

A person wearing a hat and light-colored clothing is walking away from the viewer on the crest of a large sand dune. The sky is filled with dramatic, textured clouds, and the sand dune's surface shows fine ripples in the foreground.

edited by

Joy Murray | Anne Owen

Moana Simas | Arunima Malik

A Triple Bottom Line Analysis of Global Consumption

**Economic, Environmental, and Social Effects of
Pre-Pandemic World Trade 1990–2015**



A black and white photograph of a person walking on a sand dune. The person is seen from behind, walking away from the viewer towards the horizon. The dune is covered in sand with visible ripples. The sky is filled with large, dramatic clouds. In the top left corner, there is a solid grey rectangular area.

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A Triple Bottom Line Analysis of Global Consumption: Economic, Environmental, and Social Effects of Pre-Pandemic World Trade 1990–2015

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Foreword

Making Globalization and Trade Work for the People and Planet

As of this writing, spring 2021, the world is still in the midst of the most devastating pandemic in a century. Beyond the massive death toll, the COVID-19 crisis led to the worst economic recession in modern history and to a sharp rise in poverty, hunger, unemployment and social distress. It is a considerable setback for the so-called “global goals”, officially known as the 17 Sustainable Development Goals (SDGs), adopted by the international community in 2015.

But COVID-19 may very well be just the tip of the iceberg. Damages to eco-systems and nature will likely lead to the emergence of other zoonotic diseases and pathogens. Next time, possibly, with a much higher case-fatality rate. Climate change has already led to a sharp rise in natural disasters, including droughts, sea level rise, typhoons, and heat waves. The digital revolution has moved many of our supply chains online but also increased the risk of widespread cyberattacks. And the list goes on.

These global phenomena require global solutions and partnerships.

First, because no country can single-handedly prevent, respond, and recover from these global shocks. Second, because turning our backs against multilateralism, trade, and globalization will lead to a significant drop in living standards.

As emphasized by Professor Jeffrey Sachs in *Ages of Globalization*, throughout history, globalization reversed only in some decisive moments. For instance, at the end of the Western Roman Empire or after the collapse of international trade and finance in the 1930s, but the first is remembered as the Dark Ages and the latter as the era of the Great Depression for good reasons.

International trade is of course an important part of globalization. The sum of exports and imports represents, in normal times before

the pandemic hit, about 60% of world GDP. International trade is a crucial source of income and economic activity in many countries, including some of the poorest ones. It is a driver of innovation and investment and helps address countries' national vulnerabilities, including climatic events and food insecurity. During the pandemic, trade helped address shortages in medical supplies and equipment in some parts of the world.

At the same time, unsustainable supply chains can lead to more environmental degradation, increased inequalities and other adverse effects. Prominent examples are deforestation and biodiversity loss, which are driven by trade in timber, palm oil, coffee, rubber, soy, and other commodities. The rapidly growing demand for batteries and semi-conductors increased international attention on the environmental and social sustainability of the cobalt and copper supply chains, including on the livelihoods of miners.

A fundamental objective of recovery packages and plans should be to *decouple* production and consumption from negative environmental and social impacts.

This requires a careful understanding of the alignment, or misalignment, of specific supply chains to the SDGs, the 2030 Agenda and the Paris Climate Agreement. Central to this, is the ability to put precise numbers on greenhouse gas emissions, water scarcity, biodiversity threats, accidents at work and other impacts generated through production and consumption of global traded goods and services. A focus on consumption-based impacts is needed so that the achievement of national sustainability targets (for instance on climate neutrality or biofuel strategies) do not undermine other countries' efforts towards sustainable development through deforestation, land displacement or other so-called "spillovers". Robust data systems are needed at the international-, national-, industry- and company-level to track and address negative impacts throughout the entire supply chain.

This book, *A Triple Bottom Line Analysis of Global Consumption: Economic, Environmental, and Social Effects of Pre-Pandemic World Trade 1990–2015*, provides precisely the wealth of evidence and research needed to assess the various impacts of production and consumption. Multi-regional input-output tables, combined with

satellite datasets, have become powerful tools to measure the sustainability of international trade and inform policies globally. The book also provides insights on how to manage the transformation of energy systems and other systems in a way that support a fair transition.

