLIMATE CHANGE, SPAIN	Parallel Session 8, Municipality - Room 4 Ground Floor
VALDECANTOS, SEBASTIAN	AALBORG UNIVERSITY, DENMARK	Parallel Session 8, University - Room 1 Ground Floor
VALE, VINICIUS	FEDERAL UNIVERSITY OF PARANA, BRAZIL	Parallel Session 1, University - Room 2 Ground Floor
VALLE, ELISABETH	UNIVERSITY OF BALEARIC ISLAND, SPAIN	
VALLES CODINA, ORIOL	NEW SCHOOL OF SOCIAL RESEARCH, UNITED STATES	
VARGAS, JUAN	UNIVERSIDAD AUTÓNOMA DEL ESTADO DE HIDALGO, MEXICO	
VELEROS, ZEUS SALVADOR	UNIVERSIDAD AUTÓNOMA DEL ESTADO DE HIDALGO, MEXICO	
VELLUDO, MARIANA	FEDERAL UNIVERSITY OF MINAS GERAIS, BRAZIL	
VERMA, RAJAT	CENTRE FOR SOCIAL AND ECONOMIC CHANGE, INDIA	
VERONESE PASSARELLA, MARCO	LINK CAMPUS UNIVERSITY OF ROME; UNIVERSITY OF LEEDS, ITALY	Parallel Session 10, Municipality - Room 2 Ground Floor
VILLANI, DAVIDE	JOINT RESEARCH CENTRE, SPAIN	Parallel Session 7, Municipality - Room 4 Ground Floor Parallel Session 11, Municipality - Room 2 Ground Floor
VILLANUEVA MARTINEZ, LUIS ALBERTO	ILO, SWITZERLAND	Parallel Session 3, Municipality - Room 2 Ground Floor
VILLEGAS MARTOS, PAULA	UNIVERSIDAD LOYOLA, SPAIN	Parallel Session 4, University - Room 3
WANG, CHENG	HUBEI UNIVERSITY OF ECONOMICS, CHINA	
WANG, DAOPING	UNIVERSITY OF CAMBRIDGE, UNITED KINGDOM	
WANG, FEI	UNIVERSITY OF INTERNATIONAL BUSINESS AND ECONOMICS, CHINA	

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
WANG, XIN	NANJING UNIVERSITY, CHINA	
WANG, YANG	UNVIERSITY OF GRONINGEN, NETHERLANDS	Parallel Session 3, Municipality - Room 3 Ground Floor
WANG, ZHI	GMU AND UIBE, UNITED STATES	
WEBB, COLIN	OECD, FRANCE	
WEI, RUI	SCHOOL OF ECONOMICS AND TRADE, HUNAN UNIVERSITY, CHINA	
WEI, SHANG-JIN	ASIAN DEVELOPMENT BANK, PHILIPPINES	
WELLS, JASMINE	UNIVERSITY OF LEEDS, UNITED KINGDOM	Parallel Session 3, Ancient Tower - Room 1
WILLNER, SVEN	POTSDAM-INSTITUTE FOR CLIMATE IMPACT RESEARCH, GERMANY	
WILTING, HARRY	PBL NETHERLANDS ENVIRONMENTAL ASSESSMENT AGENCY, NETHERLANDS	
WIRKIERMAN, ARIEL	GOLDSMITHS, UNIVERSITY OF LONDON, UNITED KINGDOM	Parallel Session 5, University - Room 2 Ground Floor
WOLTER, MARC INGO	INSTITUTE FOR ECONOMIC STRUCTURES RESEARCH (GWS), GERMANY	Parallel Session 10, Ancient Tower - Room 1
WONG, KHEE FUNG	STATISTICS NETHERLANDS, NETHERLANDS	
WU, HARRY	INSTITUTE OF ECONOMIC RESEARCH, HITOTSUBASHI UNIVERSITY, JAPAN	
WU, KAIYAO	SHANGHAI UNIVERSITY OF INTERNATIONAL BUSINESS AND ECONOMICS, CHINA	Parallel Session 2, Municipality - Room 2 Ground Floor
XU, SHUXIAN	TIANJIN UNIVERSITY, CHINA	
XU, XIANGYU	SCHOOL OF APPLIED ECONOMICS OF RENMIN UNIVERSITY OF CHINA, CHINA	
XU, XIAOYUE	UNIVERSITY OF CHINESE ACADEMY OF SCIENCES, CHINA	
XUE, JINJUN	GRADUATE SCHOOL OF ECONOMICS, NAGOYA UNIVERSITY, JAPAN	
YAJIMA, GIULIANO TOSHIRO	LEVY ECONOMICS INSTITUTE OF BARD COLLEGE, BRAZIL	Parallel Session 11, Municipality - Room 2 Ground Floor
YAMANO, NORIHIKO	OECD, FRANCE	Parallel Session 4, Municipality - Room 2 Ground Floor Parallel Session 5, Municipality - Room 2 Ground Floor
