NETWORKS OF INTERNATIONAL TRADE AND INVESTMENT

Understanding globalisation through the lens of network analysis

Sara Gorgoni
University of Greenwich

Alessia Amighini
University of Eastern Piedmont, Italy

Matthew Smith
University of Greenwich

Series in Economics

VERNON PRESS
# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preface</td>
<td>xi</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>xiii</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xv</td>
</tr>
<tr>
<td>List of Figures</td>
<td>xvii</td>
</tr>
<tr>
<td>List of Acronyms</td>
<td>xxi</td>
</tr>
<tr>
<td>Author Biographies</td>
<td>xxiii</td>
</tr>
<tr>
<td>Introduction</td>
<td>xxix</td>
</tr>
</tbody>
</table>

## 1. An introduction to network analysis

Matthew Smith and Sara Gorgoni

1.1 Introduction 1

1.2 Graph theory, social network analysis and network science 2

1.3 Networks as a description 4

1.4 More advanced network models 7

1.4.1 Complex Network Analysis 7

1.4.2 Exponential Random Graph Models (ERGMs) 9

1.4.3 Latent Space Models for Network Analysis 11

1.5 Summary 13

1.6 Appendix 14

1.7 References 19
2. Network Analysis and the study of international trade and investment 25
Matthew Smith and Sara Gorgoni

2.1 Introduction 25
2.2a International Trade: Traditional Approaches 26
2.2b International Trade: Network Approaches 27
2.3 Foreign Direct Investments (FDIs) 29
2.4a Fragmentation of Production: Traditional Approaches 31
2.4b Fragmentation of Production: Where can network analysis contribute? 32
2.5a The regionalisation versus globalisation debate: traditional approaches 34
2.5b The regionalisation versus globalisation debate: a network perspective 35
2.6a Multinational Enterprises: Traditional Approaches 36
2.6b Multinational Enterprise: How can network analysis contribute? 38
2.7 Summary 40
2.8 References 41

3. Structure and evolution of the world’s historical trade patterns 49
Benjamin Vandermarliere, Samuel Standaert and Stijn Ronsse

3.1 Introduction 49
3.2 Networks and trade patterns 51
  3.2.1 Globalisation 52
  3.2.2 Regionalisation 53
  3.2.3 Core-periphery 55
  3.2.4 Hub-and-spoke 56
3.3 A general descriptor: stochastic block models 57
3.4 Constructing the historical trade integration network 59
3.5 Revealing the structure of the world’s trade patterns 61
3.5.1 The first wave of globalisation: 1880-1913 61
3.5.2 The interbellum: 1919-1939 64
3.5.3 The second wave of globalisation: 1946-1989 65

3.6 Conclusion 67
3.7 Appendix: The construction of the historical trade index 68
3.8 References 69

Guillermo García-Pérez, Marián Boguñá, Antoine Allard, and M. Ángeles Serrano

4.1 Aims and scope 73
4.2 The world trade web as a complex network 75
   4.2.1 Structural features of undirected representations 76
   4.2.2 The role of distance 79
4.3 Network reconstruction 81
   4.3.1 Empirical data 81
   4.3.2 Extracting backbones of significant trade channels 83
4.4 Mapping the world trade web 87
   4.4.1 A gravity model for trade channels 87
   4.4.2 Embedding method 89
   4.4.3 Hyperbolic maps of WTW backbones 93
4.5 Trade since the 19th century 98
   4.5.1 Hierarchies 98
   4.5.2 Detecting communities in WTM: the CGM method 101
   4.5.3 WTM communities versus PTAs 103
4.6 Extension to trade volumes 108
4.7 Conclusions and outlook 112
5. **Global and local centrality of emerging countries in the world trade network**  
Luca De Benedictis and Lucia Tajoli

5.1 Introduction: Hubs and Satellites
5.1.1 The evolution of the world trade network

5.2 Which countries are emerging?
5.2.1 The changing role of emerging countries in world trade
5.2.2 Two cases: China and Mexico

5.3 Emerging countries’ position in the World Trade Network
5.3.1 Visualization
5.3.2 Network statistics: Centrality
5.3.3 Regressions

5.4 Concluding remarks

5.8 References

6. **World input-output network: applications, implications, and future directions**  
Massimo Riccaboni and Zhen Zhu

6.1 Introduction
6.2 Data

6.3 World Input-Output Network
6.3.1 Network Approach
6.3.2 Aggregate Statistics
6.3.3 Centrality Measures

6.4 Community Detection

6.5 Global Value Tree
6.6.1 Global Value Network
6.6.2 Network Pruning

6.6 Future directions
6.7 Appendix
7. Local and trans-local linkages in the aerospace industry: an emerging small world? 167
Raja Kali, Ekaterina Turkina, and Ari Van Assche

7.1 Introduction 167
7.2 Global cluster network 169
7.3 Propositions related to the small-worldness of the global cluster network 170
7.4 Data and Methods 172
7.4.1 Previous analysis 175
7.4.2 Methods 175
7.5 Data analysis and results 176
7.6 Discussion of findings, limitations and directions for future research 181
7.7 References 182

8. The international fragmentation of production: a multilevel network approach 185
Matthew Smith, Sara Gorgoni and Bruce Cronin

8.1 Introduction 185
8.2 Literature review 186
8.2.1 Network analysis and the fragmentation of production 186
8.2.2 The contribution of a multilevel network approach 187
8.3 Data considerations 188
8.3.1 Dataset construction 188
8.3.2 Descriptive analysis of multilevel networks 191
8.4. Modelling multilevel networks 194
8.4.1 Exponential Random Graph Model (ERGM) 194
8.4.2 Multilevel network configurations 195
8.4.3 Additional parameters 198
8.4.4 Estimation considerations 198
8.5 Concluding Comments
8.6 References

9. The network of European outward foreign direct investments
Giulia De Masi and Giorgio Ricchiuti

9.1 Introduction
9.2 Network: the method
  9.2.1 Bipartite network
  9.2.2 Projected network
  9.2.3 Network visualization
  9.2.4 Topological measurements
9.3 The Dataset
9.4 The Network of EU FDI
9.5 A focus on Three Sectors
  9.5.1 Coal
  9.5.2 Textile
  9.5.3 Machinery
9.6 Conclusions
9.7 References

10. Free trade agreements network: structure and evolution
Silvia Sopranzetti

10.1 Introduction
10.2 Network Analysis
10.3 The general structure of the network
10.4 The actors’ position
10.5 Conclusion
10.6 Appendix
10.7 References
Preface

“Ithaka gave you the marvelous journey.
Without her you would not have set out […]
And if you find her poor, Ithaka won't have fooled you.
Wise as you will have become, so full of experience,
you will have understood by then what these Ithakas mean.”

The roots of this book are to be traced back to the autumn of 2009 when Alessia Amighini and I were at the University of Eastern Piedmont in Italy. I was then a post-doctoral fellow on a project aimed at applying Network Analysis (NA) to the study of foreign direct investment of multinationals from emerging economies and she was an already established researcher in the area of international trade. Over a few informal lunches, we had grown quickly fascinated with the idea of using NA to map and analyse - rather than just conceptualise – the complex network of international trade, and we started working on some research questions in international trade in the automotive sector which culminated on our first publication in this area.

In September 2010 I was hired by the University of Greenwich and became part of the Centre for Business Network Analysis (CBNA). The University of Greenwich had a long tradition in the area of Social Network Analysis (SNA) thanks to Prof. Martin Everett, and was the birthplace of UCINET, one of the most widely used software in SNA. The CBNA provided me with the support an inspiration needed to carry out further research in this area.

In October 2013 Alessia and I attended an executive training seminar on Global Value Chains: Policy Implications and Opportunities by the Academy of Global Governance at the European Institute in Florence. The seminar brought together representatives from the major international organisations and renowned international professors to discuss, among other things, methodological issues related to the study of the international fragmentation of production. To us, the most relevant outcome of the three days seminar was the shared view across all participants about the limitations of the current international datasets to quantitatively map and analyse Global Value Chains (GVCs). More specifically, it was clear that there was a gap in the possibility of linking micro (firm level) strategies to macro (trade-level) flows. Timely enough, in January of that same year Prof. Bruce Cronin and I were awarded a
University of Greenwich Vice-Chancellor scholarship on a research project on Corporate Networks of International Investment and Trade, which gave us the opportunity to support for three years a PhD student to work on linking firm-level and country-level data in order to better understand the international fragmentation of production and its trade implications. Matthew Smith was selected among many talented applicants to embark with us in this adventure. During the following years Alessia, Matthew and I worked jointly and separately to better understand today's complex international organisation of production. During that time, we attended several conferences and workshops, where we increasingly saw works applying network analysis to the study of international trade. In 2015 and 2016 together with Prof. Raja Kali we also organised a special session on Networks of International Trade and Investment in the International (Sunbelt) Conference organised by the International Network for Social Network Analysis (INSNA). The experience of presenting all over the world and the submissions we received to the special sessions organised on this topic made it clear that this had become a very fertile area of research. There are scholars in different parts of the world who work on related topics and address similar challenges, yet they come from a variety of disciplines and network approaches, which makes it sometimes challenging for someone coming to this research area for the first time to make sense of the rich yet fragmented literature.

The aim of this book is therefore to provide a starting point, state of the art, and examples that will aid interested readers in the exploration of this literature and help them make sense of the inter-disciplinary nature of the work that applies network analysis to international trade and investment in the hope that this will facilitate navigation in these deep waters and push research forward towards unexplored shores.