The analyses presented in this book contribute to the international reflection about how to foster a green, inclusive and resilient recovery from COVID-19 that works for the people and planet.

Coincidentally, 2020 did not only mark the beginning of the pandemic but also the 25th anniversary of the creation of the World Trade Organization (WTO). Alongside the Committee on Trade and Environment, the WTO can play a pivotal role in accelerating the transformation of the international rules-based trade system that incentivizes sustainable development.

China's carbon neutrality pledge and the new Biden administration in the United States hold the very real promise that multilateral diplomacy will refocus on the Paris Climate Agreement and the 2030 Agenda. This year's COP15 biodiversity conference in Kunming, China, and the COP26 climate change conference in Glasgow, Scotland, will also provide opportunities for real breakthroughs.

While the COVID-19 pandemic is a setback for sustainable development, the SDGs, the 2030 Agenda and the Paris Climate Agreement provide the right compass for "building forward better". Robust scientific evidence and data, like those presented in the "Triple Bottom Line Analysis", are needed to inform a green, inclusive and resilient recovery from the pandemic.

Guillaume Lafortune

Director, Paris Office,
UN Sustainable Development Solutions Network (SDSN)



Preface

Understanding a complex whole requires knowledge about specific variables and how their component parts are related. Thus, we must learn how to dissect and harness complexity, rather than eliminate it from such systems. This process is complicated, however, because entirely different frameworks, theories, and models are used by different disciplines to analyze their parts of the complex multilevel whole. A common, classificatory framework is needed to facilitate multidisciplinary efforts toward a better understanding of complex SESs [social-ecological systems]. (Ostrom, 2009, p. 420)¹

We began work on this book in 2018. It was designed to illustrate the power of examining specific variables in a common classificatory framework—addressing the need identified by Ostrom to facilitate a better understanding of a complex whole. Multiregional input-output (MRIO) analysis was our framework and the global economy was the complex whole. The economic, environmental, and social dimensions of doing business were to be the component parts.

MRIO can reveal hidden connections across complex trade-related social, environmental, and economic systems. It can show how, in global trade, everything is linked to everything else. Change one thing and nothing remains the same; and the ripple effects can be felt not only within state boundaries but can stretch around the globe.

Contributors to the book were asked to select a group of indicators that together would reveal a story about an aspect of their country's trade, policies, production, and consumption. Authors could choose from social indicators, covering male and female employment; and environmental indicators, covering water, CO₂ emissions, biodiversity, land, energy, and extracted materials and examine them within the Eora database of the global economy.

And then the world changed.

A novel coronavirus found its way into the human population. It was thought to have originated in bats, finding its way into humans

¹Ostrom, Elinor (2009). A general framework for analyzing sustainability of social-ecological systems. *Science*: Vol. 325, Issue 5939, pp. 419–422 DOI: 10.1126/science.1172133

via another animal host. Soon it was spreading rapidly around the world with devastating effect. And keeping pace with the spread were the recriminations as well as the research—the research warning us that such events are likely to become more common.² As aggressive assaults on the environment, like deforestation for human settlement and commerce, bring other animal species closer to humans, the risk of zoonotic diseases will increase.

With businesses shutting down around the world, the entity that we had called ‘the global economy’ fragmented along socio-economic, political, and geographic fault lines. What we had considered to be a ‘complex whole’ was now revealed to be a small part in a much bigger picture encompassing the intertwined complexity of the total global environment—showing us once again that there are no such things as ‘wholes’. ‘Wholes’ are constructs defined by us to support edifices of our making. As cybernetician Ranulph Glanville pointed out time and again ‘a whole is a part in a role’.³

In many parts of the world this pandemic had been preceded by a devastating summer. Below we outline the background against which this book was developed, offering the 2019–2020 bushfires in Australia as a representative of the world-wide effects of climate change that are upending lives and livelihoods everywhere. Increasingly violent weather events and their consequences are leaving environmental, social, and economic devastation in their wake. As Robert Costanza said late last century:

*“The most obvious danger of ignoring the role of nature in economics is that nature is the economy’s life support system, and by ignoring it we may inadvertently damage it beyond its ability to repair itself. Indeed, there is much evidence that we have already done so.”*⁴

(Costanza, R., 1996, p. 148)

We began compiling chapters for this book in 2019’s summer of devastating fire and flood; signs of this ‘irreparable damage’ were evident all around. For months, Australia’s forests and wetlands⁵

²<https://www.weforum.org/agenda/2020/04/forest-loss-diseases-covid19-coronavirus-deforestation-health> (accessed 14/06/2020)

³<http://chkJournal.com/node/154> (accessed 14/06/2020)

⁴Costanza, R. (1996). Ecological Economics: Creating a Transdisciplinary Science. In Peter H. May & Ronaldo Serôa da Motta (Eds.). *Pricing the Planet*, Columbia University Press: New York, p.148.