YAN, JIN	UNIVERSITY OF GRONINGEN, NETHERLANDS	
YANG, CUIHONG	SOUTH BUILDING, ACADEMY OF MATHEMATICS AND SYSTEMS SCIENCE, CAS, CHINA	Parallel Session 1, Ancient Tower - Room 1
YAO, YE	TIANJIN UNIVERSITY, CHINA	Parallel Session 7, Municipality - Room 2 Ground Floor
YAZAN, DEVRIM MURAT	UNIVERSITY OF TWENTE, NETHERLANDS	Parallel Session 3, Municipality - Room 1 2nd Floor
YE, JIABAI	HUNAN UNIVERSITY, CHINA	
YE, MING	OECD, FRANCE	
YE, XIANJIA	UNIVERSITY OF GRONINGEN, NETHERLANDS	
YU, MENGTING	UNIVERSITY OF TUSCIA, ITALY	
YU, MIAO	ASSISTANT PROFESSOR , INSTITUTE FOR HOSPITAL MANAGEMENT OF TSINGHUA UNIVERSITY, CHINA	
YUAN, MENG	AALBORG UNIVERSITY, DENMARK	
ZAFRILLA, JORGE	UNIVERSITY OF CASTILLA-LA MANCHA, SPAIN	Parallel Session 7, University - Room 2 Ground Floor
ZANFEI, ANTONELLO	DESP-UNIVERSITA DI URBINO, ITALY	
ZENG, ZHAO	TIANJIN UNIVERSITY, CHINA, CHINA	Parallel Session 2, Municipality - Room 4 Ground Floor
ZENK, JOHANNA	INSTITUTE FOR EMPLOYMENT RESEARCH, GERMANY	
ZEZZA, FRANCESCO	SAPIENZA UNIVERSITÀ DI ROMA, ITALY	Parallel Session 11, Municipality - Room 2 Ground Floor
ZEZZA, GENNARO	UNIVERSITÀ DI CASSINO E DEL LAZIO MERIDIONALE, ITALY	Parallel Session 9, Municipality - Room 2 Ground Floor

FULL NAME	INSTITUTION, COUNTRY	CONFERENCE PRESENCE
ZHANG, HAIYAN	NANJING UNIVERSITY, CHINA	Parallel Session 7, Municipality - Room 1 2nd Floor
ZHANG, HAORAN	PEKING UNIVERSITY, CHINA	
ZHANG, JING	CHINA INSTITUTE OF BOUNDARY AND OCEAN STUDIES, WUHAN UNIVERSITY, CHINA	
ZHANG, JUNRONG	SCHOOL OF STATISTICS, UNIVERSITY OF INTERNATIONAL BUSINESS AND ECONOMICS, CHINA	Parallel Session 7, University - Room 2 Ground Floor
ZHANG, MEICHEN	UIBE, CHINA	
ZHANG, XINXIN	SHANDONG UNVERSITY AT WEIHAI, CHINA	
ZHANG, YANAN	SCHOOL OF ECONOMICS AND MANAGEMENT, WUHAN UNIVERSITY, CHINA	Parallel Session 7, University - Room 2 Ground Floor
ZHANG, YIBING	CAPITAL UNIVERSITY OF ECONOMICS AND BUSINESS, CHINA	Parallel Session 2, University - Room 3
ZHANG, YU	GRADUATE SCHOOL OF INTERNATIONAL SOCIAL SCIENCES FROM YOKOHAMA NATIONAL UNIVERSITY, JAPAN	
ZHANG, ZHUOYING	ACADEMY OF MATHEMATICS AND SYSTEMS SCIENCE, CHINESE ACADEMY OF SCIENCES, CHINA	
ZHAO, XU	SHANDONG UNVERSITY AT WEIHAI, CHINA	Parallel Session 4, Municipality - Room 1 2nd Floor
ZHAO, YAN	RENMIN UNIVERSITY OF CHINA, CHINA	
ZHENG, HERAN	UCL, UNITED KINGDOM	Parallel Session 2, Municipality - Room 4 Ground Floor
ZHENG, YU	CEPII, FRANCE	
ZHONG, HONGLIN	SHANDONG UNIVERSITY, CHINA	
ZHOU, MEIFANG	SCHOOL OF ECONOMICS, BEIJING TECHNOLOGY AND BUSINESS UNIVERSITY, CHINA	
ZHOU, QIUHUA	SCHOOL OF STATISTICS AND INFORMATION, SHANGHAI UNIVERSITY OF INTERNATIONAL BUSINESS AND ECONOMICS, CHINA	
ZHOU, WANRU	THE UNIVERSITY OF QUEENSLAND, AUSTRALIA	
ZHU, KUNFU	RESEARCH CENTER OF GLOBAL VALUE CHAINS, UIBE, CHINA	
ZHU, LINGXIU	UNIVERSITY OF GRONINGEN, NETHERLANDS	Parallel Session 2, Municipality - Room 3 Ground Floor
ZHURAVCHAK, RUSLAN	NTNU, NORWAY	
ZÜRCHER, CARMEN	OECD, FRANCE	