Sara Gorgoni
Acknowledgements

We thank our chapter contributors for their knowledge, dedication and patience in producing this book. We also thank our colleagues who provided advice, comments and invaluable feedback on the individual chapters. In particular, Prof. Bruce Cronin, Dr. Nicola Perra, Dr. Riccardo de Vita, Dr. Athina Piterou, Prof. Silvia Nenci, Dr. Paola Zappa, Dr. Gabriella Cagliesi and Dr. Cornell Jackson.
List of Tables

Table 1.1: SNA software to implement models and methods  
Table 3.1: Top 5 highest indegree: 1880-1913  
Table 3.2: Top 5 highest indegree: 1919-1939  
Table 3.3: Top 5 highest indegree: 1946-1989  
Table 5.1: GDP growth rates in 5-year periods  
Table 5.2: Emerging countries: Proportional odds logistic regressions  
Table 6.2: Top Five Sectors of the WION Based on In-Degree, Out-Degree, and PageRank Centralities  
Table 6. A1: Countries in the WIOD 2016 Release  
Table 6. A2: Sectors in the WIOD 2016 Release  
Table 7.1: Number of local and trans-local linkages, by type and time period  
Table 7.2: Statistical significance of different partitioning schemes (p-value of the fitness test)  
Table 7.3: Small world analysis (whole network)  
Table 7.4a: Small world analysis (buyer-supplier sub-network)  
Table 7.4b: Small world analysis (partnership network)  
Table 8.1: Descriptive Statistics for Trade and Ownership Networks  
Table 8.2: Core-periphery analysis of the international trade network  
Table 8.3: Multilevel ERGM – example multilevel configurations  
Table 9.1: Number of nodes and projects: projected investor network
Table 9.2: Most connected countries (hubs) in all sectors networks and sector by sector networks 214
Table 9.3: Degree and strength measures: projected investor network 215
Table 9.4: Centrality measures: projected investor network 215
Table 10.1: Statistics for the FTAs network in various year 228
Table 10.2: Power law, Exponential and Log-Normal Fits of degree partitions 230
Table 10.3: Degree assortativity in various year 231
Table 10.4: Mixing matrix by regions 2000 235
Table 10.5: Mixing matrix by regions 2010 236
Table 10.6: Mixing matrix by regions 2016 236
Table 10.7: Core countries selected years 238
Table 10.8: Higher degree centrality countries in various years 239
Table 10.9: Higher hub centrality countries in various years 240
Table 10.10: Higher betweenness centrality countries in various years 240
Table 10. A1: Table of Acronyms 245
Table 11.1: Four waves of migration flows: 1990 – 2010 256
Table 11.2: Direction of top migration flows per quantile 283
Table 11.3: Top 1 Origin and Destination countries per quantile 284
Table 11.4: Top 3 migration flows per quantile 286
List of Figures

Figure 3.1: The community structure-regionalisation 54
Figure 3.2: The core-periphery structure 56
Figure 3.3: A block-model structure 57
Figure 3.4: Nodes and Edges $hti$ network over time 61
Figure 3.5: First globalisation wave 62
Figure 3.6: Interbellum 64
Figure 3.7: Second globalisation wave 66
Figure 4.1: Time evolution of scalar variables in the World Trade Web 77
Figure 4.2: Backbone of the World Trade Web in 2013 79
Figure 4.3: Consistency between DBI and DBII in 1997 83
Figure 4.4: Disparity in trade volumes for all countries of the WTW in different years 84
Figure 4.5: Comparison of different statistics in the WTW and the corresponding backbone 86
Figure 4.6: Gravity model and hyperbolic representation 88
Figure 4.7: Distance matrices between countries in the WTW backbone in 2013 93
Figure 4.8: World Trade Maps for different years 94
Figure 4.9: Quality of the embeddings 97
Figure 4.10: Hierarchy in World Trade Maps 99
Figure 4.11: CGM space-based communities versus Preferential Trade Agreements 103
Figure 4.12: Evolution of effective and trade distances between countries in every PTA 105
Figure 4.13: Weighted model versus WTW backbone in 2013 111
<table>
<thead>
<tr>
<th>Figure</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1</td>
<td>Density of the World Trade Network</td>
<td>123</td>
</tr>
<tr>
<td>5.2</td>
<td>International trade market shares</td>
<td>126</td>
</tr>
<tr>
<td>5.3</td>
<td>The World Trade Network in 1995 and 2010</td>
<td>131</td>
</tr>
<tr>
<td>5.4</td>
<td>Comparing local and global centralities: 1995 and 2010</td>
<td>135</td>
</tr>
<tr>
<td>5.5</td>
<td>Nonparametric unconditional relation between centrality and growth I</td>
<td>140</td>
</tr>
<tr>
<td>5.6</td>
<td>Nonparametric unconditional relation between centrality and growth II</td>
<td>141</td>
</tr>
<tr>
<td>6.1</td>
<td>A Hypothetical Two-Country-Two-Sector ICIO Table</td>
<td>148</td>
</tr>
<tr>
<td>6.2</td>
<td>WION in 2000</td>
<td>149</td>
</tr>
<tr>
<td>6.3</td>
<td>WION in 2014</td>
<td>150</td>
</tr>
<tr>
<td>6.4</td>
<td>Time series of the domestic weight and the network density</td>
<td>151</td>
</tr>
<tr>
<td>6.5</td>
<td>Community Detection of the WION in 2000</td>
<td>154</td>
</tr>
<tr>
<td>6.6</td>
<td>Community Detection of the WION in 2014</td>
<td>155</td>
</tr>
<tr>
<td>6.7</td>
<td>GVT Rooted at South Korea’s Computer Sector (KOR_17) in 2000</td>
<td>158</td>
</tr>
<tr>
<td>6.8</td>
<td>GVT Rooted at South Korea’s Computer Sector (KOR_17) in 2014</td>
<td>159</td>
</tr>
<tr>
<td>7.1</td>
<td>Bombardier Aerospace (Montreal unit) ego network 2010-2014</td>
<td>174</td>
</tr>
<tr>
<td>7.2</td>
<td>Growth in number of linkages (%), 2002-05 to 2011-14</td>
<td>175</td>
</tr>
<tr>
<td>8.1</td>
<td>Example full multilevel network</td>
<td>191</td>
</tr>
<tr>
<td>8.2</td>
<td>Macro-level international trade network</td>
<td>192</td>
</tr>
<tr>
<td>8.3</td>
<td>Micro-level ownership network</td>
<td>193</td>
</tr>
<tr>
<td>9.1</td>
<td>Bipartite and projected graph</td>
<td>209</td>
</tr>
<tr>
<td>9.2</td>
<td>Projected Network for Firms: Coal 2003</td>
<td>217</td>
</tr>
<tr>
<td>9.3</td>
<td>Projected Network for Firms: Coal 2015</td>
<td>217</td>
</tr>
<tr>
<td>9.4</td>
<td>Projected Network for Firms: Textile 2003</td>
<td>218</td>
</tr>
<tr>
<td>9.5</td>
<td>Projected Network for Firms: Textile 2015</td>
<td>219</td>
</tr>
</tbody>
</table>
List of Figures

Figure 9.6: Projected Network for Firms: Machinery 2003  220
Figure 9.7: Projected Network for Firms: Machinery 2015  220
Figure 10.1: The distribution of FTAs in the network 2016  230
Figure 10.2: The global FTAs network in 200  233
Figure 10.3: The global FTAs network in 2016  234
Figure 10.4: New hub countries per year  242
Figure 10.5: Betweenness centrality versus degree in 2016 selected countries  243
Figure 11.1: The structural features of the IMN – a toy example  253
Figure 11.2(a): Global International Migration flows – 1990-1995  258
Figure 11.2(b): Global International Migration flows – 1995-00  259
Figure 11.2(c): Global International Migration flows – 2000-05  260
Figure 11.2(d): Global International Migration flows – 2005-10  261
Figure 11.3: Global International Migration flows – 1990-95 – Zooming in (US – Mexico)  262
Figure 11.4: In-Out Degree Distribution of the IMN – 1990-95  264
Figure 11.5: The cumulated degree distribution of the IMN  265
Figure 11.6: Correlations in network centrality measures  266
Figure 11.7: Spatial analysis of the IMN  270
Figure 11.8: Spatial and cultural features of the IMN  272
Figure 11.9: The structure of the IMN at various distances  275
Figure 11.10: Correlation between in and out degree  288
Figure 11.11: Correlation between In-(Out) degree and GDP  289
## List of Acronyms

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BRIC</td>
<td>Brazil, Russia, India and China</td>
</tr>
<tr>
<td>COW</td>
<td>Correlates of War Project</td>
</tr>
<tr>
<td>EMNE</td>
<td>Emerging (economy) Multinational Enterprise</td>
</tr>
<tr>
<td>ERGM</td>
<td>Exponential Random Graph Model</td>
</tr>
<tr>
<td>FDI</td>
<td>Foreign Direct Investment</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GPN</td>
<td>Global Production Network</td>
</tr>
<tr>
<td>GVC</td>
<td>Global Value Chain</td>
</tr>
<tr>
<td>GVT</td>
<td>Global Value Tree</td>
</tr>
<tr>
<td>HTI</td>
<td>Historical Trade Index</td>
</tr>
<tr>
<td>ICIO</td>
<td>Inter-Country Input-Output</td>
</tr>
<tr>
<td>IMF</td>
<td>International Monetary Fund</td>
</tr>
<tr>
<td>IMN</td>
<td>International Migration Network</td>
</tr>
<tr>
<td>ITN</td>
<td>International Trade Network</td>
</tr>
<tr>
<td>MNE</td>
<td>Multinational Enterprise</td>
</tr>
<tr>
<td>NA</td>
<td>Network Analysis</td>
</tr>
<tr>
<td>NS</td>
<td>Network Science</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>PTA</td>
<td>Preferential Trade Agreement</td>
</tr>
<tr>
<td>RTA</td>
<td>Regional Trade Agreement</td>
</tr>
<tr>
<td>SAOM</td>
<td>Stochastic Actor Oriented Model</td>
</tr>
<tr>
<td>SNA</td>
<td>Social Network Analysis</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
<tr>
<td>WION</td>
<td>World Input-Output Network</td>
</tr>
<tr>
<td>WTM</td>
<td>World Trade Map</td>
</tr>
<tr>
<td>WTN</td>
<td>World Trade Network</td>
</tr>
<tr>
<td>WTW</td>
<td>World Trade Web</td>
</tr>
</tbody>
</table>
Author Biographies