⁵<https://www.theguardian.com/environment/2019/oct/28/macquarie-marshes-bushfire-burns-3000-hectares-of-internationally-recognised-wetland> (accessed 08/02/2020)

were burning with a ferocity never seen before. People talked about the overwhelming noise and terror, the incredible orange blaze, flames ‘crested 20 metres above the trees’⁶ (Adcock, 2020). Some talked of fire roaring through the canopy like a firestorm raining fire from the sky, the heat causing cars to explode even before the flames arrived. It was reported that more than a billion animals were killed.⁷ The cost to the environment is unimaginable. Whole ecosystems have been destroyed. What’s left of native wildlife in bushfire areas was exposed to introduced predators and competitors in blackened and denuded bushland. Writing in the *Journal of Safety Science and Resilience* in September 2020, Filkov et al.⁸ reported that Australia’s 2019–2020 bushfires burned more than 19 million hectares of land, killed 33 people and destroyed over 3000 homes.

Then following the fires and the noise came the smoke and silence. No birds, no insects, no reptiles. Smoke⁹ choked New South Wales towns and villages throughout the southern hemisphere summer. It reached Sydney and covered the national capital, Canberra, reaching on one occasion to more than 22 times the hazardous level. Future health costs are estimated to be in the billions of dollars¹⁰ while deaths attributed to the smoke have been estimated at 417¹¹ and who knows how many years of life have been taken away from other individuals and whole communities. After the smoke came gale-force winds and torrential rain, bringing floods and washing ash into the river systems and reservoirs.

The tourist season was almost wiped out for much of southeastern Australia and local economies were destroyed. The Australian Bureau of Statistics counted the loss of jobs and cost to the economy in billions of dollars. A similar story played out in many parts of

⁶https://www.themonthly.com.au/issue/2020/february/1580475600/bronwyn-adcock/living-hell?utm_medium=email&utm_campaign=Sunday%20Reads%20-%209%20February%202020&utm_content=Sunday%20Reads%20-%209%20February%202020&utm_source=EDM&utm_term=Living%20hell

⁷<https://sydney.edu.au/news-opinion/news/2020/01/08/australian-bushfires-more-than-one-billion-animals-impacted.html> (accessed 08/02/2020)

⁸<https://www.sciencedirect.com/science/article/pii/S2666449620300098>

⁹<https://www.abc.net.au/news/health/2020-01-07/prolonged-bushfire-smoke-creates-new-health-risks/11844934> (accessed 09/02/2020)

¹⁰<https://edition.cnn.com/2020/01/10/perspectives/australia-fires-cost/index.html> (accessed 18/02/2020)

¹¹<https://onlinelibrary.wiley.com/doi/full/10.5694/mja2.50545>

the world. So much for ignoring the role of nature in economics. A healthy economy depends fundamentally on a healthy environment.

But what about interactions between a healthy economy and a healthy society? We don't have far to look of course. After the 2019–2020 bushfires and floods came COVID-19.

Millions of workers were told to stay home for fear of spreading the disease. Millions of businesses, large and small, shut down, many never to reopen. Supply chains around the world were completely disrupted. Hundreds of thousands of people died. This was a catastrophic public health issue (Hopkins, 2020).¹² It was also a global economic disaster. The two are not separate entities. A healthy economy depends fundamentally on healthy people, who in turn depend for their lives on a healthy environment.

If there was any doubt that the economy depended fundamentally on the environment, then fire, flood, and COVID-19 would surely have obliterated those doubts.

It is against this backdrop that we assembled the following chapters. The book is organised into 5 introductory chapters followed by 34 country chapters divided into 5 regions: Europe, Africa, the Americas, Asia and Oceania, and the Middle East. Each region is introduced by a chapter providing an overview of the region and a context for the country chapters to follow. All country chapters use the Eora input-output database and a selection of economic, environmental, and social indicators to tell a story.

