NETWORKS OF INTERNATIONAL TRADE AND INVESTMENT

Understanding globalisation through the lens of network analysis

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Series in Economics

VERNON PRESS

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www.vernonpress.com

In the Americas:
Vernon Press
1000 N West Street,
Suite 1200, Wilmington,
Delaware 19801
United States

In the rest of the world:
Vernon Press
C/Sancti Espiritu 17,
Malaga, 29006
Spain

Series in Economics

Library of Congress Control Number: 2018942478

ISBN: 978-1-62273-065-0

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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."
> (C.P. Cavafy, *Collected Poems*. Translated by Edmund Keeley and Philip Sherrard. Edited by George Savidis. Revised Edition. Princeton University Press, 1992)

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.

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List of Acronyms

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

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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.

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 Bogugñá, 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.

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