**Antoine Allard** received a Ph.D. in theoretical physics from Université Laval in Québec, Canada, in 2014. He then worked as an FRQ-NT postdoctoral fellow at the Departament de Física Fonamental of the Universitat de Barcelona and then as a senior research fellow at the Centre de Recerca Matemàtica in Bellaterra, Spain. He came back to the Universitat de Barcelona in January 2018 as a Juan de la Cierva postdoctoral fellow and will start as an assistant professor at the Département de physique, de génie physique et d’optique at Université Laval in August 2018. His research interests include the modeling of complex networks, the application of network science to neuroscience, and the mathematical modeling of the propagation of emergent infectious diseases.

**Alessia Amighini** is Co-Head of Asia Centre and Senior Associate Research Fellow at ISPI. She is Associate Professor of Economics at the Department of Economic and Business Studies (DiSEI) at the University of Piemonte Orientale (Novara, Italy), and Adjunct Professor of International Economics at the Catholic University (Milan, Italy). Amighini previously worked as an Associate Economist at the United Nations Conference on Trade and Development (UNCTAD, Geneva, Switzerland). Alessia holds a PhD in Development Economics from the University of Florence (Italy) and a Master in Economics as well as a BA in Economics from Bocconi University (Milan, Italy). She has published in many international peer-reviewed journals such as China Economic Review, World Development, The World Economy, International Economics, China and the World Economy. Alessia also published chapters in several books for Edwar Elgar, Harvard University Press, Oxford University Press, Palgrave, Routledge; she coauthored ‘L’economia della Cina’ (Carocci, 2007) and Macroeconomics: A European Perspective (Pearson, 2010 and 2013). She has contributed to several international research projects sponsored by Central Bank of Sweden, Inter-American Development Bank and UNU-WIDER.

**Marián Boguñá Espinal** is an associate professor and ICREA Academia researcher at the Departament de Física de la Matèria Condensada of the Universitat de Barcelona. He graduated in Physics in 1994 and obtained his Ph.D. also in Physics in 1998. In 1999, he moved to the USA to do a postdoctoral stay at the National Institutes of Health, Washington DC. After this period, he moved back to Barcelona where, in 2003, he was awarded a Ramón y Cajal
fellowship. He got the tenure position at the end of 2008. During this period, he has also spent several months in the USA as an invited guest scientist at Indiana University. M. Boguñá has written over 80 publications in major peer-reviewed international scientific journals. Among those, Nature, Nature Physics, Nature Communications, Proceedings of the National Academy of Sciences US, Physical Review Letters, and Physical Review X. Since January 2013 he serves as an editorial board member for Scientific Reports.

Bruce Cronin is a Professor at the University of Greenwich. He specialises in the role of business networks in strategy and innovation within and across organisational and national boundaries. He is Director of Research for the University of Greenwich Business School and Director of the University's Centre for Business Network Analysis since its establishment. His corporate clients have included Unilever, The Pensions Regulator, Defra, Nesta, NHS, The Work Foundation, The Institute of Management Consultants, Universities UK and the London Knowledge Network.

Luca De Benedictis is a Professor in Economics. He teaches International Economics at the University of Macerata and at Luiss, Rome, Italy. He serves as the Secretary General of the Italian Economic Association and as Editor in chief of the Italian Economic Journal, associate editor of the International Journal for Re-Views in Empirical Economics, and of the Journal of Historical Network Research. His research focuses on the empirics of international trade and migration. His ongoing research deals with network theory and applied network analysis, on causal models with interference, on historical trade and trade policy and on the theory and application of gravity models to international trade and migration issues.

Giulia De Masi is a Ph.D. in Physics and Visiting Professor in the Canadian University in Dubai. In her research, she applies methods from Statistical Physics and Machine Learning to several topics in Economics, including interbank market, credit market, and foreign direct investments. As a Post-Doctoral Researcher in the Polytechnic University of Marche and Visiting Researcher at Hitachi Research Laboratory in Nara, Japan, she conducted research on Italian and Japanese Credit Networks. She also leads Data Science-based Projects at the industry level. Her current research interests are the analysis of statistical properties and modelling of Complex Networks, Economic Networks, particularly Foreign Direct Investment networks, Machine Learning methods for forecasting and decision making.

Guillermo García-Pérez is a Ph.D. student in Physics at the Departament de Física de la Matèria Condensada of the Universitat de Barcelona. He graduated in Physics in 2014 and obtained his MSc with honours in Advanced Physics in 2015. Currently, his research focuses on geometric models able to explain
the universal features exhibited by complex networks from many different domains. He is also interested in science outreach; he is a cofounder of the non-profit organisation "Quadrivium per la divulgació," which has delivered more than 100 talks in schools and public libraries across Catalunya.

Sara Gorgoni is a Ph.D. in Development Economics and Senior Lecturer at the Department of International Business and Economics at the University of Greenwich Business School, where she is Programme Leader for the BA Hons Business Economics. She is part of the Centre for Business Network Analysis at the same university, and her current research activity relates to the application of network analysis to international trade and investment to investigate the international fragmentation of production. She has conducted research on foreign direct investments of multinationals from emerging economies and on innovation and upgrading in Global Value Chains. Dr. Gorgoni has worked as a consultant for the private sector and international organisations including the Food and Agriculture Organisation, the World Bank and the United Nations Economic Commission for Latin America and the Caribbean.

Raja Kali is Professor in Economics and the ConocoPhillips Chair in International Economics & Business. He received his Ph.D. and MA from the University of Maryland at College Park. His major areas of research include networks in trade and finance, industrial organization, development economics, and economics & finance of emerging markets. He has published his work in journals including Journal of Economics and Management Strategy, the Review of Social Economy, the Journal of Economic Geography, Economics and Sociology, the Journal of Interdisciplinary Economics, the Journal of Development Economics, the Journal of Comparative Economics, the Journal of Banking and Finance, the Economic Inquiry, the Journal of International Business Studies, and the Journal of International Trade and Economic Development.

Giorgio Ricchiuti is an Associate Professor at the Department of Economics and Management of the University of Florence (Italy), instructor of Macroeconomics at New York University in Florence and, since the beginning of 2016, fellow of the Complexity Lab in Economics (CLE) at Catholic University in Milan.

His research is focused on both empirical and theoretical analysis in International and Industrial Economics. His empirical research focuses on how different modes of internationalization - mainly FDI - affect productivity, sales and firms’ survival probability. His theoretical analysis focuses on dynamic models with heterogeneous agents and bounded rationality in financial markets, on the market structure when the demand is unknown, and new sources of heterogeneity among firms with different modes of internationalization.

Stijn Ronsse is visiting professor in the Economics Department at Ghent University. Stijn completed his undergraduate studies in history and economics and his Ph.D. in applied economics (2015) at the same university. His research interests lie in the area of cliometrics and quantitative economic history, ranging from international trade to industrialisation. He has collaborated actively with researchers in other disciplines, combining economics, history, and physics.

Valerio Leone Sciabolazza is a Postdoc Associate at the University of Florida (UF). He is an applied economist and his research interests center on spatial econometrics, the econometrics of networks, and the new science of networks. He received a Ph.D. in International Economics and Finance from Sapienza University in 2016. Before joining UF, he was a Postdoc Associate at the Swedish Institute for Social Studies (SOFI). He is part of the UF Network Science Program, where he conducts research on the determinants and constraints that shape professional collaborations among scientists. He also works on two different sets of topics, namely migrant networks and their impact on labor market outcomes; and the causal effect of political networks on legislative success.

M. Ángeles Serrano obtained her Ph.D. in Physics at the Universitat de Barcelona in 1999. One year later, she also received her Master in Mathematics for Finance from the Centre de Recerca Matemàtica. After four years in the private sector as IT consultant and mutual fund manager, she returned to academia in 2004 to work in the field of Network Science. She completed her postdoctoral research at Indiana University (USA), the École Polytechnique Fédérale de Lausanne (Switzerland) and IFISC Institute (Spain). She came back to Barcelona in 2009 when she was awarded a Ramón y Cajal Fellowship at UB. In February 2009, she obtained the Outstanding Referee award of the
American Physical Society. She is a Founder Member of Complexitat, the Catalan Network for the study of Complex Systems, and a Promoter Member of UBICS, the Universitat de Barcelona Institute of Complex Systems. M. Àngeles Serrano is ICREA Research Professor at the Universitat de Barcelona from October 2015.

Matthew Smith is a postdoctoral researcher at the University of Oxford. Dr Smith completed his PhD in international business and economics at the University of Greenwich in 2016, where he made use of advanced social network analysis techniques to inform on the organisation of production in the global economy. Broadly, his research interests focus on social network analysis, more specifically, the application of Exponential Random Graph Models (ERGMs) to explain how observed network structures emerge, and multilevel network analysis. Currently, Dr Smith is working on a project that aims at testing hypotheses derived from theoretical models of cultural evolution to shed light on the diffusion of innovations in a small scale society.