Our opening introductory chapter is by Kirsten Svenja Wiebe from the Department of Sustainable Energy Technologies at SINTEF Industry in Norway, who provides a global context for the 34 country chapters. She begins her discussion with the UN's Sustainable Development Goals before turning attention to other development measures, from the narrowly focused but influential GDP, to the broader triple bottom line (TBL) measures of sustainable economic, environmental, and social development. Using selected TBL indicators (GDP; CO₂, material extraction, literacy, and life expectancy) Wiebe illustrates global progress made in the social dimension, albeit slow, while global environmental pressures continue to mount. Further examination of these pressures reveals what many of the individual country chapters tell us: that higher

¹²<https://theconversation.com/high-tech-shortages-loom-as-coronavirus-shutdowns-hit-manufacturers-131646>

environmental pressures impact regions with lower per capita income, health, and education outcomes.

Wiebe is co-author of the following chapter along with Norihiko Yamano of the OECD Directorate for Science, Technology and Innovation. Together they dig deeper into the global trading system's built-in inequality, asking where and for whom global supply chains create the most value and who pays the economic, social, and environmental price. They make use of the OECD's inter-country input-output table and related Trade in Value Added (TiVA) database to reveal the foreign value added required to meet domestic demand for the output of various industries (textiles, ICT and electronics, motor vehicles). Their work reveals that Asian and RoW (Rest of the World) workers engaged in these global value chains earn considerably less than workers in the global North while being denied the benefits of the North's cleaner production technologies.

In the third chapter Alf Hornborg from the Human Ecology Division at Lund University in Sweden pursues this anomaly. He argues that mainstream economists miss these fundamental flaws in the global trading system and illustrates why we need multi-regional input-output analysis to reveal these basic inequalities. He examines the ecologically unequal exchange between high-income countries of the global North and the predominantly low-income countries of the global South. He dissects unequal exchange drawing on the work of Karl Polanyi who argued that treating land, labour, and money as commodities would inevitably result in social, ecological, and financial crises. Hornborg shows how Polanyi's warnings are confirmed by the inequalities illustrated through MRIO analyses applied to economic activities in the various countries represented in this book. He goes on to argue that these asymmetric exchanges are facilitated by the modern construct of money and that what he calls 'the conundrum of unequal exchange' is an inevitable consequence of the system. He concludes that MRIO analysis plays a crucial role in illuminating the asymmetries created by globalisation. Such an analysis can inform a post-pandemic rethink of how society operates—it can provide the foundation for change.

Chapter 4 is written by André Carrascal Incera and Esteban Fernández Vázquez from the University of Oviedo, Spain, and Mònica Serrano Gutiérrez from the University of Barcelona, Spain.

They bring us an overview of the changing patterns in global trade during the first few months following the outbreak of COVID-19. They document consequences of some of the counter-measures put in place by countries to mitigate spread of the disease and show how these country-based mitigation strategies disrupt global supply chains.

This leads us into Chapter 5: the methodology and data on which rest our country analyses. It is written by Moana Simas from SINTEF Industry, Norway. She provides a highly accessible lay-person's guide to input-output analysis and consumption- and production-based accounting. She covers the five major global MRIO databases and explains our preference to provide authors of our country chapters with data from the Eora database. She then sets out in detail the fundamentals of environmentally extended input-output mathematical modelling. Simas ends with the nub of what compelled us to put together this book and why COVID-19 convinced us to keep going: input-output analysis provides insight into the workings of an economy unavailable through any other means. It can show us the local and global ripple effects of decisions, whether made at the local or global level. Such information will be crucial to policymakers striving for post-pandemic social, environmental, and economic recovery in a globalised world.

Following the methodology chapter, we have stories from 34 countries around the world bringing together the economic, social, and environmental effects of doing business. We begin this part of the book with 12 country chapters from Europe¹³ introduced by Moana Simas (SINTEF, Trondheim, Norway) who situates the individual country chapters in a broader EU context. Following Simas' introduction, José Manuel Rueda-Cantuche from the European Commission's Joint Research Centre, provides further—global—context with a TBL perspective on how the EU compares with other major trading economies. It describes economic, social, and environmental impacts of international trade on national economies highlighting trends and patterns in value added, employment, and CO₂ emissions 2005–2015. This leads us into the individual country chapters.

Barbara Plank, Nina Eisenmenger, and Dominik Wiedenhofer from the Institute of Social Ecology, BOKU Vienna follow with their

¹³At the time of writing the UK was a member of the European Union

chapter on Austria. The authors analyse the interrelations between CO₂ emissions, resource use, employment, and economic growth (measured as GDP) using three consumption-based footprint indicators: carbon footprints (tons of CO₂ emissions), material footprints (tons of materials and energy carriers), and employment footprints (number of employed people) 1990–2015. With their analysis the authors prepare the ground for cross-cutting social–environmental policies in Austria. The chapter on Bulgaria is written by Diana Ivanova from the School of Earth and Environment at the University of Leeds, UK. The author tackles the country’s heavy reliance on lignite coal and the associated issues of high GHG emissions and poor public health. Yannick Oswald, University of Leeds, brings us the chapter on France. He discusses the difficulties faced in transitioning towards a low-carbon society and discusses the ecological transition agenda, which focuses on mobilizing entrepreneurship and engaging citizens. Using production-based accounting Oswald shows that emissions are around 4.6 t/capita, however, a consumption-based perspective reveals a much higher per capita figure of 8.4 t. The gap between the two calculations indicates a high import of emissions embodied in trade. The chapter identifies potentials for change.

Lisa Becker and Christian Lutz, from the German Institute of Economic Structures Research, contribute a chapter on Germany. They outline the challenge facing the country: to reduce emissions and energy use without affecting economic performance and employment. Italy’s is a similar story. It is told by Tullio Gregori from the Department of Political and Social Sciences at the University of Trieste who writes that the country’s challenge is to decarbonize the economy without reducing living standards. He shows how Italy has addressed this issue, changing its energy mix to become a leader in renewable energy production. Glenn Aguilar-Hernandez, João F. D. Rodrigues, and Arnold Tukker from the Institute of Environmental Sciences (CML) Leiden University discuss the Netherlands’ economy—one of the largest exporters worldwide with a 3% share of the world trade market in 2015. However, the Dutch trade balance reveals that the economy is a net importer of resources. The authors identify the regions and products associated with consumption as a basis for developing strategies to reduce the Netherlands’ resource footprint.

Like Germany and Italy, Norway also tackles the issue of decoupling its emissions from GDP. Authors Carl-Johan Södersten and Sarah Schmidt from SINTEF, Trondheim, Norway, examine a range of indicators from a production and a consumption perspective. To meet their Paris agreement, the authors conclude that Norway must address two main sources of GHG emissions: the petroleum and transportation sectors. These same authors also bring us a chapter on Sweden. They set their analysis against a backdrop of Sweden's history as a pioneer in environmental engagement and their current ambition to achieve net zero carbon emissions by 2045. The authors point to high consumption-based (CB) emissions (i.e., emissions embodied in imports), which will require concerted action over the coming years if Sweden is to realise its ambition. Simon Mair and Angela Druckman from the Centre for the Understanding of Sustainable Prosperity at the University of Surrey outline a similar issue in the UK. They outline the UK's enviable record on emissions-related legislation but also reveal how, like Sweden, the UK has 'off-shored' some of its emissions, importing them embodied in consumer goods from low-income countries. They discuss the additional issues of unsafe employment and the threat to biodiversity associated with low-cost imports. Concluding that although a leader in legislation, there is still a long way to go to solve broader environmental problems.

Marta Baltrusiewicz, University of Leeds, in her chapter on Poland discusses the country's coal-dependent energy sector. She outlines the change in production- and consumption-embodied emissions before and after Poland joined the EU, noting the consequences of the country's rise in consumerism. Martin Lábaj, from the University of Economics in Bratislava, brings us a chapter on Slovakia. He positions the chapter in Slovakia's tumultuous recent history: first transitioning to a market-oriented economy in 1989 after 40 years of communist regime, followed by independence from Czechoslovakia in 1993, and a period of isolation and mistrust until elections in 1998 heralded fresh economic momentum. He discusses the future of Slovakia's automotive industry in the face of decreasing cost competitiveness and the growing importance of electric cars. Paola Rocchi and Juan Manuel Valderas-Jaramillo, from the Joint Research Centre (JRC), European Commission in Sevilla, discuss aspects of Spain's economy. As the European Union sets the

ambitious goal of a climate-neutral Europe by 2050, their chapter examines the implications of this for Spain's emissions footprint and for employment.