Silvia Sopranzetti is research fellow at LUISS University and Adjunct Professor in International Economics at the University of Roma Tor Vergata. She holds a Ph.D. from the University of Roma Tor Vergata. Her main areas of research are international trade, global and European integration of production and value added flows and social network analysis.

Samuel Standaert postdoctoral researcher at Ghent University, visiting associate professor at Clemson University and is a FWO [PEGASUS]2 Marie Skłodowska-Curie research fellow. His research can be situated in the confluence of applied econometrics, international trade, and development economics. Examples include the study of the effects and determinants of trade agreements, gravity models, as well as how to measure corruption, migration policy and inclusive and sustainable structural transformation.

Lucia Tajoli is Professor of Economics at the Department of Economics, Management, and Industrial Engineering at Politecnico di Milano, Italy, where she teaches Economics, International Economics and Economic Policy. She is also Senior Research Fellow at the Italian Institute for International Political Studies (ISPI) in Milan, and member of the Scientific Committee of the Italian Trade Agency, the Italian Trade Study Group, and the European Trade Study Group. Her research activity deals with theoretical and empirical issues related to international trade and economic integration among countries, currently with a special focus on international fragmentation of production, and with applications of network analysis.

Ekaterina Turkina holds a Ph.D. in Public and International Affairs from the University of Pittsburgh, USA. She is associate professor at HEC Montreal and
a holder of Professorship in International Business Networks. Ekaterina is also an associate editor of Journal of Small Business and Entrepreneurship, as well as a member of International Advisory Board of International Journal of Productivity Management and Assessment Technologies. Her main research areas are social network analysis, innovation and inter-firm networks, industrial clustering, international business and international entrepreneurship. She has published in Journal of Business Venturing, Economic Geography Journal, Journal of Common Market Studies, Journal of Business Research, Physica A: Statistical Mechanics and its Applications, International Journal of Computer Science and Network and other journals. She has written four books and was a recipient of several awards, including the Highly Commended Paper Award from the Journal of Enterprising Communities, Best Paper from the European Community Studies Association.

Ari Van Assche is Associate Professor and chair of the International Business department at HEC Montreal, as well as research fellow at the research centers CIRANO and IRPP. He is deputy editor of the Journal of International Business Policy. He holds a BA and an MA in Chinese Studies from the Katholieke Universiteit Leuven and a Ph.D. in Economics from the University of Hawaii at Manoa. His research focuses on the organization of global value chains and their implication for trade and industrial cluster policy. In 2017, he co-edited the book Redesigning Canadian Trade Policy for New Global Realities.

Benjamin Vandermarliere holds an interdisciplinary Ph.D. in Physics and applied economics from Ghent University where he is currently working as a postdoc. His focus lies on the empirical analysis of economic interactions between individuals, companies, or countries. To this end, he combines tools from econometrics, machine learning, and network theory. He has published on payment networks, interbank lending, and international trade. Currently, he is working on a project concerning the drivers of social mobility.

Zhen Zhu is a Lecturer in Network Science jointly affiliated with the Centre for Business Network Analysis and the Department of International Business and Economics of the University of Greenwich. He obtained a PhD in Economics from the Sam M. Walton College of Business of the University of Arkansas in the United States in 2013. His work on trade and production networks has appeared or is forthcoming in Journal of Complex Networks, Journal of Public Economic Theory, Network Science, PLOS ONE, and The World Economy.
Introduction

The international economy in recent decades has witnessed fundamental changes in the way manufacturing is organised: production processes are often split across a number of stages located in countries that are frequently far apart from each other. Multinational enterprises (MNEs) play a focal role in this reorganisation of production, as they spread out their manufacturing and supply chain activities globally, through international investment and intra firm trade. Our ability to understand the global economy, therefore, requires understanding the interdependencies between entities involved in such fragmented production.

Traditional methods and statistical approaches are insufficient to address this challenge. Global Value Chain (GVC) analysis, the leading theoretical approach trying to make sense of these changes suffers from several limitations, most prominently the difficulty of aggregating from firm-level observations to national-level implications. As production is more and more fragmented across borders, countries are increasingly integrated through international investment and trade, channels and vehicles of a more interconnected world economy. Therefore, a useful approach would be one that allows encompassing the overall networks of investment and trade across countries, not just among firms spreading their activities across countries.

The most promising approach so far is network analysis. Among the benefits of using a network analysis over standard statistical techniques, is the fact that it assumes dependency of observations, and therefore represents a more realistic approach to analyse the interdependence that characterises investment, production, and trade today. Traditional approaches used to analyse international trade (most notably, gravity models) consider only the bilateral relationships, meaning that in analysing trade between countries $i$ and $j$, it assumes that this is independent from any other relationship $i$ and $j$ establish with other countries. This, however, is too strong an assumption, especially given that most of today's trade is a reflection of production fragmentation among different locations, which imposes the necessity to consider that the choice for a firm to source/export from/to country $i$ and country $j$ depends from the possibility of also sourcing/exporting from/to other locations. Network analysis allows to specifically model the interdependencies amongst actors, and when applied to international trade and investment data it can provide new insight.
Introduction

This edited book makes a case for network analysis to be used alongside existing techniques in answering challenging questions in the areas of international business and economics, such as whether trade has become more global or regional, to what extent emerging economies challenge the role of traditional producers in specific industries. The book looks at how the approach and methodologies of network analysis can contribute in explaining international business and economics phenomena, in particular, related to international trade and investment. It provides a comprehensive but accessible explanation of network analysis’ applications and some of the most recent methodological advances that can contribute to research in the area of international trade and investment.

In this book we bring together research originating from both network science (see the chapter by Serrano et al.; Tajoli and De Benedictis, etc.) – the majority - and social network analysis (see chapter by Smith et al.), with the aim of providing a comprehensive account of the fertile field that applies network analysis to international trade and investment. Chapter 1 by Sara Gorgoni and Matthew Smith describes the origins of social network analysis and network science – the two main approaches taken in this book - and the differences between the two. It introduces briefly to the theory and methods of network analysis and provides an overview of the most recent methodological developments and how these can be applied to push further our understanding of complex contemporary economic phenomena. It introduces the reader to what a network is, by defining key terms such as nodes and ties, and by applying these to the context of international trade in particular in order to describe the International Trade Network (ITN). It also provides an introduction to network measures that are commonly used in describing the structure of a network, and in particular, the ITN, as well as of more advanced statistical models applied to international trade and investments.

Chapter 2 by Matthew Smith and Sara Gorgoni offers a comprehensive literature review that surveys applications of network analysis to international trade and investment data and discusses how this approach and methodology can complement statistical techniques that have traditionally been used in the empirical literature. The chapter identifies five key themes in this literature: International trade; Foreign Direct Investments; The international fragmentation of production; Regionalisation and globalisation; and, finally, Multinational Enterprises (MNEs). For each of these research areas, traditional approaches will first be examined, followed by a discussion of how network analysis can contribute answering the research questions those methods have left partly unanswered.

Chapters 3-8 of the book are devoted to the application of network techniques to the analysis of a number of broad research questions in interna-
tional trade. Chapter 3 by Benjamin Vandermarliere, Samuel Standaert, and Stijn Ronsse studies the structure and the evolution of the world’s historical trade patterns from the 1880s to the late 1980s, with the aim to identify which specific pattern of international integration prevailed. Three patterns are tested: globalisation (a geographically neutral world is one where all countries trade with each other, irrespective of their distance or other geographical concerns); regionalisation (a situation where the trade network is organized into a few regions containing countries that trade intensively with each other, but where inter-regional links are sparse); and core-periphery (a world where there is a small core of very densely connected countries surrounded by a large peripheral group of countries that trades mostly with the core and not among themselves). Using the historical trade integration index that measures the relative importance of trade flows for countries around the world from as early as the 1880s, the total time-period under study is split up into three sub-periods: the first globalisation wave (1880-1913), the Interbellum, i.e. a period of de-globalisation (1919-1939) and the second globalisation wave until the fall of the Berlin wall (1946-1989). The authors find evidence of a very strong core-periphery structure during the first globalisation wave, where the core is made up of countries like the USA and Great Britain, the semi-periphery by India and China, and the periphery by Chile and Peru. However, this structure is progressively dismantled over the next two periods, when an increasing number of countries started forming their own blocks and the core itself is no longer the same homogenous group it was during the first interbellum. This is when we start seeing signs of increasing regionalisation, together with strong links with countries in the core group. Most regional blocks also start forming links with blocks other than the core (a sign of globalisation), but these links remain relatively weak. Finally, the start of the second globalisation wave is not marked by either globalisation, regionalisation or core-periphery, but rather a hub-and-spoke pattern where strong regional clusters are linked to a central hub.