Turning to Africa, Martin de Wit from the School of Public Leadership at Stellenbosch University, South Africa, provides an introduction. He places the five chapters in this section in the context of Africa's economic growth, which is driven predominantly by export commodities. He discusses the largely hidden costs of resource depletion and pollution damage incurred by many nations in their striving for economic gain and much needed employment opportunities. He concludes that these costs need to be factored into export prices to realise more sustainable development pathways. De Wit also provides the chapter on South Africa in which he discusses the challenges of poverty, inequality, unemployment, and environmental degradation and the trade-offs involved in addressing them. Takako Wakiyama from the Integrated Sustainability Analysis research team at the University of Sydney brings us the chapter on Ghana, the world's second largest cocoa producer and exporter. She discusses some of the environmental costs of cocoa production such as deforestation, bio-diversity loss, and soil fertility depletion; and its reliance on rainfall, making it susceptible to changes in weather patterns. The chapter on Kenya is written by Sofía Jiménez Calvo from the University of Zaragoza in Spain. The author cites the main sources of income for households, as land and labour. She illustrates an impressive increase in crop yield since 1990 and consistently high employment in the agriculture sector. However, further analysis shows that employment in the agriculture sector is predominantly female and demands a low level of skills. Calvo concludes that a shift to more skilled work for women is needed before the country will see much alleviation of poverty.

Patrizio Lecca and Giovanni Mandras from the Joint Research Centre of the European Commission in Seville, Spain, bring us the chapter on Morocco. Like Calvo, these authors also note the gender gap in employment. They go on to analyse Morocco's consumption- and production-based resource footprints, concluding that the country is a net exporter of resources with concomitant production-based emissions embodied in those exports. The chapter on Malawi is also written by Patrizio Lecca and Giovanni Mandras. They illustrate the effect of climate-related external shocks such

as floods and drought on the agriculture sector, which constitutes 33% of the national GDP and provides livelihoods for two-thirds of the population. Access to energy is identified as a major issue with biomass, providing 88% of the country's total energy and 98% of household energy. The authors conclude that Malawi will need to diversify its exports to lessen its exposure to climate shocks.

We now move to the Americas. Jorge Gómez-Paredes from Duke University, USA, and Yachay Tech University, Ecuador, provides the context and overview chapter. This is one of the few chapters written towards the end of 2020 and therefore during the pandemic. The author acknowledges the task of dealing with the repercussions of the pandemic and examines the trajectories and trends of each of the countries in this section, reflecting on whether or not they are moving towards sustainable development. Gómez-Paredes goes on to pose dilemmas implicit in the various stories the authors tell of their country's economy. He leaves us with two thoughts to keep in mind as we read on: sustainable development requires profound changes if we are to achieve a socioecological transition; and sustainable development is incompatible with one country developing at the expense of another—it requires collective effort and cooperation.

Gómez-Paredes also co-authors the chapter on Ecuador, along with Sofia Rojo of the University of Buenos Aires and Jordi Cravioto of the Institute of Advanced Energy at Kyoto University in Japan. In it they explore the question: Has Ecuador been following a sustainable development path or a traditional development path? In answering the question, they focus on changes in energy use, fossil fuels, blue water, CO₂ emissions, and employment.

Andrés Escobar Espinoza and Bernardo Romero Torres from the Universidad de Cartagena, Colombia, bring us the chapter on Bolivia. They describe Bolivia as a fast-growing economy that historically has relied on its natural resources. Although export of these resources has allowed for public goods such as investment in education and technological progress, they find it has come at a cost to the environment. That cost includes deforestation, water pollution, and increased greenhouse gas emissions. The authors conclude that the country must now consider how to balance economic progress with social trust and natural resource protection. The chapter on Nicaragua is written by Sarah Schmidt and Carl-Johan Södersten from SINTEF at Trondheim in Norway. Nicaragua is the second