In a nice match with Chapter 3, Chapter 4 by Guillermo García Pérez, Marian Bogugná, Antoine Allard, and Maria Ángeles Serrano offers a complementary analysis of the historical evolution of the world trade network to understand the long-term evolution of international economic integration. The authors apply a new approach to the study of international trade taken from network geometry, i.e., the so-called World Trade Atlas, a collection of fourteen decades of maps of the world trade network since 1870. Beyond the obvious advantages of visualization, the World Trade Atlas increases significantly our understanding of the long-run evolution of the international trade system and helps us to address a number of important and challenging questions. In particular, which is the role of distance in trade - not merely in geographical terms - and how far or close have countries been through recent history? The
answers lead to a clear picture in which the evolution of the international trade system has been shaped by three simultaneous forces: globalisation, hierarchisation, and localisation. The authors find that the international trade system is becoming more heterogeneous and hierarchical than ever before and, at the same time, more interconnected and clustered into natural trade communities not fully consistent with Preferential Trade Agreements. Two waves of globalisation are identified in recent history. The first wave goes from 1870 until the beginning of World War I and results from decreasing costs for transportation of materials and goods triggered by the Industrial Revolution, with steam power encouraging the expansion of railroad networks and oceanic routes and the telegraph connecting the two sides of the Atlantic. The second wave, from 1960 to the present is intimately related to the ease of the exchange of information and ideas facilitated by the Information Technology Revolution, which is causing communications costs to drop dramatically at the same time that information management capabilities are exploding. As a result, the large-scale organization of the world economies nowadays exhibits a high level of local heterogeneity and of global interdependence at the same time. The world is not flat. Instead, the authors claim it is hyperbolic. In contrast to the widespread perception that globalisation has led to a decrease in the importance of distance, countries preferentially select their significant trade partners from geographically close neighbours. According to the World Trade Atlas 1870-2013, the role of trade distance has not decreased but increased over time over the last 14 decades. Interestingly, this trend seems to have been reverted since 2009, maybe because of a fast-rising China as a new commercial power and due to the effects of the economic crisis. The World Trade Atlas approach also helps to shed light on a further issue that has long challenged scholars and policymakers alike, i.e., whether the proliferation of PTAs has effectively reduced barriers to trade between their members. The authors find only a moderate overlap of PTAs with natural communities, meaning that PTAs have not necessarily reduced barriers to trade between their members, but they may serve purposes other than trade in economics or politics since their ambiguous consequences on the creation or steering of trade depend upon several other conditions.

Chapter 5 by Luca De Benedictis and Lucia Tajoli explores the issue of emerging countries’ role in the international trade network in order to assess whether they are standing out from the rest of developing countries in relation to the central position they occupy and their effect on the overall connectivity of the network. The authors use local and global centrality measures and find that the overall structure of the international trade network changed significantly over the past decades shifting the relative position of many countries. The authors observe an international trade network composed by a
system of hubs and satellites, with emerging countries occupying different positions in this structure. The results from this chapter provide a nice complement to some of the results in Chapter 3, which also detected a hub and spoke structure as a pattern of the international integration that describes today's global economy. The authors identify a heterogeneous group of emerging countries scattered across all continents, different in economic size and population, with different levels of development and models of specialization and uneven growth paths. Among them, they focus on two cases, China and Mexico, which followed different trajectories that are quite paradigmatic in interpreting the role of emerging countries in world trade. On the one hand, China rises to a hub position at the regional level for some specific manufacturing sectors, but also globally to a certain extent. On the other hand, Mexico became the satellite of the US economy. In addition to the descriptive analysis based on centrality measures, the authors test the conditional correlation between the centrality indices discussed in the first part of the chapter with other economic variables to assess how relevant the position of the emerging countries in the international trade network is in affecting their economic performance. The analysis reveals the crucial role of trade links for emerging economies.

Chapter 6 by Massimo Riccaboni and Zhen Zhu explores the issue of the international integration of countries through trade by analysing the World Input-Output Network (WION), i.e. the complex web of trade relations that link together countries that participate in Global Value Chains (GVCs), where the nodes are the individual sectors in different countries and the links are the input-output relationships between them. The chapter takes a network approach to investigate the GVCs at the macroeconomic level by relying on a specific national accounting framework, the input-output tables, more specifically the World Input-Output Database (WIOD) 2016 release, which covers 43 major countries in the world for the period from 2000 to 2014. The authors apply a community detection method to visually detect the presence and significance of GVCs for the years 2000 and 2014 and decomposing the final demand of each sector into the value-added contributions from all over the world. They find that the sectors belonging to the same country tend to cluster together, which suggests that most transactions still happen domestically. Moreover, some cross-country communities - such as the NAFTA (North American Free Trade Agreement) - are detected for the years examined. Perhaps the chapter's most interesting contribution is that the method exposed allows them to detect the presence and significance of GVCs at the sectoral level in a clear way. The authors use a network pruning algorithm to reveal the essential value-added relationships for a selected root country. The resulted sub-network is called Global Value Tree (GVT). GVTs can be generated for each sector in the world and for each year there is data available. This allows
the authors to trace the evolution of the GVTs for a given sector or compare the GVTs across countries and sectors over time.

Chapter 7 by Raja Kali, Ekaterina Turkina and Ari Van Assche focuses on a specific industry case – the aerospace – to answer the question of whether changes in the structure of the global aerospace cluster network have allowed it to become an increasingly “small world”, i.e. a network which combines high clustering among nodes with short average distance across nodes (which can be considered an “efficient” configuration of the network). The chapter builds on previous research by the authors showing that cluster firm connections have become less agglomerated within the geographical boundaries of clusters, and more clustered within value chain boundaries that cross multiple locations. Such a transformation is because industrial clusters in the aerospace industry are gradually moving from sectoral to functional specialization, where they are now positioning in finer sliced value chain stages. The authors find that changes in the configuration of trans-local and local linkages are transforming the topology of the overall network into a “small-world,” as the growth in trans-local linkages has reduced average distance in the network while the persistence of many local linkages has maintained a high level of clustering in the network. They also find important regional trends: traditional clusters in developed countries are reorienting their supply chains and investments towards emerging industrial clusters in Eastern Europe and Mexico, while trans-local partnership linkages develop mainly between clusters specialized in similar value chain stages. Taken together, the chapter suggests that the organization of the network of global linkages across industrial clusters is becoming more efficient over time.

Chapter 8 by Matthew Smith, Sara Gorgoni, and Bruce Cronin presents a strategy for combining firm and country-level data to overcome the fictitious separation between the micro and the macro level. Studies generally examine international trade in isolation of Foreign Direct Investment (FDI) decisions, yet this is clearly not a realistic assumption in a world where production is a globally fragmented process, with many multinational and corporate groups utilising FDI and locational assets in their manufacturing activities to retain competitive advantages. Studies that make use of FDI stock and flow statistics only illustrate overall country patterns. This approach elides the fact that FDI stock and flow data are an aggregation of the international investment activity of individual firms and that therefore trade and investment flows are ultimately dependent on corporate networks. The authors argue that in order to better understand the complex nature of production as it is today, there is a need for this complexity to be reflected in the datasets used, capturing the increasing importance of MNEs and intra-firm trade. The rise of GVCs requires the creation of new datasets that can be used in quantitative studies; a
factor also recognised by international economic organisations. The chapter examines the challenges of building a multilevel relational dataset using firm ownership data from Orbis and country-level international trade data from UN Comtrade. They then propose a multilevel network model that could be used with such data to investigate the micro determinants of ties observed at the macro-level. Finally, they consider potential challenges and propose solutions to such a modelling approach.

The rest of the book includes a set of applications of network techniques and methods to selected non-trade issues in international economics. Chapter 9 by Giulia De Masi and Giorgio Ricchiuti explores the network of European outward foreign direct investments using network analysis, with the main aim to reveal the existence of heterogeneity between and within sectors and/or the possible presence of common behaviour among firms. This chapter is inspired by the rich theoretical and empirical literature on firm productivity and competitiveness in international markets. The authors reconstruct the network of the European (EU28) firms investing abroad based on the database ‘fDi markets,’ a rich global, detailed database developed by the Financial Times. They look separately at the years 2003 and 2015, in order to compare the structural change on the longest available period and try to identify changes before and after the recent financial crisis. The network they analyse is a bipartite graph, where the nodes are both investors and host countries, and a link is drawn if a parent company invests in a certain host country. The authors detect the presence of subnets and main hubs (countries/firms) within three selected sectors (Coal, Machinery, and Textile). Overall, across all the three sectors taken together, there is evidence of a structural change from 2003 to 2015 in the direction of formation of sub-networks or clusters. This is particularly evident in the Machinery sector, which experienced near-shoring of manufactures and for Coal, where there is evidence of both merging and near-shoring phenomena after the crisis. The opposite behaviour is observed for the Textile sector, which can be explained by the increasing tendency to invest not only in manufacture but more and more in retail.

In Chapter 10, Silvia Sopranzetti applies network analysis to one of the more recent and understudied topics in international economics, namely the proliferation of free trade agreements all over the world over the last twenty years. The author explores the relative position of the individual countries in the global FTA network from 1960 to 2016 (nearly 75% of all trade agreements in force in 2017 are FTA). The chapter shows how accounting for the network structure of FTAs helps to explain some aspects of FTA formations that would not otherwise be explained by countries’ economic characteristics. The chapter considers how multiple FTAs interact and evolve over time. Additionally,
the author looks at the role of geographical proximity as a condition affecting the probability of two countries signing an FTA. Results show clear signs of preferential attachment process and a semi-globalised structure in which FTA agreements are mainly inside countries’ region, while only a few countries chose partners outside their region. More recently, however, geographical proximity seems to be losing importance. In this new scenario, new countries are emerging as key players. Differently from the past, not only are the European countries to be deeply involved in FTAs formation, but also some middle-income countries, which are emerging as regional leaders in this process and are signing new agreements with partners outside their geographical region.

In Chapter 11, Valerio Leone Sciabolazza outlines a set of methods and visualization strategies to explore, describe and synthesize migratory processes from a network standpoint. The study of international migration is a natural field of application for network analysis. In fact, the set of interpersonal ties that connect migrants in origin and destination areas generate a network where each node indicates a place, and one edge connecting two nodes registers the number of people moving from one place to another. Three are the contributions of this chapter. First, it presents a number of analytical tools provided by network analysis that are particularly suited to explore the externalities generated by the interconnected nature of migration flows. Second, it provides an empirical framework to confirm and further extend our knowledge of the factors determining a decision to move from one place (push factors) to another (pull factors). Third, it shows how the level of embeddedness of one country in the international migration network (IMN) represents a powerful source of information on local processes of migrants’ sorting and self-selection. Consistent with extant literature, the main result is that geography matters also from a network perspective. The probability of observing the creation of a human corridor in the IMN decreases when considering larger distance radius. In addition to that, the analysis suggests that within the set of destinations available within a certain space, migrants do not choose at random: they prefer moving to countries sharing their linguistic-colonial heritage and with higher welfare. Moreover, comparing the GDP of the topmost sender and receiving countries at various distances, the author finds that the out-degree of one country might proxy the skill composition of its labour force: while unskilled workers from developing countries move in large numbers through few human corridors, skilled migrants from developed nations are sparsely located in a higher number of links. Finally, comparing the results over time, there is evidence of an increase in the number of topmost destinations in the IMN, largely resulting from an involvement of developing countries increasingly assimilated into the globalisation process. However, the analysis shows that the major modifications of the IMN
occurred in the intensive margin of the network, meaning that the architecture of international migration has remained stable.

Whilst each of the chapters contributes to improving our understanding of current international economics' issues by applying network techniques and approaches; there are still some limitations that should be tackled in future research, as summarised in the concluding remarks.
Index

A
aerospace, xxxiv, 167, 168, 172, 173, 175, 176, 178, 179, 184
aerospace clusters, 172, 174, 181
affiliation network, 189, 190, 198
African continent, 62
America, 235, 281
Andean Community CAN, 107
angular coordinates, 88, 95, 96, 100, 101
angular density, 101
angular distance, 87, 100, 101
apparel, 31, 44, 162
arc, 5, 55, 121, 130, 134
Argentina, 67, 119, 136
Asia, 29, 34, 41, 43, 46, 62, 64, 128, 133, 161, 224, 235, 236, 237, 245, 247, 281, 284
Asia-Pacific Trade Agreement (APTA), 107
assortativity, 6, 32, 227, 231, 232
Australia, 63, 65, 67, 133, 161, 203, 215, 240, 281
Austria, 60, 64, 65, 67, 133, 161, 239
Austro-Hungarian Empire, 60
automotive, xi, 31, 33, 35, 42, 47, 165, 169, 184, 187, 200, 202
average degree, 229
average distance, xxxiv, 77, 153, 168, 170, 172, 176, 181, 212

B
Barabási-Albert model, 2, 8
Belarus, 104
Belgium, 63, 65, 82, 98, 161
Belgium-Luxembourg, 82
Bell Helicopter, 173
betweenness centrality, 211, 213, 239, 244, 254, 266
Bilateral Migration Matrix, 254
bipartite network, 208, 209, 210
blockmodelling, 28
blocks, xxxi, 35, 47, 57, 58, 62, 63, 64, 65, 66, 67, 68, 78
Boeing 787 Dreamliner, 173
Bombardier Aerospace, 173, 174
Brazil, xxi, 12, 62, 119, 124, 126, 144, 161, 218
BRIC, xxi, 12, 126, 144, 256, 284
brokerage, 33
Bulgaria, 161, 218, 239, 240
business group, 29, 38, 39, 41

C
Canada, xxiii, 64, 65, 67, 133, 136, 161, 176, 182, 228, 243
Caribbean Community and Common Market, 104
Caribbean countries, 64
CEMAC, 104
Central America, 65, 107, 235
Central American Common Market, 104
centralisation, 32, 198
centrality, xxxii, 34, 46, 63, 97, 119, 134, 135, 136, 137, 139, 140, 141, 142, 143, 211, 212, 214, 223, 224, 227, 239, 240, 243, 246, 254, 255
centrality measures, xxxii, 34, 126, 133, 137, 140, 151, 213, 255
Chile, xxi, 63, 67, 119, 136, 238, 239, 240, 242, 243, 244
China, xxi, xxxi, xxxii, xxxiii, 12, 23, 41, 46, 48, 63, 65, 67, 78, 82, 98, 107, 113, 119, 124, 126, 127, 128, 129, 133, 136, 139, 143,
<table>
<thead>
<tr>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>CIA World Factbook, 83</td>
</tr>
<tr>
<td>closeness, 80, 108, 218, 219</td>
</tr>
<tr>
<td>closeness centrality, 212, 213</td>
</tr>
<tr>
<td>clustering, xxviii, xxxiv, 7, 9, 11, 12, 13, 21, 28, 32, 76, 78, 79, 80, 85, 87, 89, 90, 97, 108, 168, 169, 170, 172, 176, 178, 179, 181, 184, 210, 255, 266, 269</td>
</tr>
<tr>
<td>clustering coefficient, 7, 28, 76, 79, 90, 97, 170, 176, 178, 179, 255</td>
</tr>
<tr>
<td>clustering, xxxiv, 46, 146, 167, 171, 173, 175, 176, 179, 181, 182, 183, 184, 213, 235, 237, 239</td>
</tr>
<tr>
<td>Coal, xxxv, 208, 213, 214, 215, 216, 217, 218, 219</td>
</tr>
<tr>
<td>Colombia, 119, 238</td>
</tr>
<tr>
<td>Common Economic Zone CEZ, 104</td>
</tr>
<tr>
<td>Common Market for Eastern and Southern Africa COMESA, 107</td>
</tr>
<tr>
<td>Commonwealth of Independent States CIS, 104</td>
</tr>
<tr>
<td>community detection, xxxiii, 6, 17, 21, 34, 35, 36, 48, 70, 101, 102, 103, 146, 152, 153, 154, 155, 165, 167, 183</td>
</tr>
<tr>
<td>community structure, 6, 17, 21, 36, 54, 55, 67, 69, 71, 73, 93, 117, 176, 178, 180, 181, 183, 184, 203, 238</td>
</tr>
<tr>
<td>competition, 28, 182, 250, 293, 294</td>
</tr>
<tr>
<td>complex network theory, 207</td>
</tr>
<tr>
<td>complex networks, xi, xxiii, xcv, 2, 3, 4, 7, 8, 9, 13, 19, 22, 26, 27, 46, 60, 73, 74, 75, 76, 78, 80, 85, 87, 101, 108, 114, 115, 116, 117, 168, 170, 182, 184, 200, 207, 223, 245, 293, 295, 297</td>
</tr>
<tr>
<td>Comtrade, 123, 132, 135, 140, 142</td>
</tr>
<tr>
<td>conditional correlation, xxxiii, 136</td>
</tr>
<tr>
<td>core-periphery, xxxi, 6, 28, 32, 49, 50, 51, 55, 56, 57, 58, 63, 64, 66, 67, 68, 133, 192, 227, 238, 268</td>
</tr>
<tr>
<td>corporate networks, xxxiv, 46, 187</td>
</tr>
<tr>
<td>Correlates of War, xxi, 73, 81, 114, 115</td>
</tr>
<tr>
<td>Costa Rica, 242</td>
</tr>
<tr>
<td>Critical Gap Method (CGM), 95, 101, 102, 103</td>
</tr>
<tr>
<td>Czech Republic, 119, 124, 215, 239</td>
</tr>
<tr>
<td>D</td>
</tr>
<tr>
<td>degree centrality, 120, 126, 134, 136, 232, 239, 241, 244, 263, 266, 272, 281</td>
</tr>
<tr>
<td>degree correlations, 76, 78, 85</td>
</tr>
<tr>
<td>degree distribution, 5, 8, 79, 85, 87, 89, 90, 97, 227, 229, 230, 263, 264, 265, 272, 274, 282</td>
</tr>
<tr>
<td>Denmark, 65, 67, 107, 161, 202</td>
</tr>
<tr>
<td>density, 5, 8, 33, 50, 53, 54, 55, 56, 57, 60, 61, 77, 83, 120, 121, 122, 124, 129, 149, 150, 192, 193, 227, 229, 235, 237</td>
</tr>
<tr>
<td>dependency theories, 4, 25</td>
</tr>
<tr>
<td>Digitalization, 171</td>
</tr>
<tr>
<td>disassortativity, 6, 9, 252, 255, 263, 268</td>
</tr>
<tr>
<td>Distance matrices, 93</td>
</tr>
<tr>
<td>Dominican Republic, 107</td>
</tr>
<tr>
<td>Dunning, 37, 39, 43, 46</td>
</tr>
<tr>
<td>E</td>
</tr>
<tr>
<td>East African Community EAC, 107</td>
</tr>
<tr>
<td>East Asia, 29, 226, 235, 263</td>
</tr>
<tr>
<td>Eastern Europe, xxxiv, 64, 107, 168, 176, 181, 235, 263, 274</td>
</tr>
<tr>
<td>Eclectic Paradigm, 37, 46, 200</td>
</tr>
<tr>
<td>Economic Cooperation Organization ECO, 104</td>
</tr>
<tr>
<td>economic geography, 26, 113, 183, 184</td>
</tr>
<tr>
<td>economic integration, 29, 167</td>
</tr>
<tr>
<td>economic networks, 4, 6, 7, 9, 20, 117, 294</td>
</tr>
<tr>
<td>economic performance, xxxiii, 9, 124, 136, 139, 182, 184</td>
</tr>
<tr>
<td>economic shocks, 26</td>
</tr>
</tbody>
</table>
Index

economic size, xxxiii, 26, 68, 81, 86, 87, 88, 89, 95, 98, 100, 107, 113, 120
Econophysicists, 7
ECOWAS, 104
Egypt, 119, 120, 136, 238, 239, 240, 242, 244
E-I index, 35, 36
eigenvector centrality, 120, 126, 134, 135, 136, 137, 139, 141, 151, 239
electrical equipment, 162, 189
electronics, 31, 47, 193
emerging countries, xxxii, 12, 28, 41, 44, 119, 120, 121, 122, 123, 124, 125, 127, 128, 129, 133, 136, 138, 139, 140, 143, 144, 212, 222
Emerging countries, 121
emerging economies, xi, xxv, xxx, xxxii, 12, 28, 33, 39, 40, 44, 116, 124, 125, 126, 127, 143, 256, 298
emerging markets, xxv, 37, 38, 39, 143
EMNEs, 37, 38, 39
Erdős – Rényi model, 8
Estonia, 59, 161, 240
EU, 161, 213, 215, 219, 221, 225, 228, 232, 238, 239, 240, 241, 242, 245, 294
EU28, xxxv, 207
Eurasian Economic Community EAEC, 104
Exponential Random Graph Models (ERGM), xxi, xxvii, 9, 14, 20, 194