poorest country in Latin America and the Caribbean. It has low levels of education, a high adolescent pregnancy rate, malnutrition, and a high proportion of the population living in rural areas with agriculture as their primary source of income. Recent years have seen a steady growth in GDP but again this comes with environmental costs. The authors cite increased crop land, with a growing share linked to export demand, as coming at the expense of the country's forests. Alessandra Maria Giacomini and Sergio Almeida Pacca from the University of São Paulo bring us the chapter on Brazil. They note that imports are displacing indigenous production, which could be good news for workers in the exporting countries but could be detrimental to local employment and skills development in Brazil. They apply production- and consumption-based accounting to analyse the embodied energy, materials, and employment in Brazil's imports and exports.

The chapter on Colombia is authored by Lina I. Brand-Correa from the School of Earth and Environment at the University of Leeds. Like Bolivia, Colombia enjoys an abundance of natural resources. However, Free Trade Agreements negotiated in 2009–2014 have made the country more reliant on fossil fuel exports, and with privatised environmental management in place, regulations have been weakened and the environment has suffered. The country has also seen a decrease in quality employment at the local level with new jobs being created in the informal economy. Thus, despite liberalisation of the economy, the authors observe that there remains much poverty. Gibran Vita from the Open University of the Netherlands and the Centre of Environmental Systems Research at the University of Kassel, Germany, also discusses employment in his chapter on Mexico. He points out that since signing the free trade agreement with North America (NAFTA) in 1994, while new jobs were created that required a higher skill level benefitting many, those in southern states found themselves profoundly worse off. The author finds that while the economy grew following NAFTA, domestic employment did not. Vita also explores other aspects of trade with North America, concluding that the country's rise in carbon emissions may have been slowed, however, land and water embodied in exported goods have risen to concerning levels.

María Priscila Ramos and Carlos Adrián Romero, from the University of Buenos Aires, examine Argentina's energy transition to

a cleaner economy. They discuss the environmental dilemma created by the opportunity to exploit the shale gas in Vaca Muerta, which could guarantee energy security but at the same time jeopardise the country's progress towards reaching Sustainable Development Goal commitments. Loreto Bieritz from the Institute of Economic Structures Research in Germany brings the chapter on Chile. Chile is another country rich in resources with an economy focused on copper, forestry, agriculture, and fishery. Like other South American countries reliant on natural resources, Chile's economy is at the mercy of variations in global raw material prices. Bieritz writes of Chile's high level of income inequality and the Chilean Water Code that leaves water ownership in the hands of a few international companies. She concludes with observations on social unrest and the need for change if the government is to fulfil its commitment to climate action.

T. Reed Miller from the Department of Chemical and Environmental Engineering at Yale University, and Catherine Benoit Norris, Executive Director of the Social Hotspots Database, bring us the chapter on the United States of America. They discuss some of the main environmental impacts bearing down on the US economy, analysing CO₂ emissions extracted biomass materials, extracted total materials, and blue water during the period 1990–2015 from a production- and a consumption-based perspective. Not surprisingly, given what we learn from Vita's chapter on Mexico, the analysis reveals Mexico as a leading source of imported biomass. However, the authors find that the US itself through its production and consumption, plays the main role in generating potential environmental impacts.

Our six chapters from Asia and Oceania are introduced by Keisuke Nansai from the Center for Material Cycles and Waste Management Research at the National Institute for Environmental Studies in Japan. He begins by outlining the ties that exist among the conglomerate of countries that make up this region. In the first instance, he introduces the environmental impacts of China, Russia, Japan, Australia, and New Zealand based on their global supply chains and their abundance, or lack thereof, of natural resources. In Indonesia we see a different approach with a report on the effect of the COVID-19 pandemic on the country's economy. Nansai

introduces each of the chapters in this section, providing the reader with pointers directing attention to features of the note.