F
fDi markets, 205, 207, 210
FDI network, 187
financial crisis, xxxv, 29, 121, 122, 128
First World War, 52, 64
Foreign Direct Investments (FDI), xxi, xxiv, xxvi, xxx, xxxiv, 10, 21, 26, 29, 30, 31, 37, 40, 41, 42, 43, 44, 185, 187, 188, 199, 201, 202, 205, 206, 207, 212, 223, 242, 293
free trade agreements, xxxv, 225, 226, 228, 229, 238, 241, 244, 245, 247, 298
Free trade agreements network, 225
French colonies, 39, 62, 63
Fruchterman and Reingold algorithm, 132
FTA, xxxv, 226, 227, 228, 232, 234, 237, 238, 245
FTA network, xxxv, 226, 227, 228, 230, 232, 234, 237, 241, 244

G
GDP growth, 127, 128, 139, 140, 141, 142
General Bilinear Mixed Effects, 12
general equilibrium models, 29
general equilibrium theory, 29
generative random graph, 8
geographic clustering, 172
geographic distance, 86, 194, 198
geographic neutrality, 49, 53
geographic space, 31, 186
geographical distance, 269
geographical proximity, xxxvi, 227, 251
generic distance, 210
geometric network model, 87
geometrical positions, 79
Germany, 34, 63, 65, 67, 78, 81, 98, 127, 133, 156, 161, 193, 201, 215, 218, 262
GINI index, 274
Global Migration database, 254
Global Migration Tables, 254
Global Production Networks, 31
global supply chain, 37
Global System of Trade
Preferences, 104, 228
Global Value Chains (GVCs), xxi,
xxix, 31, 32, 186
Global Value Network (GVN), 146,
156
Global Value Tree (GVT), 6, xxi,
xxxiii, 146, 156, 157, 158, 159
globalisation, xxx, xxxi, xxxii,
xxxvi, 26, 28, 34, 35, 36, 37, 40,
43, 45, 46, 47, 49, 51, 52, 53, 57,
61, 62, 63, 64, 65, 66, 67, 70, 71,
75, 86, 98, 112, 113, 114, 115,
116, 117, 118, 183, 205, 227,
247, 295, 298
goodness of fit, 198, 199, 230
governance, 31, 39, 200, 201
graph, 13
graph theory, 1, 2, 13
gravity models, xxiv, xxvii, xxix, 7,
12, 13, 26, 27, 28, 29, 30, 36, 73,
74, 79, 80, 87, 88, 89, 95, 97,
112, 114, 115, 117, 185, 187,
249, 251, 269, 293, 298
Great Britain, xxi, 52, 63, 65, 67,
216, 282, 286, 287
Great Depression, 52
GVC, xxi

H

homophily, 6, 11, 21, 76, 194, 198,
226, 235, 237, 252, 281
Hong Kong, 82, 123, 243
hub-and-spoke, xxi, 51, 56, 66,
68, 247
hubs, xxxiii, xxxv, 34, 45, 78, 100,
114, 124, 143, 208, 211, 213,
214, 218, 231, 232, 241, 244,
252, 268, 274, 282
Hungary, 60, 119, 161, 215, 218,
239, 240
hyperbolic distance, 88, 89, 100,
101
hyperbolic plane, 87, 89, 95, 103
hyperbolic space, 74, 80, 89, 96,
113

I

Iceland, 67, 122, 243
ICIO table, 146, 147, 148
Imperial Colonies, 77
in-degree centralisation, 191
in-degree centrality, 134
India, xxi, xxxi, 52, 63, 65, 67, 71,
98, 119, 124, 126, 133, 144, 161,
215, 216, 240, 244, 286, 287
Indonesia, 65, 119, 124, 161
industrial clusters, xxiv, 167, 168,
169, 170, 171, 172, 181, 182
Industrial Revolution, xxxii, 112
industries, xxx, 29, 31, 33, 36, 47,
129, 147, 175, 187, 199
Information Technology
Revolution, xxxii, 112
input-output tables, xxxiii, 33,
146, 188
Inter-Country Input-Output
(ICIO) tables, 145
international fragmentation of
production, xi, xxv, xxvii, xxxi,
26, 31, 120, 185, 186, 199, 201
international investment, xxix,
xxxiv, 40, 187, 298
international migration, xxxxi, 4,
249, 252, 253, 293, 298
International Monetary Fund, xxi,
81, 116, 125
International Standardised
Industry Classification (ISIC),
190
international trade, xi, xii, xxiv,
xxv, xxxvi, xxvii, xxviii, xxix, xxx,
xxxi, xxxii, xxiv, 1, 4, 5, 6, 7, 9,
10, 11, 12, 13, 17, 19, 20, 22, 25,
26, 27, 28, 29, 30, 31, 32, 33, 36,
40, 45, 49, 51, 52, 55, 60, 70, 71,
73, 74, 75, 77, 78, 80, 81, 85, 87,
120, 127, 129, 143, 144, 145,
166, 167, 183, 185, 186, 187,
188, 191, 192, 193, 194, 195,
196, 197, 198, 199, 200, 207,
247, 293, 294, 295, 297, 298
International Trade Network ITN,
xxi, xxx, xxxii, 1, 4, 5, 6, 7, 8, 9,
11, 13, 17, 19, 20, 23, 26, 27, 28,
29, 35, 36, 40, 44, 45, 48, 55,
Index

114, 143, 189, 190, 192, 196, 197, 198, 246, 293, 298
intra-firm trade, xxxiv, 11, 26, 42, 185, 188, 196, 197, 199, 201
intra-industry trade, 28
Ireland, 107, 161
Israel, 119, 238, 241
Italy, xi, xxiv, xxvi, xxvii, 65, 67, 98, 127, 156, 161, 182, 193, 223, 247

J
Jacob Moreno, 2
John A. Mathews, 37, 38, 46
Jordan, 119, 136, 238, 239

K
Kalman, 69
Kamada-Kawai algorithm, 210
Kazakhstan, 104
Kolgomorov-Smirnov, 230
Kosovo, 82
Kronecker-delta function, 210
Krugman hypothesis, 237

L
LAIA, 104
latent space models, 11, 12, 13
Latin America, 29, 133, 207, 284
Less Developed Countries, 121
liberalization, 52, 114, 115, 294
LLL framework, 39, 41
localisation, xxxii, 75, 98, 101, 107, 113, 114, 171, 172, 178, 212
localism, 103, 107, 113
locational assets, xxxiv, 187
locational decisions, 30
Longitudinal ERGMs, 10
Louvain method, 102, 103, 104
Luxembourg, 82, 161
Machinery, xxxv, 152, 162, 163, 208, 213, 219, 220
Maddison Project, 83, 115
Malaysia, 119, 124, 193
manufacturing, xxix, xxxiii, xxxiv, 37, 42, 120, 128, 144, 151, 163, 182, 187, 201, 205, 214, 219, 221
market competition, 101
market shares, 119, 125, 127, 134, 136
Markov chain, 11, 146, 152
maximum likelihood, 11, 176
medical and precision instruments, 191, 192
Medtronic Inc., 193
MERCOSUR, 222
Merger and Acquisition (M&A), 39, 43, 206
Metropolis Hastings, 91
Micronesia, 123
Middle East, 234, 235, 236
Mongolia, 225
Monte Carlo Markov Chain, 11, 58
Monte Carlo simulations, 176
Morocco, 119, 120, 238
multilateral resistance, 27, 249, 251
Multilateral trade agreements, 53
multilevel analysis, 186, 196
multilevel configurations, 196, 198
multilevel dataset, 186
Multilevel ERGMS, 195, 196, 199
multilevel network, xxxv, 11, 185, 186, 187, 191, 198
multilevel network analysis, 188, 194
multilevel network models, xxxv, 186, 194, 198, 199
Multinational Enterprises (MNE), xxix, xxx, xxxiv, 26, 27, 30, 36, 37, 38, 39, 40, 46, 129, 188
Multiple regression, 16
Multiplex analysis, 9