The chapter on China is written by Yafei Wang from the Institute of National Accounts at Beijing Normal University. Her chapter provides an historical analysis of China's CO₂ emissions and is set against the country's pledge to reduce its annual CO₂ emissions in line with international efforts to stabilise the global climate. The author shows that growth of consumption-based emissions has been higher than the growth of production-based emissions, indicating that China's rapid development has increased incomes, and therefore consumption, and investment in infrastructure. However, the author illustrates that energy-efficiency gains and industrial structure upgrades have been responsible for a steady decrease in emissions since 2014. These improvements, and the country's shift to high value-added sectors such as high technology and services reducing embodied emissions, will help in the global effort to stabilise the climate. Takako Wakiyama from the University of Sydney brings us the chapter on Japan. Like many countries with low levels of natural resources, Japan relies on imports to grow its economy. However, such reliance leaves it vulnerable to supply chain disruption. Wakiyama's chapter focuses on the complex resource dependencies that affect the economy. The chapter on Indonesia is written by Futu Faturay from the Fiscal Policy Agency in the Ministry of Finance of the Republic of Indonesia. As one of a handful of country chapters to be written in 2020, it reports on early indications of supply chain disruption due to the ravages of COVID-19. It cites loss of the tourist industry and a shortage of essential manufacturing inputs first from China then from USA, Japan, and Korea, as major economic disasters. The author provides suggestions for economic recovery.

Russia is covered by Kirill Muradov from the Ministry of Industry and Trade's Centre for Information and Analysis of Foreign Trade. He examines the contribution made to the federal budget income by the sale of oil, gas, and petroleum products. He concludes that the environmental costs of being an 'energy superpower' are larger than they seem with 650 million tons of fossil fuels embodied in exports. Jacob Fry from Integrated Sustainability Analysis at the University of Sydney; Murray Hall from the Institute for Sustainable Futures at the University of Technology, Sydney; and Barney Foran of the Institute

for Land, Water and Society at Charles Sturt University contributed the chapter on Australia. In the context of climate change, they discuss Australia's position as the largest exporter of coal for steel production and the second largest exporter of thermal coal for energy production in the world. These exports, they say, have come to be viewed as a major threat to neighbours in the Pacific where sea level rise is already evident in some low-lying islands. The chapter on New Zealand is written by John Holt from Holt Data Science. He discusses New Zealand's 'Wellbeing Budget' that takes into account human, social, natural, and economic and physical capitals, which align well with TBL accounting. However, the chapter focuses on New Zealand's issue with water quality and its CO₂ emissions, which are increasingly being displaced onto trading partners such as China and Australia.

The Middle East introductory chapter is written by Moslem Yousefzadeh and Syed Muhammad Hassan Ali from the School of Physics at the University of Sydney who have also written the two chapters included in this section. In their introductory chapter, Yousefzadeh and Ali discuss the dilemma, common to much of the region, of plentiful oil, a scarcity of water, and high unemployment. They point out that while the region is home to 4.5% of the world's population and is a leading supplier of petroleum, it contains only 1% of global freshwater resources. And with on-average 9% unemployment, it is classed as the most unequal region in the world. Each brings its own problems.

In the chapter on Iran, Yousefzadeh examines employment in relation to the country's water, emissions, fossil fuel and metal-ore extraction, and agriculture and forest land. With oil exports accounting for 50% of Iran's total exports in 2015 and with 47% of its non-oil exports related to the oil and gas industry, Yousefzadeh points out the country's precarious reliance on global oil prices and the potential of solar energy as a key strategy towards a more sustainable economy. Ali, in his chapter on Iraq, discusses the effects of the ravages of war and political strife on the country's economy. He also points out the economy's heavy reliance on the oil sector and makes suggestions for future diversification.

Post-Script

MRIO analysis can't do everything—it can't tell us the personal stories of people who have lost everything in fire, flood, and disease—but it can help us understand how vulnerable our global supply chain edifice is and what can happen when we tip the fine balance of economy, society, and environment and bring it tumbling down. Likewise, it can also show us the power of understanding how we can find harmony between the economy, society, and environment without exploitation and point to new sustainable relationships that will hold good for all of us.

It takes a while to put a book together, especially one with around 60 contributing authors. The first chapters started arriving in mid-2019. Since then world trade has changed considerably. This book stands as a snapshot of local and global supply chains in a pre-COVID-19 world. What a post-COVID-19 world will look like is hard to imagine right now. What is certain, however, is that the world will need a holistic systems view of how supply chains work and the skills, knowledge, and expertise of MRIO practitioners to help build a fairer, healthier world on the other side of this disaster. The challenge is to make this happen. MRIO analysis is a powerful tool to help tackle this challenge.

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