Macao, 82
Index

N
Nature, xxiv, 3, 22, 114, 115, 117, 184
Netherlands, 98, 161, 184, 193
NetSci, 3
network configurations, 194, 195, 199
network evolution, xxxi, xxxii, xxxiv, 7, 13, 12, 13, 45, 46, 49, 50, 51, 52, 55, 70, 74, 75, 77, 81, 86, 95, 98, 100, 102, 103, 104, 107, 117, 120, 127, 129, 143, 147, 157, 170, 183, 184, 202, 208, 219, 224, 225, 226, 227, 235, 244, 246, 247, 294, 297, 298
network formation, 7, 13, 36, 226, 227, 244
network geometry, xxxi
network measures, xxx, 1, 5, 13, 28, 36
network positions, 169
network pruning, xxxiii, 152, 157
Network Science (NS), xxi, xxiii, xxvi, xxx, 1, 2, 3, 4, 7, 8, 13, 19, 21, 22, 23, 26, 27, 47, 74, 75, 80, 152, 160, 166, 294, 295, 297
network structure, xxxv, 5, 7, 8, 13, 30, 36, 39, 51, 56, 57, 58, 63, 67, 68, 170, 189, 194, 213, 226, 251, 297, 298
network theory, xxiv, xxviii, 2, 49, 51, 54, 169, 208, 223
network visualisation, 4, 33, 192
New Trade Theory, 27
Newton’s law of gravitation, 73, 79, 87
nodes, 13
Nomenclature Statistique des Activités Économiques dans la Communauté Européenne (NACE), 190
normalised degree centrality, 211
North American Free Trade Agreement, xxxiii, 53, 104, 128, 156
North-Africa, 235
null model, 8, 84, 85

O
Oceania, 62, 235, 236, 237, 257
OECD, xxi, 31, 41, 46, 120, 121, 122, 123, 127, 130, 132, 133, 135, 136, 137, 138, 139, 140, 142, 188, 200, 201, 202, 284, 288, 293, 294
offshoring, 37, 42, 144, 168, 200, 202
OLI paradigm, 37
ORBIS, xxxv, 30, 50, 71, 185, 186, 189
outdegree, xxxvi, 5, 28, 122, 123, 128, 130, 134, 137, 138, 140, 151, 239, 254, 255, 284, 288, 290
out-degree centralisation, 191
out-degree centrality, 134
outsourcing, 37, 42, 185, 202, 205
out-strength, 134, 136
ownership networks, 26, 39, 41, 189, 191, 193

P
Pacific Island Countries Trade Agreement, 104
PageRank, 151, 152, 165
Pajek, 17, 55, 224, 225
Pakistan, 119, 124, 133, 284
Pan-Arab Free Trade Area PAFTA, 107
Pearson correlation, 86, 98
Peixoto, 50, 58, 67, 71
Peru, xxxi, 63, 67, 119, 286
Philippines, 119, 136
Poland, 119, 124, 161, 215
policy networks, 10, 201
political science, 4, 25, 194
positional analysis, 28
preferential attachment, xxxvi, 8, 22, 28, 32, 227, 231, 263
Preferential Trade Agreement (PTA), xxi, xxxii, 74, 75, 83, 104, 106, 107, 242, 246, 247
Proceedings of the National Academy of the Sciences, 3
production, xii, xxvii, xxix, xxxiv, 27, 28, 31, 32, 33, 34, 35, 37, 40, 42, 43, 55, 112, 128, 129, 145,
Index

147, 162, 163, 165, 167, 169, 182, 184, 185, 200, 201, 202, 222, 297
production networks, 34, 184, 222, 297
productivity, xxvi, xxxv, 27, 32, 38, 206, 222
projected networks, 209, 213
Protocol on Trade Negotiations, 228
puzzle of distance, 10
Python, 4, 17, 49, 73

Q
quadratic assignment procedure, 16
Queretaro, 174

R
R&D, 164, 172, 173, 206, 248
random effects model, 11
random network, 78, 176, 178
reciprocity, 9, 189, 191, 194, 198
regional blocks, xxxi
regional clusters, xxxi, 68
regional factories, 34
regional production blocs, 34
Regional Trade Agreement (RTA), 36, 46, 103, 118, 225, 227
regionalisation, xxxi, 7, 34, 35, 36, 40, 49, 51, 53, 54, 56, 57, 67, 70, 144, 227
Republic of Korea, 193
rich club, 78
Richard Baldwin, 34
Russia, xxi, 12, 98, 119, 126, 144, 215, 216
Russian Federation, 104, 124, 274, 288

S
SADC, 104
Samsung Electronics, 193
satellites, xxxiii, 124, 133, 143
SBM, 50, 57, 58, 61, 62, 63, 64, 65, 68
scale free networks, 8
scale-free distribution, 78
Scandinavian countries, 64, 274
Second World War, 52, 127
semi-periphery, xxxi, 63, 67
Separable Temporal ERGMs, 10
Serbia, 82
services, 25, 73, 112, 163, 164, 187, 202
small world, xxxiv, 2, 167, 168, 170, 178, 179, 201
small-world property, 73, 76, 79, 85, 87, 178
Social Network Analysis (SNA), xi, xxvii, xxviii, xxx, 1, 2, 3, 6, 13, 21, 22, 168, 169, 176, 184, 200, 297
sociology, 1, 2, 3, 4, 6, 25, 143, 184, 194
South Africa, 124
South America, 62, 235, 263
South Asia, 235
South Korea, 119, 124, 136, 157, 158, 159, 160, 161, 242, 243
South Pacific Regional Trade and Economic Cooperation Agreement (SPARTECA), 107
Southeast Asia, 207, 235
Southern African Customs Union SACU, 107
Southern Asia, 263
Southern Common Market MERCOSUR, 104
Soviet Union, 60, 77, 104
Spain, xxiii, xxvi, 98, 161, 193, 215, 218
Spanish colonies, 62, 63
spatial effects, 10
spatial proximity, 10
Standard International Trade Classification (SITC), 5, 189
state-space model, 59, 68, 69
statistical approaches, xxix, 27
strength centrality, 134, 136
structural equivalence, 12, 28
structural position, 33, 138
sub-network structures, 152
subnetworks, xxxv, 78, 85, 171, 174, 176, 177, 179, 208, 237, 251, 272, 274, 281, 282, 283, 284
Sunbelt, xii, 3
supply chains, xxxiv, 45, 168
Taiwan, 82, 120, 161  
tariffs, 52, 171  
technological diffusion, 25  
technological progress, 52  
Temporal Stochastic Block Model (TSBM), 50, 67  
Textile, xxxv, 208, 213, 217, 218, 219  
Thailand, 120, 124  
THALES Avionics SA, 173  
third country effects, 28  
topological distance, 210  
topological properties, 27, 44, 70, 76, 95, 116, 144, 208, 226, 244, 246, 251  
topological space, 130, 210  
topological structure, 44, 76, 252  
trade agreements, xxvii, xxxv, 10, 71, 117, 129, 227, 242, 245, 297, 298  
trade blocks, 236, 237  
trade data, xxxv, 4, 5, 11, 12, 25, 26, 32, 33, 40, 63, 73, 81, 82, 83, 89, 119, 129, 136, 185, 186, 187, 189  
trade distance matrices, 81  
trade diversion, 232  
Trade in Value Added (TiVA), 31, 188  
trade integration index, 49, 51, 59  
trade intensity, 36  
trade resistance, 74, 80  
trade theory, 27  
trade-matrix, 135  
trading blocs, 101, 103, 104, 113  
transactions matrix, 147, 148, 156  
transitivity, 7, 11, 80, 108, 194, 198, 226  
transportation costs, 171, 232, 237  
triad census, 35  
triadic configurations, 35  
triadic ties, 35  
Turkey, 120, 124, 161, 176, 181, 238, 240, 241  

UK, xxiv, 98, 107, 117, 127, 161, 193, 215, 284  
UN Comtrade, xxxv, 119, 129, 186, 189  
UNCTAD, 36, 47, 126, 127, 185, 187, 203  
United Arab Emirates, 120  
United Kingdom, 78, 82, 294  
United Nations Commodity Trade Statistics Database, 81, 118  
United Nations Harmonised System (HS), 190  
USSR, 51, 61, 65, 235  

value chains, xxviii, 32, 43, 47, 120, 164, 165, 167, 169, 171, 173, 175, 181, 187, 200, 202, 203, 222  
Venezuela, 65, 67, 120, 136  

WAEMU, 104  
Wallerstein, 28, 47, 49, 55, 63, 71  
Watts-Strogatz model, 2, 170, 178  
weighted adjacency matrix, 210  
weighted network, 5, 70, 108, 130, 144, 210, 246, 247  
weighted ties, 195, 199  
Western Europe, 66, 176, 235, 263  
wine sector, 28  
World Bank, xxv, 44, 46, 47, 82, 83, 115, 118, 125, 128, 140, 142, 254, 269, 294, 295
<table>
<thead>
<tr>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>World Economic Forum, 119</td>
</tr>
<tr>
<td>World Input-Output Database (WIOD), xxxiii, 31, 145, 146, 160</td>
</tr>
<tr>
<td>World Input-Output Network (WION), xxi, xxxiii, 43, 146, 148</td>
</tr>
<tr>
<td>World Systems Theory, 28</td>
</tr>
<tr>
<td>World Trade Atlas, xxxi, 73, 74, 81, 93, 98, 113, 114, 116</td>
</tr>
<tr>
<td>World Trade Map WTM, xxi, 101, 103</td>
</tr>
<tr>
<td>World Trade Network, xxi, 4, 43, 120, 131, 143, 144, 223, 226, 252</td>
</tr>
<tr>
<td>World Trade Organisation (WTO), 31, 83, 103, 118, 128, 188, 225,</td>
</tr>
<tr>
<td>242, 243, 245</td>
</tr>
<tr>
<td>World War I (WWI), xxxii, 51, 64, 69, 78, 83, 98, 100, 112</td>
</tr>
<tr>
<td>World War II (WWII), 52, 66, 69, 77, 100, 101</td>
</tr>
</tbody>
</table>